

A Study on the Future Sustainability of
Sejong, South Korea's Multifunctional
Administrative City, Focusing on
Implementation of Transit
Oriented Development

Jeongmuk Kang

Examensarbete i Hållbar Utveckling 93

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Kang, J., 2012: Study on future sustainability of Sejong city, South Korea's multifunctional administrative city, focusing on implementation of Transit Oriented Development. *Master thesis in Sustainable Development at Uppsala University*, No. 93, 41pp, 30ECTS/hp

Abstract: Since the appearance of steam engines in the late 18th century, cities have been growing with the development of transportation and the consequent increase of its urban population and economic activities. Presently, cities accommodate more than half of the world population and are expected to be responsible for 73% of the world's energy use in 2030. Cities come to the fore as a problem, being also the roots of solution for current environment and energy-related problems. The Transit-Oriented Development (TOD) and Bus Rapid Transit (BRT) systems applied in Latin American cities have shown the possibility of establishing efficient urban transport networks and sustainable urban structures at low cost. Meanwhile, Asian cities are anticipated to accommodate 54% of the world urban population by 2050. Sejong city, South Korea is the newest planned city in the region aiming to see its completion in 2030. The aim of this paper is to assess the future urban sustainability of Sejong city by analyzing first the Master Plan of the construction of the city in accordance with PEBOSCA (Physical, Economical, Biological, Organizational, Social, Cultural, and Aesthetical) resources, and second its implementation in general with a focus on the expected role of Transit-Oriented Development in particular looking at BRT. Putrajaya's case is referred for anticipated shortcomings which Sejong should be prepared for. Secondary data and interpretations from books and articles regarding contemporary urban problems are comprehensively reviewed to systemically analyze the influences of implementation of TOD upon urban sustainability.

This study revealed that planned actions derived from TOD will play an important role in resolving urban problems in Sejong city by relieving urban traffic congestion, CO₂ emission and fossil fuel consumption. And systemic influences on improvement of business activities, government tax income, social activities and equity, and olfactory quality of the city are expected. Therefore, TOD is deemed to be a better option for existing cities and is necessary for newly developing planned cities in Asia and Africa.

Key Words: Sustainable Development, Sustainable Urban Planning, Transportation, Transit Oriented Development, Sejong, system analysis, PEBOSCA.

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Summary: People have been changing the environment and even the climate of our planet by using and consuming huge amounts of natural resources, especially during the last six decades. Since the invention of steam engines in the late 18th century, cities have been growing with the development of transportation and the consequent increase of its urban population and economic activities. Presently, cities accommodate more than half of the world population and are expected to be responsible for 73% of the world's energy use in 2030. Among various energy consuming sectors, transport accounts for approximately 19%, standing for 23% of energy-related carbon dioxide emissions; these figures are expected to increase in the future. Many cities in the world have been seeking for solutions to reduce the use of fossil fuel and the consequent CO₂ emissions from transport in cities, which is a problem, being also the roots of solution for current environment and energy-related problems. Meanwhile, Asian cities are anticipated to accommodate 54% of the world urban population by 2050. Eco-City and new administrative city projects have been implemented in several places in Asia, for the sake of easing congestions and overpopulations in their major cities and achieving a balanced regional development in the future. Transit-Oriented Development (TOD) and Bus Rapid Transit (BRT) systems applied in Latin American cities have shown the possibility of establishing efficient urban transport networks and sustainable urban structures in developing countries at low cost. Sejong city in South Korea is the newest planned city in the region aiming to see its completion in 2030. The aim of this paper is to assess the future urban sustainability of Sejong city by analyzing first Physical, Economical, Biological, Organizational, Social, Cultural, and Aesthetical resources of the city on the basis of the Master Plan of the construction of the city and second its implementation in general with a focus on the expected role of Transit-Oriented Development in particular looking at BRT. Putrajaya's case is referred for anticipated shortcomings which Sejong should be prepared for. Secondary data and interpretations from books and articles regarding contemporary urban problems are comprehensively reviewed to systemically analyze the influences of implementation of TOD upon urban sustainability.

This study revealed that planned actions derived from TOD will play an important role in resolving urban problems in existing and newly developing cities by relieving urban traffic congestion, CO₂ emission and fossil fuel consumption. And systemic influences on improvement of business activities, government tax income, social activities and equity, and olfactory quality of city are expected. The success of Sejong will be loaded with symbolic significance for the country's balanced and sustainable development with less energy consumption and carbon footprint, and more equally distributed resources and opportunities. Investing on transportation on the basis of TOD is regarded as investment in welfare which returns benefits to all. Therefore, TOD is deemed to be a better option for existing cities and is necessary for newly developing planned cities in Asia and Africa.

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Introduction

1. Background

Human beings have been altering the environment and climate of our planet by excavating and consuming huge amounts of natural resources. Our main fossil fuel sources – oil, coal, and gas – are finite and are being depleted at a rapid rate (WWF, 2011). Furthermore they are considered as the main contributors to global warming and climate change. Actually, resulting from Green House Gases (GHG) overly released to the atmosphere, surface temperatures of the Earth have risen by around 0.74 °C over the past hundred years (ICLEI, 2009). Since record keeping began in 1880, the five warmest years on record have occurred since 1997 (ICLEI, 2009). Meanwhile, natural disasters, such as earthquakes, tsunamis, and floods, strike many places around the globe, and its magnitude and impact are becoming even greater and unpredictable despite the constant development of protection and forecast technologies against natural disasters. Now, people doubt if our way of treating natural resources is right or not.

On the 31st of October, 2011, the world's seven billionth baby was born in a crowded government-run hospital in the Philippines (Coleman, 2011). Our planet is getting packed and cities are getting even more congested with those people who rush into urban areas looking for job opportunities and income. Currently, 50.9 per cent or 3.5 billion of the people on Earth live in cities, and the size of the urban population is expected to be 56.6 per cent in 2025, and 68.7 per cent in 2050 (United Nations, 2010). According to the World Energy Outlook 2008 published by the International Energy Agency, by 2030, cities will be responsible for 73% of the world's energy use. Therefore, when it comes to CO₂ emissions and climate change, the targets that need to be focused on are the cities. Estimating the urban performance and its sustainability is a crucial step to help cities conserve Earth's natural resources in the long term (Alberti, 1996). Cities themselves are the greatest asset in promoting and pursuing sustainable development and also offer the best climate change solutions, such as generating lower emissions and consuming less energy by designing a compact, densely populated and well-planned city (UN-Habitat, 2012). In short, cities are problems, being also the roots for the solutions.

Among various energy consuming sectors, transport accounts for approximately 19 per cent energy use, standing for 23 per cent of energy-related carbon dioxide emissions and these shares are expected to increase in the future (IEA, 2009). Given population and income growth rate, transport energy use and CO₂ emissions are projected to increase by practically 50% by 2030 and more than 80% by 2050 (IEA, 2009). According to the Intergovernmental Panel on climate change (IPCC), to avert the worst impacts from climate change, global CO₂ emissions must be cut by at least 50% by 2050. To achieve this, transport will have to play a great role (IEA, 2009). Based on the scenario developed by the Pew Center on Global Climate Change, by improving vehicle efficiency, shifting to less carbon intensive fuels, changing travel behavior, and operating more efficiently, GHG emissions from the transportation sector would possibly be able to be cut by up to 65 per cent below 2010 levels by 2050 (Greene *et al.*, 2011). In this section, we will look at how transport has closely been related to urban growth and structure by referring to historical backgrounds of the development of cities, rapid urbanization in developing countries in Asia and Africa after World War II, urban problems and the occurrence of new urbanism movements, construction of planned cities in the developing world for sustainable and balanced national development, and urban reformation in Latin America on the basis of Transit-Oriented Development programs.

1.1 The Industrial Revolution and the spread of transport networks

The structures of a city have dramatically changed since the industrial revolution which began in England in the late 18th century. Since the appearance of steam engines, which were the technical basis of trains and railroads, cities have been transformed into places where higher economic productivity is concentrated and started to spread out like the spokes of a wheel (Sung, 2009). The density of the population in a city is determined by food supply which is limited by natural resources. The development of the means of transport and food-preservation has increased the capacity of cities and has raised new industrial cities in Europe and led to massive urbanization (Childe, 1950). This progressive change in economic structure and social organization of communities in the middle of the 19th century was accompanied by a dramatic increase in the population, which was a remarkable growth in the population of London (Childe, 1950) (Figure 1). Therefore, the industrial revolution can be regarded likewise as marking the transition between historical stages in economic and social development (Childe, 1950). And it is also regarded as the trigger to the Age of Imperialism, which played a great role in spreading the new economic and social structure, Capitalism (Lenin, 1917).

Under the changed economic structure, Europeans needed more raw materials, labor, and overseas markets to export their manufactures. Steam engines for boats and trains, and telegraphs which were invented during the industrial revolution made Europeans able to reach remote countries in Africa and Asia by allowing them to keep in contact with their home countries more efficiently (Gollwitzer, 1979). Not only the United Kingdom but also relatively developed countries such as France, Germany, Italy, Japan, and the United States took over less developed regions and expanded their own power. And those industrialized countries underwent the process of unprecedented urbanization in this period (Knox, 2010). The colonists who had economic power and technologies constructed transportation infrastructures in colonized areas as their first action in order to move troops and transport raw materials efficiently. Especially, the railway played a key role in the extraction of market crops and raw materials from colonized areas as well as in the spread of machine-manufactured goods exported overseas from Europe (Adas, 1992). Consequently, the establishment of land and maritime transport networks contributed to the creation of an integrated, capitalist-dominated international economic system (Woodruff, 1996).

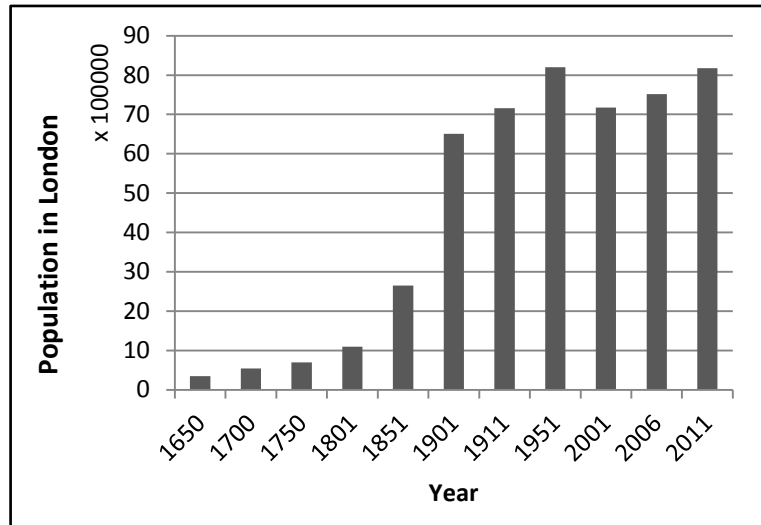


Figure 1. Population growth in London

Source: <http://www.londononline.co.uk/factfile/historical/>
<http://www.demographia.com/dm-lon31.htm>

1.2 Rapid urbanization in Asia after World War II

Economies of agglomeration in trade and industry generate the growth of cities where the highest rate of growth of labor productivity is located, and urban transport oils this engine of growth (Gwilliam, 2012). Global urbanization in the first half of the 20th century mainly took place in European cities like London, Paris, and in American cities which were formerly pioneered by European countries acting as the economic and industrial centers of the world. However, the global distribution of urban population has been changing rapidly since the end of World War II with the liberalization of previously colonized countries in Asia and Africa.

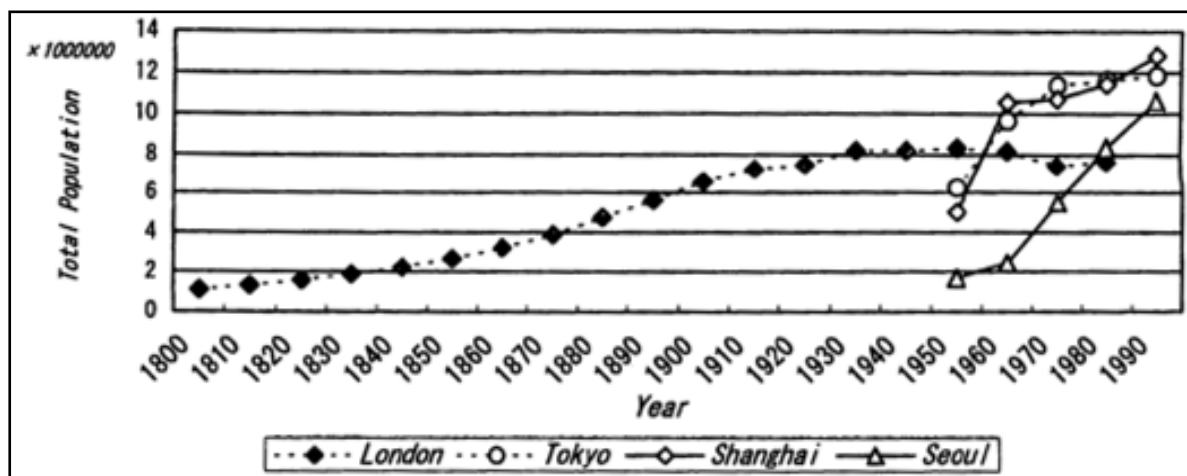


Figure 2. Population growths in London and major Asian cities

Source: Yokohari *et al* (2000) Beyond greenbelts and zoning: A new planning concept for the environment of Asian megacities, pp.160

Manufacturing industries have been moving from Europe and Northern America to Asian and African countries pursuing lower labor costs and lower barriers of regulations. The consequential economic growth in Asian and African countries has caused rapid urbanization in those areas (Sung, 2009). The majority of urban residents today live in Asian cities such as Tokyo, Seoul, Shanghai, and Mumbai which have experienced or been experiencing rapid economic development since World War II (IEA, 2009). Figure 2 represents how drastic urbanization and population growth in those Asian mega cities have undergone since 1950 in comparison to that of London experienced since 1850.

As shown in Figure 3, the total population of the world has been constantly growing since 1950. And the world urban population grows at an even higher rate than the world population growth. While the urban population in Europe has slightly increased in the past six decades and is estimated to be maintained evenly in the future, the increase of the world urban population has been and expected to be boosted by Asian and African countries. According to the World Urbanization Prospects report, Africa and Asia will experience a remarkable increase in their urban populations. By 2050, most of the urban population of the world is anticipated to be concentrated in Asia (54% or 5.2 billion people) and Africa (20% or 1.9 billion) (United Nations, 2010). This is why we should pay more attention to Asian and African cities which are expected to accommodate more than 70% of the world urban population to have global sustainability improved in the future.

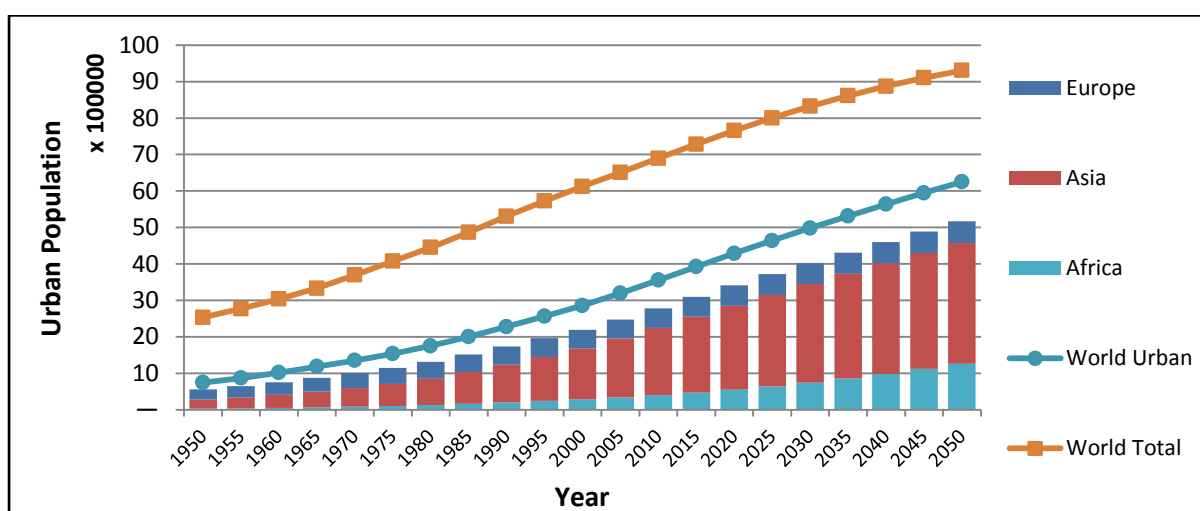


Figure 3. World Total and Urban Population 1950-2050

Source: <http://esa.un.org/unup/CD-ROM/Urban-Rural-Population.htm>

1.3 Urban congestions and New Urbanization

The rapid increase of the urban population is obviously a key factor in the demand for urban access and mobility (Bulman, 1988). Cities in Europe and Northern America, most of which have experienced economic development and urbanization have been dealing with their urban sustainability problems through policies over several decades. In the US, the movement known as ‘New Urbanism’ has arisen as an alternative to avoid traditional urban patterns of low-density, auto-dependent land development (Ellis, 2010). The point of this movement is its focus on the improvement of the efficiency of the public transport sector using traffic management techniques and the revitalization of urban areas. European countries and the United States have expanded their railway networks respectively in the late 1990s and in the mid 2000s, which represents their efforts to enhance the role of the railway rather than automobiles in accordance with urban sustainability (Figure 4). While there must have been a large portion of additional travel demands in the rest of the developing countries shown on the figure 4 during the last three decades, no significant increases in railways are observed. That implies that the automobile has been main travel mode to meet increased travel needs in those countries.

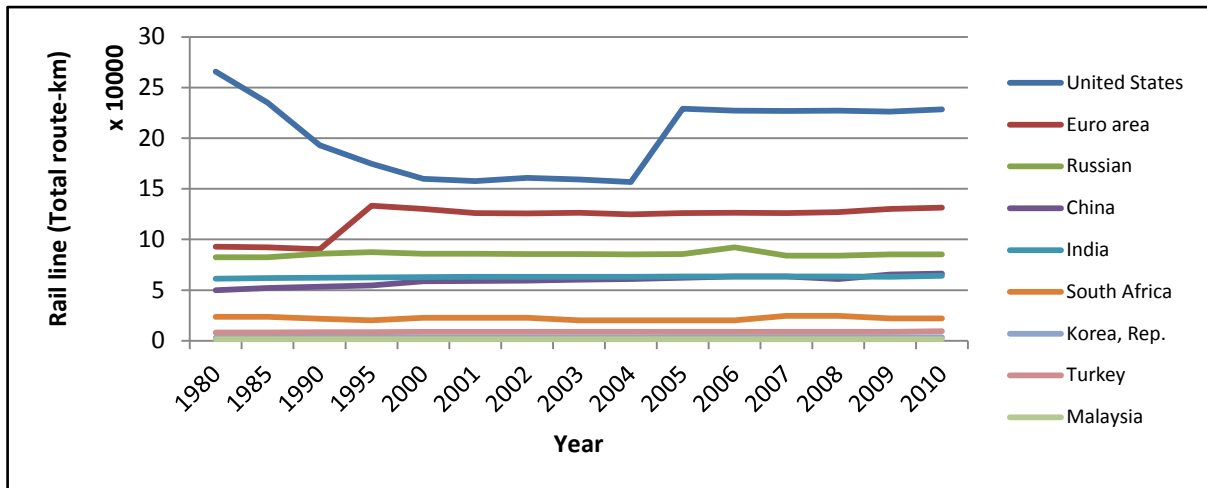


Figure 4. Total route of rail line

Source: <http://data.worldbank.org/indicator/IS.RRS.TOTL.KM>

Asian cities which have presently been experiencing unprecedented rapid economic development and population growth have not had enough time to pay proper attention to taking care of urban sustainability since they have been busy with chasing western countries in economy and improving their living standards under the colonial patterns of urban structures that western powers left behind (Banjo & Dimitriou, 1983). Recently, many cities in Asia are trying to develop sustainable cities by introducing green technologies and eco-friendly urban structures. Most of all, China has been developing more Eco Cities than any other countries in Asia. Since the end of the 1990s, many cities in China have engaged in the setting up of plans for “Eco-Cities”. By 2003, there were 135 cities or local municipalities that began their planning of Eco-City projects (C T YIP, 2008). However, some grand plans of Eco-Cities in China have stalled due to discords between the urban planning project operators and the existing dwellers in the project areas, most of which were intended to be models of green urban design (Larson, 2009). More often than not, these eco-cities were designed by foreign architectural and engineering firms who merely brought their ways and experiences from home with little understanding of Chinese politics, culture, and economy. Eco-city plans also are frequently utilized by politicians to gain fame and popularity before elections (Larson, 2009). Therefore, it seems to be urgently needed for Asian cities to have proper models of sustainable cities which are designed and constructed in proper accordance with their own local circumstances and culture by paying more attention on transportation.

1.4 Decentralization and balanced regional development

During the colonial period and immediately after, the settlement patterns of many formerly colonized cities in Asia were largely molded by the interests and the economic activities of past colonizers, especially in the case of capital cities (Banjo & Dimitriou, 1983). Transport Research Laboratory (1992) estimates that an addition of 1,000 to the population in a city in a developing country is associated with 1,500-2,000 additional trips each day. Thus, as cities grow and become richer, the ownership of private vehicles and the use of motorized vehicles such as small buses and 2~3 wheelers grow faster than the capacity of roads, which causes severe congestion and deterioration of the air quality in the city (Gwilliam, 2012). Banjo and Dimitriou (1983) assert that the application of standardized traffic and transport planning approaches to developing countries have not only failed to resolve their urban traffic problems, but have themselves created additional transport problems.

In order to tackle severe congestion and excessive concentration of economic and political functions in capital regions, there have been efforts to decentralize government powers and functions pursuing balanced regional development and ease of overcrowding in capital areas in developing countries. Brasilia, the capital city of Brazil, and Chandigarh, the capital city of Haryana and Punjab states in India, are good examples of the creation of planned cities and the relocation of government units in developing countries. Once looking into recently created or being created planned cities in Asia, Putrajaya city, the federal administrative center of Malaysia, has been developed as an administrative city sharing functions with Kuala Lumpur. And Sejong city, multifunctional administrative city in South Korea, is being developed for the same purpose of decentralization of government power and balanced regional development.

PUTRAJAYA city, Malaysia

Putrajaya, located 25km south of Kuala Lumpur, is a planned city serving as the federal administrative center of Malaysia (Figure 5). Putrajaya is planned and designed as a model for Malaysia's future urban development. The Master Plan was first drawn up in October 1995, but the idea of relocating the Federal Government's administrative function out of Kuala Lumpur (KL) was rooted around fifteen years ago. Since the early 1970s, KL has been under pressure by its increasingly untenable infrastructure, worsening traffic jams, and the frequent occurrence of flash floods in company with rapid and unprecedented economic growth. All federal-level government ministries were relocated from Kuala Lumpur to Putrajaya in 1999 and the whole construction plan of the city was completed in 2012. The name of the city is a reference both to the first Malaysian Prime Minister, Tunku Abdul Rahman Putra, and the Sanskrit-derived *putra*, meaning 'son' or 'prince' and *jaya*, a common part of place names in Indonesia and Malaysia.

The vision as set by the chief proponent of the project is to develop the new city as a 'City in a Garden' and an 'Intelligent City', a city designed and developed to meet the needs of the present population and but also be relevant to future generations (Ariffini 2003). Putrajaya is a valuable contemporary example of a master planned administrative city and demonstrates the struggle of many former colonies to forge a distinct national identity that both reflects the values and aspirations of the new nation and differentiates itself from its colonial past (Moser, 2010).

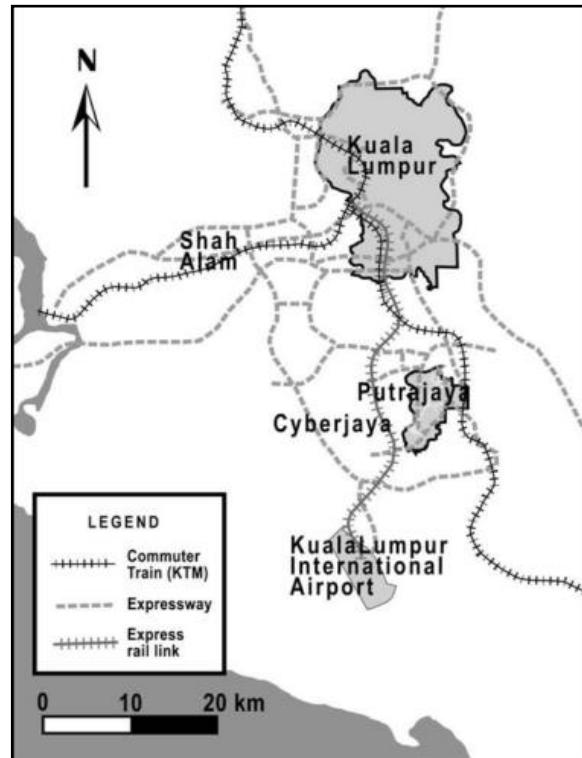


Figure 5. Location of PUTRAJAYA city

Source: Moser (2010)

SEJONG city, South Korea

Sejong, located in the heart of South Korea, about 120km south of Seoul, is South Korea's newly developing administrative city (Figure 6). This historical moment is the valuable fruit of coherent efforts of a visionary leader, the late president Roh Moo-Hyun who passed away with his masterpiece left behind. The history of Sejong dates back to 2002 when the then presidential candidate Roh set out the construction of a new national capital as his main election promise. The master plan of construction of the city was drawn in 2007, and the Sejong special autonomous city government was officially launched on 1st July 2012 in an uncompleted state. The Korean government will relocate 36 administrative organizations and departments including the office of the Prime Minister to Sejong by 2015 in three phases. And this city is being developed with its completion due in 2030 with hopes to become an internationally recognized planned city.

The city is named after Joseon Dynasty King Sejong who profoundly impacted Korean history with the introduction of Hangeul, the originative alphabet system of the Korean language, in the 15th century. According to the Multifunctional Administrative City Construction Agency, Sejong will show the idea of the keystone for a balanced national development by

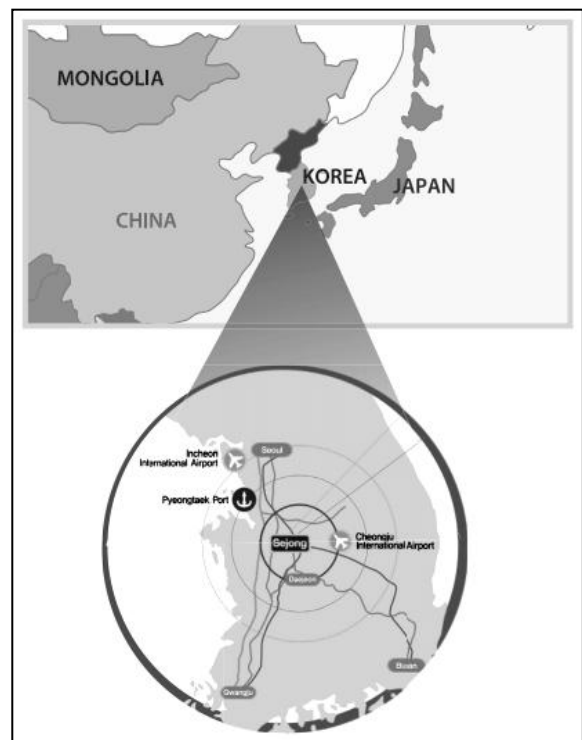


Figure 6. Location of SEJONG city

Source: MACCA (2007)

decentralizing the country's administrative function which is currently heavily centralized in Seoul, the capital city of South Korea. Especially, the ring-shape structure of the city will represent the significance of the eco-friendly development and make the city sustainable through the preservation of a central space. And the public transportation of Sejong was designed to act a crucial role for the function and development of the city. Transit transfer centers will be allocated in each living area laying on a ring-shaped public transportation axis. And by introducing Bus Rapid Transit (BRT), public-oriented transportation system is expected to take charge of more than 70% of the whole transport (Shin *et al*, 2011).

1.5 Urban Transform with Transit-Oriented Development (TOD)

When it comes to sustainable development and urban sustainability, many cities and local governments are considering countermeasures against the growing consumption of fossil fuels in the transport sector. Since travel derives from the necessity to work at other destinations, travel networks has to increase as cities expand their population and areas(Ohmori & Harata, 2008). And transport is a vital element in determining the quality of people's lives and plays a significant role in urban politics and influences both the economic growth and the distribution of the benefits (Gilbert, 2008). To make a city sustainable, people's travel demands must be fulfilled with smaller energy use and lower CO₂ emissions. Rapid mass transit, such as subways, light-rails, and rapid buses, not only provides a major means to accommodate urban travel but also plays an important role in shaping urban development (Zhang, 2006). Implementing Transit-Oriented Development (TOD) does not mean merely providing public transit services and good access to it. Among many definitions of TOD, one by Center for Transit Oriented Development (2007) states that:

Transit-Oriented Development is typically defined as more compact development within easy walking distance of transit stations that contains a mix of uses such as housing, jobs, shops, restaurants and entertainment. TOD is really about creating walkable, sustainable communities for people of all ages and incomes and providing more transportation and housing choices (p.2).

While the term "Transit-Oriented Development" was formally conceptualized in North America in the early 1990's, the TOD practice has a long history in many places in the world and its principles are gaining increasing popularity worldwide in the global effort towards sustainable development (Zhang, 2006). Especially, several cities in developing countries in Latin America have shown the possibility of the implementation of TOD at relatively low cost and the distribution of high benefits to all. The Latin American bus-way has inspired transport planners world-wide and is becoming a popular option of choice (Gilbert, 2008).

Curitiba, Brazil

Curitiba, the 8th most populous city in Brazil, is well known for its unique transportation system and urban planning. Despite the small size of the city, Curitiba has a well-planned, easily-accessible, efficient, and environmentally-responsible transportation system that big cities around the globe have been trying to mimic. Since the Curitiba Master Plan was adopted in 1968, Curitiba's cost-conscious urban planners integrated its bus-only public transportation into all the other elements of the urban planning system. As buses travel on urban roadways, infrastructure investments were able to be substantially lower than the capital costs needed for rail systems or subway system (Goodman *et al*, 2006). Additional growth in the central area is suppressed, and the development of commercial areas along the public



Figure 7. Bus Rapid Transit in Curitiba

(© Mario Roberto Buran Ortiz)

transportation axis is encouraged instead. Curitiba's Bus Rapid Transit (BRT) (Figure 7) is used by 75 percent of commuters in the city (Richard, March 31 2009). According to Curitiba's 1991 traveler survey results, the introduction of BRT was estimated to cause a reduction of about 27 million auto trips per year, saving about 27 million liters of fuel annually (Goodman *et al*, 2006). And Curitiba's success inspired the implementation of BRT based TOD in other cities in developing countries including *TransMilenio* in Bogota, Colombia.

Bogota, Colombia

Bogota, Colombia, is a city increasingly viewed as a model of urban development which might come as a surprise given the negative images associated with the city. Bogota's surprising transformation started when the city's local leaders initiated a project of the city's transformation since the late 1980s. Bogota's *TransMilenio* BRT system (Figure 8) was started in 1998 after mayor Penalosa's determined that a subway system which requires high costs would not meet the city's needs and rather a BRT system was more efficient and economical. The goal of the *Transmilenio* BRT system was to provide a well-organized, efficient means of public transport. In addition to the BRT system, Bogota changed the physical aspects of the city, like pedestrian zones, road infrastructure, especially the implementation of paths reserved exclusively for bicycles, and the revitalization of parks and sidewalks. Through those investments in public infrastructures and services, the city has been transforming itself as an equitable and accessible city with having its tax revenues from the increase of land prices and revitalized business activities and credit qualification for internal debt improved considerably (Montezuma, 2005). Bogota's success in making positive changes was enhanced by key planning documents such as the city's general plan and a set of master plans, including one for public space and another for transportation, and most importantly, by the continuity of key staff in the District's planning department (Berney, 2010).



Figure 8. Transmilenio in Bogota

Source: Wikipedia Commons

2. Aim of the study

TOD and BRT systems applied in Latin American cities have shown the possibility of establishing efficient urban transport networks and sustainable urban structures in developing countries at low cost. In the meantime, Eco-City and new administrative city projects have been implemented in several places in Asia for the sake of easing congestions and overpopulation in their major cities and achieving balanced regional development. However, there have been limited studies focusing on the role of implementation of TOD in planned cities in the developing world. Thus, the aim of this paper is to preliminary assess the future urban sustainability of Sejong city by analyzing first the Master Plan of the construction of the city, and second to anticipate the shortcomings from its implementation in Sejong and Putrajaya focus on the expected role of Transit-Oriented Development in particular by looking at BRT. Therefore the purpose of this paper is to answer the following research questions:

1. What construction and action plans for achieving urban sustainability and balanced regional development have been established for the future city of Sejong?
2. What shortcomings have been observed in Sejong and Putrajaya which were developed for the same purposes?
3. How is the implementation plan of TOD expected to systemically influence urban sustainability and balance regional development in the future?

3. Methodology

To assess the role of the transportation sector and sustainable urban design in the effort to tackle global warming and climate change, both primary and secondary sources will be comprehensively reviewed. Among the first include databases by international organizations which have public confidence like United Nations, Organization for Economic Co-operation and Development, and International Energy Agency, and local databases served by the Korean government and Sejong local authorities. Among the second include books and articles regarding urban issues worldwide, in particular focusing on urban transport.

For the preliminary inventory analysis of the future sustainable features of Sejong city, it will be based on the Master Plan of the construction of the city. The PEBOSCA framework (Physical, Economical, Biological, Organizational, Social, Cultural, and Aesthetical) of the UN Habitat Agenda 1996 will be used. The PEBOSCA framework consists of the following seven resource packages:

1. **Physical resources:** Use of land and energy flow
2. **Economic resources:** Opportunities for local business and enterprises
3. **Biological resources:** Preservation of natural area and biodiversity
4. **Organizational resources:** Public services and urban structure
5. **Social resources:** Social equity and life satisfaction
6. **Cultural resources:** Preservation of cultural heritage and identity
7. **Aesthetic resources:** Visual and olfactory quality

To discuss the shortcomings of the city, the completed parts of the master plan in Sejong will be critically reviewed by referring to related news and data collected from a field trip to Sejong city which was conducted for the sake of collecting visual data and getting a hands-on experience of the city in July 2012. Sejong city is being constructed from nothing, so most of the constructions works are still ongoing. Thus, anticipated shortcomings will be comparatively studied by reviewing literature regarding Putrajaya, recently completed administrative center of Malaysia which has been completed its construction in 2012.

To assess the expected role of BRT based TOD in Sejong, the feature of implementation and construction plan of BRT based TOD will be reviewed based upon the Master plan for a high-level BRT of Sejong first. And next, the implementation actions of TOD and their anticipated influence upon urban sustainability will be systemically analyzed. For the system analysis on TOD, secondary data and interpretations in preceding books and articles studying transport-related phenomenon in urban areas using both qualitative and quantitative researches will be reviewed.

Result

1. Preliminary Inventory analysis of the Master plan of Sejong city

In this section, the preliminary inventory analysis on Sejong will be performed in accordance with the Master Plan of construction of the city in order to draw a blueprint for the future sustainability of the city.

Sejong was being developed as a fully planned city under the control of the government agency, the Multifunctional Administrative City Construction Agency (MACCA) in accordance with the Special Act for construction of Sejong Special Autonomous City. As described in Table 1, the Master Plan of the construction of the city was completed in 2007, and the relocation of government units has just started in 2012.

Table 1. Sejong city in brief

	SEJONG city
Country	South Korea
Official name	SEJONG Special Autonomous City
Distance from Capital city	120km
Area	73 km ²
Master plan established	2007
Relocation of government unit	2012
Completion of construction	2030 (projected)
Population (Current/Projected)	103,127/500,000

Source: MACCA (2007)

Sejong is supposed to be developed in three stages (Table 2). By the end of the first stage of development, the transfer of governmental agencies will be completed, which is one of the main functions of the city. For the second and third stages of development, MACCA has been attracting foreign and domestic investors based on the urban zoning plan of the city by offering various benefits on taxes and tariffs in order to improve the economic feasibility of the city and to make it into a self-sufficient and multifunctional city.

Table 2. Three stages of construction plans for distributing population at each stage

	2007 - 2015	2016 - 2020	2021 - 2030
Division	Cooperative stage at the beginning	Self-sufficient matured stage	Completion stage
Population	150,000	3000,000	5000,000

Source: MACCA (2007)

In this part of the paper, the construction and action plans of this future mini capital of the country will be preliminarily analyzed according to seven inventories; physical, economical, biological, organizational, social, cultural, and aesthetic resources, based on the Master Plan of the construction of the city.

1.1 Physical Resources

Cities or urban systems need a basic sustainable life support of its population with physical resources like energy, water and material. And now, these physical resources need to use partly new and efficient bio-systems technologies and eco-construction methods to create resilient urban and rural landscapes (Berg, 2010). The Master Plan of the construction of Sejong city includes zonal land use plan and the introduction of waste collection systems.

Zonal land use plan

By zoning the city depending on their special purposes, the land can be used more efficiently. Basically, zoning aims to create well-ordered urban areas by promoting urban development. Benefits from zoning and urban planning are already stressed by many municipalities and governments in western countries (Freire, 2006).

Furthermore, land planning policies can play a significant role in reducing demand for travel, and thus energy consumption, also reducing CO2 emissions to atmosphere (Gross *et al.*, 2009).

Zoning cities have been criticized for the reason that it basically violates private property rights by limiting the land use right of the land owner (Nelson, 1979). In case of Sejong, however, all the land in the project area has already been purchased by the government and allocated to project operators of each zone. Sejong city would eliminate the critical factors of zoning related to privately owned land issues in advance and maximize the positive effects of zoning by zoning the city from its designing and planning level.

The land of Sejong, 73 square kilometers (28 square miles), will consist of a huge central green area and six major functional zones that are connected by a ring-shape public transportation network which provides most convenient and fastest access from zone to zone (Figure 9). By conserving a green area at the center of the city, accessibility to the central park from all around the city will be maximized. Especially, the achievement of a high level of travel efficiency and reduction of CO2 emissions through zoning the city in accordance with accessibility to public transit and encouraging the use of bicycles within zones are expected (Bae, Lee & Jeon, 2008).

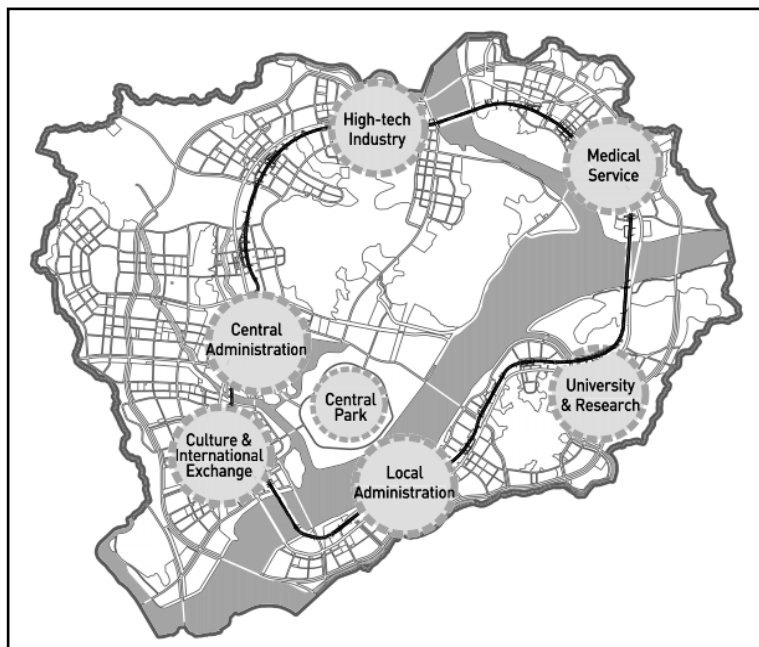


Figure 9. Multi-core structure of Sejong and public transport axis (plan)

Source: MACCA (2011)

Plan of Tube-based Waste Collection system

A tube-type automatic domestic waste collection system is being introduced throughout Sejong. Under this system, waste which is initially collected from designated indoor or outdoor collection facilities are transferred into the underground storage at the rate of 60-70km/h through highly pressurized tubes laid underground. Once waste arrives to the central collection storage, it will be divided into air containing dust and solid waste (LH Corporation, 2007). The air will be discharged to the atmosphere after a purification process, and the solid waste will be transferred to the respective processing sites after being pressured. This system is available for most types of wastes including combustible, incombustible, recyclable, and food waste. Since glasses which are likely to be broken during transportation will lose its recycle value, a separated collecting system should be established in cooperation with local recycling companies. The main tube acting as a waste corridor will be placed in the Common Utility Duct (CUD), which will be installed under the BRT route.

Table 3. Brief comparison between Tube-based and Vehicle-based system

	Tube-based	Vehicle-based
Estimated total energy consumption for 30 years	2.07 * 10 ³ – TOE/FU	2.85 * 10 ³ – TOE/FU
Proportion of energy consumed for operation and maintenance	87.3%	99.9%
GHG emission (CO ₂ , SOX, NOX)	2.117kg – C/FU 0.053kg – SOX/FU 0.015kg – NOX/FU	2.387kg – C/FU 0.060kg – SOX/FU 0.017kg – NOX/FU
Proportion of variable cost	10 ~ 20%	70 ~ 80%

Sources: LH Corporation (2007)

Implementing the tube-type automatic domestic waste collection system would lower GHG emissions and energy consumption by substituting vehicles which are usually used for collecting and transporting wastes throughout the city. Table 3 shows the superiority of a tube-based transport system through its energy consumption, GHG emission, and economic feasibility. The energy consumption of a tube-based system is calculated based on the electricity consumption for the operation of facilities while the energy consumption of a vehicle-based system is calculated based on the fuel consumption of vehicles to collect and transport waste over 30 year's assumed minimum life cycle. Consequently, the tube-based system is expected to have 27.4% of reduced energy consumption compared to a vehicle-based system. The tube-based system also shows merit in coping with climate change since it emits a comparably less amount of Green House Gases than a vehicle-based system. When it comes to economic feasibility, the proportion of variable costs of a vehicle-based system is 70~80%, most of which are wages for labor forces while a tube-based system counts only 10~20% of variable cost (Table 3). According to an empirical analysis of the tube-based waste system in *Yongin* which has been in operation since 2000, the break-even point with the previous vehicle-based transport system was achieved in 10 years (LH Corporation, 2007).

There are several more merits of a tube-based waste system other than those mentioned above. Since all the wastes discharged from household will be collected and stored in underground storage via underground tube facilities, the level of health and sanitation of the city is expected to be high. And the city will be free from traffic jams around waste collection areas and assembly places of vehicles.

1.2 Economic Resources

Cities or urban systems need a robust economic system for allocating society's values to its inhabitants, combining theories and practices in sustainable economics. Thus, future cities need incentives for economic construction and for maintenance systems of the city (Berg, 2010). Fundamentally, the creation of Sejong city is based on the concept of a balanced national development by relocating government functions and economic opportunities from the Seoul metropolitan area to the region. The city is aiming to be developed by promoting knowledge-based industries in cooperation with neighboring cities.

The plan of balanced national development

In South Korea, the Seoul metropolitan area is a so-called primate city, which means the biggest city in a developing country having a much larger population than the second biggest city in the country (Urban Zoning, 2011). Approximately 25 million people, around half of the entire population of the country, reside in the Seoul metropolitan area, and it's the second largest in terms of population in the world following the Tokyo metropolitan area in Japan. The most critical drawback of this phenomenon is the disproportion in economic opportunities between the capital area and other local cities, and it has been one of the country's main concerns for decades (Shin *et al*, 2011). Since the huge population of job seekers and their families from all around the country has

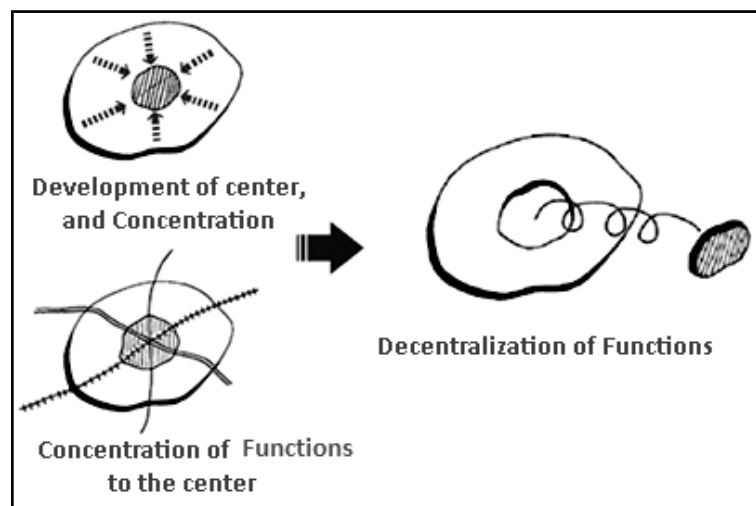


Figure 10. Decentralization concept of Sejong

Source: MACCA (2007)

been moving to Seoul, the capital area has become more and more saturated. This kind of highly compact and densely populated city might show high efficiency in generating huge amounts of economic values in a small area when the social infrastructure and welfare system are well established. However, the economy of the city may not be sustainable once those workers who are the main agents of economic activities of the city get tired to live and work in the big city due to the lower quality of life despite higher incomes and other opportunities (Sung & Oh, 2011). In the meantime, industries based on small and medium-sized enterprises in smaller regional cities suffer from the lack of labor force since many job seekers move to the big cities pursuing higher income, more job opportunities, and a better educational environment for their children.

As Figure 10 shows, the ring-shaped city spatial structure represents the harmonized democratic city. There will be no Central Business District in Sejong but multi functional cores which have their own specialized functions alongside the public transport axis surrounding the city. Instead, green (city forest and parks) and blue (stream and waterfront) areas will be placed in the central location of the city so that accessibility to these areas from every district of the city can be equal and efficient. And these central green and low-density areas will act as buffers to those compact and dense areas surrounding it. Sejong is planned to accommodate 16 government agencies and several huge economic entities including Samsung, Lotte, and Hanwha by 2020 (Schwartz, 2010). By creating and relocating more than 260,000 jobs to the region, Sejong is expected to become a symbol of decentralization in regards to governmental power, economic possibilities, and educational opportunities by sharing those functions and relocating the functional units which are currently too much concentrated in Seoul and its surrounding satellite cities (Table 4).

Table 4. list of government agencies and enterprises (plan)

	Entities to be relocated or invested	Expected No. of jobs
Public sector	• 36 of Government agents and organizations	10,452
	• 16 of National research agencies	No data
Private sector	• Enterprises including Samsung, Lotte, Hanwha, Woongjin	230,000
	• Private sector businesses	23,000
Educational institutes	• Korea Advanced Institute of Science and Technology	No data
	• Korea University	No date
Total amount of jobs expected		263,452

Source: MACCA (2007), Schwartz (2010)

The Plan of International Science Business Belt

The ministry of Education, Science and Technology of Korea has recently released the implementation plan for the International Science Business Belt aiming to be the world top class science-based innovative cluster by establishing a fundamental science research environment. 5.2 trillion Korean won, approximately 4.5 billion US dollars, will be invested in this project for the 1st phase by 2017 (Ministry of Education, Science and Technology of Korea, 2012). The master plan of this project consists of one foothold area in *Daejeon*, which will act as the hub of the International Science Business Belt, and three functional districts in *Cheonan*, *Cheongwon*, and *Sejong*, which are adjacent cities to *Daejeon*. The core area of ISBB will be located 10km away from *Sejong* to the south, alongside the BRT corridor which will effectively be connecting *Sejong* and *Daejeon* (Figure 11). The estimated settled population in the core district in the future is approximately 11,000, and half of the population is expected to reside outside the core district. That means *Sejong* would embrace those 5,000 employees and their families in addition to the settled population in the functional district in *Sejong*. According to the Ministry of Education, Science and Technology (2012), this project will create 1,400,000 of jobs and have 214 billion Korean won of spin-offs on production inducement in the project area by 2029. Consequently, *Sejong* would become an example of a self-sufficient

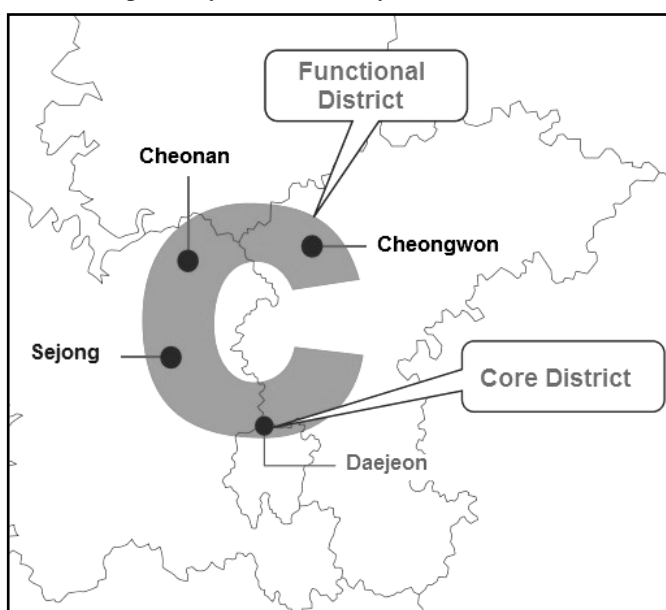


Figure 11. Core and functional districts of the Belt (plan)

Source: Ministry of Education, Science and Technology (2012)

planned city combining multi functions into the city, differentiating itself from the other planned cities that have single functions like residential, industrial, or educational.

1.3 Biological Resources

Cities or urban systems need to nurture its biological resources on all scales from aesthetic entrance greenery to connections to wild nature and large-scale cultural landscapes. The specific task required is to highlight the connection between urban morphological dynamics and green structure development (Berg, 2010). The unique structure of Sejong, preserving green and blue areas in the center of the city, and the land use plan are expected to lead the city as one of the most environmentally friendly cities in the world.

Preservation and revitalization plans of the blue areas

In the past, wetlands were regarded as wasteland or useless land and their crucial functions and values for the ecosystem were underestimated. However, wetlands have come into the spotlight due to the extinction of many species, global warming and more frequent and larger scaled natural disasters (Choi *et al*, 2009). Korea, as one of the contracting parties to the *Ramsar convention on Wetlands*¹ since 1997, is also actively participating in conserving wetlands. *Geum* River and *Miho* Stream running through the center of Sejong are currently being preserved and revitalized as a part of the Korean government's green initiative project for the biggest four rivers of Korea. 800,000m² of existing natural wetland and 400,000m² of new man-made wetland will become a home of the local inland flora and fauna and will constitute the ecological diversity of the city. The natural functions of the rivers will be divided into three spaces including preserved, reconstructed and water-friendly space as shown in Table 5 below.

In residential areas, installing water detention facilities storing rainwater and water from inflowing streams larger than 10m in width in each direction and deeper than 1m are obligatorily (MACCA, 2007). In natural water detention areas, man-made wetlands larger than 5m in width have to be created to increase biological diversity. Small sized streamlets alongside trails connecting residential areas to green buffers would be created so that it acts as a drain and infiltrate surface water.

Table 5. Decision of zone for each river (plan)

Category	Water-friendly area	Reconstruction area	Preservation area
The river- upped riverside	<i>Geum</i> River – 2,506,000m ²	<i>Geum</i> River – 985,000m ²	<i>Geum</i> River – 1,692,000m ²
		<i>Miho</i> Stream – 540,000m ²	<i>Miho</i> Stream – 398,000m ²
	Active use	River scenery and ecosystem reconstruction	Use limited
Principles of management	Connection with nearby town	A buffer of Water-friendly-preservation	River ecosystem preservation
	Water-friendly, rest facilities	Passive, limited use	Wild life habitat, swamp
	Gymnastic facilities, multipurpose plaza	Flower gardens, nature education space	Observation, education facilities
Preservation / Use	Use		Preservation

Source: MACCA (2007)

¹ The Convention on Wetlands of International Importance, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. (Source: Official website, <http://www.ramsar.org>)

Land use plan fostering large green areas

In Sejong, a “Green Network” and a “Blue Network” will be designated where as much of the natural environment will be left as intact as possible. According to the land use plan of Sejong, a variety of riverside amenities harmonized with the surrounding green sceneries such as *Wonsu Mountain*, *Jeonwol Mountain* or *Jangnam Plain* will be created. The proportion of green and blue spaces of Sejong will amount to 53%, the biggest proportion of the entire land use, when the construction is completed (Shin *et al*, 2011). And the green and blue areas will consist of park, green land, river, public vacant land, others such as squares and reservoirs as shown on Table 6.

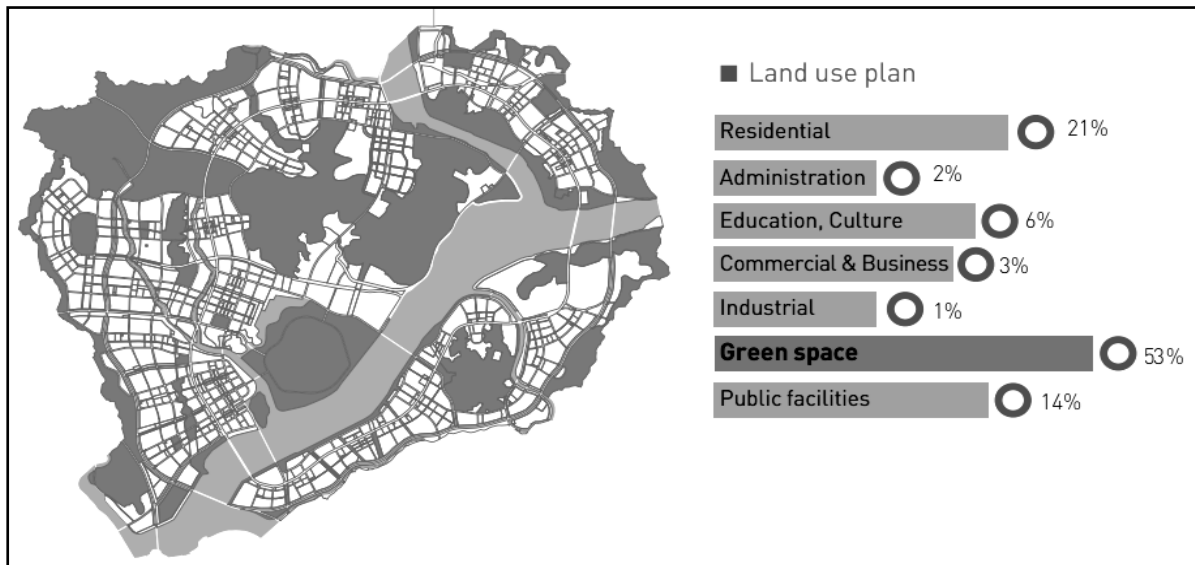


Figure 12. Land use plan of Sejong

Source: MACCA (2007)

Compulsory provisions regarding the green environment of the city will be strictly applied in accordance with related legislations. For instance, larger than 10m of green buffer zones bordering railroads, express ways or wide transport infrastructures have to be installed. The width of the green corridors functioning as ecological pathways constructed in accordance with the result of environmental effects evaluation must be larger than 10m, and its greening ratio should be higher than 70%. In order to create green networks, those urban parks located within 50-100m of each other will be linked through green footpaths. Throughout the project area, all of the existing trees which are supposed to be removed for construction will be reused in urban gardens and green corridors.

Table 6. Future composition of parks and green land of the city (plan)

Category	Scale (1,000 m2)	Comments
Park	17,537	Central open space, Living zone park, Theme park, etc.
Green land	7,606	Buffer/connecting green zone, Land required for green zone, etc.
River	11,843	National river, Local river, etc.
Public vacant land	593	Local river surrounding
Others	911	Square, Neighboring playground, Reservoir, etc.
Total	38,490	Accounts 52.8% of total city area

Source: MACCA (2007)

As a consequence of those efforts, each citizen who will live in Sejong in the future is expected to enjoy larger park areas than any others (Shin *et al*, 2011). The ratio of urban park area per person of Sejong is supposed to be more than 5 times the average urban park area per person in Korea and also much higher than other global cities in developed countries (Table 7).

Table 7. Comparison of urban park area per person

Scale	Sejong	Avg. in Korea	Toronto	London	Berlin	New York
(m2/person)	50 (planned)	8.2	29.6	24.1	24.5	10.3

Source: MACCA (2007)

The annual CO2 uptake by Sejong’s urban green space is estimated at 70,641 ton of CO2/yr based on the annual plant growth, and the CO2-uptake-to-emission ratio (Shin *et al*, 2011). The large proportion of green and blue areas properly harmonized with man-made urban structures may attract not only people who pursue better living conditions but also animals and plants seeking the same as humans do. And urban biodiversity today can play an important role for the ecological and cultural identity of a city (Müller *et al*, 2010).

1.4 Organizational Resources

Cities or urban system need to organize its morphology and integrated structures. It also needs formal and informal control and management systems for logistic and cybernetic function of future city-lands (Berg, 2010). A smart city plan using Information Technology convergence and an electronic government system are the basis of Sejong’s strategic and efficient utilization of resources.

The Plan of Integrated Urban Information networks

Today, state of the art technologies can be utilized for all people across the world to develop more sustainably, and e-government can be a booster of development for the people (United Nations, 2012). E-Government, short for electric government and also known as E-Gov, digital government, online government, and connected government, is a digital interaction system connecting the government to its citizens, to business, to employees. Korea has been ranked in first place on the list of world e-government development leaders 2012 issued by the United Nation two times in a row. Since the main function of Sejong is the administration of government, high technologies and experiences on e-government would be applied in the entire information network of the city.

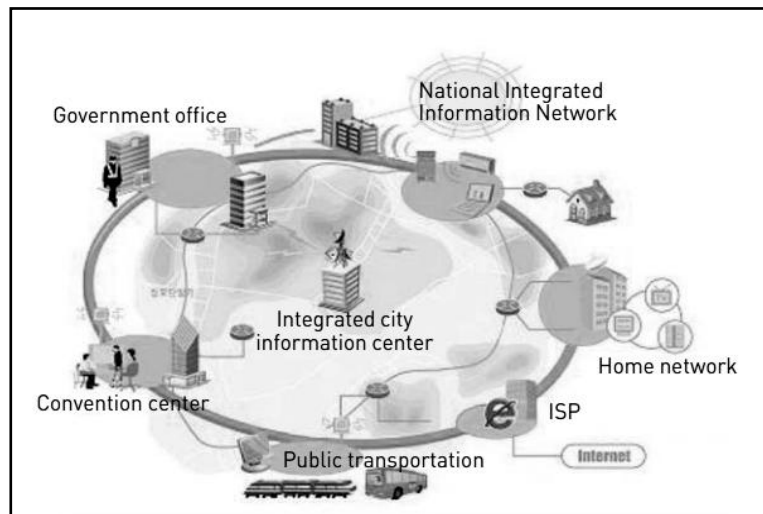


Figure 13. the concept of integrated information network

Source: MACCA (2007)

The integrated city information center will be the hub of all the organizational and administrative information created and distributed in the city (Bae *et al*, 2008). The center has been constructed in the central administration zone where the government complex is located. It is designed to manage the city by comprehensively perceiving and controlling the entire functions of the city in real time in combination with transportation department, crime and disaster prevention department, environment monitoring department, facility management department, and public equipments management department.

The Plan of establishing Intelligent Transport System (ITS)

Amongst various information services consisting of integrated urban information network, Intelligent Transport System is one of the most noticeable features in terms of the sustainability of the city (Knox, 2010). The implementation of a high level of Intelligent Transport System is expected to contribute to the increase usage of public transportation by providing human-oriented transportation information services, and thus improving users' satisfaction and credit (Bae *et al.*, 2008). More precisely, various information systems will be combined into the Intelligent Transport System including the application of a bus priority signature system, bus information system, and bus fare managing system, using functions such as sensing unexpected situations, installing transit facilities, warning accidents, and automatically controlling the violating vehicles, and providing real time transportation information and parking information.

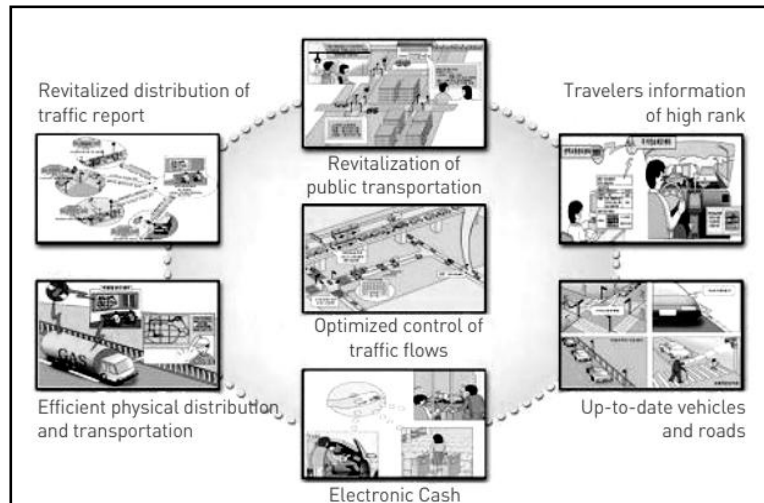


Figure 14. ITS Service Concept

Source: MACCA (2007)

1.5 Social Resources

Cities or urban system needs to promote local communities everywhere where its inhabitants feel safe and secure, a clear identity and a sense of home. Thus, a city needs to create and maintain communities with a mix of ages, apartment sizes and tenure-ship with sustaining neighborhood security, safety and a balanced social control (Berg, 2010).

The Plan of establishing an advanced anti-crime system

In regard to safety, the assault rate of South Korea is 2.1%, lower than the OECD average of 4.0% and overall safety level is ranked in 10th place followed by Finland (OECD, 2012). However, women report lower feelings of security than men, and the assault rate for the bottom 20% of the population is 2.9% higher than that for the top 20%. This implies that the level of social safety service for women and the low income population in Korea is relatively lower (OECD, 2012). Furthermore, the community level of South Korea is poorer than any other OECD countries, except Turkey. In South Korea, around 60% of the bottom 20% has someone to count on for help in time of need, compared to over 87% for the top 20%.

Sejong is aiming to be the most livable and secure city for women, which would also lead Sejong to be an egalitarian society through providing better living conditions to children, the elderly and the disabled who especially need more attention and care. For instance, mothers in Sejong would be able to monitor the movements and activities of their children and aged parents by using RFID² devices. This security system will increase the security level of the city with auto warning services, position tracking services and advanced anti-crime systems. Crime Prevention through Environmental Design (CPTED) strategy by which the spaces which involves crime-causing factors are controlled beforehand is being applied to the city from its construction level. On the other hand, this advanced safety system might be considered as all the citizen are monitored and controlled by the system, which sounds quite negative since the system might violate an individual's privacy. Today, however, we are already exposed to countless closed-circuit televisions in every corner of the streets and being tracked by telecommunication providers through mobile phones, and the information collected from it is being utilized for criminal investigation presently (Knox, 2010). The safety system presented in this section can

² Radio-frequency identification (RFID) is the use of a wireless non-contact system that uses radio-frequency electromagnetic fields to transfer data from a tag attached to an object, for the purposes of automatic identification and tracking. (Source: Wikipedia, <http://en.wikipedia.org/wiki/Rfid>)

be understood as an attempt to improve the level of universal safety from the dimension of sustainable urban structures with better utilization of existing data and derived information in a more secure way. Nevertheless, the fact that someone or something is monitoring people's daily activities is still uncomfortable. Ironically, concrete security for safety service would be highly required in Sejong.

Plan of construction of mixed communities

In Sejong city, public facilities, educational, cultural and welfare facilities will be united two or three-dimensionally to increase the efficiency of land use. And one-stop public service will be achieved for the convenience of the residents. Especially, a community center which will accommodate a fire station, a police station, a library, a welfare facility, and a sports facility in each of the 22 communities will enhance the community spirit and the sense of belonging to their own communities by increasing the opportunity to contact among community members themselves (Sung, 2011b). Traditional marketplaces will be organized in plazas for the sake of functioning as places of communication and direct trade of local foods among community members (Miranne & Young, 2000).

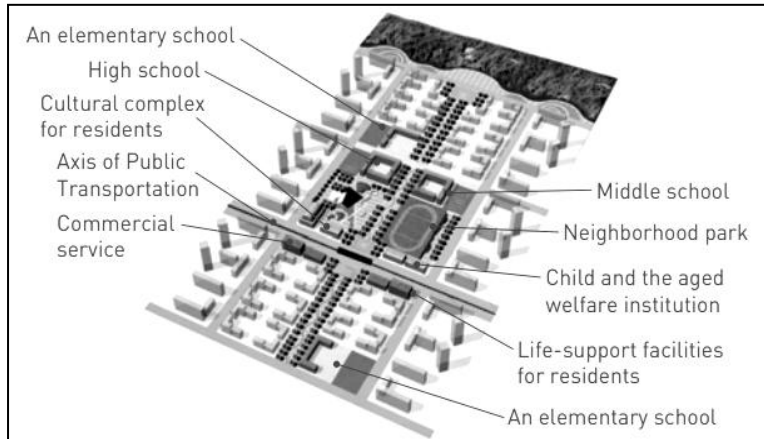


Figure 15. A layout plan of convenience facilities in fundamental living zone

Source: MACCA (2007)

A high level of living satisfaction of residents in the city is expected with the multi-functionality of communities providing easily accessible essential services and various opportunities for social interactions within the community (Sung, 2011b). In other words, people in Sejong would be able to have easy reach of basic services without taking a long trip and also able to get to higher or advanced service facilities located in other communities or functional zones by using the BRT which will be efficiently connecting them all together. Consequently, Sejong is expected to be maintained with a high level of social equity by providing good access to public transportation and essential social services to each district unit without discrimination.

1.6 Cultural Resources

Cities or urban systems need to adapt any design or function to its cultural context: history in different time scales, ceremonies, traditions, art and social codes, hidden rules and the community spirit (Berg, 2010). Sejong city is not being merely developed or expanded from small residential area to greater urban area, but being absolutely newly created on farmlands, natural areas, and small villages. Previously, the project area was a suburb area of *Yeongi-Gun*³ which had been mainly used as farmlands (Figure 16). According to Sejong city administration, around 3.5 thousand of the indigenous people used to reside in the project area. Thus, there must have been either visible or invisible cultural contexts accumulated from the past and the natural environment, which were



Figure 16. An aerial view of a part of the project area

Source: Song (2011)

³ Lower level of administrative division than city being comparable to *county* in western countries

likely to be destroyed or neglected through the creation of the new city (Song 2011). In light of the symbolic identity of Sejong as a special autonomy city representing the country in the future, attempts to establish a national identity and to recognize and reserved the ancient history of the area are being implemented.

The name of the city, SEJONG

Originally, Sejong is the name of the fourth king of the *Joseon* Dynasty of Korea which was a Korean state founded in the 14th century and which lasted for approximately five centuries. He is considered as one of the greatest kings in Korean history for his creation of the unique and creative Korean alphabet, or ‘Hangul’ in Korean (Lee & Ramsey, 2000). Sejong city will be developed as a space where history and tradition coexist harmoniously with the future for the sake of the realization of the creativity and the spirit of King Sejong which became a fundamental motivation of the city. Cultural and historical facilities are being built in places throughout the city to commemorate the achievements of King Sejong (Schwartz, 2010). As part of those efforts, all of the roads, bridges, facilities, and 1,400 public institutions and administrative districts in the city are being named after pure Korean words, whereas most of the names of administrative districts in Korean cities, and even the name of cities, are based on Chinese letters and modern words (MACCA, 2007) (Lee & Ramsey, 2000). It is expected for Sejong city itself to become a historical site where future descendants visit and can feel the spirit of Sejong the great in every place throughout the city.

Preservation and management of cultural assets

Even though Sejong is broadly known for its unique design of the city and government complex and newly developed towns using state of the art technology, there are the most valuable things left from the past that we should not overlook, which is not visible right now though, in order for the city to be sustainably developed in to a charming and attractive city (Song, 2011).

An investigation of cultural properties in Sejong which is a project for the largest area since the dawn of Korean history is being done for 6 years. The main purpose of this investigation is to restore the history of Korea and to conserve the historical identity of the city. Once the Bronze Age habitats and the *Baekje*⁴ Age burial mound excavated during the investigation are well-conserved without damage, those will be the invaluable educational assets not only for us but also for our next generations to understand the history of the city and the country where they were born. Furthermore, the history and the tradition of the city would become sustainable by carefully managing and conserving relics and sites from the ancestors in spite of this large-scale development which might erase numerous valuable historical traces which have been left in the area for centuries (Song, 2011).

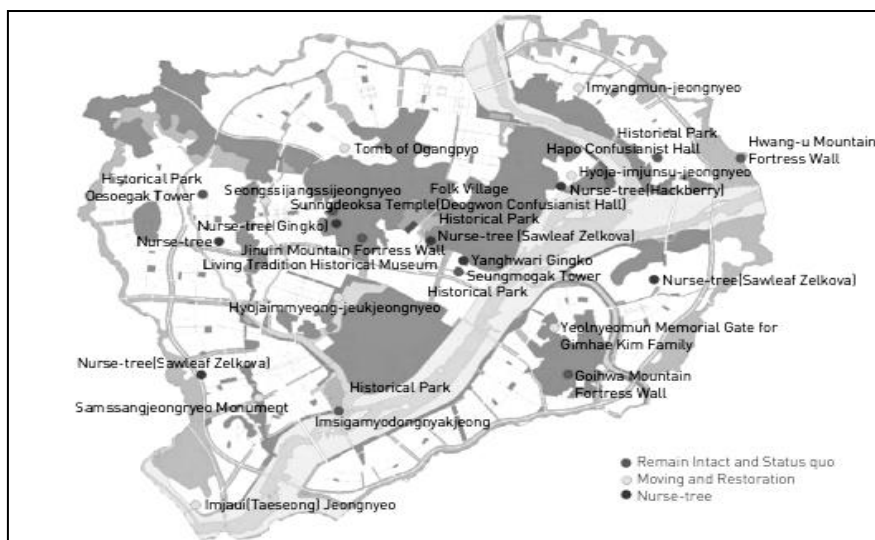


Figure 17. Illustration of Cultural asset preservation plans along with development plans

Source: MACCA (2007)

⁴ Baekje (18 BCE – 660 CE) was a kingdom located in southwest Korea. It was one of the Three Kingdoms of Korea, together with Goguryeo and Silla. (Source: Wikipedia, <http://en.wikipedia.org/wiki/Baekje>)

1.7 Aesthetic Resources

Cities or urban systems need to plan and design residential, commercial and public places and spaces with all human senses in mind. Cities, towns and communities as well as its buildings, squares, streets and other public spaces should be built and designed mainly with a visual focus (Berg, 2010). On the other hand, Ferretto (2012) asserts that master planning and endless zoning creates a form of genetically modified cities where everything looks and feels right, yet there is no identity. Diversity in accordance with the functions of each zone is a key to prevent Sejong from all becoming the same.

Comprehensive landscape plan

The visual images of Sejong city has been planned and managed in accordance with a comprehensive landscape plan from the designing level of the city. The landscape plan of the city was finished after the urban planning had been completed and before the construction plan was started. Since the landscape plan is in the upper level of planning and which acts as a guideline, all of the developments and construction implemented in Sejong based on the master plan of construction are supposed to follow the landscape plan. According to the landscape plan of the city, there are seven major assignments for the landscape of the city regarding urban structures, public facilities, green and blue areas, lighting at night, outdoor advertisements, urban environment colors and the beauty of urban landscapes. The themes and the concepts of each assignment are different from zone to zone since each zone has its own function and theme. However, the comprehensive image identity is being applied to every zone identically so that each district has its own character in accordance with its functions. The first demonstration project will take place in two basic residential zones embracing 4,263 thousand square meters through which the circular public transport axis and the *Bangchuk* stream which is a branch of the *Geum* river passes through and to which the outer beltway is adjacent to (MACCA, 2007).

The city without 5 things

People would not be able to see five things in Sejong which are commonly seen in other cities in Korea and spoil the street views. Those five things are none other than utility poles, garbage, private walls, advertising signboards and curb parking. Since utilities for electricity, gas and telecommunications are being placed in underground Common Utility Ducts, utility poles which deteriorate the visual sense and which poses a risk to safety will not be present in Sejong unless deemed necessary.

Household garbage which not only ruins the street view but also stinks pedestrian out are being managed by Clean-Net (Figure 18), the Tube-based automatic domestic waste collection system of Sejong, so household wastes from residential areas are directly transported to underground storage through the tubes installed in Common Utility Ducts. This may also prevent the street from an invasion of homeless cats and dogs searching for food wastes for their dinner. And the city would have human-oriented and walk-able streets by regulating indiscreet advertising signboards and curb parking. Private walls which are still very common in Korean cities for security reasons have interrupted communication and contact within neighborhoods. Sejong is expected to have open and barrier free landscapes by prohibiting installation of private walls surrounding private properties. Intelligent security systems using advanced technologies that are mentioned in organizational resources are supposed to reinforce the security function of the city which might get weak due to the absence of private walls.



Figure 18. Waste collecting facilities in the First town of Sejong

2. Present and anticipated shortcomings of planned cities

Basically, Sejong city has closely referred to the concept of Putrajaya city, the federal administrative center of Malaysia. Putrajaya and Sejong are either planned cities developed or being developed for the sake of easing congestion and overcrowding in the capital region of the countries. In this section, the negative aspects observed in the two cities will be assessed. While it is still early to fully assess Putrajaya's shortcomings, all the portions of the city has been constructed by 2012 and it has been functioning as a completely planned city. Thus, more practical and visible shortcomings are expected to be found in Putrajaya's case rather than that of Sejong which still has a long way to go to see its completion.

Table 8. Brief comparison of Sejong and Putrajaya

	SEJONG	PUTRAJAYA
Country	South Korea	Malaysia
Distance from Capital city	120km	25km
Area	73 km ²	49 km ²
Master plan established	2007	1995
Relocation of government unit	2012	1999
Completion of construction	2030 (projected)	2012
Population (current/projected)	103,127 / 500,000	100,000 / 350,000

Source: Official website of Putrajaya city (<http://www.ppj.gov.my/portal/>), Official website of Sejong city (<http://www.sejong.go.kr/stats/index.do>)

2.1 Shortcomings observed in Sejong

Side effects of collecting renewable energy sources

The central bicycle lane utilizing idle spaces of central reservation of road is attempted for the first time in South Korea. The central bicycle lane is located on the main road connecting Sejong and *Daejeon* in which one of the government complexes is located (Figure 19). One of the most prominent and innovative features of energy generation of Sejong is electric generation using roof-style solar panels covering the central bicycle lane to produce electricity for the households. 4.6km out of 9km of the central bicycle land is covered with solar panels. This is the first attempt to generate electricity from the facilities on the bicycle lane in the world. Around 6,000KWh of electricity is currently being generated daily under 1,875KW of capacity and being provided to adjacent households, which is the equal amount of capacity for 600 households to consume for a day.



Figure 19. Solar panels covering central bike lane.

On the other hand, these facilities have shown demerits on biological resources. Since the installment of the central bicycle lane and solar panels on it, the number of wild animals killed on the road has increased due to the solid obstacles located in the middle of the road (Lee, 2012). That implies that the central reservation

of road had overlooked its function as a stepping stone where wild animals stay and take breath to cross the road. And effectiveness of 9km of the central bike corridor which provides neither pleasure of cycling nor encouragement in the use of bicycles for commuters is still open to dispute.

Unsustainable restoration of the river basin

As part of the national project, the restoration of the four major rivers, Sejong dam has been constructed across the *Geum* River, which passes through Sejong. A hydroelectric power plant having 2,310kW of capacity has been embedded in the Sejong dam and generates 12million kWh of electricity annually. It has just started its operation since the 30th of April in 2012, and its substitution effect is anticipated to be equal to the import of 20 thousand barrels of petrol. Consequently, eight thousand tons of CO₂ reduction effect is also anticipated (Jeong *et al.*, 2009). Sejong is aiming to achieve a 15% ratio of new and renewable energy utilization from solar, geothermal, and hydro power plants out of the entire energy use of the city.

On the other hand, this hydroelectric power plant and the entire project of restoration of the four major rivers have also been criticized by environmental organizations and NGOs for its harmful effects on aquatic ecosystems and natural wetlands. And environmental issues regarding small scale dams installed on the four major rivers for the sake of water level control and artificially made ecological parks and bike paths on catchment area are still open to dispute for their effectiveness. Actually, the restored *Geum* river basin area looked desolate accommodating neither cyclers nor animals. I was the only user of the shade-less bike path and benches on the park during my field trip (Figure 20).



Figure 20. Savage scenery of the Geum river basin after restoration project

2.2 Shortcomings observed in Putrajaya

Lack of 'green' in 'a city in a garden'

While Putrajaya was planned as 'a city in a garden', little attempt for lowering energy consumption and CO₂ emissions in the city has been made except for large green parks surrounding the lake. Daytime temperatures in Malaysia rise above 30°C throughout the year and humidity is high. However, many of the buildings in Putrajaya are made of steel and glass which is aesthetically pleasing but allows sunlight to directly enter inside buildings, which requires massive amounts of air-conditioning for maintaining a pleasant temperature inside (Moser, 2010). Despite the widely accepted New Urbanism's emphasis on dense buildings and walkability, Putrajaya is still low density and requires long walks to get anywhere. Green transport modes like bicycles are encouraged as recreation rather than as a mode of transportation showing lack of bicycle paths on key routes through the city. Most of the sidewalks throughout the city have not enough plants which act as a green cover. The lack of shade on walking paths also discourages 'green' forms of transportation such as walking and cycling, which persuades travelers to move around the city in air conditioned cars (Moser, 2010). According to research by Qureshi and Siong (2011), making walking as a preferred transport option will reduce 2.4% of CO₂ emission in Putrajaya.

Severe traffic jams during peak time and curbside parking

The problems of traffic and car parking have sprung up in this new city. Initially, an urban rail system was planned to act as the backbone for the public transport infrastructure in Putrajaya. However, due to the delay of developing the rail transit system, the public in the city became highly dependent on private vehicles, which constitutes 85% of traveling (Ghani *et al.*, 2006). Currently, public transport services in Putrajaya are

provided by three bus companies for inter-city public transport, which carry passengers from Kuala Lumpur and major towns in the surrounding area, and another private bus company for intra-city bus services. Several contract buses are transporting government servants working in Putrajaya from towns located on the outskirts of the city. Besides buses, rail transport services that link Kuala Lumpur and Kuala Lumpur International Airport are provided by KLIA Transit.

The existing public transport system in Putrajaya doesn't meet the actual travel demand in the city (Ghani *et al.*, 2006). Since almost all of the government complex, commercial centers, and sport and recreation facilities are located in the center of the city, occurrence of huge volume of travel toward and from the core area of the city is expected (Figure 21). However, the intra-city bus company operates only 14 buses to transport passengers from residential areas on the periphery to governmental offices and commercial centers in the core area. In terms of availability of public transport which is a critical factor of people's choice of transport mode, intra-city buses have poor service frequency with an average of 2 per hour, even during the morning and afternoon peak periods (Ghani *et al.*, 2006). In the meantime, bus services in Putrajaya gained less than 0.65 million USD of annual income, causing them to suffer a loss of 5.80 million USD each year. Ultimately, the government would be the one who pays the bill (Lim, 2012). Improving public transport service and imposing penalties on private vehicle travels are highly recommended in order for public transport to make up 70% of the city transport as set in the new plan for 2025. The current modal split in Putrajaya is 70% for private cars; 15% motorcycles; 15% public transport (Ghani *et al.*, 2006).

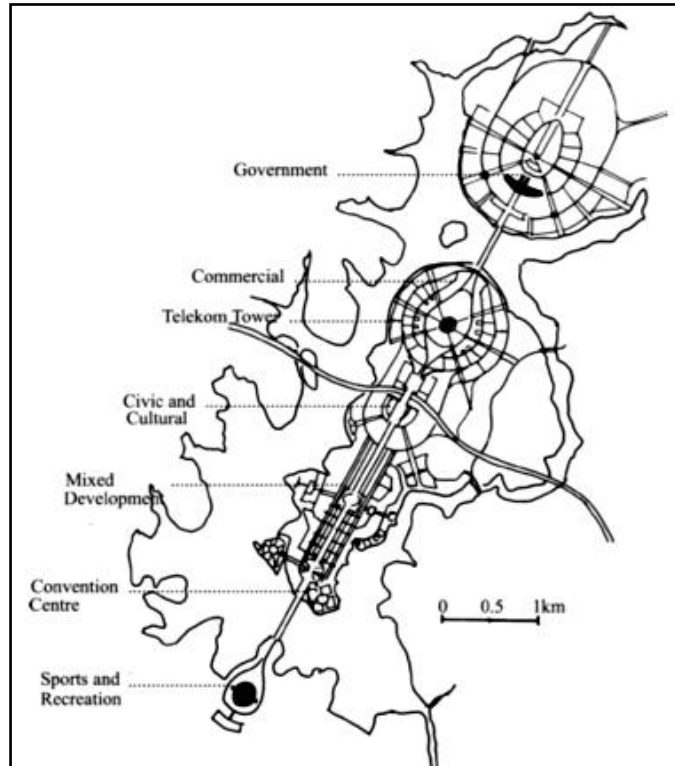


Figure 21. Formalized structure of Putrajaya

Source: King (2007)

3. Expected role of TOD in the future sustainability of Sejong

In this section, first the Master Plan of BRT and urban transport policies in Sejong, and second their expected demands upon other resources of the city will be assessed in order to answer how the implementation actions of TOD are supposed to relieve urban problems and contribute to urban sustainability.

3.1 Master Plan of High-level BRT in Sejong

Transportation infrastructures in Sejong will be highly optimized for public transportation and green transport modes rather than for automobiles. The entire structure of the city, constitution and the size of roads and regulation policies are effectively designed to restrain people's willingness to use automobiles through the increase of travel costs for operating automobiles in the city while increasing travel efficiency and environment for public transport users, foot travelers and cyclists (Bae *et al*, 2008).

Bus Rapid Transit (BRT) for intra-city transportation

The highly advanced planning of the BRT system will act as the main travel mode in the city by rapidly and accurately connecting all of the functional zones and neighboring cities. The plan consists of an Inner Circular BRT which will be operating inside the city within the ring-shaped dedicated BRT lanes (Figure 22).

The Inner Circular BRT system is a symbolic feature of TOD in Sejong with its ring-shaped urban structure which is unique in the world (MACCA, 2011). All the citizens from any district of the city will be able to access a BRT station within 20 minutes on foot or by green transport modes. For those dwellers that live in certain districts which are far more than 500m away from BRT stations,



Figure 22. Route of inner circular public transport axis (plan)

Source: MACCA (2011)

community buses will be operated along local distribution roads. Inner circular BRT is supposed to provide the fastest and the most credible public transportation service to travelers inside the city by having exclusive rights to use central exclusive lanes for public transport and transportation priorities over private cars on the roads. Inner urban transit centers equipped with parking lots will be installed adjacent to each BRT station so that private cars, bicycles or community bus users can conveniently transfer to public transportation. In order to control inner-city traffic and disperse it to the outer city, outer ring roads are being constructed surrounding the city through which private car users can get to the other side of the city without using the inner circular public transport axis which is highly prioritized and optimized for BRT and wide area buses. Those two transportation rings, outer ring roads and inner circular public transport axis, are expected to accommodate most of the city traffic (Bae *et al*, 2008). Figure 23 shows how the circular BRT axis in Sejong is being constructed and operated when they are completed. Only BRT and wide area buses are allowed to run on the central dedicated bus lanes which are distinguished by green reservation lanes. Particularly, the BRT system is considered as the most suitable public transport system in Sejong which is supposed to accommodate 500 thousand people in the future since the construction and operation costs for BRT is a tenth of that of a subway system (Goodman *et al*, 2006).

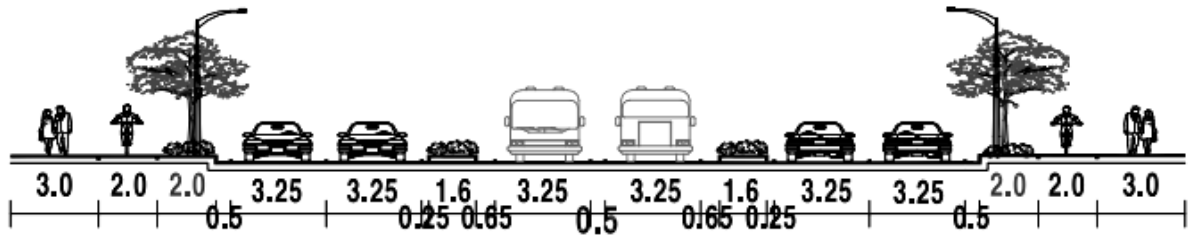


Figure 23. Cross-sectional diagram of standard public transport-oriented road

Source: MACCA (2011)

Meanwhile, MACCA is in the process of selecting the vehicle model for the BRT system which will be operating on inner circular and wide area BRT lanes between bimodal trams, electricity buses and several CNG⁵ hybrid buses. Even though it is still under estimation, bimodal trams are noticeable with its auto-driving function and higher capacity for passengers than competitors so they are considered as the leading candidate. This bandy bus, so-called light train running on the road with tire wheels with a capacity of 99 passengers, can be automatically driven using magnetic guidance tracks installed under the BRT lanes like a subway (Figure 24).



Figure 24. Bimodal tram on test operation in Sejong

Source: ©The Naeil News.

Transit Transfer Centers and inter-city transportation

In order to promote the use of public transport among inner and outer city travelers, and aiming for public transport to comprise more than 70% of the city's transportation, different types of transit centers specialized for their own purposes will be installed on the main transportation nodes throughout the city. Basically, all the transit centers will be located on the inner circular BRT axis in different forms in accordance with their main functions. Parking-oriented transit center will be located on the 5 main transportation nodes where wide arterial roads link neighboring cities and the inner circular BRT (Table 9 and Figure 25).

Table 9. Three types of transit center in Sejong

	Transfer in between		No. of facilities
Parking-oriented Transit center	Wide arterial roads	Inner Circular BRT	5
Public Transportation Transit center	Community buses	Inner Circular BRT	Each BRT station
Terminal type Transit center	Intercity buses	Inner Circular BRT	2

Source: MACCA (2011)

⁵ Compressed Natural Gas

This type of transit center will provide large parking lots in order to access Sejong from outside the city by car and to transfer to public transport for inner city travel conveniently. Each BRT station equipped with parking facilities for cars and bicycles will also function as a transit center linking inner circular BRT, community buses and other green transports. Two of the terminal-type transit centers will be located in the far south and the far north of the city. These facilities are supposed to accommodate passengers traveling to the outside city by using intercity buses and wide area BRT. Those transit centers are expected to play a great role in controlling city traffic by providing passengers with conveniences in using public transportation and transfer BRT to BRT, private car to BRT, and green transportation to BRT. Overpasses and underpasses optimized for transfers will maximize the passenger's travel efficiency by minimizing the moving distance for transfers.

In regard to outer city transportation, Sejong is being linked to arterial transportation axis such as express roads and express railways to access the major cities within 2 hours and expanding the transportation system with neighboring cities (Figure 26). Work on a widening project on the road connecting Sejong with *Deajeon* has recently been completed on which wide area BRT will be operating on the central exclusive BRT lanes. For the sake of providing trouble-free administration and international travel functions, a feasibility study on strengthening the transportation linkage with *Cheongju* International Airport has been completed, and designing for the project has started in May 2012.



Figure 25. Locations of parking-oriented transit center

Source: Bae *et al.* (2008)

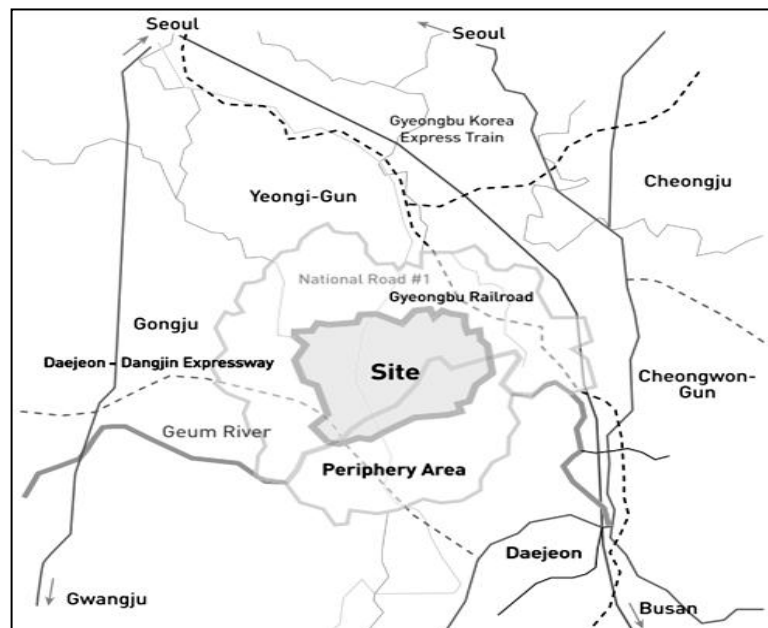


Figure 26. Existing transportation infrastructure around Sejong

Source: MACCA (2007)

Green network for bicycle and pedestrian traffic

In addition to TOD, the concept of Bicycle Transit Oriented Development (BTOD), which is derived from TOD, is applied to Sejong's development and landscape plan. In BTOD, bicycles act as an auxiliary function of public transportation in certain areas where public transport cannot be reached properly by taking prospective passengers to the nearest station safely. Two different types of bicycle roads are being introduced in Sejong in accordance with the core function of each type (Figure 27).

One type of bicycle road is to provide easy access to public transport and sometimes substituting private car use for short distance travel in certain sections. The main bicycle roads are being installed alongside the inner circular BRT road and outer ring belt, which will form the network in its linkages with pedestrian-oriented paths and community level bicycle paths through which people can safely access BRT stations on foot or by bicycle. Since the core function of this type of bicycle road is transportation itself, bicycle lanes are being located on the side of the motor roads on the same level so that bicycle traffic will not overlap walking traffic.

Another type of bicycle road is designed for multifunctional uses like leisure and daily life within community areas. Since the core function of this type of bicycle network is to provide a pleasant travel environment for pedestrians and cyclists rather than assuring rapid

travel, the bicycle lanes will be installed to the side of pedestrian paths on the same level. In commercial areas where large volumes of walking traffic is expected, however, bicycle lanes can accordingly be located next to motor ways in order to avoid collision between cyclists and pedestrians.

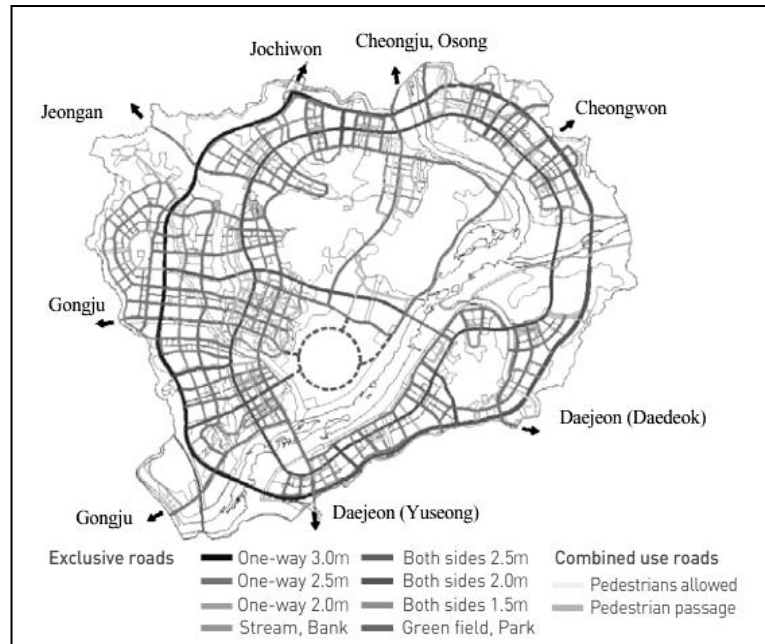


Figure 27. Bicycle roads installing diagram

Source: MACCA (2007)

3.2 System analysis on influence of implementation of TOD

In this section, systemic influence of the implementation of TOD to other inventories of the city will be studied. Figure 27 briefly shows the expected systemic influences of action plans of TOD on other resources of the city. Gray-colored boxes are the main implementation actions and directly derived actions of TOD. The analysis will be done focusing on those gray-colored boxes.

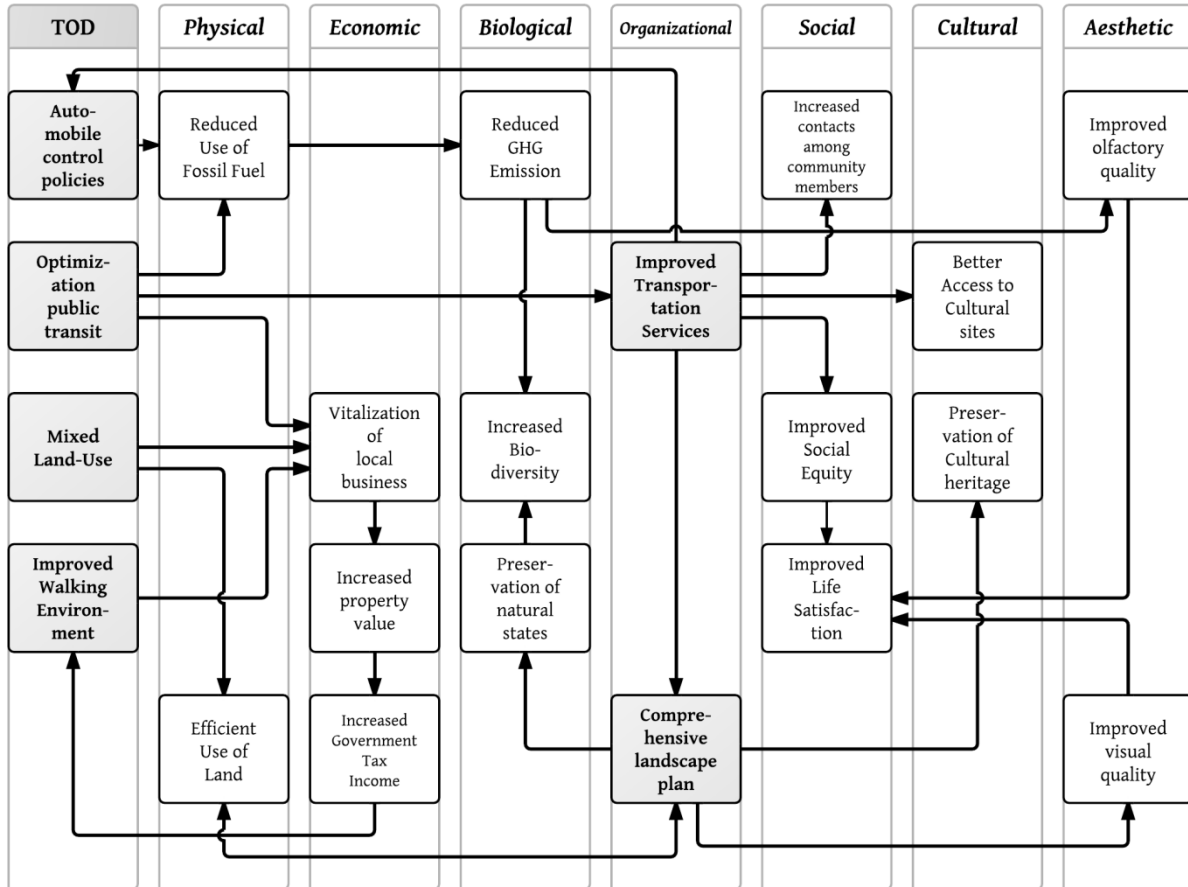


Figure 28. Implementation of TOD and its association with the PEBOSCA resources

Urban traffic control

Since Asian cities have been experiencing rapid changes, they have expanded the volume of roads and parking spaces to meet the rapidly growing urban traffic demand in urban areas. However, broader roads and free curbside parking spaces have resulted in more and more cars poured on to the streets (Banjo & Dimitriou, 2008). In most Asian mega cities, parking becomes especially important and problematic with rapid urbanization, rapid motorization and dense cities, and auto-centric conventional parking policies in western countries, especially in the United States, have shown problematic results (Barter, 2010). Automobile travel requires enormous terminal capacity, and free curbside parking spaces on the streets which worsens the traffic situation by generating huge amounts of excess driving searching for free parking spaces on streets (Shoup, 1997). Shoup (1997) has calculated that the distance driven while cruising for a free parking space in Westwood, the central portion of the Westside of Los Angeles, over the year was equivalent to two round trips to the moon, using 47,000 gallons of gasoline and producing 728 tons of CO₂. He says curbside parking on the street must be limited and charged at a certain price in comparison with off-street parking prices. Furthermore, providing free curbside parking on streets, which is actually subsidizing automobile users in cash, causes more serious congestion on the streets and other derived problems on a broader scale (Shoup, 1997).

Limited and priced curbside parking spaces would lead people to use off-street parking spaces or to switch their transportation mode to public transportation and walking (Figure 28). On the other hand, in order to get feasible effects of urban traffic control through pricing and down-sizing of curbside parking, the establishment of alternative transport modes like easily accessible public transport and safe walking and cycling paths for commuters should be implemented in advance. Actually, the study by Willson (1992) has partially proved the

impact of pricing on parking spaces upon people’s choice of travel mode showing that the price of parking in business areas has a significant impact on the share of commuter mode in Los Angeles. Urban design factors like narrow streets and pedestrian-friendly designs are positive planning factors in reducing automobile use through the reduction of automobile traffic speed and improving pedestrian accessibility to a transit center (Sung and Oh, 2011). In this respect, TOD is one of the necessary conditions for cities to effectively control urban traffic through restraining policies to reduce the number of automobiles running on the streets.

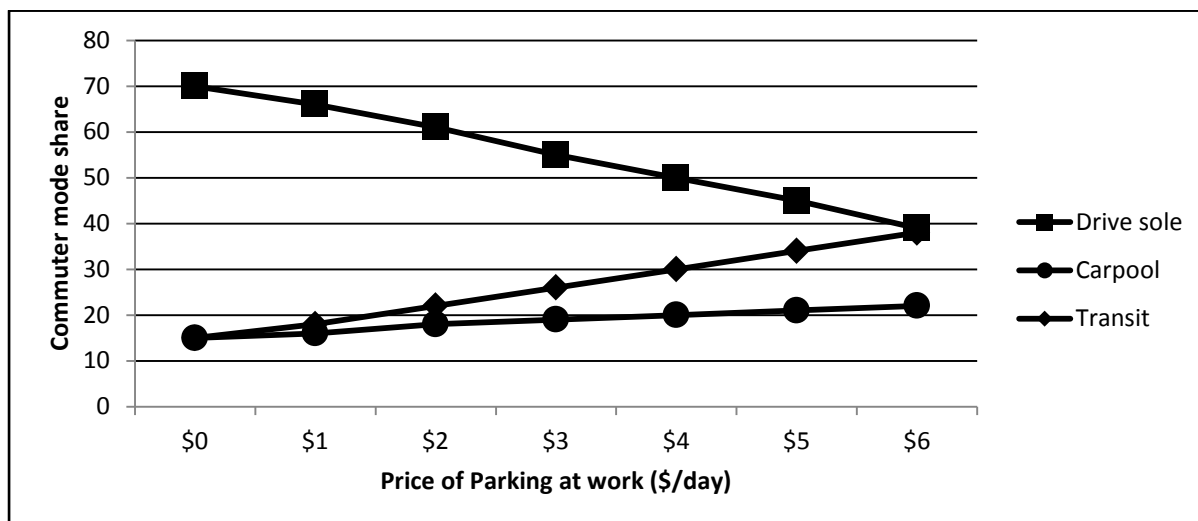


Figure 29. Estimated commuter mode share in accordance with price of parking at work

Source: Estimated from Willson (1992)

Optimization of public transport

It is commonly believed that expanding public transport services is beneficial for the reduction of energy consumption and CO2 emissions. However, ridership, that is, the number of passengers in a vehicle, is deemed to be the key variable for transit buses to assure high energy efficiency and low CO2 emission per passenger. When looking at the figure of energy consumption per passenger kilometer of different travel modes in Table 10, energy consumption per passenger kilometer, the measure of energy efficiency, of automobile is lower than that of Transit buses both in the UK and the US. It implies that merely transfer from automobile to a conventional form of public transport is unlikely to bring major benefits in urban sustainability in terms of energy consumption and CO₂ emission (Lowson, 2001).

Table 10. Energy consumption per Passenger kilometer in UK and US

Travel modes	BTU ⁶ / Passenger km	
	UK (2001)	US (2011)
Commuter rail	1,821	1,843
Transit bus	2,987	2,781
Automobiles	2,257	2,319
Personal Trucks	2,807	2,401

Source: Lowson (2001), US Transportation Energy Data Book (2011)

Public transit fails at energy efficiency without ridership (Nusca, , 2010). Then the key factor we should focus on is average ridership which is used for the calculation of energy consumption per passenger kilometer. For the US data, load factors which means number of persons per vehicle for transit buses and

⁶ British Thermal Units:

automobiles are respectively 9.2 and 1.55 (U.S. Department of Energy, 2011). Let us assume that the load factor for transit buses increases by 1 point to 10.2. This change decreases the energy efficiency of transit buses from 2,781 to 2,524. Figure 30 shows an exponential decrease of energy consumption per passenger of transit buses as average bus loads increase, which implies that the energy efficiency of transit buses is heavily dependent on ridership. And ridership of public transit in different cities within the same country results in significant CO2 emission differences. The average emissions in the U.S. city of Denver is two times higher per person than the average New Yorker, and this is due to the high popularity of public transport in New York (Urban Zoning, 2011b). Even within a city like Toronto in Canada, in a district that has a good public transport system, the average Toronto citizen emission rate is ten times less than a poorly accessible suburb according to researchers (Urban Zoning, 2011b).

Portland in the state of Oregon, USA has shown a practical case of the impact of improvement of ridership on energy efficiency of transit buses on the basis of the TOD program. Portland has initiated its TOD program by adopting the 2040 regional growth management plans in 1994. In accordance with this long-term plan of the city and other various TOD related actions; Portland opened a 5.5-mile branch and a 5.8-mile branch of transit bus lines respectively in 2001 and in 2004. This new bus transit service has increased bus ridership in adequate combination with existing train and bus services, called *TriMet*. It boosted energy efficiencies of transit buses running in Portland from 2,547 to 2,236 BTU per passenger kilometer between 2000 and 2002 and from 2,261 to 2,087 BTU per passenger kilometer between 2003 and 2005 (O'Toole, 2008).

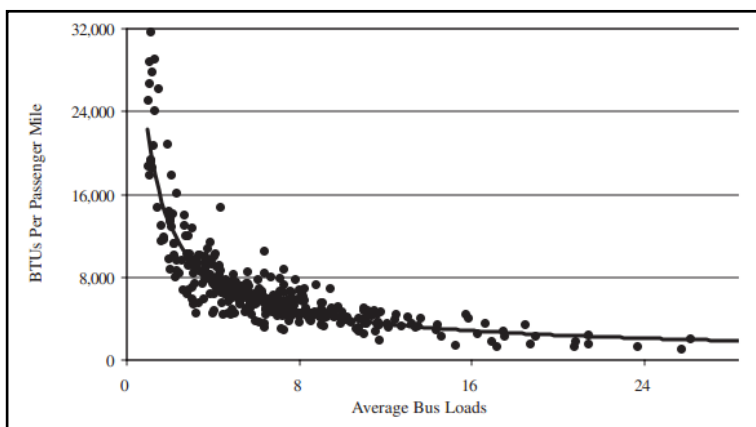


Figure 30. Energy efficiency of Bus Transit

Source: Federal Transit Administration, “Energy Consumption,” 2006 *Provisional National Transit Database* (Washington: U.S. Department of Transportation, 2007), tinyurl.com/3cdn6k

And several cities which have adopted the TOD program in their long-term urban growth management plans in advance have proven the positive impact of the implementation of TOD on improving ridership and consequently on energy efficiency of urban public transit and CO2 emission. In addition, transfers from conventional bus burning oil to newly invented transit modes like bimodal trams, CNG-hybrid bus and electric buses are expected to boost the energy efficiency of public transit and its contribution to reduction of GHG gases.

Mixed land-use and ring-shape urban structure

In addition to the issue of ridership itself, public transit is also criticized for its energy inefficiency resulting from the high fluctuation of ridership. For example, when people living in the suburbs take buses or trains to work during the rush hour, it seems full and achieves high energy efficiency. However, buses and trains that move from Central Business Districts to the suburbs, seems empty for most of the time except during rush hours in the evening. Consequently, it is hard to imagine that transit vehicles to the suburbs can possibly average much more than one-fifth full (Nusca, 2010). In Sejong, the zone where transit centers of BRT are located is designed as a compact and mixed land-use area, and there will be no Central Business District which sucks people all around the city in the morning and spit out in the evening but several functional and mixed zones which are linked in parallel by the ring-shape circular public transport axis. In this kind of urban structure, the fluctuation of ridership will be minimized since travel demands are generated within or among different zones, not merely between suburbs and CBD. In regards to the mixed land-use, the study by Sung and Oh (2011) identified that a mixed land-use pattern has almost the same relationship as high-density development with increased transit ridership. And in comparison with the mixture between non-residential uses, the mixture of residential and non-residential use is found to even better promote transit ridership (Sung & Oh, 2011).

According to the UK National Travel Survey, in most cases, bus services offer little benefit and show low ridership even though 89% of people in the UK live within 6 minutes of a bus stop. This is because very few people live close to everyday facilities, and the buses do not go where people wish to make their trips (Lowson, 2001). In Sejong, multifunctional communities providing most of everyday facilities will be

constructed around BRT transit centers, which is also the main stop for community buses. This implies people in every community in Sejong can easily access everyday facilities once they get to BRT transit centers. For bigger or special facilities, people can easily and rapidly get to different zones of the city by BRT.

Improvement of the walking environment and local businesses

The urban streets which are developed or regenerated on the basis of TOD will be filled with walking traffic accessing transit centers rather than automobile traffic passing through or searching for parking spaces (Kang & Kim, 2012). The improved quality of the walking environment on the streets through the absence of indiscreet curb parking and lower auto traffic would attract more people to walk on the streets and let stores have more opportunities. Thus, increased and prolonged foot traffic would revitalize the economy of local businesses on the streets (CTOD, 2007). Increased foot traffic and vitalized economic activities on the streets around transit centers would naturally lead to an improvement of economic and actual value of real estates, which also leads to the rise of taxable income for local governments from increased property and income taxes (CTOD, 2007) (Sung, 2011a).

Improvement of life satisfaction and social equity

According to a study on happiness on transportation environment by Duarte *et al* (2010), in terms of travel modes, the highest level of happiness is found among people who use bicycles for their work related trips followed by people who walk to their work place. In the research paper, Duarte *et al.* (2010) state that:

Transport not only is a key factor in modern economies, but also plays an important role for the individual happiness. Optimization of transport system is crucial to meet increasing demands and sustainable development (p.30).

In urban societies, travel is a necessary demand for people to sustain their lives along with housing, clothing, and food. Since people living in large cities spend considerable time on traveling between home and the work place, they consider not only travel distances but also travel conditions when they choose a house to live. Commuting via busy transport routes and urban sprawl is one of the factors which degrade social capital through deterioration of social connections (Putnam, 2001). And social connections have positive ripple effects for individual and societal well-being (OECD, 2011).

Providing well organized and optimized public transport service and travel environment is deemed to be a better way of providing universal welfare to all citizens regardless of car ownership or family income levels. According to a study by Shoup (2011) regarding the cost of free parking in the United States, the total subsidy for off-street parking was between \$135 billion and \$386 billion in 2002. During the same period, the federal government spent \$231 billion for Medicare and \$349 billion for national defense. In an automobile-oriented society, a huge amount of money is spent only for subsidizing motorists, which means that everybody is paying for motorists and gets back congested streets, narrow and dangerous pedestrian paths, and even more polluted air quality from cars cruising vacant free parking space. This sort of biased subsidy would be relocated to investment in the optimization of public transport and regeneration of pedestrian paths which provide universal opportunities and the right to travel to every citizen alike through implementation of TOD. Consequently, well-organized public transportation service would help the society proceed towards an egalitarian society with more people who fulfill their necessary travel demand in good condition.

Discussion

The study shows the fact that the implementation of TOD in Sejong city would contribute to the future sustainability of the city by eliminating anticipated urban problems of the planned city in advance. Implementation actions and transportation policies derived from BRT based TOD program in Sejong are expected to make up for the innate weak points of a planned city and shortcomings observed in planned city of the same type, Putrajaya, Malaysia. The major feature by which TOD in Sejong distinguishes itself from preceding conventional transportation policies is in the setting of a system controlling and managing travel demand, which not merely tries to supply infrastructures in accordance with demand. In other words, TOD is not such a passive public transport service aiming to meet urban travel demand timely, but an active urban restructuring system generating and controlling travel demands in proper time and places. TOD in Sejong is again distinguished from TOD in other cities with its ring-shape urban structure preserving the central portion of

the city in its natural state. It has no central business district but several functional zones along the circular BRT axis, which assures a more stable ridership of public transport and which consequently improves the energy efficiency of public transit. Mixed land-use policies around transit centers would generate more floating populations on the streets and vitalize the business economy in each zone, and provide good accessibility to most of the necessary facilities to community members at the same time. A well-organized and accurate public transit system will take the biggest proportion of travel demands in the city. And by doing so, the city is expected to improve people's living conditions, life satisfaction, local business economy, and government with reduced urban CO₂ emission, energy consumption, and ecological footprints. In short, through urban traffic control policies, the optimization of public transport, mixed land use plan, and the establishment of a green network for walking and cycling, Sejong is expected to achieve a high level of urban sustainability. From a long-term perspective, adequate relocation of functional components in association with optimized linkage would maximize the overall efficiency of resource flow and sustainable use of them rather than merely linking functional components regardless of location. Even though there have previously been several newly developed towns and cities seeking to be Eco-Cities in South Korea, Sejong is the only and the first city which adopted the TOD program and BRT system from its designing level. Thus, the success of Sejong will be loaded with symbolic significance for the country's balanced and sustainable development with less energy consumption and carbon footprint, and more equally distributed resources and opportunities.

This study is unique since there have not been related studies on preliminarily assessing the future sustainability of this newly developing planned city, Sejong, focusing on the role of its transportation system. The role of TOD in this planned city has not been emphasized enough so far. While the city has been advertised as a model of a future sustainable city playing a role for balanced regional development by the Korean government, Sejong's unique urban structure and public transportation system have been mentioned just as one feature among many other sustainable features which Sejong city will show in the future. Previous research regarding urban issues in developing countries have mainly focused on the transformation of existing cities by implementing TOD programs or on the creation of planned cities for the sake of decentralization separately. This study is meaningful because two issues which have been separately studied previously; the transformation of existing cities and the creation of planned cities in developing countries, have been studied in convergent association with the implementation of TOD.

On the other hand, this study has two weaknesses. The first one is the fact that the assessment of the future sustainability of the city was mostly based on the Master Plan of the construction of the city which might describe the city like a utopia with expectations rather than looking dispassionately at the reality might lower the feasibility of the result. The second one is lack of studies on the efficiency of government functions. There have been worries that the division of the central government bodies can cause inefficiency. The Prime Minister of Korea himself will commute from Seoul for a while even after the relocation of his office to Sejong. Critics say the split government function will lead to wasted travelling hours and inefficiency (AFP, 2012). Therefore, further studies are needed on policies which make effects the decentralization and relocation of population and on IT solutions which suppress the generation of physical travel demand between Seoul and Sejong. Meanwhile, several environmental issues regarding hydro power plants and artificially made ecological parks and bike paths in catchment areas are still open to dispute for their actual effectiveness and harmful effects on aquatic ecosystems. From my personal impression from a field trip to Sejong, the city is still under construction and not being properly managed even in the *First Town* where people have already moved in and are living their daily lives. In order for planned cities to achieve their goals of sustainability and resilience, sustainable aspects should be proven even in its construction process in accordance with the respective phases of development, and people's expectations and needs should be met in a timely manner.

The vision of Sejong regarding its sustainability was presented in accordance with the PEBOSCA resources in the first part. And anticipated shortcomings in reality were found by referring to Putrajaya, Malaysia in the second part. Basically, Sejong city has closely referred the concept of Putrajaya city, the federal administrative center of Malaysia. Even though there have been a lot of projects for the construction of planned cities worldwide, Putrajaya is the most likely reference for a planned city for Sejong in developing countries in Asia in terms of its function and vision; the decentralization of governmental functions without relocating the national capital in the pursuit of the creation of a model of a future sustainable city. Therefore, urban problems which Putrajaya currently experiences indicate what Sejong city should be aware of and prepared for. Finally, the solutions were drawn on the basis of the Master Plan of BRT-based TOD in Sejong by systemically analyzing the cases worldwide where TOD-derived actions made positive influences on resolving urban and urban-related problems.

Conclusion

According to the Master Plan of the construction of Sejong city, various state of the art technologies and polities for sustainability of the city and balanced regional development are being applied in this symbolic future city. Based on implemented actions in Sejong so far, the generation of electricity from renewable sources is regarded to be harmful to the eco system. And urban traffic problems derived from a shortage of public transport and failure of urban traffic control were observed in Putrajaya. Sejong's BRT system and TOD program on the basis of a unique urban structure distinguish the city from other preceding planned cities in the developing world. The implementation of TOD and transport policies is expected to systemically relieve urban traffic problems and positively influence to the environment, economy, and the social sustainability of the city in the future.

Through the remarkable development of information technology, several travel demands where physical travel was necessarily needed are being met by teleconference tools and virtual reality simulation technologies. However, for humans as a social creature, travelling itself can be the purpose of travel in many cases. Therefore, the transportation service is part of a necessary welfare service which heavily affects people's living conditions and should be provided to everyone without discrimination. Investing in transportation on the basis of TOD is regarded as an investment in welfare which returns benefits to all. This study is expected to generate people's awareness on the importance of effective transportation systems and policies on solving urban problems for existing cities, and even more critical for new cities being developed from scratch. Therefore, TOD would be deemed to be a better option for existing cities and is necessary for newly developing planned cities in Asia and Africa.

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