Chapter 3

Compact city policy in Daejeon and Hwaseong, Korea

This chapter performs narrative case studies of two cities (Daejeon, Hwaseong) with the corresponding urban simulations seeking applicability of compact city policies on the cities. Daejeon is the fifth biggest metropolitan city, a representative of developed urban areas. Hwaseong is a local city showing a trend of rapid development. The first part assesses the two cities in terms of compact city policies. It examines current relevant policies, such as the Daejeon Green City Plan, the Urban Renaissance Project of Daejeon and the Hwaseong-Dongtan New Town project, and suggests policy recommendations in terms of compact city policies. The second part addresses the importance of an integrated urban modelling in selecting the customised set of compact city policies for a city. In the same vein, it suggests a framework to develop an integrated urban model and performs two pilot simulations of the two cities. The simulations were performed using a newly developed model and a modified version of the current model based on parts of the framework.

The following case studies shed light on how to cope with challenges in implementing compact city policies. To illustrate the trends and challenges in Korean cities, the case studies focus on two cities at different developmental stages, demonstrating different policy approaches; one for rapid growth and the other for stagnated growth. Hwaseong was selected as a local city (not yet at the metropolitan level) exemplary of a rapidly growing urban centre; its population doubled between 2005 and 2010, much faster than the national average (0.3%)[1] and its gross regional domestic product (GRDP) growth rate is roughly 120.1%, much higher than the national average (5.89%). Daejeon was selected from the seven metropolitan cities in Korea as a typical instance of stagnated growth. Its population growth rate over the period between 2005 and 2010 was stable (0.65%), and its GRDP growth rate (5.21%) over the same period was the lowest among large metropolitan areas, which average 5.94%. The two cities also show varying urban growth patterns, size and urban problems, which help to examine how compact city strategies can help deal with complex urban issues.

Policy examples from Hwaseong and Daejeon have been collected to identify challenges and assess current compact city policy practices. The major policies to be reviewed include measures to limit and manage urban sprawl, promote inner-city revitalisation and promote mixed land uses and mass transit linkages. The following points are of interest:

- Are the existing compact city policies appropriate in the local context? How effective are they? How does the combination with other policies work?
- What is the resistance to the regulations and the adverse effects of compact cities, for example, congestion problems, escalating housing prices even in the most modest areas, and strong opposition from landowners and developers, who face limitations of greenfield exploitation in suburban areas?
- What kind of vertical and horizontal governance arrangements are being implemented by the different levels of government? What tools are being developed and adopted for monitoring and evaluating compact city policies at the city level?

Assessment of compact city policies in Daejeon and Hwaseong

As shown in Table 3.1, the two cities vary widely in terms of geographical location, population size, policy tools, etc. Examining the case cities[2] in view of the five key compact city strategies proposed by the OECD (2012a) suggests that each city has unique policy challenges, and more importantly, that most would be best addressed in close co-operation with the national government. The survey eliciting reaction in the case cities to the compact city strategy was instructive. In general, the concept of the compact city was accepted, but the assessment varied depending on how the cities recognise urban challenges and on their policy priorities.

Daejeon

City profile

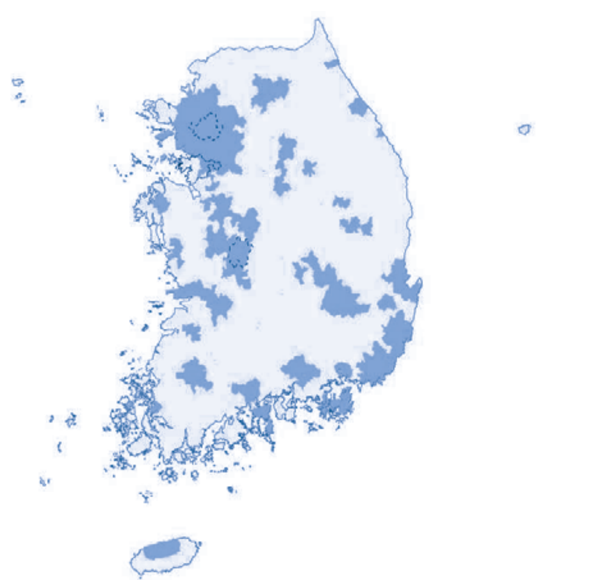
Daejeon is the fifth-largest city in Korea after Seoul, Busan, Daegu and Incheon, with a population of 1.5 million people and an area of 540 km². Roughly 150 kilometres from Seoul, it was upgraded to metropolitan city level[3] in 1995 and built a central government complex in 1997. Located in Korea's geographical centre, Daejeon serves as a nationwide transport hub. Major expressways and railways connecting the country from north to south pass through the city (Daejeon, 2013b).

Table 3.1. **Summary of the case city profiles**

	Daejeon	Hwaseong
General information	– Population: 1.5 million (stagnant over the past 10 years) – Size: 539.9 km² – Location: 150 kilometres from the centre of Seoul	– Population: 532 000 (doubled over the past 10 years, due to the new development aiming to help accommodate the population of Seoul) – Size: 689 km² – Location: 40 kilometres from the centre of Seoul
Urban challenges	– Expansion of built-up areas and restructuring of the town – Development of Sejong City New Town, close to Daejeon – Establishment of the International Science and Business Belt (ISBB)	– An exponential increase in population led to delays in infrastructure provision – Disparities in residents' living conditions, due to scattered development – Lack of infrastructure in the suburban area after large-scale development
Key urban policies	– Providing attractive and sustainable public transport – Reducing the rate of greenfield development and restoring brownfields for settlements – Minimising development gaps between the centres of the new and old towns	– Promoting urban centres to address the city's scattered development – Developing infrastructure to improve access to urban and suburban areas – Reinforcing urban management strategy and controlling suburban sprawl

Sources: Own elaboration based on Daejeon (2013a), "Introduction of compact city-related policies in Daejeon", presentation by Daejeon to the OECD mission team in April 2013; Hwaseong (2013a), "Policies for compact city in Hwaseong", presentation by Hwaseong to the OECD mission team in April 2013.

Figure 3.1. **Location of the two case cities**



Note: This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

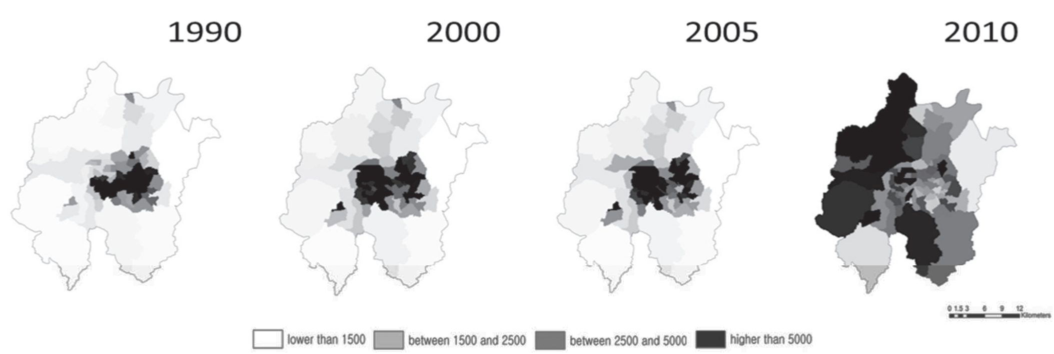
Source: Own elaboration based on OECD (2012b), *OECD Urban Policy Reviews, Korea 2012*, OECD Publishing, Paris, http://dx.doi.org/10.1787/10.1787/9789264174153-en

Daejeon is also a major centre for cutting-edge science and technology in Korea and home of several key institutions for research and education, including the Daedeok Science Complex, comprised of the Korea Advanced Institute of Science and Technology (KAIST), the Electronics and Telecommunications Research Institute (ETRI), the Korea Aerospace Research Institute (KARI) and the Korea Atomic Energy Research Institute (KAERI). The success of the Daedeok Science Complex led to new development projects: the Daedeok Valley Development project, providing research facilities, manpower and administrative assistance, and strong linkages with surrounding areas; and the Daedeok Techno Valley Development Project, for the construction of a new industrial park equipped with residential and leisure facilities and an industrial zone for foreign investors. The projects are expected to boost the local economy.

Urban challenges

Expansion of built-up areas and relocation of the town centre[4] resulted in various problems, such as the decline of retail businesses in the old downtown, the need for new settlements in the suburban area and the decay of the old urban centres with poor (or uneven) access to local services. This accelerated a redistribution of population in the city (Figure 3.2). Development of Sejong City, a new administrative city surrounded by Daejeon, Cheongju and Gongju, was also a significant challenge (Box 3.1). Daejeon is now in competition with its adjacent cities, and requires strong urban policies to prevent the resulting urban sprawl, in co-operation with surrounding cities, including Sejong.

Figure 3.2. **Population distribution change in Daejeon, 1990-2010**



Note: This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Own elaboration based on National Geographic Information System Data and Korea Statistical Information Service, www.kosis.kr.

The Integration of International Science and Business Belt (ISBB) project with urban policy offers Daejeon a big challenge and a great opportunity. The project aims to build a National Innovation Cluster that will serve as an engine for national economic growth. The central district of the ISBB will function as a basic science and research hub that hosts the national Institutes for Basic Science and a Rare Isotope Accelerator, a large-scale research facility promoting science-based, cutting-edge business and the research development service industry (Daejeon, 2013a). This project, led by the national government, is expected to transform the urban structure of Daejeon and offer an opportunity to enhance its potential for growth.[5] The challenge is now to find a way to restructure the city's urban space to accommodate this change and effectively communicate with the national government to take advantage of this opportunity.

Box 3.1. **Sejong City**

To address such social problems as the shortage of housing, rising housing prices, congestion and pollution due to over-concentration in the capital area, the Korean government adopted a balanced national development strategy, one of whose principal initiatives was the construction of Sejong City, a multifunctional administrative city (MAC). Located in the centre of the country, 120 kilometres from Seoul, it has an area of 72.9 km^2, and its population is expected to have reached half a million by 2030. The Multifunctional Administrative City Construction Agency (MACCA) was set up on 1 January 2006 to build the city. The formal name for the MAC, Sejong, the name of the great Korean king who invented the Korean alphabet at the time of the Chosun Dynasty, was chosen in 2006 with the help of preference surveys and a special naming committee. The Korean government planned to relocate 36 of its organisations to Sejong City by 2014. According to the Master Plan, green space in Sejong City will take up more than half of the entire city area. A massive Central Park will be located in the middle of the city and six major functions, such as the central administration, cultural and international activities, the local administration, university and research, medical and welfare and cutting-edge industry will be established along its ring-shaped public transport network.

Source: Korean Multifunctional Administrative City Construction Agency (2010), "Multifunctional administrative city", English brochure, Korean Multifunctional Administrative City, Sejong, Korea.

Another key challenge for Daejeon is to balance its growing and declining areas and to create a genuine partnership between the key stakeholders. Policy makers, academia and citizens must come together to find a mutually acceptable way forward. City authorities will be called upon to show strong leadership in this initiative. With a clear understanding of the issues of the compact city, they must develop the appropriate policies and a creative programme to educate the local population on the benefits of the new policy and to win public support.

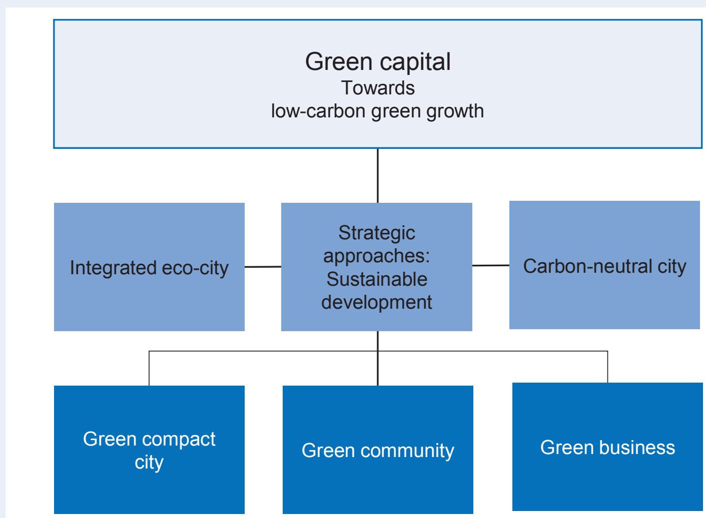
Assessment of compact city policies

The framework of Daejeon's urban policy incorporates the three core aspects of compact city policies: "environment," "society" and "economy". While the term "compact city" is not widely presented as an explicit theme, the concept implicitly underlies the city's current urban policy. Meanwhile, from the local governments' perspective, the central government is not necessarily leading the compact city policy, which suggests the need for more active communication between the central and local governments. In Daejeon, policies such as the Green City Plan (Box 3.2), transport-oriented development (TOD) and the Urban Renaissance Project have already been set in place. Packaging these policies as compact city policies, supplementing their inadequacies and setting clear goals will help the project move forward. Although Daejeon can itself be regarded as forming a certain independent urban area, it will be necessary to build a vision with a broader perspective in co-operation with its new neighbour, Sejong City.

Box 3.2. **Daejeon's Green City Plan (2010)**

The Green City Plan, set up in 2010, proposes to integrate spatial restructuring and physical redevelopment and match urban planning strategies with environmental sustainability. The plan is inspired by the three Gs: the green compact city, green community and green business, which are believed to contribute to a more sustainable urban form. Special action plans to achieve the green compact city include: *i)* establishing a polycentric, compact transit-oriented structure and promoting land use that avoids urban sprawl; and *ii)* building an environmentally sound urban plan to preserve green fields, for instance through increasing reuse of land.

Vision the plan



Source: Adapted from Daejeon (2013a), "Introduction of compact city-related policies in Daejeon", presentation by Daejeon to the OECD mission team in April 2013.

Daejeon's land-use regulations maintain a certain flexibility, reflecting the conditions prevailing in Korea. Urban centres are crowded with a dense mixture of residential, commercial and other uses. The city's Urban Basic Plan also suggests a fine-meshed mix of uses, combining living, retail and/or office uses at the level of floors, buildings and blocks as one of its subsidiary goals. This is partially supported by the evidence that average commuting distances in Daejeon are shorter than in several metropolitan cities, including Seoul, Ulsan and Incheon (Table 3.2). However, as discussed in Chapter 2, the mixed land use is limited to the vertical plane and concentrated in residential areas, typical of a new town development with a less clear goal of mixing urban functions at a larger scale.

Table 3.2. **Average commuting distance in metropolitan cities in Korea**

Kilometres per trip

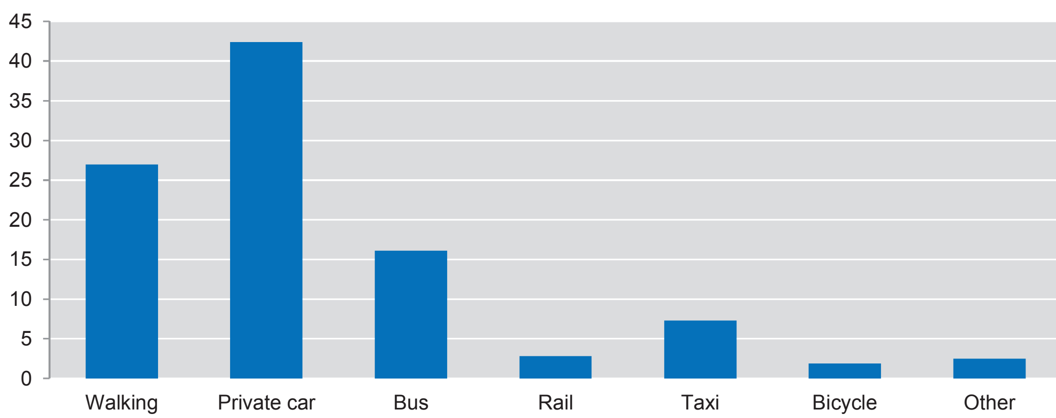
Daegu	Gwangju	Busan	Daejeon	Incheon	Ulsan	Seoul	Average of metro cities
4.76	4.87	5.32	5.60	5.82	5.96	7.54	5.7

Source: Adapted from Korea Transport Institute (2012b), *Korea Transport Database*, Korea Transport Institute, Korea.

TOD concepts could be more fully applied to urban development strategies in Daejeon. The goal is for an urban structure linked by public transport, with 2 urban cores, 7 local cores and 17 community centres. Ten projects were recently selected for the initial phase. Daejeon has already presented a proposal for its TOD plan, but it is worth noting that the appeal of TOD may be limited if it is not fully supported by better access to public transport. The connection between the Daejeon KTX Station and the subway station is not particularly convenient because they are so far apart. Better connections between inner-city transports must be explored. Notably, the share of railways as a transport mode in the city is only 2.8%, while the share of buses is 16.1% (Figure 3.3). This reflects inadequate railway service, including the subway in the urban area, and a lack of co-ordination of public transport services. The subway has only one line at present, which suggests the need for rapid development of a railway network.

Figure 3.3. **Modal share in Daejeon, 2010**

In %



Source: Korea Transport Institute (2012b), *Korea Transport Database*, Korea Transport Institute, Korea.

Urban renewal attempts are reflected in several urban renaissance projects and relevant urban development programmes. The city government has invested considerable resources in the renewal projects, as the declining urban centres have become a challenge[6] (Figure 3.4). However, successful urban renewal will require further analysis. Large scrap-and-build urban development projects around Daejeon Station are planned,[7] but better use of existing urban assets must be examined.[8] The main industrial policies support high-tech industries benefitting from the convenience of broad-area transport. However, the redevelopment of brownfields and active infill approaches to urban renewal must be thoroughly explored if such an industrial policy is to prevent scattered development. Establishing explicit density targets and concentrating urban functions in the city centre might help revive the urban centres. Toyama's policy initiatives to increase population in residential promotion districts with grant programmes could provide useful guidelines (Box 3.3).

The growth of the urban area in Daejeon has slowed in the centre and increased at the outskirts of the city, as shown in Figure 3.2. Emphasis has already shifted to improvements in quality, including diversity, rather than geographical expansion. Meanwhile, the districts that have been neglected during development in both the centre and suburbs require attention. Among these areas, some consideration has been given to the city centres. The principles guiding regeneration of the housing complexes, however, are not clear from the existing policy framework, although the Daejeon city government's Rainbow projects aim to provide affordable housing in the inner city (Box 3.4). This requires the city government to develop policy measures as residents grow older and buildings deteriorate, and incorporate them into the urban planning process.

Box 3.3. **Toyama's density target and grant programme**

Toyama City has set a density target along bus routes of 40 persons/hectare (the current density is 34 persons/hectare) with a 20-year plan to increase the population in the residence promotion districts. The plan specifically aims to raise the density along the railways to 50 persons/hectare (the current density is 44 persons/hectare) The city expects to expand the residence promotion districts from 2 927 to 3 489 hectares by improving the frequency of bus and railway service. The city's total population is expected to be 389 510 and the districts are expected to house 42% of the city's predicted total population (389 510) in 2025.

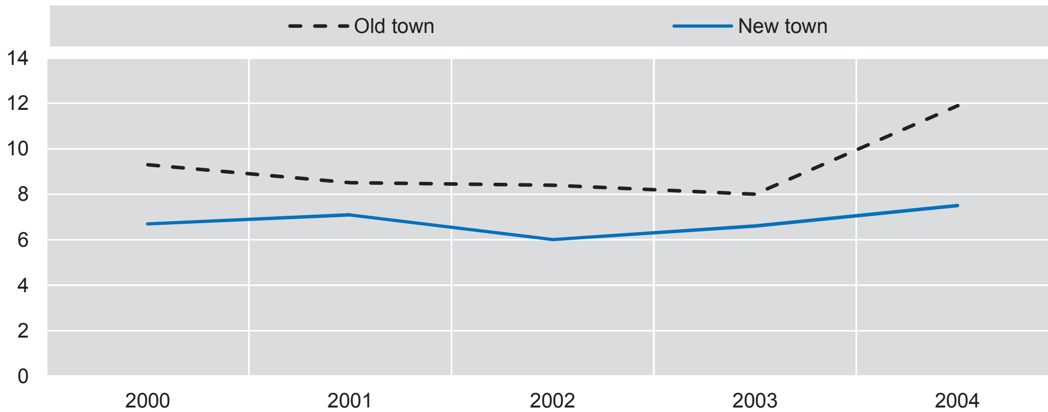
To expedite this process, Toyama City has implemented two subsidy systems, the City Centre Dwelling Promotion Scheme and a scheme to promote housing along the public transport axes:

- City Centre Dwelling Promotion Scheme (2005): The city has promoted the purchase or rent of housing in the city centre through a subsidy for construction companies and citizens. The average subsidy provided is JPY 199 438/house. Approximately 3 000 houses were to be provided in the city centre between 2004 and 2014 to achieve the target population density in the city centre (from 55.7 persons/hectare in 2004 to 65 persons/hectare in 2014).
- A plan to promote residential housing along the public transport axes (2007): The city has promoted the purchase or rental of a house in the designated areas easily accessible to public transport through subsidies for construction companies and for citizens (see table below). The average subsidy provided is JPY 691 071 per house. The city plans to raise the share of the population in these areas from 28% in 2005 to 42% by 2025.

Target areas	Beneficiary	Types of cost to be subsidised	Subsidy limit (JPY)
City centres	Construction companies	Construction cost of apartment buildings	1 million/house
		Construction cost of high-quality houses for rent	500 000/house
		Conversion of office/commercial buildings to apartment buildings	1 million/house
		Construction costs of installing stores, medical and welfare facilities in apartment buildings	20 000/m²
	Citizens who purchase or rent a house	Loans for purchasing houses or units in apartment buildings	500 000/house
		Rents for transferring to a downtown area	10 000/month (maximum three years)
Public transport axes	Construction companies	Construction costs of collective housing	700 000/house
		Construction costs of high-quality houses for rent	Two-thirds of the cost of the shared space
	Citizens who purchase or rent a house	Building/purchasing a house/unit in an apartment building	300 000/house
		Special supplement for two-family houses	100 000/house
		Special supplement for residents moving in from outside areas	100 000/house

Source: OECD (2012a) based on City of Toyama (2010), "Toyama City's efforts toward compact urban development", presentation to the OECD delegation, Toyama, 12 October 2010.

Figure 3.4. **Vacancy rate of office buildings in Daejeon**



Source: Daejeon (2013a), "Introduction of compact city-related policies in Daejeon", presentation by Daejeon to the OECD mission team in April 2013.

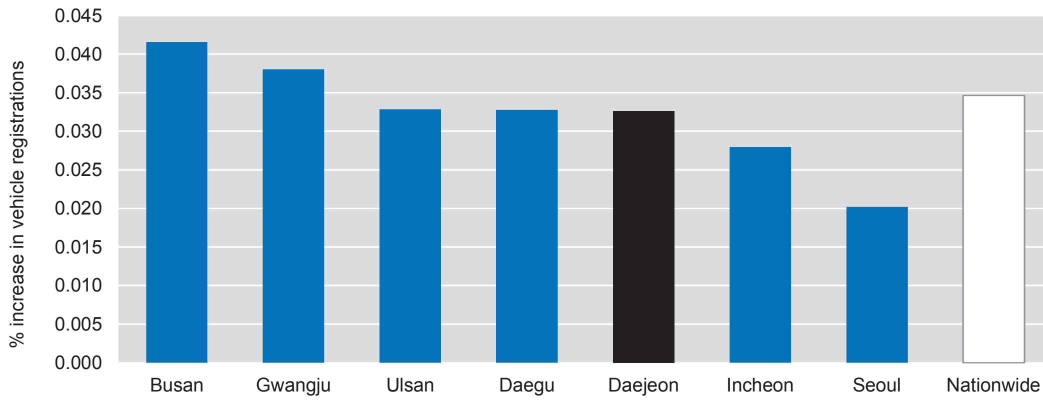
Box 3.4. **Daejeon's Rainbow Project**

The Rainbow Housing Project, initiated in 2006, is one of the Daejeon city government's initiatives to expand affordable housing. Including improvement of the residential environment and an urban renewal project, it has several goals: *i)* providing appropriate housing for different lifestyles, income levels and household types; *i)* providing housing for low- to middle-income workers in the redevelopment area, through provision of public rental housing or financial support for residents relocated from their original dwellings; *iii)* providing public housing for the lowest income households and special needs groups; and *iv)* revitalising the urban community by offering such social infrastructure as cultural and welfare services, healthcare services, housing for the elderly, sport and other leisure facilities.

Source: Daejeon (2013a), "Introduction of compact city related policies in Daejeon", presentation by Daejeon to the OECD mission team in April 2013.

Major road development has helped ease traffic congestion. However, vehicle ownership has increased in the past decade, at a rate even higher than that of other metropolitan cities (Figure 3.5). Moreover, traffic congestion is increasing as the urban areas expand. The Urban Renaissance Project, in particular, is expected to increase urban concentration. Measures to ease traffic congestion as a result of compact-sizing of the city must be considered now. This could be achieved by increasing the modal share of non-motorised transport, and public transport in particular.[9] Other local governments' strategic plans have been successful. The Portland Bicycle Plan, established in 2010, sets the stage for expanded bicycle transport in Portland, highlighting key principles such as attracting new riders, forming dense networks of bike routes and increasing parking lots. As a result of the city government's efforts, Portland ranks first among the United States' 51 largest cities for bike commuting (Alliance for Biking & Walking, 2010).

Figure 3.5. **Rate of increase in vehicle registrations in metropolitan cities in Korea, 2000-10**



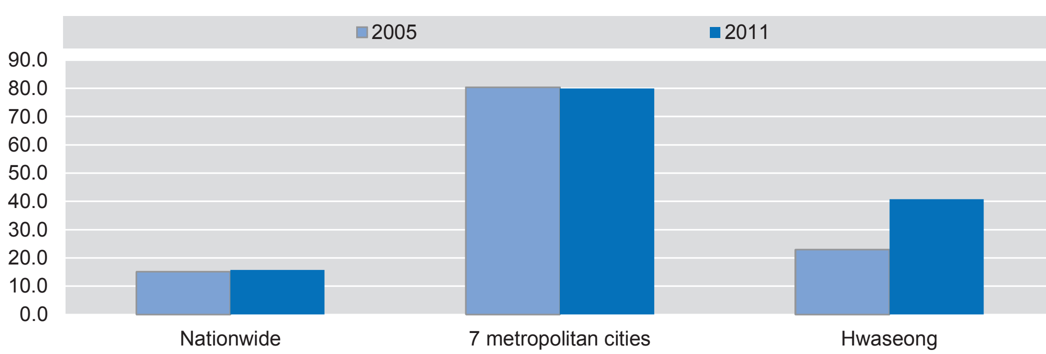
Source: Own elaboration based on Korea Statistics Office (2013), Korea Statistical Information Service, www.kosis.kr.

Hwaseong

City profile

Hwaseong is located on the southwest coast of Gyeonggi-do. Surrounded by several cities, it also faces the West Sea of Korea. It is the 5th-largest of the 27 cities in Gyeonggi-do, with an area of 689 km², which is larger than Seoul (605 km²), and its rapidly growing population has reached nearly 500 000 (the annual population growth rate was roughly 17% between 2000 and 2010). Hwaseong, nearly 40 kilometres from Seoul, is the location of large development projects, such as industrial facilities and in particular housing sites, developed to accommodate the population of Seoul and Gyeonggi-do. Urban, rural, fishery and mountain areas are distributed evenly throughout Hwaseong, but the urban area's population has dramatically increased in recent years (Figure 3.6).

Figure 3.6. **Change in share of urban land in total land**

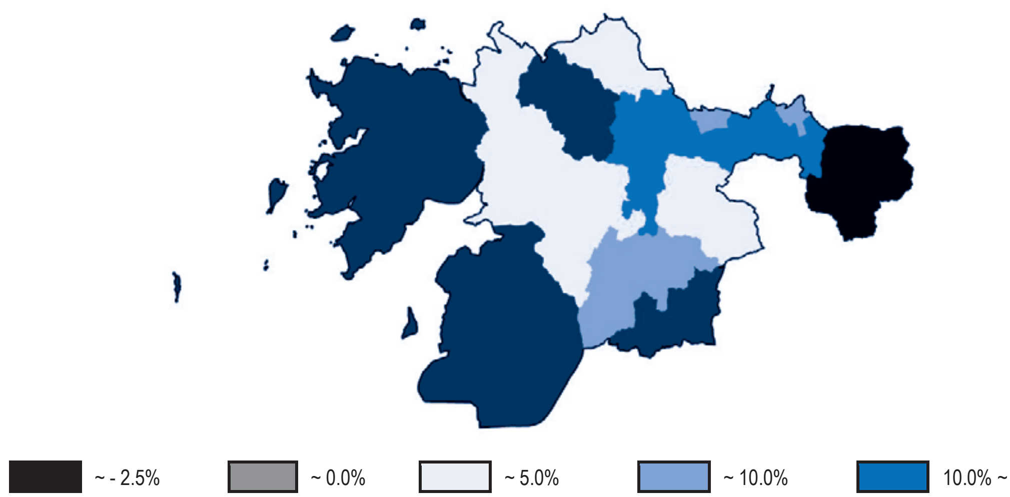


Source: Own elaboration based on Korea Statistics Office (2013), Korea Statistical Information Service, www.kosis.kr.

Urban challenges

Improving a disorderly urban spatial structure is Hwaseong's biggest challenge. Large-scale development and the Gyeongbu Express and high-speed railway crossing eastern Hwaseong from north to south have created a development gap between eastern and western parts of the city, and between its urban and rural areas. Of its total population, 67.5% is now concentrated in the eastern area, thanks to several new town developments, including the Dongtan New Town (Figure 3.7). The non-urban area has been rapidly developed in a haphazard fashion inimical to organised and balanced spatial development. Individual developments have sprung up around large-scale development projects, and factories have been randomly located in non-urban areas. Warehouses, industrial plants and apartments in rural areas have spoiled the city's landscape (Figure 3.8). A lack of urban infrastructure is also problematic. Insufficient transport between east and west, as compared to that between south and north, has distorted its spatial structure.

Figure 3.7. **Discrepancies in population growth rates across Hwaseong between 1990 and 2010**



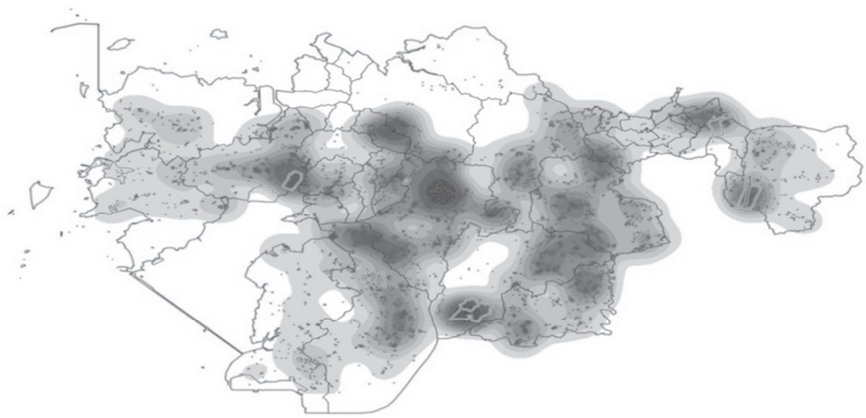
Notes: The units analysed in this map are based on the TL5 administrative borders of Hwaseong in 2010. The map does not reflect the changes in Hwaseong's administrative borders since 2010. This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Own elaboration based on Korea Statistics Office (2013), Korea Statistical Information Services (in Korean), www.kosis.kr.

Assessment of compact city policy

Hwaseong covers a large area, and part of its territory is included in the Seoul Metropolitan Area. This puts it under strong pressure to urbanise, following the type of urban structure promoted in the Seoul Metropolitan Area. Hwaseong must strategically take systematic action while devoting full attention to the policies of the central government and the Seoul Metropolitan Area, building on its ambitious Urban Master Plan and the numerous guidelines for policy embedded in it (Box 3.5). The Gyeonggi-do government, under whose jurisdiction Hwaseong falls, maintains a horizontal network of local governments through, for example, transfers of deputy mayors within the region. Hwaseong could maximise this opportunity to achieve compact city goals by close co-operation with neighbouring cities.

Figure 3.8. **Distribution of factories across Hwaseong**



Note: The dark shaded areas represent the areas where industrial plants are concentrated. This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Hwaseong (2013a), "Policies for compact city in Hwaseong", presentation by Hwaseong to the OECD mission team in April 2013.

Beyond such ambitious plans, it should be noted that there is a major mismatch between the central government and local governments on the approach to urban development. The national government, and the government-funded Land and Housing Corporation, are conducting large-scale new developments and infrastructure to support such developments. Meanwhile, local governments are establishing their own urban development/management plans, which often come into conflict with the national plan. In Dongtan New Town, Hwaseong requested that the national government build more cultural and multi-purpose facilities (e.g. sharing school yards with the public to provide cultural facilities, sports facilities and welfare facilities). The national government, however, declined to comply, due to increasing costs and security problems. Meanwhile, the financial resources at the disposal of the city government are not adequate for urban development on the scale envisioned by their plan. The delicate issue of how much decision-making power and financial resources can be transferred to the local government has occasioned considerable debate. However, before any change is made in the decision-making system, quantitative information should be gathered on the extent of gaps in infrastructure development to avoid unnecessary investment and obtain further support from the national government.

Hwaseong may need to improve its urban policies to reshape its urban form. Its urban areas are crowded with high-rise buildings (e.g. Dongtan New Town) especially in the east, and conventional villages are scattered throughout its broad territory. However, a wide area of the city is still covered largely by agricultural land and forests.[10] In addition, about 73.5% of its small factories have sprung up randomly with poor infrastructure. To address these challenges, built-up areas, conventional villages, farmland and forests must be clearly defined in the development plan to establish a long-term vision for the city. Particular attention must be paid to deregulating land use, as a similar deregulation of land use is often demanded in other districts within the city for reasons of social equity. Such deregulation would lead to an overall easing of regulations within the city area, resulting in low-density developments scattered throughout the area, the typical experience of many cities that have many undeveloped areas. The risk of such a shift away from a compact city calls for careful strategic examination to avoid scattered developments and design based on a wider polycentric city system beyond its administrative boundaries. Powerful instruments to protect land resources, such as the Agricultural Land Commission created by the Province of British Columbia (ALC), could be helpful. The ALC is responsible for the Agricultural Land Reserve (ALR), a provincial zone in which agriculture is recognised as the priority use, and has protected farmland and helped promote more compact communities (OECD 2012a).[11]

Box 3.5. **Hwaseong's Urban Master Plan**

The key urban challenges Hwaseong faces are the distortion of its urban spatial structure caused by the development concentrated mostly in its eastern district; a strong dependency on neighbouring large cities in terms of socio-economy and culture; and its lack of infrastructure due to the speed of recent urban expansion. To address these problems, the city has established a vision for the future and promotion strategies by examining changes in the domestic and foreign environments as well as the urban one in the Urban Master Plan. Three goals of city development have been set: a high-tech industry/research/education city aiming to cultivate the new industries of the 21st century; a historic, cultural and tourist city, involving a comprehensive plan for tourism development; and an environment-friendly, ecological city, through the conservation of shore and tideland. Numerous policy initiatives have been set up to achieve these goals, as laid out in the following table. Finding the resources to realise them may present a challenge.

Policy measures illustrated in the Urban Master Plan of Daejeon

Policy goals	Policy measures
"High-tech industry/research/ education city" by cultivating the 21st century's new industry	– Encouraging infrastructure industry, the automobile parts industry and other conventional manufacturing industries to locate in the collective district – Creating an automobile parts cluster (Songsan-Namyang-Jangan-Ujeong) – Creating a biological and health cluster (Bibong-Maesong-Bongdam-Hyangnam) – Creating a semiconductor and IT cluster (Suwon-Dongtan-Osan-Pyeongtaek) – Building a human resource-based network, forming a consultative group between industry, the university and government for collaboration – Ensuring widespread synergies through the research of Dongtan New Town, created into a ubiquitous city and by promoting self-sufficiency – Expanding the competitive educational infrastructure of the region to ensure excellent educational conditions
"Historic, cultural and tourist city through a comprehensive tourism development plan	– Promoting traditional culture and tourism clusters (Gungpyeong-Hyangnam-Byeongjeom) – Using the theme of filial piety and reform to promote the city, based on the Yung-neung and Geon-neung Royal Tombs – Creating a marine tourism and recreation cluster (Gungpyeong port-Jebu island-Jeongok port-Songsan green city) – Developing theme park-style tourism (Hwaseong USKR, Autopia, etc.) – Creating spa/health resorts by using spa resort tourism resources (Wolmun spa, Hwaseong spa and Annyeong spa) – Connecting farming special zones, silver villages and weekend/tourism farms – Creating cultural experience space for the agricultural and livestock industries by using agricultural reclaimed land
"Environment-friendly, ecological city through the conservation of shore and tideland	– Creating a "green-blue" network connecting ocean scenery and mountains on the western coast – Ensuring the city's appeal by ensuring sufficient green area – Realising a future-oriented, self-sufficient city by building ubiquitous amenities – Providing a vital, attractive residential environment by creating mid and low density, environmentally friendly housing complexes

Source: Hwaseong (2013a), "Policies for compact city in Hwaseong", presentation by Hwaseong to the OECD mission team in April 2013.

The number of factories scattered around Hwaseong might deepen concern that further development will take place around such factories. Pressure for expansion and relatively low land prices are compelling factories to relocate either within or outside the city. This would result in more sprawl and increase workers' commuting time. Factories contribute to the city's economic and employment base (the share of employment in the manufacturing sector is 56.6% of the total). Compact city policies should be carefully designed so that dense and proximate development does not reduce economic activity. Vancouver's new Regional Growth Strategy provides a useful example, where industrial areas are located not only in suburbs but also in the city core. In this instance, Metro Vancouver monitors demand for and supply of industrial-purpose land (Metro Vancouver, 2011).

Dongtan New Town is expected to house a substantial population of workers for large factories in the city. This policy is an effective way of rapidly establishing the new town. Relocating factories outside the city, however, could strongly affect the new town. To reduce this risk, diversifying economic activities in the region is called for. One way of attracting new residents to the new town might involve incorporating state-of-the-art schools or clinics. This approach has been used in the regeneration of parts of Manchester in England, where the new Millennium Community of New Islington is using the creation of a new school to draw professional and high-income residents to a previously deprived area of the city.[12]

Because Hwaseong is undergoing a growth spurt, the renewal of its urban centres does not appear to be as urgent a policy priority as other issues. Without well-prepared development strategies, however, tailored to the city's potential for growth, the social costs could be great. Providing a transport network for the large populated area and connecting the east to the west side of the city in a timely manner are imperative. The time lag between the development of the Dongtan New Town and introducing public transport will otherwise generate serious problems, including heavy traffic congestion due to commuting between Seoul and Dongtan New Town.[13] Public transport planning must be carefully timed with development. Before finalising any plan for public transport, a quantitative analysis of the level of current demand for the connection of the urban centres must be conducted.

Dongtan New Town's land-use plan shows intentionally mixed land use, which seemingly satisfies the compact city requirements (Box 3.6). However, an adequate block size should be applied to avoid large-scale, automobile-dependent developments and maximise the positive impact of mixed-use development. What types of use should be mixed, at what scale and whether appropriate mixed land use is applied within the living scale of walking distance must be determined by analysis of residents' actual lifestyles. Mixed-use development should not be encouraged if it results in greater car use, and care needs to be taken to encourage public transit, cycling and walking.

The concept of TOD is reflected in the city's plan to develop a transit network around a new KTX (Korea Train eXpress) station to be built in Dongtan New Town. Hwaseong plans to build multi-unit dwellings near the station, and connect the other transport modes to the station (Hwaseong, 2013a). It also aims to attract the headquarters of multinational companies, conventions, hotel and shopping malls to the station. This plan could be a good start for combining land-use policy with transport policy, but the success of such projects will depend on how construction of a new KTX station conducted by the central government is proceeding. The city's plan appears to be oriented toward physical development, without an overall strategy for maximising this opportunity to enhance the city's competitiveness.

Box 3.6. **Mixed land use in Dongtan New Town**

The first Dongtan New Town, completed in 2007, included a multi-use complex, located in the centre of the town. At the centre of this complex, a multi-level mixed-use building cluster, called MetaPolis (114 000 m²), was developed under the Special Planning Areas of District Unit Planning. This high-rise model complex included residential units, office and commercial space and a retail shopping centre, multiplex theatre, ice-rink, fitness centre, medical service and restaurants, as well as parks and open space. The District Unit Planning determined that the six-story commercial buildings in the neighbourhood commercial areas in this multi-use complex could introduce residential use on the fourth floor and above.

The second Dongtan New Town, which is currently under construction, also aims to achieve mixed land use, using seven special planning areas, such as the Metropolitan Business Complex. It adopts the TOD concept and a mix of residential, business and commercial uses. The second Dongtan New Town project covers the Seoku-dong, Bansong-dong and Dongtan-myeon areas (about 24 million m²) with the goal of a population of 285 878 (119 persons/ha), or around 115 323 households (2.5 persons/household). The project aims to not only create a self-sufficient hub city where residence, education, culture and business as well as high-tech industries exist in harmony but also to absorb the housing demands of the southern metropolitan area, contributing to the stabilisation of the housing market. With development concepts such as a "business hub city of the southern metropolitan area", "Mecca of high-tech industries", "Korean-style new town" and "a healthy and sustainable evolving city", the project has proposed implementation strategies including high-density development, job-housing proximity, mixed land use and housing diversity, green traffic support programmes (such as an Intelligent Transportation System type rental bicycle project), enhancing links among public transport, introducing new transport modes, and so on. The project's development objectives and concepts for a sustainable urban development are reflected in its land-use planning.

Sources: Korea Land and Housing Corporation (LH) (2013a), "Introduction of Dongtan New City", http://dongtan.lh.or.kr/dongtan_1/02_Introduction/01_1_business.asp?key1=1&key2=1&key3=0; Korea Land and Housing Corporation (LH) (2013b), "Move to the second Dongtan" (English brochure), LH, Gyeonggi-do, Korea.

Adverse effects such as traffic congestion from compact development are expected to be minimal for the moment within the city, if transport infrastructure is provided in a timely manner. However, since it is located on the outskirts of the Seoul Metropolitan Area, it could increase highway congestion. Possible bottlenecks should be identified through analyses such as traffic simulations. This will require the city government's strong commitment to reducing traffic congestion, using existing policy instruments such as fees for facilities-induced traffic (Box 3.7).

Box 3.7. **Fees for facilities-induced traffic**

The fees for facilities-induced traffic were introduced to reduce traffic and provide the budget to improve public transport. Unlike a general congestion charge, these fees are imposed on the owners of facilities with total floor area of each story exceeding 1 000 m², which cause traffic congestion in any urban traffic improvement districts on an annual basis. Local authorities run the programme, and Hwaseong is encouraging the facilities to run traffic congestion relief programmes such as car-free days by reducing their charges if they operate them.

Source: Hwaseong (2013b), "Introduction of fees for facilities-induced traffic", www.hscity.net (accessed 1 September 2013).

Simulation of compact city policy toward sustainable cities

Why urban modelling?

As the OECD (2012b) noted, there is an apparent disconnect in Korea between the highly advanced planning concepts presented in the various framework documents and the current state of spatial planning and territorial governance on the ground. Urban modelling could increase the awareness of future consequences and support long-term strategic decision making. In particular, urban modelling is important for compact city policies because a developed urban model[14] can identify the best combination of compact city policies for each city. Policy makers need to select compact city policies with the best output available. Urban models are useful because they can simulate the impact of multiple combinations of policies so that policy makers can choose the best combination based on the simulations outputs. They are also effective for communicating with citizens by incorporating their voices into the simulation process and visualising the output on a map.

Given the complexity of compact city policies, and the interconnectivity/interaction between their impacts, an integrated urban model is required to help explain the complicated relationship in a holistic manner. For example, compact city policies have various impacts on land use, travel behaviour, economy, environment and society. They affect decisions of households and businesses, so-called agents, their behaviour changes the pattern of land use and travel behaviour, and the resulting economic viability, environmental and social impacts associated with the change. Furthermore, land use interacts with transport because transport access encourages development while urban expansion requires more transport infrastructure (Hansen, 1959). A model for assessing compact city policies should consist of several sub-models representing each part, such as land-use changes and transport, and interacting with each other.

Developing a comprehensive urban modelling framework

The goal of the modelling work in this report is to find the best combination of compact city policies that maximise the benefit of urban development. In the context of each city's institutions, culture and physical environment, the policy package it pursues must be different. In addition, a single policy by itself does not work effectively, because compact city policies are naturally complementary. Multiple packages of compact city policies should be tested to identify the most promising combination. A model needs to capture different relationships and interconnectivity for each scenario.

Several modelling tools capable of being used for examining compact city policy effects partly have been developed. These models cover different styles of urban modelling theories, such as spatial interaction models, economic models and micro-simulations. Table 3.3 illustrates urban modelling approaches and reviews urban models. Examining the applicability of assessing compact city policies, several topics for further discussion suggest themselves.

The models in Table 3.3 are able to evaluate the impact of compact city policies to some extent, but from different angles respectively. While ITLUP, PECAS, UrbanSim and ILUTE can evaluate the impact of different policy scenarios by relocating the spatial distribution of households, employment and the transport network, SLEUTH and CLUE can only perform such evaluations by establishing spatial and/or socio-economic constraints on a land-use map. In this case, a partial examination of compact city policy impacts is possible, but identifying the overall policy impact may be very difficult.

Table 3.3. **Classification of different urban models**

Approach	Model theory	Models
Top-down approach[1]	Spatial interaction	ITLUP
	Spatial econometrics	PECAS, UrbanSim
Bottom-up approach[2]	Cellular automata	SLEUTH, CLUE
	Multi-agent systems, or agent-based model	ILUTE, UrbanSim

Notes: 1. It is called "spatial interaction and spatial econometrics". A spatial interaction model specifies its relations between transport networks and locations as a cluster of aggregate relationships based on the behaviour of a representative individual, usually the average calculated from a representative sample of population (Iacono et al., 2008). A spatial econometric model is a statistical method analysing the relationships between the variables related spatially considering the spatial auto correlation (Jiyeon, H. et al., 2003)). Several models addressing auto correlations have been developed by statistical theories. 2. It is called "cellular automata and multi-agent system (or agent-based model)". A cellular model is comprised of discrete cell space representing real attributes such as population, environment and is known as the simplest way of modelling in that they combine entirely their populations with their environment (Batty, 2012). The agent-based model simulates agents, such as individuals, households, entrepreneurships or developers which are regarded to have autonomy to interact with others, to adapt and to modify, with some restrictive theories, to see the results judged by average responses of the agents (University, R., 2014).

Sources: Own elaboration based on Iacono, M. et al. (2008), "Models of transportation and land use change: A guide to the territory", *Journal of Planning Literature on line*, Vol. 22. No°4, SAGE, pp. 324-340; Jiyeon, H. et al. (2003), "Application of spatial econometrics analysis for traffic accident prediction models in urban area", *Proceedings of the Eastern Asia Studies*, Vol. 9, pp. 390-397; University, R. (2014), "Lecture 9: Agent based urban models", Centre for advanced spatial analysis, www.casa.ucl.ac.uk/rits/rits-lecture-9.pdf (accessed 6 July 2014).

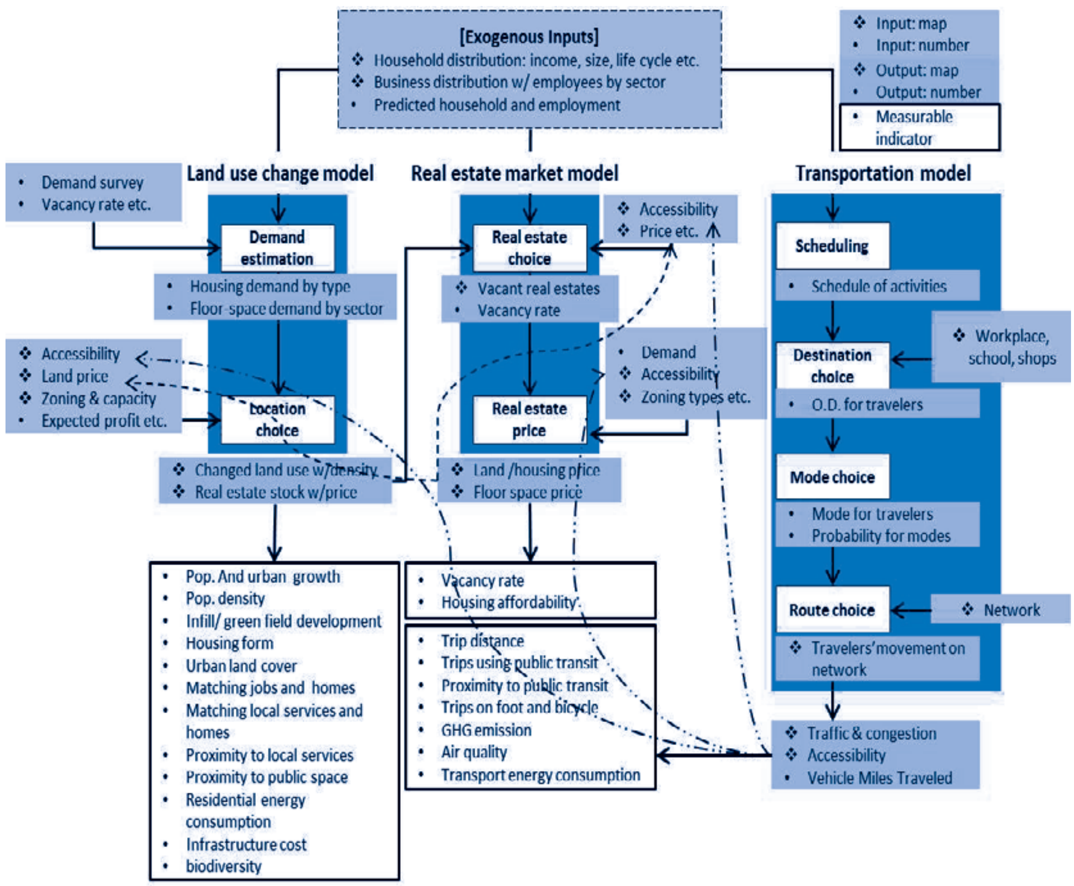
The generic models are developed for use in many different regions, which have similar policy problems that the model can handle, and are not designed to address place-specific unique policy problems and modelling resources in different regions. Indeed, because OECD countries are at different stages in building databases for modelling, flexibility in the modelling frameworks is required, as the degree of available data varies. For example, some countries have land price data by the parcel whereas others may not even have the aggregate data by zone. In such cases, the model using sophisticated data such as PECAS, UrbanSim and ILUTE cannot be applied. Unfortunately, generic urban models do not have the flexibility to be applied to all OECD countries and their varying conditions.

"Agent-based modelling" (ABM), which defines and simulates the behaviours of agents and their environments, fits the purpose of evaluating compact city policies. ABM has also been known as "one of the most exciting practical developments in modelling since the invention of relational database" (Macal and North, 2005) due to these features. Each activity regarding an agent's decision making requires different functions, algorithms and procedures, and needs to be modelled into a sub-system as well as the interactions between the sub-systems so that the whole integrated urban model describes the real world more effectively. The integrated urban model also responds to policy scenarios and processes the inputs using data, and produces results or outputs.

The integrated urban model adopts "demand-supply" interaction and profit maximisation principles to explain the real world's brief mechanism. Current and predicted population and businesses create demand, for which developers formulate plans to provide real estate products to meet. They tend to choose sites that will maximise development profit. As a result of developers' activities, land is changed due to greenfield development or infill development (redevelopment), thereby increasing the stock of real estate.

Meanwhile, households and businesses also move to maximise their profits and the price of real estate in specific places is determined at which the demand and the supply meet. Price varies among different locations because a preferred location attracts demand while a less desirable location attracts less demand. An oversupply of vacant real estate will depress prices because it indicates that consumers, suppliers and developers do not value it. The price of real estate is also influenced by such factors as accessibility, zoning types and conditions. Housing affordability can be computed using the price and income of agents. The land-use change model and the real estate market model in Figure 3.9 illustrate this mechanism. The interactions and relations among indicators need to be verified by further justifiable researches in process of a comprehensible model development.

Figure 3.9. **Proposed conceptual framework for examining compact city policy impacts**



Source: Own elaboration based on Korea Research Institute for Human Resources (2013), "Conceptual framework for urban simulation model to assess impacts of compact city policies", presentation to the OECD expert seminar on 14 May 2013.

A transport model, a subsidiary model, maps individuals' travels. The first variable concerns time, as decisions are made when to travel, according to a daily schedule. Some commuting abides by routine patterns, such as to the workplace or attending school. Location is the next variable. A hospital, for instance, may be a destination for a household. Next, the mode of transport is chosen, and whether to walk, bike or take a car or the metro. Finally, travellers determine which route to use. Mapping these decisions (for the transport model) makes it possible to model traffic volume on the road network and to identify potentially congested areas. Based on the congestion, accessibility to public services can be calculated for each location where agents live and work. Vehicle miles travelled can also be calculated for each agent and can be used to compute CO_2 emissions, air quality and energy consumption.

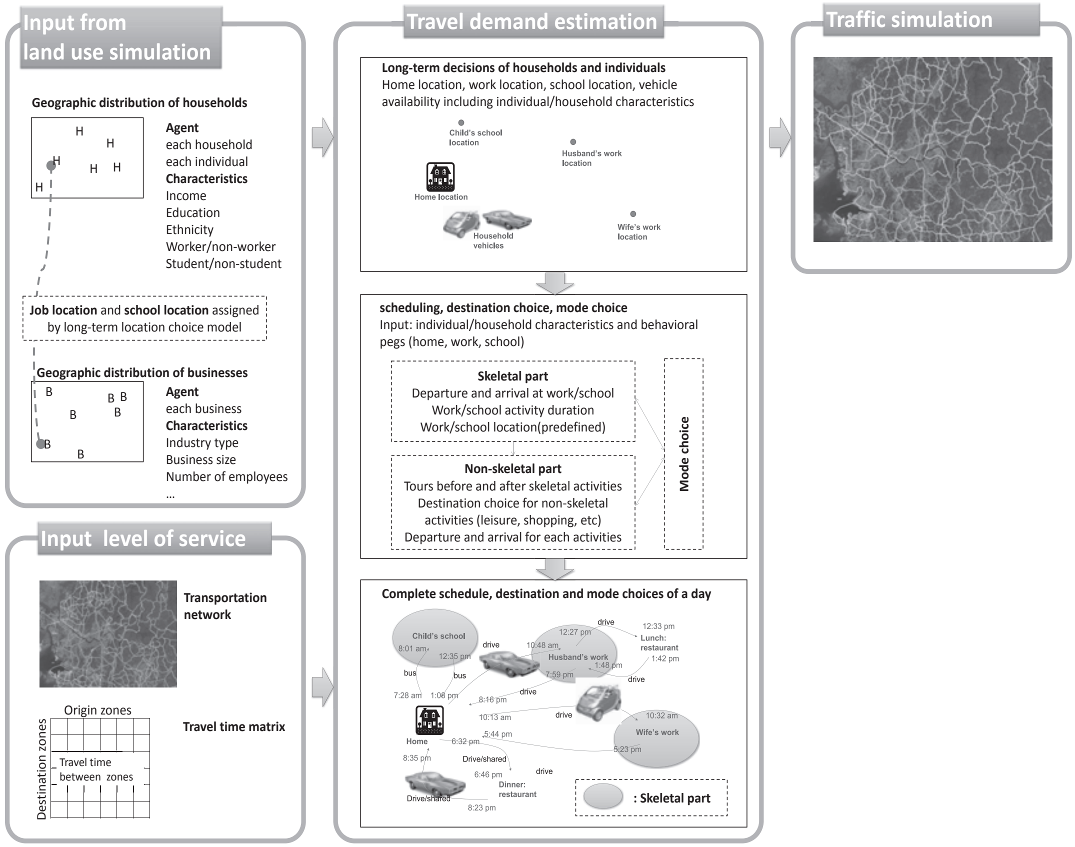
This report suggests the "activity-based transport model" as the most appropriate model in that it explains overall individual behavioural patterns rather than just fits the traffic volumes on the transport networks as traditional modelling has done. ABT induces traffic demands from the individual decision-making mechanisms of the activities so that it can provide outputs with richer details with higher disaggregation in time and space than traditional transport models. Figure 3.10 shows the general flow of ABT, in which land-use agent-based models interact closely to coup with the agents' activities.

The development of comprehensive models should include inputs and outputs as far as possible while considering interactions between sub-models, but should be followed by a long-term research effort. This involves the development, application and examination of a knowledge framework to address the problem at hand, i.e. the impact of compact city policies. Such a knowledge framework can be collapsed into a more tangible form, such as a computer programme. The conceptual framework for examining compact city policy impacts is proposed in Figure 3.9. In this framework, integrated urban modelling could be developed by testing existing models, building sub-models reflecting different policy environments.

Designing a conceptual model is the next step after this conceptual framework, in which computational algorithms are produced reflecting the relevant analytical methodologies as well as inputs to the data management procedures. Then we can develop a real model with specific computer languages checking if the language codes satisfy the algorithms and the codes work on the data properly. We also need to develop appropriate Data Base Management System (DBMS) fitting the analytical methodologies and algorithms. Eventually, the model needs to calibrate the parameters before the main simulations through repetitive comparison between the simulated and the data observed in reality.

This study proposes selecting the appropriate strategy, either an entirely new development, utilisation of existing models or a combination of the two, in order to develop a model based on data and resource availability. An approach based on a combination of the two is more appropriate to the further development of this study in that a new method requires data, money, time and resources and no generic existent model fits all cities. In the same vein, this research operated two pilot urban modelling simulations through compromised approaches in order to see if the urban areas are developed in a compacted manner when some compact city policies are introduced. More specifically, we developed a new urban modelling tool adopting ABM with restricted resources to simulate compact city policies on Daejeon and we used SLEUTH, an existing modelling tool, to simulate them on Hwaseong. These pilot simulations are good examples of integrated urban modelling justifying compact city policies at a basic level. The simulation results are described in the following sections.

Figure 3.10. **General procedure of travel demand modelling using an activity-based model**



Sources: Own elaboration based on Korea Research Institute for Human Resources (2013), "Conceptual framework for urban simulation model to assess impacts of compact city policies", presentation to the OECD expert seminar on 14 May 2013; Arente, T. and H. Timmermans (2000), *Albatros: A Learning Based Transportation Oriented Simulation System*, Elirass, Eindhoven; Pendyala, R.M. et al. (2012), "An integrated land use transport model system with dynamic time-dependant activity travel microsimulation", *91st Annual Meeting of the Transportation Research Board*. Vol. 2012/1, Washington, DC.; Goulias, K.G. et al. (2012), "Simulator of activities, greenhouse emission, networks, and travel (segment) in Southern California", *Annual Meeting of the Transportation Research Board*, Washington, DC.; Salvani, P. and A.E. Miller (2005), "ILUTE: An operational prototype of a comprehensive microsimulation model of urban systems", *Networks and Spatial Economics*, Vol. 5, No. 2, pp. 217-234.

Simulation exercise (1): The impact of compact city policies on Daejeon

As an example of a basic level's integrated urban modelling based on the framework in the previous chapters, an agent-based urban simulation model was developed for this study to assess a set of compact city policies for Daejeon.[15] As noted earlier, the nature and impact of the compact city is multi-dimensional, and only a purpose-built comprehensive model will cover all the necessary aspects of the compact city. The development of such a model is a long-term project, and this research offers an experimental pilot model with a focus on a particular component of the compact city – new development, redevelopment and densification, which scenario 2 addresses in Table 3.4. Dense development is often considered a critical component of a compact city. The impact includes mitigation of urban sprawl, as well as reduced commuting and shopping trips.

An agent-based model integrated with microeconomic location choice theories is a good fit with the study of compact city in this context in that it simulates agents' interactions with each other and with their environments based on their realistic behaviours (Macy and Willer, 2002; Gilbert, 2008). This research adopts and extends the urban simulation model developed in the work of Kim and Batty (2011) and Kim (2012). These studies extended the bid-rent theory of Alonso (1964), Mills (1967) and Muth (1969), in order to define the location choice behaviour of households. To make a more comprehensive model, this research will define urban location choice behaviour of households with a reference to the random utility maximisation principle in place of the bid-rent theory, which reflects more heterogeneity and stochastic features of agents (Abraham and Hunt, 2007). In addition, this model introduces multi-level submodels to describe more realistic socio-economic features such as "global restriction on total urban growth" and "allocation of urban demand based on population". The preference for urban development will be considered as a part of the utility function, and the model will present the formation of resulting urban growth.

As regards the study of the compact city, this pilot model focuses narrowly on the impact of dense urban development on urban growth. This study will pay attention to developing and testing model behaviour with the use of geographic data for Daejeon. A logistic regression to determine model variables is conducted on an empirical basis, but at a limited scale, due to the constraints of time and budget. The model and results are both experimental and exploratory. However, since the land-use model is the core of any comprehensive urban model and the impact of dense development is not as thoroughly studied by existing urban models, the pilot model in this research will provide useful implications for the further development of a compact city model.

Box 3.8. **Comparison between "bid-rent theory" and "random utility maximisation theory"**

Bid rent theory

According to this theory, householders all compete for the most accessible dwelling within the central business district (CBD) and choose it in a way that maximises its utility within the budget constraints. "Bid rent" means the amount that households are willing to pay for the location. The bid rent maximizing utilities of a specific place is determined by the Cobb-Douglas utility function. Households always face a trade-off between transport costs and land rent. The bid rent always decreases as the distance from the CBD increases.

The Cobb-Douglass utility function is:

$$U = q^{\alpha} g^{1-\alpha} a(u,v)^{\gamma}$$

U is utility, *q* is the floor space of a household, *g* is non-housing good, *a (u,v)* is the amenities at location *(u,v)*. The CBD's location is (0,0). α(0< and <1), γ (>0) are parameters. Land developers choose the location and density of development to maximise the profits, the amount after the costs are deducted from the benefits of the developer.

The procedures for a city to be developed until equilibrium are as follows: *i)* housing prices are bid up in desirable locations such that no household wants to move; *ii)* the price that households are willing to pay equals the price that developers are willing to accept at each location; *iii)* land prices are bid up in desired locations such that development profits are zero everywhere and developers are indifferent to the locations of development; *iv)* the total demand for floor space equals the total supply; *v)* at the city boundary, the land rental price equals the exoneous agricultural rent.

Box 3.8. **Comparison between "bid-rent theory" and "random utility maximisation theory"** (*cont.*)

Random utility maximisation theory

This theory assumes that each agent, such as a household or a business, decides to maximise its utility on finite alternatives and that the utility is composed of an observable deterministic part and an unobservable stochastic part. The utility that individual *i* is associating with alternative *a* is defined by:

$$U_{ai} = \sum_{s=1}^{S} \beta_s x_{ai} + \varepsilon_{ai}$$

Where *S* is a choice set, β_s is a vector of *s* estimable coefficient, x_{ai} is a vector of an observed independent attribute of individual *i* on alternatives *a*, and ε_{ai} is an unobserved random disturbance that is assumed to follow a Gumbel distribution, which models the distributions of the maximum (or minimum) of a number of samples of various distribution such as the distribution of maximum level of river of a particular year. From this, a multinomial logit model, *P*, for the probability of choosing an alternative *a* out of the choice set S_n. The key model behaviour is defined by a short run random utility maximising location choice of spatial agents.

$$P_{ai} = \frac{e^{x_{ai}}}{\sum_{k \in S_n} e^{x_{ki}}}$$

Sources: Kim, D. and M. Batty (2011), "Modeling urban growth: An agent based microeconomic approach to urban dynamics and spatial policy simulation", *CASA Working Paper Series*, No. 165, University College London, London; Abraham, J.E. and J.D. Hunt (2007), "Using random utility theory in spatial economic modelling: Recent advances", 10th International Conference on Computers In Urban Planning and Urban Management, Iguassu Falls PR, Brazil; Wu, J. and A.J. Plantinger (2003), "The influence of public open space on urban spatial structure", *Journal of Environment Economics and Management Issue*, Vol. 46, Issue 2, pp. 288-309; Mcfadden, D. (1973), "Conditional logit analysis of qualitative choice behaviour", in P. Zarembka (ed.), *Frontiers in Econometrics*, Academic Press, New York, pp. 105-142.

Forecasts of future urbanisation for Daejeon have been conducted on the basis of two scenarios: business as usual and compact development. The first scenario focuses on the extension of current trends, and the second on the effect of a compact city policy. Unlike the compact development scenario for Hwaseong, we assume the promotion of urban redevelopment and densification for Daejeon. Urban redevelopment and densification can reduce urban sprawl and loss of open space, and this is considered an important characteristic of compact city development. However, few urban models can simulate such urban redevelopment and densification practices. Thus, we introduce the notion of spatial redevelopment and densification into the agent-based modelling framework. Since the estimation of the amount of redevelopment and densification requires the development of relevant empirical models, we simply utilise random stochastic effects to determine them. Nevertheless, this simulation will show how urban redevelopment and densification will change overall urban structure. Table 3.4 shows the key assumptions in the two scenarios.

Figure 3.10 shows comparisons of urban development in 2030 between the current trends scenario and the alternative scenarios for a compact growth. Daejeon is not a rapidly growing city, but it will experience a certain degree of urban expansion and sprawl. The simulation results show that the new urban growth will occur near the existing urban areas in the case of the business as usual scenario. Mid- to large-scale new development will take place in the western part of the city, where most mid- to large-scale developable lands are available. This simulation proves that the residential development districts like Doan, Dukmyung, Gubong and Hakha will see intensive new development. On the other hand, small-scale spontaneous development will occur in the south-western and south-eastern part of the city, especially around the foot of the Bomun Mountain. These areas are now mainly filled with detached and semi-detached houses, agricultural barns and small manufacturing firms. This type of development is likely to expand in the future.

Table 3.4. **Key assumptions of the two scenarios (Daejeon)**

Scenario 1	Business as usual scenario: – Assume no changes in policies or land-use change drivers
Scenario 2	A compact city with promotion of dense urban development: – Assume continued protection of all existing protected lands – Assume no new roads in or near existing villages – Assume growth will occur near transport networks such as primary roads or rail stations – Assume urban redevelopment around old town centre – Encourage urban development to occur near urban amenities such as cultural facilities – Assume high-density development – Retain existing population growth trends

In the case of the compact growth scenario, urban redevelopment and densification will actively take place around the old town centre. Generally, urban models assume the urban development is irreversible and tend not to consider redevelopment of urban areas. Therefore, existing urban models keep those which had been once converted to urban land as urban land during the rest of the model run even if some of them contained areas of redevelopment. This model assumes the redevelopment of old town centres, and thus reduces new development in the urban fringe areas. Certainly, this will not remove the need for a large-scale urban development, and thus the overall spatial structure is similar to that of the business as usual scenario. But small-scale sprawling developments are clearly reduced in this scenario. Figure 3.11 and Table 3.5 present and compare the results of the simulation.

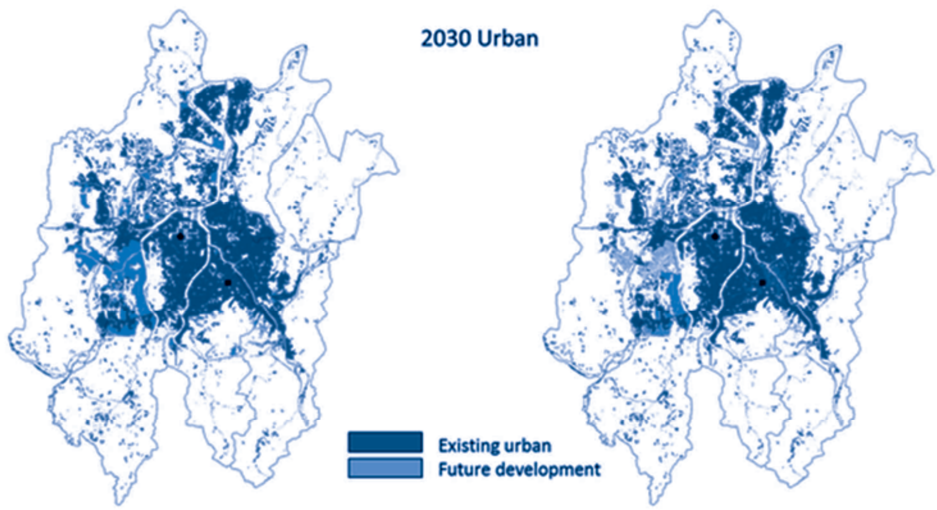
Table 3.5. **Comparison of results between different scenarios (Daejeon)**

	Business as usual	Compact development
Urban development within 2 500 metre buffers from the new and old central business district	0.25 km²	1.6 km²
Urban development outside 2 500 metre buffers from the new and old central business district	21.85 km²	17.9 km²

Note: The location of the new central business district is assumed at the point of Daejeon City Hall (upper left black point in Figure 3.11), and the location of the old central business district is assumed at the point of Junggu Borough Hall (bottom right black point in Figure 3.11).

Figure 3.11. **Different development patterns according to different scenarios (Daejeon)**

(a) Business as usual (b) Compacted development



Note: The grey area is the existing urban region and the blue area is the future development region.

Source: Own elaboration based on National Geographic Information Data and Korea Statistical Information System Data.

Simulation exercise (2): Impact of compact city policy on Hwaseong

To estimate the compact city policy effect for Hwaseong, the SLEUTH model[16] was applied in this study. The model is built upon the core notion of cellular automata, as well as other statistical methods, and is one of the most widely used cellular urban models for simulating land-use change and urban growth (Clarke, 2008; Jantz et al., 2010; Rafiee et al., 2009; Silva and Clarke, 2005). One of the most important strengths of this model is its "compact" data requirement, and even without the intensive use of socio-economic data, this model efficiently simulates the land-use change and urban growth process. Although the model is not designed to study the impact of the compact city itself, it is one of the most widely used urban growth simulation models capable of offering some insights for the study of the compact city.

This model offers opportunities to simulate some compact city policies, such as land-use regulations and the provision of transport, and to examine the impacts of those policies on the urban and environmental landscape. It is important to note that, due to the nature of the model, SLEUTH has certain limitations for considering more diverse socio-economic determinants, and it creates the results of land-use change and urban growth in a physical perspective. To compensate for this, this study implements various factors with scores according to the degree of attraction (5: attraction; 90: strong resistance) as simulation input data.

To simulate urban development patterns over the next 20 years under different conditions, this study designed two urbanisation scenarios for Hwaseong: business as usual and compact development. The first scenario assumes that current urban patterns will continue 20 years into the future, and no specific policy actions are assumed in this scenario. The second scenario reflects the concept of compact city. Along with conservation of natural resources and the environment, a denser, clustered development is assumed in this scenario. Table 3.6 explains the key assumptions of the two scenarios.

Table 3.6. **Key assumptions of the two scenarios (Hwaseong)**

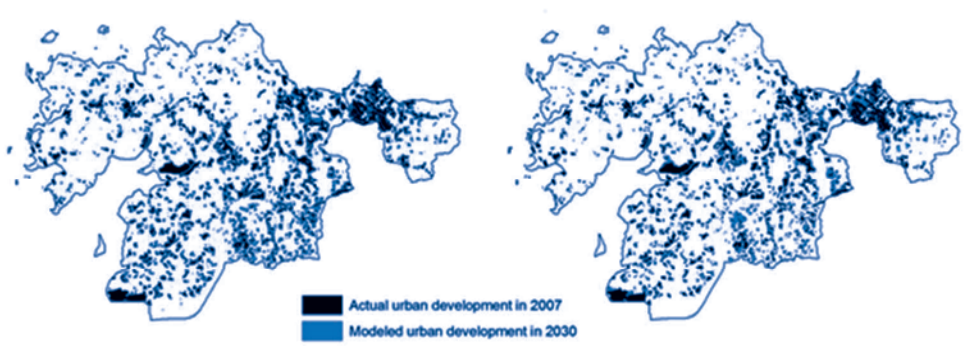
	Scenario 1: Business as usual	Scenario 2: A compact city with strong protection of natural resources and the environment
Assumptions	Assume no changes in policies or land-use change drivers	1. Assume continued protection of all existing protected land
		2. Assume a protected buffer (of 300 metres) around bodies of water, streams, wetlands and coastal areas
		3. Assume growth will occur in or near existing villages and near primary road networks or rail stations
		4. Assume no new roads in or near existing villages
		5. Enhance proximity to the Suwon region as a driver
		6. Retain existing population density trends
		7. High-density development
		8. Encourage development to occur in or near existing villages, expanded by adding a 300-metre buffer

The simulations for Hwaseong show a continuation of scattered urban development over the next 20 years. Spontaneous and edge growth dominates the pattern of growth in Hwaseong. This is largely due to the current urban form and spatial structure of the city. However, the results indicate that the overall amount and detailed spatial pattern of urban development between the two scenarios is different. The business as usual scenario resulted in a higher level of urban growth, with a more dispersed growth pattern, but the compact growth scenario generated a lower level of growth, with a more clustered pattern.

The result of the business as usual scenario presents an intensification of scattered urban development across the region. Some notable urban clusters occur around the Dongtan and Bongdam New Town development areas, but some areas with sprawled development, like Songsan, Hyangnam, Balan and Paltan, are likely to experience further scattered development in the future. On the other hand, the results of compact growth show reduced urban sprawl. Major urban clusters will form around Dongtan and Bongdam in this scenario, but sprawling development around Songsan, Hyangnam, Balan and Paltan are reduced. Figure 3.13 shows comparisons of urban development in 2030, between the current trends scenario and the alternative scenarios for compact growth. Table 3.7 shows more detailed urban growth trends under the two scenarios. The business as usual scenario increases urbanised areas by 188%, to 173 km². The compact growth scenario leads to a 150% growth, to 138 km². The net increase in case of the business as usual scenario is 88 km², with 49 km² for the compact growth scenario.

Figure 3.12. **Different development patterns according to different scenarios (Hwaseong)**

(a) Business as usual (b) Compact growth



Source: Own elaboration based on the National Geographic Data and Korea Statistical Information System Data.

Table 3.7. **Comparison of results according to the two scenarios in 2030 (Hwaseong)**

	Scenario 1 Business as usual	Scenario 2 Compact growth
Total urban area by 2030 (km^2)	173	138
Percentage of urban land (%)	31.6	27.2
Projected population by 2030	576 745	576 745
Urban population density	3 334	4 206
Urban population within 500 metres of local services	255 683	259 862

Source: KRIHS and OECD elaboration based on the aforementioned simulation.

Conclusions of the simulations

This research suggests a conceptual framework of the integrated urban model (Figure 3.9) to assess compact city policy scenarios to find the one that is the most adapted for each city as well as the further works to complete the model development. Considering the limited resources, we developed and simulated a smaller version of the integrated model, based partly on the framework, using one of the most advanced theories in order to see if a set of compact city policies (Table 3.4) will induce compacted development of the Daegeon area. To better support the results of the simulation on Daejeon, we simulated another set of similar polices (Table 3.6) on the Whaseong area using a current advanced urban modelling tool with additional comprehensible factors scored by attraction for development.

Both simulations confirmed that compact city policies can develop urban areas compactly. Encouraged by the result, this study strongly recommends developing a more comprehensive and concrete urban model to find the best set of compact city policies for each urban area.

Notes

1 . This rapid increase in population is mainly due to the new town developments built to accommodate the population from the Seoul Metropolitan Area.

2 . This analysis is based on background reports from each city, and meetings with city governments.

3 . This put the city on the same footing as the next level of government (*do*) and gave it broader autonomy.

4 . The relocation was accelerated when the City Council and the City Hall moved to a new downtown in 1998. Since then, Daejeon has had two city centres.

5 . Tsukuba, a well-known Science City in Japan, could offer some insights to Daejeon. It was established by the national government in the 1960s to facilitate research and development and improve the quality of scientific discovery. Its population growth rate of 2.6% over the last 40 years (1970-2010) was much higher than the national average (0.53%), possibly thanks to such policies as the provision of public housing for researchers, the development of a commercial complex near the railway station and a welcoming city centre, and more recently, the establishment of Tsukuba Express in 2005, connecting the city with Tokyo. This has improved its accessibility to major cities (OECD, 2012, Country Statistical Profiles Tsukuba City (2012), Statistical Data, Tsukuba city).

6 . In the late 1990s, new downtowns were created, and the city's population and functions were moved from existing urban areas to a new urban area. A typical pattern of urban expansion, with the construction of suburban new towns, transfer of public agencies to suburban areas and large-scale shopping centres, have led to the decline of the old urban area. This has resulted in a dispersed spatial structure with low density.

7 . This project aims to regenerate the old district around Daejeon station. The designated area, which covers 887 000 m², includes a population of 7 250 and much old housing stock (73.8% of its housing was built before 1980). Convention and cultural facilities, transfer centres, hospital and commercial centres will be built to replace old buildings.

8 . The recent economic recession has forced Daejeon to reconsider its ambitious redevelopment projects. The plan is now to reduce the number of candidate projects after examining the feasibility of the proposed projects, and to target investment at community-based redevelopment (discussion with Daejeon officials during the OECD mission, 11 October 2013).

9 . The Daejeon city government's efforts to reduce private car use include the "One Day Without A Car" campaign, started in 2012. Target vehicles are fewer than ten-seater, non-business purpose passenger cars. Participants in the campaign who refrain from driving from 7 a.m. to 10 p.m. one day a week receive benefits including a 10% reduction of the car tax, 30% off public parking fees, an 8.7% discount on auto insurance premiums and 10% discounts on car inspection fees and the Public Transport Free Insurance Service. The benefits of those who are found to have

infringed the ground rules more than five times in a year are suspended. As of December 2012, the number of the car-free day participants exceeded 10 000 people (Daejeon, 2013c).

10 . Population is concentrated in the eastern residential area, which houses 67.5% of the total population.

11 . Despite strong population growth, the urbanised land in Metro Vancouver has increased by only 149 hectares since 1986, primarily as a result of the constraints of the Agricultural Land Reserve.

12 . For more details, see www.urbansplash.co.uk/residential/new-islington.

13 . A mismatch between land use and transport policies has all too often aggravated traffic congestion around metropolitan cities. The introduction of a beltway around Seoul in 1999 was succeeded by the construction of five new cities (Bundang, Ilsan, Pyeongchon, Sanbon and Jungdong) three years later, leading to considerable traffic congestion (OECD, 2012b).

14 . Urban modelling is the process of abstracting the complicated and interdependent processes of the real world into a simplified computer model. Important components and interconnectivity are identified and illustrated using a mathematical or formal model, which is developed into a computer system. Urban models represent processes of components of a city and their functions and interaction. Typically, urban models are built using GIS (geographic information system) technologies and analytical methodologies. Citizens and physical environments such as roads and houses can be effectively represented as entities on the map using GIS.

15 . A description of this model and application process are described in Annex 3.A1.

16 . SLEUTH is a cellular automata urban model developed by Keith Clarke at the University of California, Santa Barbara (Clarke et al., 1997). A description of this model and application process are described in Annex 3.A2.

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Annex 3.A1
Modelling process for Daejeon

Modelling description

Agent-based modelling is a simulation method composed of agents that interact with each other and their environments. It is a computational modelling approach, in that it takes the form of a computer programme and in that there are inputs and outputs for the programme. The programme holds attributes of agents and environments and defines the behaviour of agents as well as the interaction with their environment (Macy and Willer, 2002; Gilbert, 2008). On the conceptual level, the agents and environments are simply generic terms describing their general characteristics, and there are no fixed definitions of their forms, attributes and behaviours. These are rather defined by a specific target system of modelling, and thus there could be widely different operational definitions of agents and environments. Many different academic domains, such as biology and economics, can use the agent-based modelling for their own research focus.

Agent-based modelling as an approach to the study of land-use change and urban growth is a relatively new idea. The urban modelling field has continuously adopted theories and methodologies from varying academic domains, and agent-based modelling is one of the latest techniques in urban modelling. It is gaining in popularity in the urban modelling field, but fully fledged generic models have not yet been well developed (Parker et al., 2002; Matthews et al., 2007).

One of the most important challenges of developing agent-based urban models is the specification of agents' behaviour and their interaction with the environment. Although the approach provides a useful framework for understanding the temporal dynamics of complex urban systems at a fine scale, it does not provide substantive knowledge of how urban systems change and evolve. In the past, these applications have been mainly centred on the study of self-organising urban morphologies, with a focus on generative knowledge discovery (Batty, 2009; Crooks et al., 2008; Matthews et al., 2007; Manson and O'Sullivan, 2006; Epstein, 2007), and this has limited their applicability in real planning.

Recently, a new approach to integrating urban economic theories into agent-based modelling frameworks has emerged through the study of land-use change. The main benefit is not only stronger explanatory power from the perspective of agent-based modelling, but also a greater behavioural/spatial heterogeneity with respect to how the urban economy is modelled and represented. Taken together, these developments have the potential to offer a new type of dynamic and operational spatial policy support system to planning practice.

The model in this research integrates the random utility theory (McFadden, 1973) into the agent-based modelling framework. Random utility theory models the choice of individual entities such as households and businesses on a finite alternative, and it breaks the utility down into observable deterministic elements and unobservable stochastic elements. Then, the land-use change and urban conversion occurs as a result of such agents' location choices.

The utility that individual *i* associates with alternative *a* is defined by:

$$U_{ai} = \sum_{s=1}^{S} \beta_s x_{ai} + \varepsilon_{ai}, \qquad \varepsilon_{ai} = a - b[\ln(-\ln\delta), \qquad \delta \in [-\delta_i, \delta_i]$$

Where S is a choice set, β_s is a vector of s estimable coefficient, x_{ai} is a vector of an observed independent attribute of individual i or alternative a, and ε_{ai} is an unobserved random disturbance that follows a Gumbel distribution.

Assuming that the unobserved random part varies with the Gumbel distribution, we are led to the multinomial logit model for the probability of choosing an alternative i out of the choice set S_n.

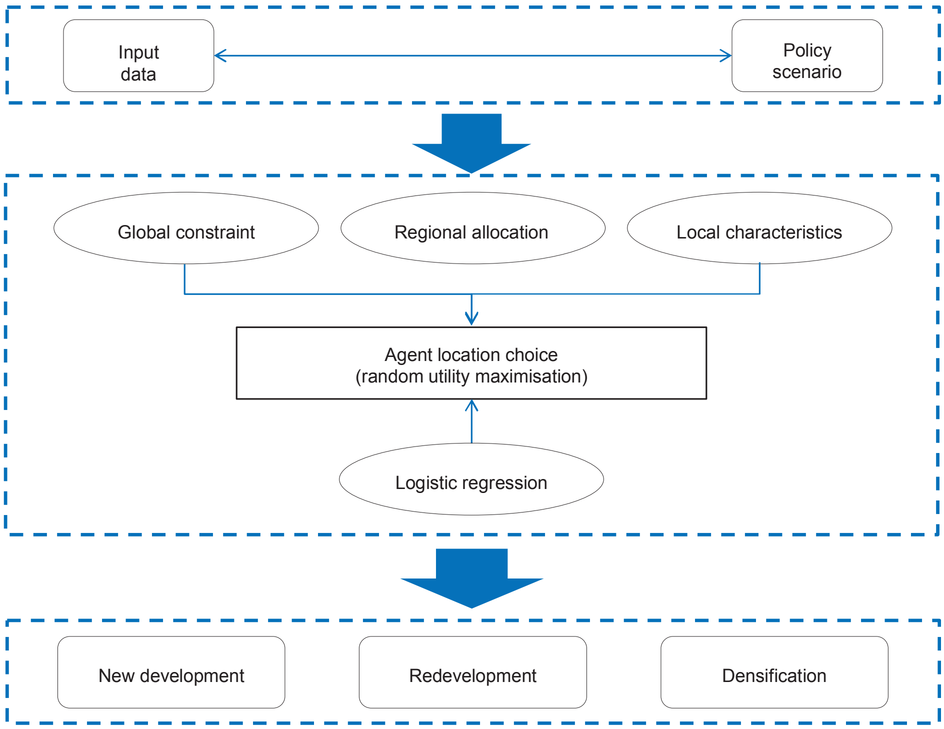
$$P_{ai} = \frac{e^{x_{ai}}}{\sum_{k \in S_n} e^{x_{ki}}}$$

The basic spatial and behavioural configuration of the model to be developed here conforms to the fundamental assumptions of the random utility theory. The random utility theory is used to model location choice behaviour of spatial agents. However, urban systems are affected not only by location choice behaviour of individual agents but also by various socio-economic factors. Thus, this study introduces a multi-level modelling framework comprised of “global” and “regional potential” micro-level submodels into an agent-based modelling system, which distinguishes this approach from the existing models. The global potential is controlled to prevent unrealistically excessive urban growth quantity. On the other hand, such urban demand is regionally allocated with a reference to the regional potential (or population). Then, each agent makes location choices at a local level. Combined with further policy assumptions, the resulting patterns are new development, redevelopment and densification. The overall model structure is described in Figure 3.A1.1.

Input data

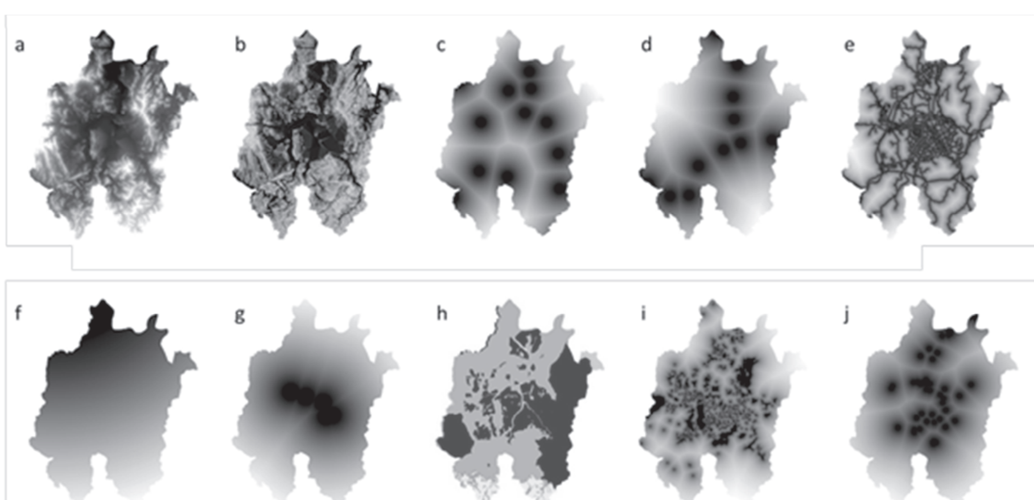
The model is designed to have a multi-level structure, and each level requires different types of input data. The macro level acts as a global constraint, and it defines a quantity of total urban demand by the target year. The total urban demand can be derived from an internal or external economic model, but this study used a number from a previous study.[1] It estimated the future urban demand of Daejeon city by 2030 as 22.1 km², and adopted this figure as a macro-level constraint. The meso level acts as a means to calculate sub-regional attractiveness or developmental potential. Total urban demand is not uniformly distributed for the whole of Daejeon, but is differently allocated according to this factor. It can also be calculated by an external or internal model, but it is calculated by the ratio of population growth rate in each of Daejeon’s sub-administrative levels (*gu*). The micro level acts as a location choice model, under the influence of the total demand and regional attractiveness, and individual spatial agents make location choice with a reference to their preference on different factors. Geospatial input data to define local determinants of location choice are depicted in Figure 3.A1.2.

Figure 3.A1.1. **Overall model structure (agent-based model)**



Source: KRIHS and OECD elaboration.

Figure 3.A1.2. **Input layers used for a micro-level location choice**



Note: a) elevation; b) slope; c) distance to nearest motorway junction; d) distance to nearest railway station; e) distance to nearest road; f) distance to Sejong City; g) distance to town centres; h) zoning; i) distance to nearest open space; j) distance to nearest cultural facility. This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: KRIHS and own elaboration based on National Geographic Data and Korea Statistical Information System Data.

Model calibration

The purpose of the model calibration is to find better fit parameters and hence to make the model work properly for a given study area. Different models adopt different calibration methods, and some models adopt a quantitative calibration method while some use a qualitative one. Nevertheless, the model calibration requires an analysis and examination of intensive empirical data, and this is one of the most time-consuming tasks of urban modelling. The methodology for calibrating a microscopic urban model is not yet fully developed, and more research will be required in the future (Batty and Torrens, 2005).

To calibrate the pilot model, quantitative and qualitative methods are used together. First, a binomial logistic regression to determine empirically justified model variables is conducted. Table 3.A1.1 presents the results of the regression. Next, a utility function with the selected variables is formed. The simulation is then conducted and the results examined to find if it matches with the reality.

Table 3.A1.1. **Results of logistic regression**

Variable		B	Significant.	eExp(B)
Topography	Elevation	-0.129	0.000	0.879
	Slope	-0.794	0.000	0.452
Transport	Distance to nearest motorway junction	-0.113	0.000	0.893
	Distance to nearest railway station	-0.349	0.000	0.706
	Distance to nearest road	-0.530	0.000	0.589
Socio-economic	Distance to Sejong City	-0.873	0.000	0.418
	Distance to town centres	-0.696	0.000	0.499
	Zoning	-1.126	0.000	0.324
	Distance to nearest open space	-0.038	0.000	0.963
	Distance to nearest cultural facility	-0.362	0.000	0.696
Constant		26.576	0.000	3.480E+11

Source: KRIHS and OECD elaboration based on the aforementioned simulation.

Note

1 . For example, please refer to Korea Research Institute of Human Settlements (2011).

Annex 3.A2
Modelling process for Hwaseong

Modelling description

The SLEUTH model is an urban growth and land-use change model developed around the notion of the cellular automata system. The model's name is derived from the model's input data requirements: slope, land use, excluded area, urban area, transport and hillshade. The model captures changes in land uses, which are represented as individual cells, with a set of transition rules. The growth rules, i.e. cell transition rules, form the core of urban growth dynamics in SLEUTH. These rules regulate how individual cells become "urban" or remain "non-urban" when they meet certain conditions.

The urban growth process in SLEUTH is represented by four types of growth rules: spontaneous growth, new spreading centres, edge growth and road-influenced growth. Spontaneous growth represents the new urbanisation occurring without pre-existing urban areas and transport networks. New spreading centre controls whether such spontaneous growth will further expand and become a new urban centre for continued urban development. Edge growth defines urbanisation from the surroundings of existing urban areas. Road-influenced growth represents urbanisation, along with transport networks.

The above four growth rules are controlled by five growth coefficients: dispersion, breed, spread, slope and road gravity. Each parameter has a range of 0 to 100 and controls one or more growth rules. Together, these parameters control the importance and amount of each growth rule.

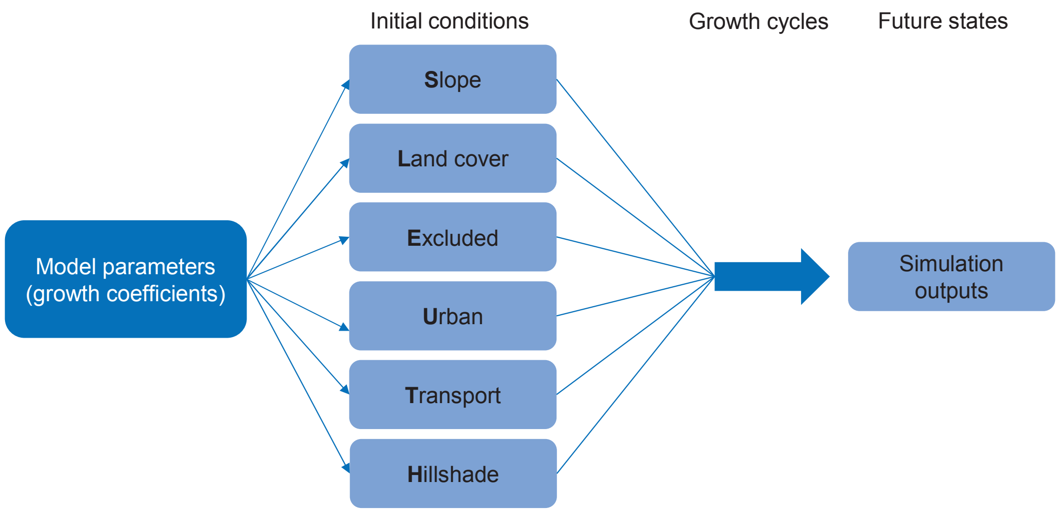
The SLEUTH model simulates future urban growth with the above input data, growth rules and parameters. The model uses the random stochastic disturbance factor in the growth rules to increase the reality of model outcomes, and the model produces final outcomes after multiple Monte Carlo runs. The overall model structure is illustrated in Figure 3.A2.1.

Input data

The model requires six types of input data layers: slope, land use, exclusion, urban, transport and hillshade as Figure A3.2 shows. These layers should be greyscale 8 bit GIF image format, and each layer holds relevant cell values, which range from 0 to 255. All layers should have the same extent and resolution.

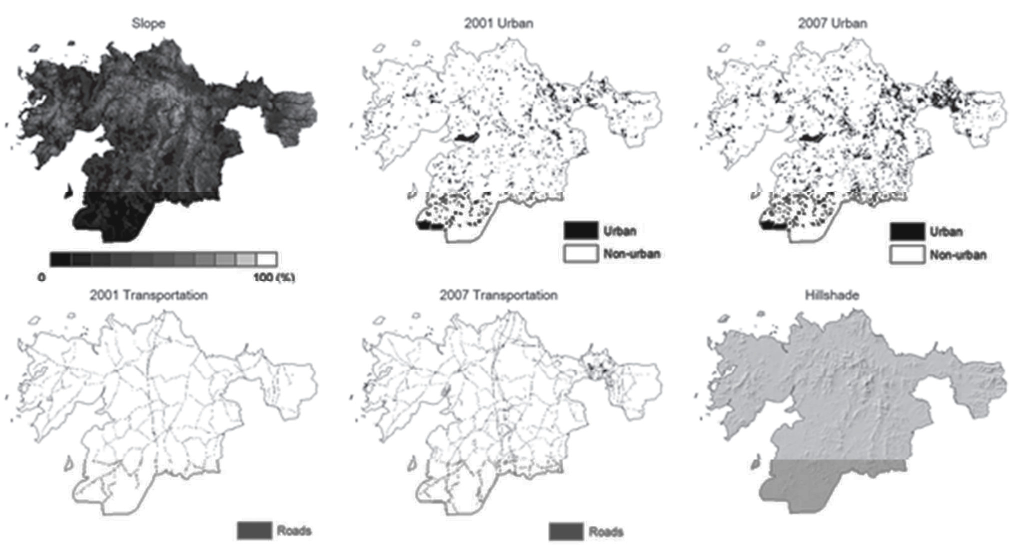
The strength of the SLEUTH model is that it requires less data compared to traditional urban models, but this also limits the consideration of various factors affecting urban growth. One possible remedy for this is to take various factors into account when making the exclusion layer. To do so, exclusion/attraction layers were further developed for the study region. This study identified factors that would either attract development or repel development. These exclusion and attraction factors were combined using GIS overlay modelling and the class values of the resulting map ranged from 5 (attraction) to 90 (strong resistance), with 50 representing a neutral value. This study then identified lands that would be completely excluded from development, such as bodies of water and protected zones (Table 3.A2.1) and assigned a value of 100 to indicate complete resistance and added those features to the final excluded/attraction layer. Overall inputs layers for the Hwaseong simulation are depicted in Figure 3.A2.2; Figure 3.A2.3 illustrates all the data layers that were included for the exclusion and attraction models and the final exclusion/attraction layers used for model calibration.

Figure 3.A2.1. **Growth rules and controlling coefficients**



Source: KRIHS and own elaboration based on University of California, Santa Barbara (2014), "Basic simulation", Project Gigalopolis, www.ncgia.ucsb.edu/projects/gig/About/bkStrSimulation.html (accessed 30 July 2014).

Figure 3.A2.2. **Input layers for the urban growth simulation of Hwaseong**



Notes: This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: KRIHS and own elaboration based on National Geographic Data and Korea Statistical Information System Data.

Table 3.A2.1. **Exclusion/attraction for business as usual and compact growth scenarios**

	Description	Business as usual	Compact growth with best protection of natural resources and environment
		Level of protection (%)	
Protected areas	Lakes and bodies of water	100	100
	Wetlands	100	100
	Riparian buffer zones	No protection(50)	100
	(300-metre buffer around wetlands, lakes, and water bodies)		
	Green belt for preservation	100	100
	Wildlife and plant conservation area	100	100
	Conservation forest with common interests	100	100
	Conservation forest with forestry goods	80	80
	Park and nature preservation areas	100	100
Other resistance/ attraction	Distance to major roads	30	30
	(500-metre buffer around the roads)		(1 500-metre buffer of 102, 102 and 108 roads)
	Distance from rail stations	30	30
		(2 000-metre buffer from rail stations)	(2 000-metre buffer from rail stations)
	Distance to Suwon	10-100	10-100
		(classified into 10 classes)	(classified into 10 classes)
	Population density by EMD	5-100	10-100
		(classified into 7 classes)	(classified into 7 classes)
	Residential development district	10	10
	Green corridors	N/A	90 (first class)
			70 (second class)

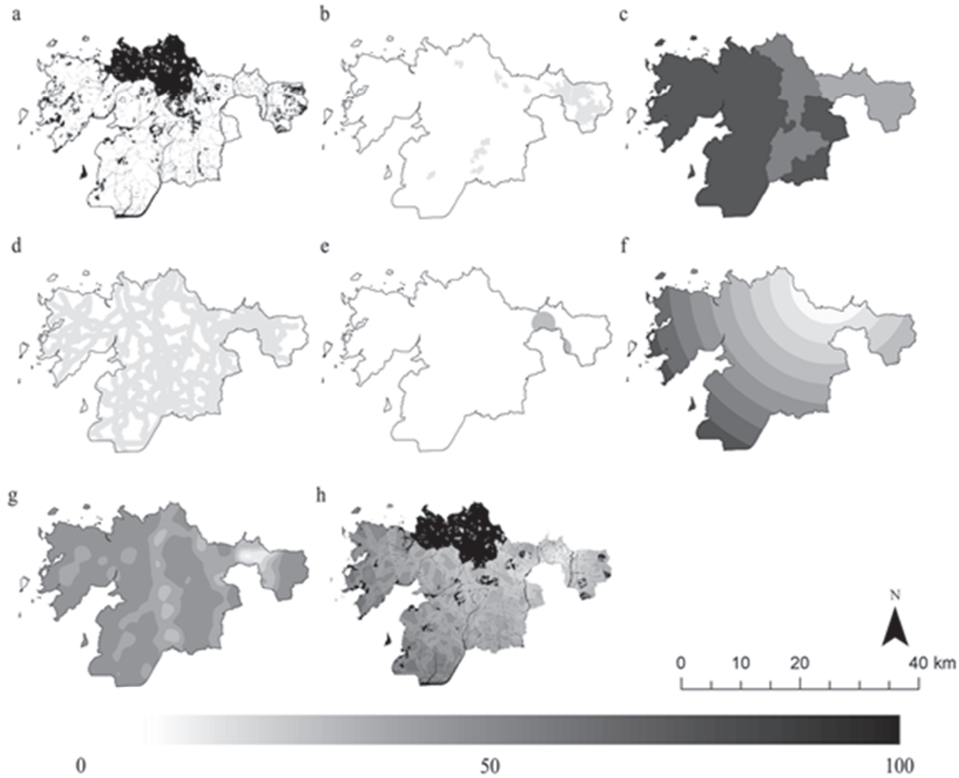
Source: KRIHS and own elaboration based on National Geographic Data and Korea Statistical Information System Data.

Based on these narratives, an exclusion/attraction map was generated for each scenario to represent the corresponding spatial changes to policies or drivers of land-use change. For the business as usual scenarios, the simulation used the same exclusion/attraction layers that were used for calibration, assuming no change in land-use policies. For the compact growth scenario, forecasts of future urbanisation were created through modification of the exclusion/attraction layers and by applying alternative future growth rates using SLEUTH's self-modification function (Table 3.A2.1).

Model calibration

Calibration is a process of testing and adjusting model parameters to find the best set of parameter values. The process involves iterative comparison of the actual map and simulated map. The purpose of calibration is to make the model produce outcomes as realistic as possible by changing parameter values. Once appropriate parameters are chosen through the calibration process, the model is run for the future.

Figure 3.A2.3. **Attraction and resistance layers used for calibration**



Notes: a) protected lands; b) residential development district; c) population density; d) distance from roads; e) distance from rail stations; f) distance from Suwon; g) road density; and h) final exclude/attraction map. This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: KRIHS and own elaboration based on National Geographic Data and Korea Statistical Information System Data.

The calibration of SLEUTH is to determine the best fit values for the five growth coefficients: dispersion, breed, spread, slope and road gravity. The SLEUTH model offers a range of measurement metrics that can be used for the determination of the best parameter set. Two measurements were used in this study to identify the best fit values for the growth parameters (Jantz et al., 2010): the population fraction difference (PFD), which measures a direct comparison between the number of urban pixels in the urban land maps and the corresponding simulated maps and the cluster fractional difference (CFD), which measures direct comparisons between the number of urban clusters in the urban land cover maps and the corresponding simulated maps. Table 3.A2.2 presents the selected parameters and the value of two measurement metrics.

Table 3.A2.2. **Best fit parameters derived from a calibration**

Diffusion	Breed	Spread	Slope	Road growth	Population fraction difference	Cluster fractional difference
1	90	100	1	20	-0.137	0.118

Source: KRIHS and own elaboration based on the SLEUTH simulation on Hwaseong.