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A Study on the Sustainability of Compact Cities in Korea*

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Abstract

Purpose: The purpose of this study is to examine the policy implications of establishing a compact city in Seoul, analyzing whether it is an appropriate and efficient eco-friendly housing supply alternative. **Research design, data, and methodology:** The analysis criteria include efficiency, safety, and comfort, with efficiency encompassing economic, energy, and public transport links' efficiency. Safety and comfort are aspects of eco-friendliness, housing safety, and improvement in living environments. **Results:** In terms of economic efficiency, compact cities are a less expensive option than purchasing land for housing construction. To increase energy efficiency, we plan to adopt eco-friendly energy sources. Transportation efficiency is high in locations near public transport stations. To enhance safety and comfort, we intend to create large-scale parks and forests in Seoul. To ensure residential safety, measures will be taken to reduce road vibration, vehicle noise, and scattering dust. **Conclusions:** Selecting an appropriate location that provides convenient public transportation is essential for creating a compact city for housing in a large city. Combining a compact and smart city is necessary, and implementing smart technologies is needed to prevent dust, noise, and vibrations, which are undesirable in a residential environment.

Keywords: Compact city, Energy efficiency, public transportation connectivity, Residential stability

JEL Classification Code: E44, F31, F37, G15

1. Introduction

The phenomenon of population concentration in cities worldwide is gradually intensifying. Since 2009, the number of people living in cities has been increasing at a higher rate than those living in rural areas. Currently, more than half of the world's population lives in urban areas, and this number is projected to continue rising. The United Nations predicts that by 2050, more than two-thirds of the world's population will live in cities. These trends are likely to have undesirable and irreversible consequences in terms of the demand for natural resources.

The phenomenon of population concentration in cities has become increasingly pronounced, leading to a range of problems. One of the most significant issues is the shortage of housing in large cities, which has become a major concern worldwide. As more people migrate to cities in search of better economic opportunities, the demand for housing has skyrocketed, leading to rising costs and limited availability.

Moreover, as the population continues to concentrate in urban areas, environmental problems such as excessive waste discharge, the heat island phenomenon, and carbon dioxide emissions are intensifying. These problems have significant consequences for the environment, including air

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pollution, water pollution, and global climate change. In fact, urbanization has been identified as one of the main drivers of global climate change, as cities are responsible for a significant proportion of greenhouse gas emissions.

The heat island phenomenon, which is caused by the absorption of heat by buildings and pavement in cities, also contributes to rising temperatures in urban areas. This can have serious health consequences, particularly for vulnerable populations such as the elderly and young children.

In addition to environmental problems, urbanization can also lead to social and economic issues. For example, the concentration of poverty and inequality in urban areas can exacerbate social problems such as crime, while the high cost of living in cities can make it difficult for low-income families to access essential services and resources.

To address these issues, compact cities have emerged as a sustainable urban paradigm. Compact cities aim to integrate urban functions and residences for the efficient and sustainable use of natural resources, including land.

As small- and medium-sized cities develop on the outskirts of a city, away from the old city center, urban hollowing out intensifies. Population decline in these local small- and medium-sized cities increases the burden of infrastructure maintenance costs. To address these urban problems, compact cities have reemerged as a sustainable urban paradigm. The concept of a compact city aims to spatially integrate urban functions and residences for the efficient and sustainable use of natural resources, including land (Kwon & Seo, 2019).

Compact cities have the potential to positively impact the environment by addressing environmental problems, increasing energy efficiency, and improving the convenience and accessibility of residents through public transportation, thus reducing the use of internal combustion vehicles. They can also be considered a positive development concept, as they improve the living environment for human beings and help solve the housing shortage problem in large cities, as well as the issue of population decline in provinces.

This study aims to determine the policy implications of establishing a compact city as a solution for the global housing shortage problem in large cities. The study examines five compact cities for public housing and six compact cities near public transportation stations that are being promoted in Seoul. Additionally, an analysis framework is developed based on a review of previous studies and foreign case studies.

2. Literature Review

2.1. Compact City

Compact cities are a potential solution to the housing shortage problem that many large cities face, as well as the issue of population decline in provinces. They offer numerous benefits, including addressing environmental problems, increasing energy efficiency, and improving the convenience and accessibility of residents through public transportation, which reduces the use of internal combustion vehicles. Compact cities are also considered a positive development concept, as they improve the living environment for human beings by promoting efficient land use and creating sustainable communities with a range of amenities and services.

This study aims to determine the policy implications of establishing a compact city as a solution for the global housing shortage problem in large cities. The study examines several compact city initiatives in Seoul, including five compact cities for public housing and six compact cities near public transportation stations. The analysis criteria for this study include efficiency, safety, and comfort, which are aspects of eco-friendliness, housing safety, and improvement in living environments.

To develop the analysis framework, the study reviewed previous studies and foreign case studies. The framework assesses economic feasibility, energy efficiency, public transport connectivity, eco-friendliness, safety, and the effect on improving the residential living environment. By evaluating the potential benefits and challenges of the compact city initiatives, this study aims to provide a comprehensive understanding of their policy implications and the potential for sustainable urban development in other cities around the world.

In the late 1990s, a new urban phenomenon emerged that introduced mixed-use development, the expansion of parks and green spaces, the reduction of energy consumption, urban design focused on neighborhood districts, improvement in building and urban design quality, TOD, and pedestrian-oriented communities. This phenomenon emphasized the establishment of facilities, preservation of valuable cultural and historical buildings, locality, sense of place, and equity. In the early 2000s, the concept of the "compact city" was revisited, which is based on reduced travel distance within the city, low dependence on automobiles, improvement in energy efficiency, the recycling of an entire region, the appropriate use of land resources, strengthening connectivity between urban and rural areas, the provision of efficient public services, and the provision of various local services and businesses for enhancing accessibility. This concept emphasizes the importance of sustainable urban development, efficient land use, and the promotion of public transportation and eco-friendly practices for improving the quality of life for urban residents.

Table 1: Compact City

Period	Concept	Main Features
Late 1970s	Compact city	- High-density complex development - Land-transport system with short travel time - Public transportation-oriented urban development - Buildings that can increase energy efficiency
Early 1980s	Eco city	- Establishment of ecological network - Quality improvement of urban environment - Restoration and creation of ecological environment -Emphasis on regional and cultural diversity
Late 1980s	Smart growth	- Composite land use - High-density neighborhood development - Diversity of transportation options - Creation of a pedestrian-oriented community - Creation of a differentiated and attractive community - Open space, favorable natural environment, and farmland conservation - Development based on predictability, fairness, and efficiency - Cooperative development among stakeholders
1992	Sustainable development	- Recognizes the coexistence of environment and economy - Sustainable development plan considering environmental sustainability - Economic and social sustainability - Introduction of eco-friendly planning techniques for urban development
Late 1990s	New urbanism phenomenon (1996)	- Mixed-use development - Expansion of parks and green spaces - Reduces energy consumption - Urban design centered on neighborhood districts - Qualitative improvement of buildings and urban design - Public transportation-oriented urban development - Creation of pedestrian-oriented community facilities - Preservation of valuable cultural and historical buildings - Emphasis on locality, placeness, and equity
Early 2000s	Compact city re-illumination	- Reduction in travel distance within the city - Low car dependency - Enhancing energy efficiency and recycling energy throughout the region - Appropriate use of land resources and strengthening the connectivity between urban and rural areas - Provision of efficient public services -Reinforcement of access to various local services and workplaces

Sources: Jung (2019); Park (2015)

2.2. Prior Studies

In a study conducted by Kim (2020), the public nature of an eco-friendly compact city in France was analyzed as a humanistic smart city. A time policy was implemented in large French cities, and Fort d'Issy was established as the first eco-friendly smart pilot city of Issy Les Moulineaux, located in Paris 15. The city provides emotional and public values to the residential community, rendering it a humanistic smart city. The study compared the buildings in Fort d'Issy with modern architecture and cities as buildings are considered to determine whether an area qualifies as a city. Researchers found that Pordy, an eco-friendly compact city that retains cultural time, is not reduced to the function of uniform reproduction of residents' various existential times through walking accessibility. Residents were allowed to participate in the urban community while communing with the architecture and natural environment without segregating residences and workplaces.

Hong (2020) conducted a study on how to alleviate environmental problems in original cities by creating shared spaces in compact cities. She analyzed representative cases from the WeWork project, conducted an expert survey, and empirically analyzed the different characteristics of the shared workspace. The research method was based on theoretical considerations and related characteristics of the "compact city" concept. The study identified the most important characteristics of shared spaces as accessibility, openness, interchangeability, contingency, and variability. The less important characteristics were complexity and convenience, while individuality, territoriality, playfulness, and centrality were identified as the least important characteristics. The different levels of importance indicate the significance of the characteristics in the design of shared workspaces in a compact city.

Researchers have conducted studies on the "compact

city" concept to address population decline, such as the cases of Kurashiki-shi Mikan and Takamatsu-shi Eco-Compact City in Japan, as analyzed by Nam (2020) to form regional urban regeneration strategies. Furthermore, studies on public transportation-based urban development plans for compact cities have been conducted, such as those by Azmi et al. (2021) and Røe et al. (2022). Byun (2021) analyzed the developing transportation system and preparations for Busan, arguing for the urgent need for a new transportation method to prepare for the rapid evolution of transportation modes and services.

Regarding Seoul's public housing development, Jun (2020) investigated a three-dimensional project related to a public garage in the Seoul compact city from an architectural perspective, arguing for the need for more flexible social support to implement new forms of urban and architectural experimentation successfully. Kim (2021) reinterpreted the use of low-density public facility sites in the Sinnae, Jangji, and Gangil regions using three international design schemes, providing a common facility for living, convenience, leisure, and work activities to urban residents. Additionally, studies were conducted on the SOC for supply chain.

Studies conducted after 2020 have continued to investigate compact cities as a solution to population decline and as part of a public transportation-based urban development plan. Previous studies have focused on compact cities for domestic public housing supply and included architectural analyses and studies on living-type SOC.

In this study, we analyze the compact city of Seoul, which is being developed based on economic feasibility, energy efficiency, transport connectivity, eco-friendliness, safety, and improvement in residential living environment. Our aim is to determine the suitability of the newly proposed compact city as an efficient and eco-friendly alternative for housing supply in Seoul, and to suggest and discuss policy implications based on our analysis.

3. Analysis Framework

3.1. Foreign Case Analysis

3.1.1. Compact City of Hong Kong

Hong Kong is known to be the most densely populated city in the world, with steep slopes covering approximately 20% of its total land area, making them challenging to develop. To combat this issue, Hong Kong has become a compact city, with high-density residential areas being developed vertically using advanced construction technologies. Despite this, the city has managed to maintain natural conservation efforts, with about 67% of its land area being naturally green, and half of it designated as a national park.

Furthermore, Hong Kong's compact city model has been successful in creating a dense economy, with high population density and mixed-use neighborhoods promoting the concentration and parallelism of economic activities, as well as better work-life balance, generating and disseminating knowledge, and creating economic opportunities (Korea Land Transport Science and Technology Agency, 2013).

Additionally, the high population density of Hong Kong allows for efficient implementation of TOD, one of the benefits of compact cities. Infrastructure such as railways that connect multiple high-density urban centers can recover development costs through large-scale transportation demand based on economies of scale (Korea National Transportation Science and Technology Agency, 2013).

However, the compact city of Hong Kong also faces several challenges. The urban heat island (UHI) phenomenon, typically caused by concrete buildings, is prevalent in Hong Kong. UHIs can lead to frequent rain and other environmental issues that may affect the global climate. Moreover, high-rise buildings can trap polluted air, leading to environmental pollution in cities.

3.1.2. French Compact City

The La Defense Development Committee, composed of local governments such as the French president Mitterrand and Paris authorities, created a long-term development plan for a period of 30 years starting in 1958, and most of the construction was completed by the 1990s. La Defense is a high-technology business hub featuring commercial, sales, and residential facilities built in high-rise and high-density buildings on 460,000 square meters of land. Highways, subways, and general roads are placed underground to prevent congestion in the city center (Ko.wikipedia.org). The success of La Defense is attributed to its high-density development and the availability of wide-open spaces, which provide comfortable land use, pedestrian supremacy, and a transportation plan that promotes an automobile-free city. In addition, the connection between new and existing cities is secured by historicity (Jeong, 2020).

The implications of La Defense are as follows. First, the connection of the Great Axis is assumed as an important concept (Moon et al., 2020). La Defense not only previously served as a gateway to Paris but is also an area of historical significance connected to the Louvre, Place de la Concorde, Avenue Saint-Élysées, and the Arc de Triomphe. Second, comfort is afforded owing to the ample open space of the two-story structure. All transportation modes to La Defense were directed to the first floor of the multistory city, and the second floor was used as a cultural space for various

activities as a pedestrian-only space (Han, 2020). Hence, an automobile-free city was realized. The final implication is the continuous development driven by long-term planning. After the master plan for regional development was established in 1964, the plan for La Defense was revised several times to accommodate changes in internal and external conditions. However, continued development was promoted under the same concept; in fact, it has been promoted for approximately 50 years (Ryu & Shin, 2020). The new town development of La Defense offers significant implications for the development of new towns in Korea, which is currently being pursued with the goal of completion within a short duration.

3.2. Analysis Framework

The analysis framework, which was prepared based on advanced foreign cases, is presented in Table 2. The analysis criteria were economic feasibility, energy efficiency, public transport connectivity, eco-friendliness, safety, and improvement in the residential living environment.

Table 2: Analysis Framework

Category		Main Features
Efficiency	Economics	- More economical compared with other construction methods - Economic effect via the use of existing infrastructure
	Energy efficiency	- Establishment of ecological network - Quality improvement of urban environment - Restoration and creation of ecological environment - Emphasis on regional and cultural diversity
	Public transport connectivity	- Composite land use - High-density neighborhood development - Diversity of transportation options - Creation of a pedestrian-oriented community - Creation of a differentiated and attractive community - Open space, favorable natural environment, and farmland conservation - Development based on predictability, fairness, and efficiency - Cooperative development among stakeholders
Safety comfort	Eco-friendliness	- Recognizes the coexistence of environment and economy - Sustainable development plan considering environmental sustainability - Economic and social sustainability - Introduction of eco-friendly planning techniques in urban development
	Residential safety	- Mixed-use development - Expansion of parks and green spaces - Reduces energy consumption - Urban design centered on neighborhood districts - Qualitative improvement of buildings and urban design - Public transportation-oriented urban development - Creation of pedestrian-oriented community facilities - Preservation of valuable cultural and historical buildings - Emphasis on locality, placeness, and equity
	Improvement of living environment	- Reduction in travel distance within the city - Low car dependence - Enhancing energy efficiency and recycling energy throughout the region - Appropriate use of land resources and connectivity strengthening between urban and rural areas - Provision of efficient public services - Reinforcement of access to various local services and workplaces

4. Case study of Compact City in Seoul

4.1. Compact City Promotion Status in Seoul

4.1.1. Public Housing Compact City in Seoul

The criteria for selecting the major destinations for the compact city project in Seoul were as follows: (i) areas

where existing infrastructure, such as public transportation and roads, can be utilized and a residential environment cannot be secured; (ii) areas that do not interfere with future scalability, the maintenance of original functions, and the use of infrastructure; and (iii) areas requiring infrastructure improvement in terms of urban management, such as bus depots, roads, reservoirs, water regeneration centers, parking lots/public government complexes, and railway depots.

Five regions were selected for building a compact city in Seoul, and their details are listed in Table 3. The Sinnae 4 compact city was created through the three-dimensionalization of the northern arterial road. Its details are as follows: area, 75,339 m2; number of public housing units, 990; living SOC, 11,500 m2; and infrastructure, arterial road.

Currently, civil work is underway for the Yeonhee compact city. The current status of the Jeungsan compact city is under review, and the basic design for the Gangil/Jangji compact city is being drafted. Figure 1 shows the current appearance and view map of the five areas selected for building the Seoul compact city.

Table 3: Characteristics of the Five Compact City Areas in Seoul

Project	Area (㎡)	Public housing (no.)	Living SOC (㎡)	Infrastructure	Progress
Sinnae 4 compact city Three-dimensionalization of the northern arterial road	75,339	990	11,500	arterial road	district designation
Yeonhee compact city Combination of rainwater pumping station	4,887	154	5,241	rainwater pumping station	district planning approval
Jeungsan compact city Combination of rainwater pumping station	6,746	166	1,827	rainwater pumping station	civil work in progress
Gangil compact city Public garage complex	38,119	784	8,800	public garage	deliberation in progress
Zhangj compact city Public garage complex	35,804	688	8,340	public garage	basic design in progress
	160,895	2,782	35,458		

Source: Seoul Housing & Communities Corporation

Figure 1: Aerial View of Seoul Compact City Promotion Site (Source: Seoul Housing & Communities Corporation)

4.1.2. Compact City Near a Station in Seoul

In an effort to promote sustainable urban development and efficient use of space, the city of Seoul has selected six regions for the establishment of a compact city near a station. This compact city will feature mixed-use development, with a focus on creating a livable and walkable environment that is accessible to public transportation.

Six regions were selected for establishing a compact city near a station in Seoul. This compact city features mixed-use development. The characteristics of the six compact

cities near the station in Seoul are listed in Table 4. The locations and view maps of those six areas are shown in Figure 3.

Overall, the goal of these compact cities is to create livable, sustainable, and vibrant communities that are accessible to public transportation and promote efficient land use. By focusing on mixed-use development and creating a range of amenities and services, these compact cities have the potential to become models for sustainable urban development in other cities around the world.

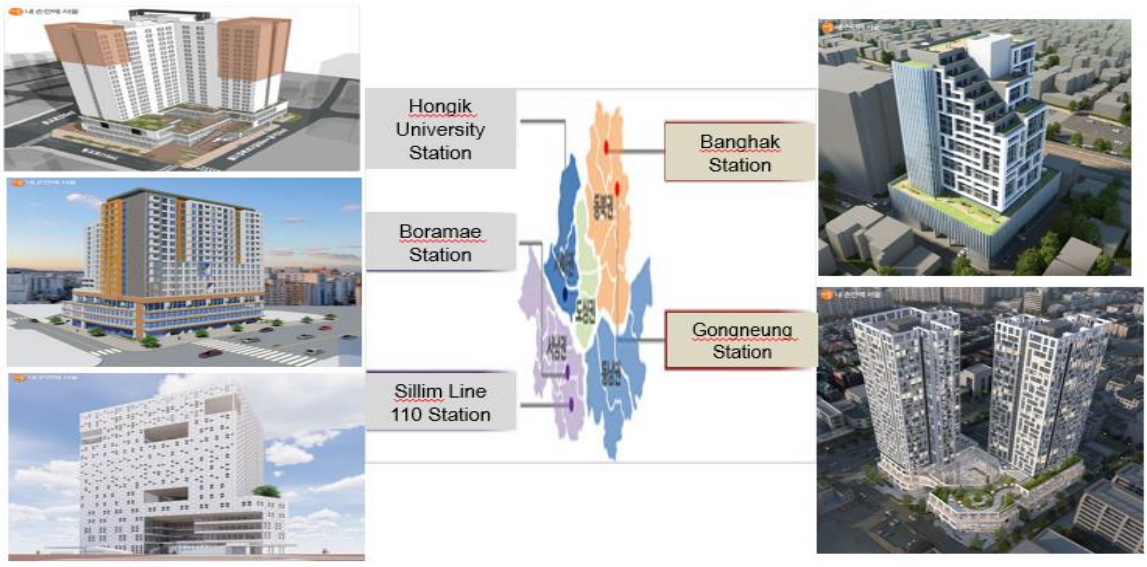

Figure 3: Compact City Near a Station in Seoul (Source: Seoul City)

4.2. Case study of Seoul Compact City

An analysis of the Seoul compact city based on economic feasibility, energy efficiency, public transport connectivity, eco-friendliness, safety, and the effect of improving the residential living environment, which are the analysis frameworks, is presented next.

4.2.1. Economics

The cost of land for compact city construction is higher than that for housing site development because of the release of the green belt. However, it is lower than the cost of purchasing land for housing. Land purchase costs are not involved, as compact cities are constructed on public property. However, artificial land creation costs (e.g., land cover) are involved. The cost of creating artificial land is 48%–77% lower than the land purchase price in the same area (Korea Appraisal Board, 2017). The cost of constructing a compact city is 97%–148% higher than that of supplying housing by releasing the green belt (Choi, 2021).

4.2.2. Energy Efficiency

The Gangil and Zhangji compact cities use renewable energy to increase energy efficiency in an environmentally friendly manner. Efforts are being expended to increase the energy efficiency of the compact city of public housing supply using urban infrastructure by considering the use of eco-friendly energy and the circulation structure of air. However, plans have been drafted to supply high-rise complex buildings by increasing the floor area ratio of the compact cities near the station. The supply of high-rise and densified buildings increases the infrastructure load and reduces the energy efficiency.

Table 4: Characteristics of a Compact City Near a Station in Seoul (source: Seoul city)

Destination	Territories (Site area)	Supply	Characteristics
Gongneung Station	Northeast (6,971 m^2)	450 households (Private sale 378. public rental 72)	▲ Inhabited primarily by people in their 20s and 30s ▲ Inadequate living SOCs such as sports, childcare, and cultural facilities
Banghak Station	Northeast (3,265 m^2)	276 households (Private sales 202. public rental 74)	▲ Promising as a double-station area owing to the new construction of the Ui Sinseol Line (extended line) ▲ Insufficient public medical service facilities
Hongik University Station	Northwest (4,727 m^2)	538 households (Private rental 472. public rental 66)	▲ Seoul's highest density of young one- to two-person households ▲ High pedestrian and floating population; high parking demand
Sillim Line 110 Station	Southwest (1,779 m^2)	21 households (Public rental)	▲ Light Rail Transit Sillim Line new station ▲ High proportion of young people living near Seoul National University in one- or two-person households
Boramae Station	Southwest (2,740 m^2)	186 households (Private sale 114. public rental 72)	▲ Potential of transfer station area due to the new construction of the Light Rail Sillim Line
Hongik University Station	Northwest (4,727 m^2)	538 households (Private rental 472. public rental 66)	▲ Seoul's highest density of young one- to two-person households ▲ High pedestrian and floating population; high parking demand

4.2.3. Public Transport Connectivity

The compact city for the supply of public rental housing in Seoul enhances the commute to Kyoto via the utilization of the public bus parking lot and the northern arterial road site. The Sinnae compact city is the gateway to the northeastern region of Seoul. It is a triple-station area that intersects the Gyeongchun Line, Line 6, and Myeonmok Line, while it features high public transport connectivity. Meanwhile, in the Gangil and Zhangji compact cities, public transport connectivity is enhanced by the development of bus stop-focused TOD. Seoul's compact city near a station is developed around subway stations. Supplying high-rise complexes around subway stations will increase the connectivity of residents to public transportation.

4.2.4. Eco-friendliness

The aim of the Gangil and Zhangji compact cities is to transform the living environment of neighboring areas to an eco-friendly environment by modernizing large-scale bus depots. Meanwhile, the aim of the Sinnae, Yeonhui, and Jeungsan compact cities is to provide healthy urban forests to local residents through large-scale parks. The total area of the park is 32,568 m^2, and a park built on an artificial land measuring 25,800 m^2 has been planned. Additionally, a step garden for entering the artificial land has been designed.

4.2.5. Residential Stability

In the Sinnae compact city, an artificial tunnel is completed separately from the road and apartment buildings owing to road vibrations. Regarding public housing, modular housing is implemented to reduce weight and load. Vehicle noise can be eliminated by preventing noise generation via the transformation of the road into a tunnel. Meanwhile, the emission of pollutants at the entrance and exit of the tunnel can be suppressed by installing a clean tube. We plan to prepare for fire hazards in tunnels by applying facility standards equivalent to those for third-level disaster prevention.

4.2.6. Improvement of Living Environment

The Sinnae compact city initiative is designed to address the issue of isolated living areas caused by the northern arterial road and to improve the living environment of local residents. The initiative aims to interconnect these areas through various measures that promote walkability and accessibility.

One of the key strategies is to transform the paved road into eco-friendly ecological spaces that can be enjoyed by residents. This involves the creation of parks and green spaces that provide a range of benefits, including improved air quality, reduced urban heat island effects, and increased

opportunities for physical activity and social interaction. These ecological spaces will not only improve the quality of life of residents but also enhance the visual appeal of the surrounding area.

Another important aspect of the Sinnae compact city initiative is the promotion of sustainable and energy-efficient buildings. This involves the use of green technologies and materials, such as solar panels, energy-efficient lighting, and natural ventilation systems, which reduce energy consumption and greenhouse gas emissions. The initiative also prioritizes the development of mixed-use buildings that integrate residential and commercial spaces, making it easier for residents to access essential services and amenities.

5. Conclusions

In this study, a compact city was proposed for addressing rapid urbanization. Accordingly, the current status and tasks of five compact cities for public rental housing in Seoul and near a station were analyzed. The compact cities of Seoul were analyzed in terms of economic feasibility, energy efficiency, transportation connectivity, eco-friendliness, safety, and improvement of the living environment from six perspectives.

The results of the study are as follows:

(i) Efficiency—The land cost for a compact city is higher than the green belt removal cost; however, it is lower than the cost of purchasing land for housing construction. Meanwhile, plans have been drafted to utilize eco-friendly air circulation structures to increase energy efficiency in the Gangil and Zhangji compact cities. However, for a compact city near a public transport station, the problem of energy efficiency degradation due to high-rise buildings must be addressed. This issue directly affects the connection efficiency of public transportation. The Shinnae compact city is in a triple-station area with high transportation efficiency. The Gangil and Zhangji compact cities feature high traffic efficiency as they are constructed around bus stops. A compact city close to a public transport station offers high transportation efficiency, primarily for subways.

(ii) Safety and comfort—In compact public housing, hazardous facilities are converted into eco-friendly facilities by modernizing outdated garages and rainwater pumping stations. In addition, forests are provided to the city by creating parks on artificial land. To ensure residential safety, plans are being drafted to remove road vibrations, vehicle noise, and scattered dust. The Sinnae compact city aims to improve the living environment of local residents by interconnecting living areas that are isolated by the northern arterial road.

Based on the results of this study, we offer the following suggestions. First, location selection is important in creating a compact city as a housing supply for large cities. Urban expansion will be possible after a compact city is created by selecting an area with excellent public transport connectivity. Second, a compact city uses public infrastructure to reduce the cost of supplying housing land. At this time, the economic aspect must be considered; however, the safety and comfort of the residential environment must be prioritized. Third, a combination of compact and smart cities is necessary. Furthermore, smart technologies that can prevent dust, noise, and vibrations, which are undesirable in residential environments, must be implemented.

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