도시계획학석사 학위논문

Does land-use mix contribute to vacant housing?

혼합토지이용이 빈집을 줄이는데 기여하는가?

- 서울의 용도지역과 엔트로피 지수를 활용하여 -

2022년 2월

서울대학교 환경대학원
환경조경학과
이 승 구

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서울대학교 환경대학원 환경조경학과
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위 논문은 서울대학교 및 환경대학원 환경조경학과 학위논문 관련 규정에 의거하여 심사위원의 지도과정을 충실히 이수하였음을 확인합니다.

2022년 2월

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Abstract

Does land-use mix contribute to vacant housing?

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Cities worldwide are facing many urban problems, including increased numbers of vacant housing units. Various urban planning techniques have been proposed to cope with these problems. This current study investigated the influence of land-use mix (LUM) and zoning, which are key planning approaches to urban decline, as practiced in smart growth theory and the New Urbanism approach.

Previous studies have focused predominantly on architectural and socioeconomic factors as causes of vacant housing. Along with these variables, this current study examined the effects of urban-scale factors in Seoul, South Korea by analyzing housing vacancy data at the minimum local-spatial unit (census tract) level. A zero-inflated negative binomial model was implemented to estimate the number of vacant housing units. In addition, the results were verified using the spatial cluster pattern method and hierarchical cluster analysis.

The results indicate that LUM is positively correlated with housing vacancy, which supports the hypothesis that vacant housing occurrence rates tend to be higher in mixed land-use areas than in single-use areas. This study identified some limitations of LUM, of which benefit is generally taken for granted. Rather, the creation of a stable and tranquil residential environment by carefully controlling LUM could be an effective way to respond to a housing vacancy.

Keywords : vacant housing, zoning, land-use mix, entropy index, zero-inflated negative binomial model

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Chapter 1. Introduction

1. Introduction

Housing vacancy is a major factor in the decline of a community and its economy. Discussions on the cause and seriousness of vacant housing are actively held worldwide (Baba and Hino, 2018). Housing vacancies in South Korea tallied at about 370,000 units in 1995 and reached 1.07 million units by 2015, a threefold increase in 20 years. By 2020, the number of vacant housing units had increased by 440,000 over five years to about 1.51 million units (Statistics Korea, 2020a). If this trend continues, it is expected that vacant housing units will account for 10% of South Korea's total housing units by 2050 (Ministry of Land Infrastructure and Transport (MOLIT), 2017a).

Vacant housing units in certain areas tend to negatively influence adjacent neighborhood environments and spread into surrounding areas (Morckel, 2014; Noh and Yoo, 2017; Park, 2019; Yoo and Kwon, 2019). According to the broken windows theory, if a single vacant house is not properly managed and left unattended, this will accelerate an economic downturn, a decline in the neighborhood environment, and a reduction in land prices (Han, 2013; Nassauer and Raskin, 2014). Therefore, the spread of vacant housing can initiate a vicious circle in areas and lead to urban decline and a loss of regional vitality (Kim et al., 2018; Kim and Lee, 2016; Morckel, 2014; Park, 2019; Yoo and Kwon, 2019).

Many countries have investigated the status of housing vacancies. For example, the United States (U.S.) government conducts a Housing Vacancy Survey (HVS) to estimate vacant housing stock (Molloy, 2016). In South Korea, academics have been actively researching vacant housing since the 2010s. Local governments are also aware of the seriousness of housing vacancies, which are rapidly increasing across the country. To manage this vacant housing, the Land and Geospatial Informatix Corporation (LX), a public corporation dealing with land information, has established information platforms for vacant housing units. Despite these efforts, housing vacancies are still increasing, and research and policies on vacant housing units are still insufficient (Kim, 2010).

Researchers have attempted to shed light on the causes of housing vacancies, mostly focusing on a community's architectural and socioeconomic characteristics (Baba and Hino, 2018; Han, 2017; Jeon and Kim, 2016; Yin and Silverman, 2015). Most studies have interpreted housing vacancy as a combination of various factors, such as housing deterioration and an aging population, rather than being caused by a single factor (Accordino and Johnson, 2000; Immergluck, 2016; Park and Oh, 2018). However, few studies have examined the relationship between regional urban-scale characteristics (e.g., land use and development density) and vacant housing. To fill this gap, this study investigates urban-scale factors, including land-use mix and zoning, that may affect living environments, activity patterns, and the occurrence of vacant housing.

Land-Use Mix (LUM) is an urban planning strategy that involves integrating complementary functions within a building or area. LUM is an element of modern planning approaches, such as smart growth theory and New Urbanism, which are frequently recommended to create vibrant and resilient places (Grant, 2002). However, while the positive aspects of LUM are highlighted, little is known about how LUM is correlated with housing vacancies.

The present study examined the relationship between housing vacancy and LUM, frequently measured by the Land-Use Mix Index (LUMI). Therefore, this paper aims to gain insight into the potential negative influence of LUM, which may result in vacant housing.

The rest of this paper is structured as follows: Section 2 discusses the theoretical and literature studies on housing vacancies and LUM; Section 3 introduces the research data collection and methods; Section 4 and 5 present the results of analyzing and verifying vacant housing and LUM; and this paper concludes with a discussion of this current study's implications and limitations and offers suggestions for future research.

Chapter 2. Background

2.1. Definition of vacant housing unit

Before the review of previous studies related to the occurrence of vacant housing, the definition of vacant housing units under the South Korean legal system and previous studies were examined, and the definition of vacant housing units in the present study is specified.

In Korea, the definition of vacant housing units differs depending on the legal system and statistical data. Thus, there are difficulties in grasping the current status of vacant houses and implementing related policies (Kang, 2018; Park et al., 2017). Article 81-2 of the building act, article 2 subparagraph 12 of the agricultural and fishing villages improvement act, and the local vacant house management ordinance all stipulate vacant housing units as houses or buildings that have not been lived in or used for more than one year from the date of confirmation of residence or use (Ministry of Government Legislation (MOLEG), 2021). The act on special cases concerning the improvement of vacant houses defines vacant housing units as houses that no one lives in or uses for a period prescribed by presidential decree within one year or more from the date of confirmation of residence or use and excludes unsold houses (Ministry of Government Legislation (MOLEG), 2021).

In the case of the national statistical population and housing census, vacant houses were defined as uninhabited houses at the time of the survey and included houses that had not been newly built and moved in (Statistics Korea, 2021). In the case of Seoul, ordinances define vacant houses as not having been lived in or used for more than one year. Table 2-1 shows the definition of vacant houses by law in South Korea (Seoul Metropolitan Government, 2021).

Table 2-1. Definition of vacant houses by law

Name of the law	Unused period	Category	Status
Special cases concerning the improvement of vacant houses act	1 year	Housing (excluding unsold houses, etc.)	No one lives or uses it
Building act, Agricultural and fishing villages improvement act	1 year	Houses or buildings	No one lives or uses it
National statistical population and housing census	The time of the survey	Houses	No one lives due to neighbors such as sales, rental, sale, and moving
Seoul metropolitan ordinances	1 year	Houses or buildings	No one lives or uses it

2.2. Relationship between a city and vacant housing

Reviewing previous studies related to the direct factors in the occurrence of vacant housing, the author examined the relationship between urban areas and vacant housing. These studies have commonly revealed that the decline of cities is a fundamental background that causes vacant houses in the region. In this section, previous studies dealing with urban decline patterns in major countries around the world are first reviewed.

In highly urbanized and globalized large cities, the decline of certain regions is common, and an increase in vacant houses in the region, which signals urban decline, is also common. The failure to manage urban decline in a region in a timely manner leads to the occurrence of vacant houses, which soon establishes itself as a vicious cycle (Kim et al., 2018; Kim and Lee, 2016; Morckel, 2014; Park, 2019; Yoo and Kwon, 2019; Jeon and Kim, 2020). In the U.S., the Rust Belt is a representative region that has experienced urban decline (Yoshimichi, 2017). Emmanuele et al. (2013) introduced cases of urban decline due to the reduction of U.S. manufacturing and heavy industries in the 1970s. As a result of the urban decline at that time, these regions experienced side effects, such as a decrease in regional tax revenue, a decrease in urban infrastructure investment, and a deterioration in the settlement environment. In particular, one of the most visible urban decline results was the increase in vacant real estate in cities.

Annegret et al. (2013) pointed out Liverpool and Glasgow in the United Kingdom (U.K.) as the representative traditional industrial cities that have suffered from urban decline due to deindustrialization. These cities experienced complex urban problems, such as population outflow and an increase in vacant houses. However, it also suggested that cities that experienced urban decline due to system changes were caused by the collapse of socialism in the 1990s. For this reason, Halle in Germany is the city that has experienced the most severe urban decline in Europe.

As South Korea also experienced changes in its industrial structure in the 2000s, many regions are experiencing urban decline. Jeon and Kim (2019) focused on the decline of East Asian cities and, more specifically, defined the path of decline in large cities. First, there is a pattern that leads to the decline of established old cities due to the development of new cities led by the government. Second, projects drift for a long time due to delays or cancellations of rearrangement projects in the region. Third, slums developed without proper planning has continually suffered from poor living environments since their initial settlement.

As a result of reviewing studies on urban decline in major countries and cities around the world, it was confirmed that common side effects in all urban decline were the increase in vacant houses and vacant real estate. In addition, urban decline can be explained as the fundamental background that causes vacant houses.

2.3. Cause of housing vacancy

Previous studies on housing vacancies can be classified into the status and features of housing vacancies, legal systems related to housing vacancies, the utilization of vacant housing units, and the causes of vacant housing (Choi and Yon, 2020). First, studies have revealed that, globally, vacant houses tend to be concentrated in rural areas where housing demand is relatively low (Kamata and Kang, 2020; Shim and Kim, 2019). However, other studies have also identified an increase in housing vacancies in dense cities; for example, the number of vacant housing units in Korean cities is soaring (Korea Research Institute for Human Settlements (KRIHS), 2017). Second, studies on the legal systems associated with housing vacancies have proposed legal definitions and administrative management measures for vacant housing units (Henderson, 2015; Mallach, 2017; MOLIT, 2017b; Morckel, 2014; Nam, 2014). Third, other studies have suggested the utilization of vacant housing units in conjunction with urban regeneration projects, improvement of neighborhood environments, and securing community facilities (Mariko, 2018; Nam, 2014).

Finally, many studies have attempted to unveil the causes of vacant housing. Researchers have identified architectural factors for housing vacancies, such as narrow streets, the age of houses, and enclaved blocks that are segregated from adjacent blocks (Baba and Asami, 2017; Han, 2017; Jeon and Kim, 2016; Morckel, 2013; Yin and Silverman, 2015). For example, Baba and Hino (2018) used a logistic regression model to analyze the built environment factors affecting the occurrence of vacant housing in Japan. They found that the older a housing unit is, the higher the probability that it will become vacant. Jeon and Kim (2016) interpreted the cause of vacant housing as a mixture of the built environment and socioeconomic characteristics. Analyzing vacant housing units in Soongui-dong Incheon, South Korea, the authors identified factors for vacant housing clusters in the area. Their analysis found that the key built-environment factors for housing vacancies were enclaved blocks, narrow streets, irregular lot shapes, and small lot sizes.

Other studies have identified the influence of socioeconomic factors on vacant housing, with population variables being one of the most important. Most studies have underlined that population decline is the most critical cause of vacant housing (Bassett et al., 2006; Edward and Joseph, 2005; Immergluck, 2016; Mallach, 2017; Nassauer and Raskin, 2014; Page, 2010; Wilhelmsson et al., 2011; Yoo and Kwon, 2019). In particular, the proportion of elderly people has a significant relationship with the occurrence of vacant housing. Yoo and Kwon (2019) divided the spatial characteristics of vacant housing distribution into three categories—

declining city type, growing city type, and stagnant city type—and derived a significant correlation between the proportion of the elderly population and vacant housing for declining urban types. Page (2010) also detected an increase in vacant housing in areas where older residents are concentrated.

Bassett et al. (2006) used multiple regression analysis to determine the causes of vacant housing units in the Flint area in Michigan. Their study empirically confirmed that a wide range of socioeconomic and spatial characteristics, such as population decline, low birth rates, and poverty rates, contributed to the occurrence of vacant housing units. In contrast, some studies have found that residents' education levels and employment rates tend to be negatively correlated with the number of vacant housing units (Bassett et al., 2006; Immergluck, 2016; Silverman et al., 2016). Silverman et al. (2016) analyzed the causes of vacant housing units in Buffalo, New York. The results revealed that the poverty rate and business address ratio affected the occurrence of vacant housing units.

Immergluck (2016), who defined a vacant house as one left unattended for over six months, analyzed the causes of vacant housing units at the census tract level in the 50 largest cities in the U.S. Negative binomial regression analysis results indicated the positive effects of the number of houses in the region and the proportion of poor households on the occurrence of vacant housing units. The negative effects of the proportion of those who commuted for more than 30 minutes and Hispanic and Asian-American households were also identified.

2.4. Land use mix

In modern urban planning, LUM is regarded as a core principle and an innovative urban planning technique (Land and Housing Institute (LHI), 2017). In the past, rigid zoning-oriented urban planning, which emerged as an alternative to overcoming residential hygiene problems after the Industrial Revolution, became a dominant practice until the mid-twentieth century. However, in the 1960s, urban problems, such as excessive consumption of land and energy, air pollution, and social segregation, occurred due to the private car-oriented urban sprawl of large cities in the U.S. (Grant, 2002).

As an alternative to these problems, the New Urbanism movement began. Jacobs (1961) emphasized that LUM and transportation-oriented development promote short-distance commuting, pedestrian-centered urban transitions, and, ultimately, urban vitality. The theory of smart growth, which emerged in the 2000s, is still known as a mainstream theory of urban planning, inheriting New Urbanism's view of LUM and public transportation-oriented development (Gu et al., 2019; Seasons, 2014).

Many existing studies on LUM in the urban planning field are limited mainly to specific topics, such as urban walking volume and housing price (Burnell, 1985; Jacobs-Crisioni et al., 2014; Lee and Ahn, 2007; Shultz and King, 2001; Wu et al., 2018; Yang, 2008). For instance, Jacobs-Crisioni et al. (2014) used mobile phone usage data in Amsterdam, the Netherlands, to confirm that high numbers of urban activities take place in areas with high LUM intensity. This led to the conclusion that mixed land-use areas are more attractive to citizens than single land-use areas.

In the case of Seoul, South Korea, Lee and Ahn (2007) empirically confirmed that the higher the intensity of LUM in areas, the larger the amount of walking that takes place. Meanwhile, Burnell (1985) identified a rise in property prices in residential areas that are mixed with appropriate levels of commercial use. Wu et al. (2018) analyzed the impact of LUM on housing prices in Beijing, China. This study also showed that housing prices rise when residential use is mixed with commercial use.

LUM with these characteristics is found to occur mainly in general commercial areas in Seoul (Kim et al., 2012; 2015, Jun and Yang, 2014). Kim et al. (2012) pointed out that the problem of general commercial areas in Seoul, where LUM is recommended and mainly occurs, is a deformed development pattern that fills the legal floor area ratio (FAR) of 800% without considering the context of the surrounding areas. In addition, Kim et al. (2012) raises the vulnerability of settlement in officetels[1] which are representative facilities that contribute to the residentialization of commercial areas.

Jun and Yang (2014) examined the phenomenon of LUM, such as residentialization in commercial areas targeting Gangnam in Seoul. Through this study, it was found that the preferred lots' characteristics of residential and commercial facilities are different, and in the urban design process, the block is divided differently in consideration of density and sunlight, depending on the area of use.

Contrary to these positive discussions of LUM, Alexander (1977) emphasized the need for the control of outsiders' access to neighborhoods with clear boundaries to maintain the livability of the neighborhoods from a theoretical perspective. Lynch (1984) also defined people as territorial animals and argued for the importance of the space that individuals can control. Such individual spatial rights were cited as one of the five measures of implementation of the "good city form" (Lynch, 1984). This

1) The Korean Building Act defines officetels as business facilities, but defines them as accommodation and lodging in some sections. Based on the legal concept of officetels, officetels for residential purposes in commercial areas are being built on a large scale (Min, 2014).

can be interpreted in a context that contradicts LUM, where neighborhood boundaries are ambiguous and spatial forms are difficult for individuals to occupy completely.

Overall, urban planning theory and empirical studies emphasize the positive influence of LUM, which may facilitate activities and improve urban vitality. However, little is known about how LUM affects vacant housing occurrence. The following figure explains the relationship between previous studies and this study's subject in a diagram.

A diagram of the relationship between the structure of previous studies and the subject of the present study is illustrated in Figure 2-1.

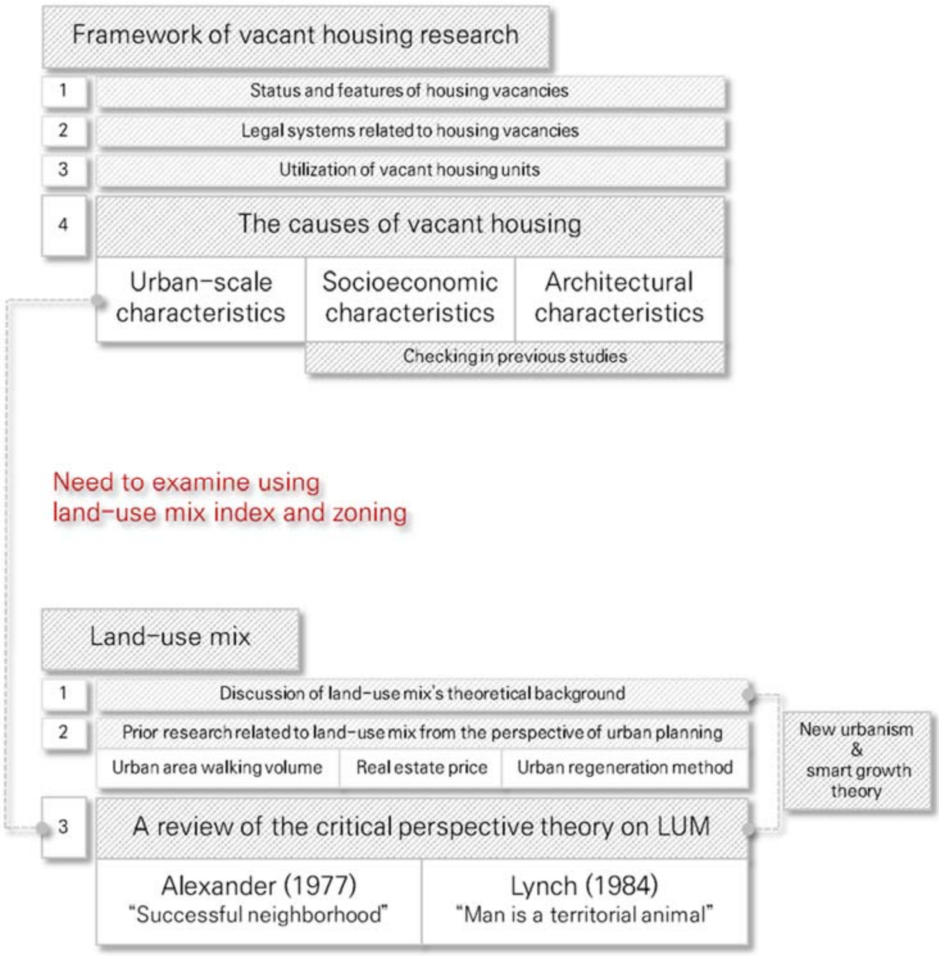

Figure 2-1. The relationship between the structure of previous studies and the subject of this present study

2.5. Research contribution

The present study contributes to the literature by elucidating the relationship between land-use patterns and vacant housing. Many prior studies that identified the causes of housing vacancies focused on architectural, community, and socioeconomic characteristics. However, considering that vacant housing occurs in urban spaces, there is a lack of consideration of urban-scale approaches, such as land use and development density. Therefore, this study investigates the impact of LUM on housing vacancies from an urban planning perspective, which highly recommends that LUM improve urban environments.

Additionally, the present study employed a fine spatial unit at the census tract level to alleviate the modifiable aerial unit problem (MAUP) (Vogel, 2016). Most previous studies have established the research area unit, such as a city, county, or district. In this case, even in the same spatial unit area, there may be areas where completely different urban forms coexist. Therefore, the author analyzed the census tract to minimize such problems. The present study tested the hypothesis that the vacant housing occurrence rate is higher in mixed land-use areas than in single-use areas. LUM may interfere with the stable settlement environment of an area, contributing to an increase in vacant housing. Alternatively, the present study tested a rival hypothesis that LUM promotes local activities and contributes to reducing the incidence of vacant housing.

Chapter 3. Material and Methods

3.1. Field Site

This study covered the total area of Seoul, which is the capital of South Korea and one of the most densely populated cities in the world. It occupies 605.25 km2 and has a population of 9,828,094 as of 2021. Composed of 25 districts (called gus in Korean), Seoul can be divided into five living zones by comprehensively considering its natural and built environments, urban growth, land-use characteristics, school districts, and population characteristics (Seoul Metropolitan Government, 2014). These areas vary greatly in area, land-use patterns, and other local characteristics. Gus are divided into administrative neighborhoods (called administrative dongs in Korean), and the gus of Seoul consist of 423 administrative dongs. The dongs are also subdivided into census tracts called jipgegus, which are administrative units of at least 300 to 1,000 people. Seoul consists of 18,748 jipgegus (Statistics Korea, 2015, 2020b). Seoul's administrative boundaries are illustrated in Figure 3-1.

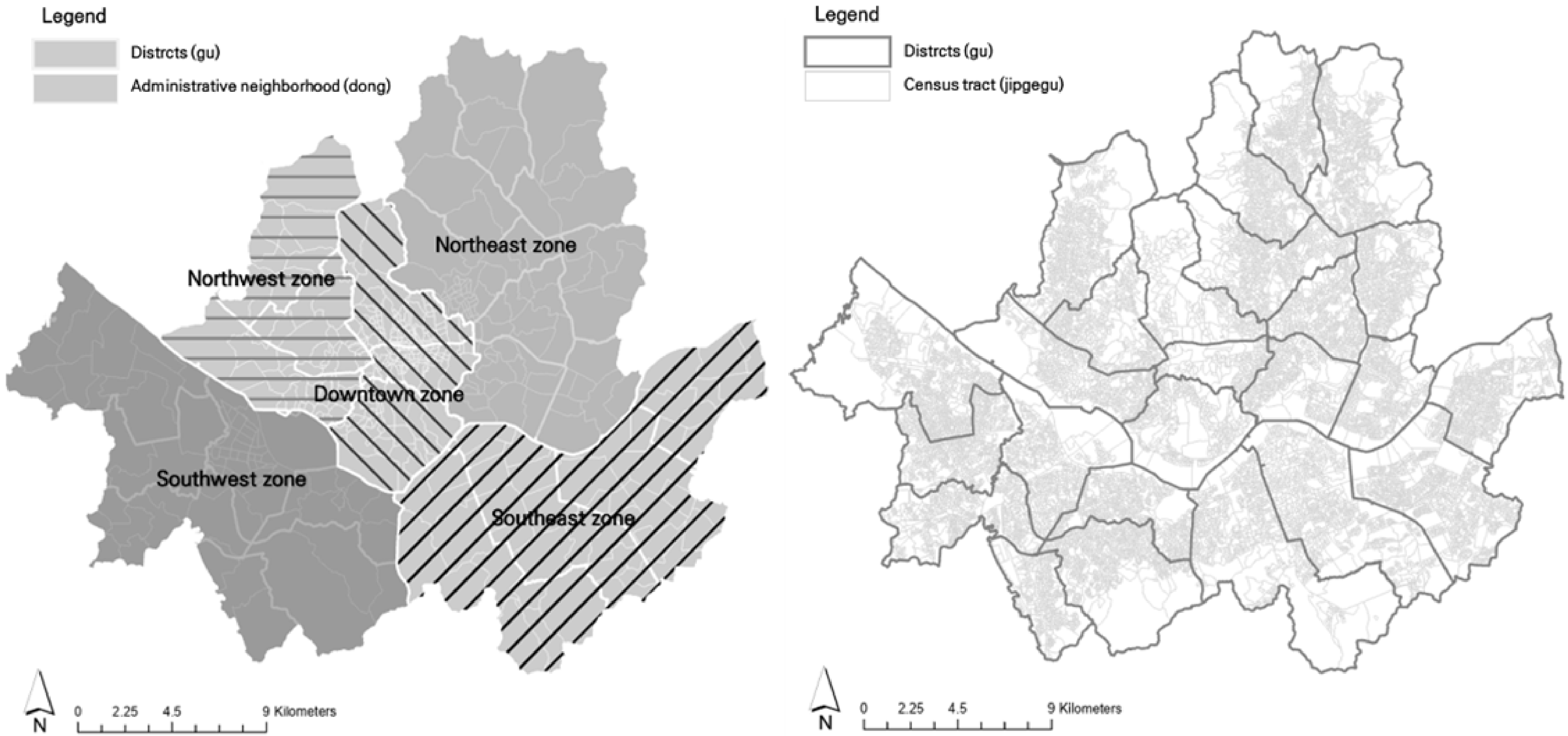

Figure 3-1. The study site: Seoul's five living zones, 25 districts, 423 dongs, and census tracts

Since 1950, a wide variety of urban development projects have been executed in Seoul, along with rapid population and economic growth. However, since 1990, Seoul's population has been decreasing, and the aging population has gradually increased (entering an aging society in 2020). Rapid urban development has also consumed greenfield development sites. Meanwhile, the number of vacant housing units increased during the urban decline process. Therefore, rather than new developments, various urban renewal projects have been implemented. In this context, the city government commissioned the Korea Real Estate Board (REB) to conduct a survey on the status of vacant housing throughout Seoul. According to the survey, vacant housing units are located in various areas of Seoul.

Seoul restricts land use, building coverage ratio, floor area ratio, height, and so on, according to land-use zoning codes. Seoul's land consists of five major uses: residential (46.89%), green (43.60%), semi-residential (2.98%), semi-industrial (1.81%), and commercial (4.72%). These five uses were subcategorized to control for land use. Each land use is designated to control the characteristics of a certain area, including recommended, allowed, and prohibited uses, and density, height, and building types.

Table 3-1 summarizes the definitions and characteristics of Seoul's major land-use areas (MOLIT, 2020). A map of major Seoul land use is illustrated in Figure 3-2.

Table 3-1. Definitions and characteristics of major land use in Seoul (2020)

Major land-use classification	Definition	Building coverage ratio	Floor area ratio	Percentage in Seoul
Class 1: general residential area	To create convenient residential environments for low-rise housing	0.6	1.5	14.42
Class 2: general residential area	To create convenient residential environments for mid-rise housing	0.6	2.0	17.26
Class 3: general residential area	To create convenient residential environments for mid/high-rise housing	0.5	2.5	12.35
Semi-residential area	To provide commercial environments to residential areas	0.6	4.0	2.98
General commercial area	To provide general commercial and business functions	0.6	8.0*	4.35
Central commercial area	To expand commercial functions in the center/sub-center	0.6	10.0**	0.03
Semi-industrial area	To admit light industry and other industries, but in need of supplementing residential/ commercial functions	0.6	4.0	1.81
Natural green area	To secure green area space and supply of future city sites	0.2	5.0	14.94

* 6.0 within the historical center
** 8.0 within the historical center

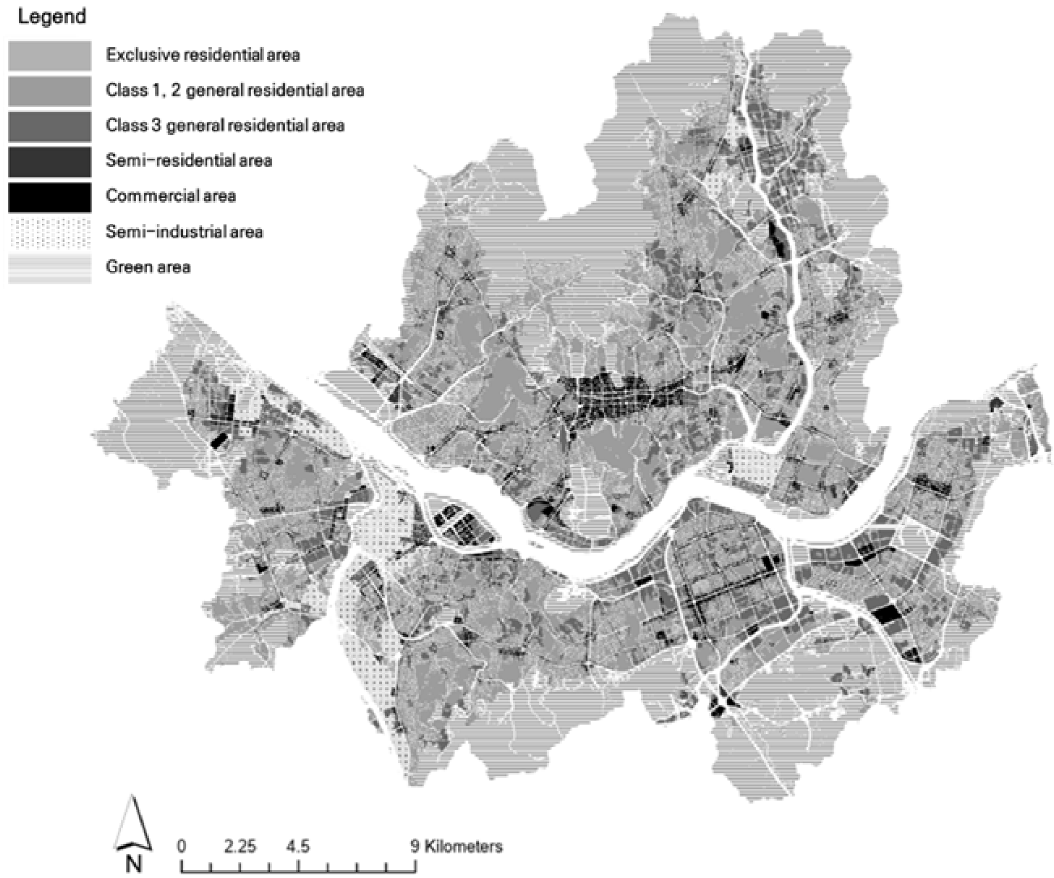

Figure 3-2. Seoul land-use map

The Seoul Metropolitan Government designated 4.77% of Seoul's total land as a rearrangement project area in 2019. Urban rearrangement projects defined in the act on the Maintenance and Improvement of Urban Areas and Dwelling Conditions for Residents in South Korea include "urban regeneration projects" that maintain old urban structures as much as possible and "urban redevelopment and reconstruction projects" that demolish the existing urban fabric.

The urban rearrangement projects can be categorized into residential environment improvement projects, redevelopment projects, and housing reconstruction projects. First, residential environment improvement projects were implemented to improve residential environments in low-income areas where urban infrastructure and aged buildings have deteriorated. Second, redevelopment projects aimed to improve deteriorated residential (not necessarily low-income) areas, commercial, and industrial areas. Last, housing reconstruction projects targeted areas in which infrastructure was well maintained but where aging buildings were concentrated. A diagram of the Seoul rearrangement zone is illustrated in Figure 3-3.

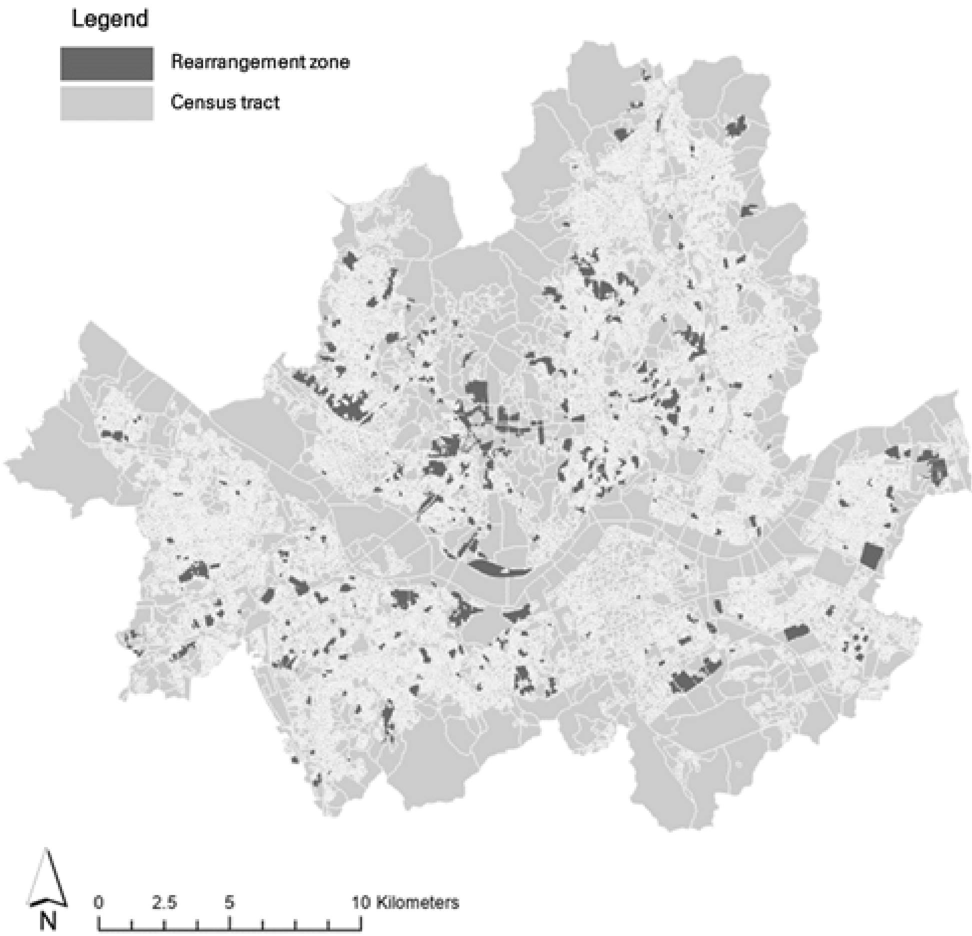

Figure 3-3. Status of Seoul rearrangement zone

Thus, Seoul, which includes a variety of land-use patterns and an increasing occurrence of vacant housing, is a suitable area for studying the correlation between land use and housing vacancies.

3.2. Data

To examine the relationship between land use and housing vacancy, this study's author used data from the REB's vacant housing survey, which established a complete data list of vacant housing in Seoul in 2019. In these data, vacant houses are defined as having been confirmed through onsite surveys among the housing that have had no water and power supply for one year. Therefore, similar to many previous studies, this study defined vacant houses as unused houses for more than one year. These data include the addresses and housing types of individual vacant housing units. All the vacant housing units were geocoded based on their addresses and aggregated into the 18,748 census tracts to compute the number of vacant housing units in each census tract. The status of Seoul's housing vacancy is illustrated in Figure 3-4.

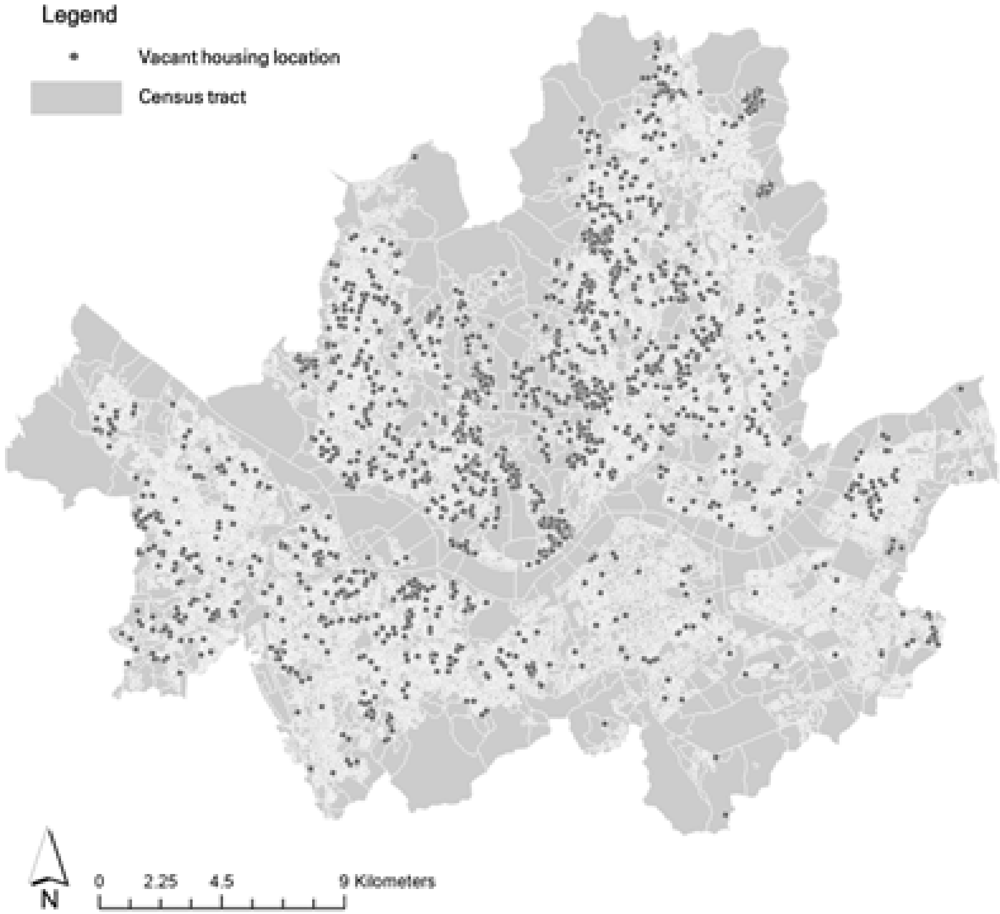

Figure 3-4. Status of vacant housing in Seoul on a census tract map

Also, this present study collected land-use data from the National Spatial Information Portal Open Market data (MOLIT, 2020), as well as environmental variables (i.e., architectural and socioeconomic) from the Population and Housing Census (2019) in Statistical Geographic Information Services (SGIS) data (Statistics Korea, 2020b). In previous research, these variables were expected to influence housing vacancy occurrence (Accordino and Johnson, 2000; Baba and Asami, 2017; Immergluck, 2016).

3.3. Measures and descriptives statistics

The dependent variable for this study was the number of vacant housing units in a census tract. The independent variables encompassed architectural, socioeconomic, and urban-scale variables.

Architectural variables included housing density, the percentage of aged housing (i.e., old and new housing), the percentage of housing types (i.e.,apartments, multifamily housing, low-rise housing, and detached housing), and socioeconomic factors (i.e., population density, average age of residents, old-age-dependency index, number of businesses, and employment density). The variables that represented urban-scale features were the area of a census tract, the LUMI, the percentage of first-, second-, and third-class residential areas, and the percentage of general commercial, semi-industrial, and natural green areas. Urban rearrangement projects (during construction) can temporarily or permanently increase the number of vacant housing units. Thus, the percentage of rearrangement area controls for the temporary vacant housing due to urban rearrangement projects.

A land-use entropy index is a key question predictor that measures the degree of LUM in each census tract and considers the relative percentage of two or more land-use types within an area. Higher levels of the entropy index mean more LUM. If the measured area consists of a single-use area, the entropy index will appear as zero, and if all types of applications are mixed in equal proportions, it will appear as one.

Let $N \geq 2$ be the number of land-use types i and p_i be the percentage of each land-use type in the area (1).

$$\textit{The Entropy Index} = -\frac{1}{\ln N}\sum_{i=1}^{N}(P_i \times \ln P_i) \quad (1)$$

Finally, because the census tracts were nested within Seoul's five living zones (see Figure 3-1), zone dummies were included to account for the unobserved effects of the zones. The definitions and descriptive statistics for all variables are shown in Table 3-2.

Table 3-2. Definitions and descriptive statistics of the variables

Variable	Definition	Mean (S.D.)	Min	Max
Dependent Variable				
Number of Vacant Housing Units	Number of vacant housing units in a census tract	0.158 (1.348)	0.000	97.00
Independent Variables				
Architectural Factors				
Housing Density	Number of housing/area of a census tract (ha)	148.9 (113.4)	0.000	1290
Old Housing	Number of housing over 30 years/total number of housing x 100	19.12 (30.43)	0.000	100.0
Young Housing	Number of housing less than 30 years/total number of housing x 100	51.94 (39.81)	0.000	100.0
Apartment	Number of apartment/number of total housing x 100	14.06 (22.14)	0.000	100.0
Multifamily	Number of multifamily housing/number of total housing x 100	26.24 (31.86)	0.000	100.0
Low-Rise	Number of low-rise housing/number of total housing x 100	3.484 (9.964)	0.000	100.0
Detached	Number of detached housing/number of total housing x 100	14.06 (22.14)	0.000	100.0
Socioeconomic Factors				
Population Density	Number of people/area of a census tract (ha)	451.3 (278.8)	0.000	5148
Average Age	Average age	41.85 (6.122)	0.000	84.80
Aged Dependency Index	Number of persons aged 65 and older/number of persons aged between 15 and 64 x 100	21.64 (27.40)	0.000	2040
Businesses	Number of businesses	32.70 (175.8)	0.000	9939

Employment Density	Number of workers/area of a census tract (ha)	68.75 (152.6)	0.000	0.357
Urban-scale Factors				
Area	Census tract area (ha)	3.231 (18.44)	0.040	968.0
Entropy Index (LUMI)	Land-use mix index (equation 1)	0.302 (0.343)	0.000	0.999
First-Class Residential	Area of first-class residential district/census tract area x 100	6.358 (20.04)	0.000	100.0
Second-Class Residential	Area of second-class residential district/census tract area x 100	40.37 (44.56)	0.000	100.0
Third-Class Residential	Area of third-class residential district/census tract area x 100	36.56 (44.63)	0.000	100.0
General Commercial	Area of general commercial district/census tract area x 100	3.406 (16.28)	0.000	100.0
Semi-Industrial	Area of semi-industrial district/census tract area x 100	4.525 (20.39)	0.000	100.0
Natural Green	Area of natural green district/census tract area x 100	1.342 (7.968)	0.000	100.0
Rearrangement	Area of whole maintenance zone/census tract area x 100	7.661 (24.21)	0.000	100.0
Zone Dummies				
Northeast Zone (reference category)		0.316	0	1
Downtown Zone		0.051	0	1
Northwest Zone		0.120	0	1
Southeast Zone		0.211	0	1
Southwest Zone		0.302	0	1

3.4. Analysis

The dependent variable (i.e., the number of vacant housing units) is a count variable. The distribution of the dependent variable is skewed with an excessive number of zeros. Approximately 92.8 percentage of the census tracts include zero vacant housing units, implying that the zero-inflated negative binomial regression model (ZINB) is suitable. The following Figure 3-5 is a histogram showing the current status of the dependent variables, with most of the data being zero.

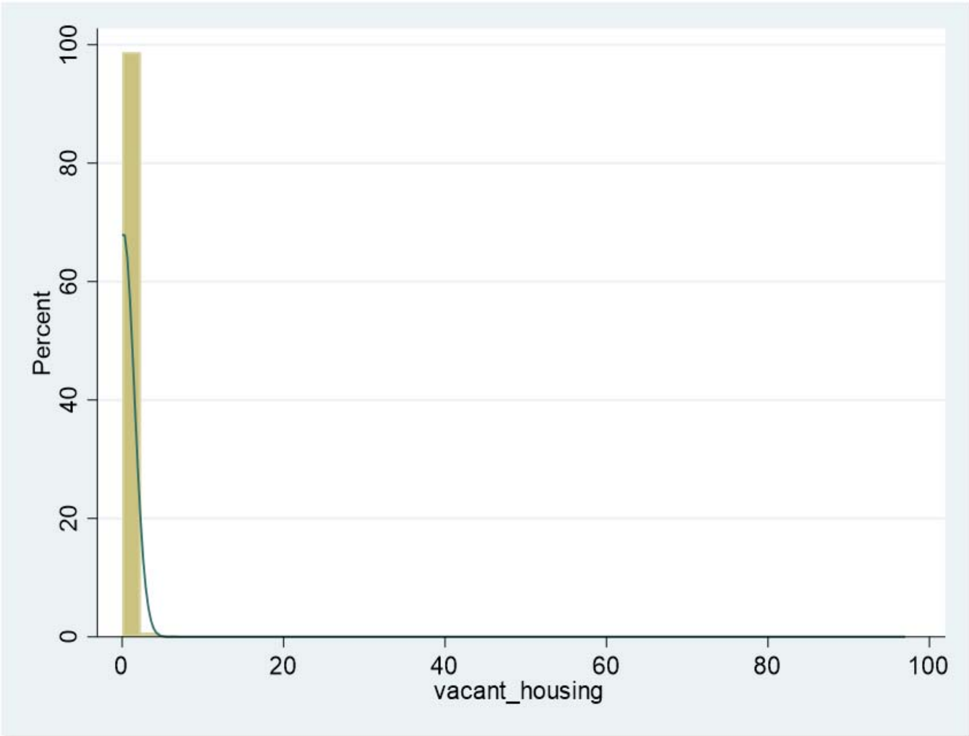

Figure 3-5. Histogram showing the current status of dependent variables

In addition, comparing the akaike information criterion (AIC) and bayesian information criterion (BIC) values of a Poisson regression, negative binomial regression, zero-inflated Poisson regression, and zero-inflated negative binomial regression model, it was concluded that the ZINB model is the most appropriate model to estimate the number of vacant housing units. Therefore, the ZINB model was selected as an analytical model to improve the accuracy and explanation of the estimated results (Yang and Yoon, 2020). The ZINB model combines two analysis processes: 1) the inflated model, the likelihood of being in the zero-vacant housing group, and 2) a negative binomial model, which estimates the counts for vacant housing in census tracts with the probability of including at least one vacant house.

Equation (2) is an expression that summarizes the ZINB model.

$$f(Y = y_i) = \begin{cases} \phi_i + (1 - \phi_i)\left(\dfrac{\alpha^{-1}}{\mu_i + \alpha^{-1}}\right)^{\alpha^{-1}} \\ \qquad\qquad for \;\; y_i = 0 \\ (1 - \phi_i)\dfrac{\Gamma(y_i + \alpha^{-1})}{\Gamma(y_i + 1)\,\Gamma(\alpha^{-1})}\left(\dfrac{\mu_i}{\mu_i + \alpha^{-1}}\right)^{y_i}\left(\dfrac{\alpha^{-1}}{\mu_i + \alpha^{-1}}\right)^{\alpha^{-1}} \\ \qquad\qquad for \;\; y_i = 1, 2, 3 \ldots \end{cases} \tag{2}$$

In this equation, f(Y=yi) is the random variable for vacant housing. The parameter Φi is the mean of the zero-inflated probability. The parameter α is the over-dispersion coefficient. The parameter μi is the mean of the incidence rate of y per unit of exposure.

First, in the case of the ZINB model analysis, which is the core analysis model of this study, it is difficult to identify a multicollinearity problem between variables. Therefore, the present study alternatively tried to avoid the multicollinearity problem between variables in advance by checking the value of the variation inflation factor (VIF) result of correlation analysis and general linear regression analysis (Park, 2014).

In general, multicollinearity problems are suspected when the VIF value is 10 or more using the VIF test (Lew and Kang, 2012). In the case of all variables applied to the ZINB model, the VIF value was confirmed to be less than 10. The housing density, population density, and the second class and third class residential were found to be relatively high values of around five, but statistically, this is no problem, and these are used as control variables and analyzed without exclusion. The multicollinearity results are confirmed in Table 3-3.

Table 3-3. Multicollinearity test results

Variables	VIF	1/VIF
Housing Density	6.920	0.144
Population Density	6.620	0.151
Second-class Residential	5.180	0.193
Third-class Residential	5.050	0.198
Semi-industrial	1.980	0.505
First-class Residential	1.920	0.522
Apartment	1.840	0.544
General Commercial	1.760	0.569
Multifamily	1.750	0.571
Old Housing	1.610	0.622
New Housing	1.550	0.646
Average Age	1.530	0.652
Employment Density	1.530	0.655
Southwest Zone	1.430	0.698
Southeast Zone	1.430	0.700
Entropy Index (LUMI)	1.310	0.764
Businesses	1.270	0.785
Northwest Zone	1.270	0.788
Aged Dependency Index	1.240	0.809
Natural Green	1.230	0.813
Downtown Zone	1.180	0.847
Low-Rise	1.160	0.861
Area	1.140	0.877
Rearrangement	1.080	0.930
Mean VIF	2.210	

For empirical verification of the results derived through such ZINB analysis, a result verification was conducted by combining spatial cluster pattern analysis and hierarchical cluster analysis (Koo and Cho, 2020; Hah et al., 2021). In this study, the spatial cluster pattern (Getis-Ord Gi*) method was first used. This method can test individual clustering trends with neighboring regions within a certain range.

Equation (3) is a calculation equation that derives a spatial cluster pattern. Here, i, j is the unit of analysis, x_i, x_j is the attribute data of the i or j region, $w\_(i, j)$ is the spatial weight between the i and j regions, and n is the number of analysis space units.

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j} - \bar{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{[n\sum_{j=1}^{n} w_{i,j}^2 - (\sum_{j=1}^{n} w_{i,j})^2]}{n-1}}} \qquad \bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \tag{3}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} {x_j}^2}{n} - (\bar{X})^2}$$

For spatial cluster pattern visualization, Getis-Ord Gi*, which shows the degree of each cluster, is a value calculated by calculating the z-score value of an object and has the characteristic that the value of the area must be high and surrounded by high-value adjacent areas. A cluster with high values and high values in adjacent areas means hot spots, and vice versa, cold spots.

Based on the spatial cluster pattern analysis results, the ZINB analysis results were verified through hierarchical cluster analysis, which is generally calculated based on the Euclidean distance calculation method (Song and Chang, 2010). In this process, there are various methods for determining the number of clusters, but the Pseudo-F method developed by Calinski and Harbasz is typically used, and this study also uses this method. The following equation (4) calculates the Pseudo-F.

$$pseudo - F = \frac{\begin{matrix}Sum\ of\ squared \\ Between - Cluster\ Distance\end{matrix} \Big/ df_{between}}{\begin{matrix}Sum\ of\ squared \\ Within - Cluster\ Distance\end{matrix} \Big/ df_{within}} \tag{4}$$

After calculating the Pseudo-F value of each cluster using the equation, the number of clusters and Pseudo-F are plotted in a graph to determine the appropriate number of clusters and conduct a clustering analysis.

Chapter. 4 Analysis results

4.1. Results

The ZINB comprises the inflated model and the negative binomial model (see Table 4-1). The inflated model estimated the probability of being in the zero-vacant housing census tract group. Thus, a negative coefficient in the inflated model indicates that the variable is positively associated with the probability of having at least one vacant housing unit. The negative binomial model estimated the number of vacant housing units in the non-zero vacant housing census tracts. Table 4-1 shows the final parsimonious models that exclude some insignificant variables; the two models consist of different variable sets. Both raw coefficients and exponentiated coefficients were included in reporting the odds ratio for the inflated model and the incidence rate ratios for the negative binomial model.

The inflated model indicated that the higher the percentage of architectural factors, such as old, multifamily, low-rise, and detached housing, the lower the probability of being in the zero-vacant housing group. Among socioeconomic factors, a census tract with a greater number of businesses is less likely to be in the zero-vacant housing group. Among the urban-scale factors, the larger the area and the entropy index, which was the question predictor of the present study, the lower the probability of being in the zero-vacant housing group. On the contrary, a census tract with a higher percentage of first- and third-class residential and natural green areas tends to have a higher probability of being in the zero-vacant housing group.

The negative binomial model results showed that, among architectural factors, housing density and percentage of apartments are positively correlated with the number of vacant housing units. In contrast, the percentage of new housing is negatively associated with the number of vacant housing units. Population density and employment density are negatively correlated with the number of vacant housing units. However, a census tract with a greater percentage of general commercial areas, semi-industrial areas, and rearrangement zones tends to have a greater number of vacant housing units.

Finally, the zone dummies took unobserved zonal characteristics into account. Seoul's northeast zone, in which the amount of vacant housing was the median among the five zones, was selected as the reference category. The coefficients of the dummies indicate that the downtown zone has a greater number of vacant housing units, whereas the southwest zone has a smaller number of vacant housing units than the reference category. In addition, the southeast zone tended to have a higher probability of being in the zero-vacant housing group than the reference category.

Along with the ZINB analysis results, the observed values of the actual data and the predicted values through the ZINB analysis are plotted as graphs, respectively, as shown in Figure 4-1. The graph of the observed and predicted values appears in almost similar forms, so it can be judged that the predictive power of this model is quite high.

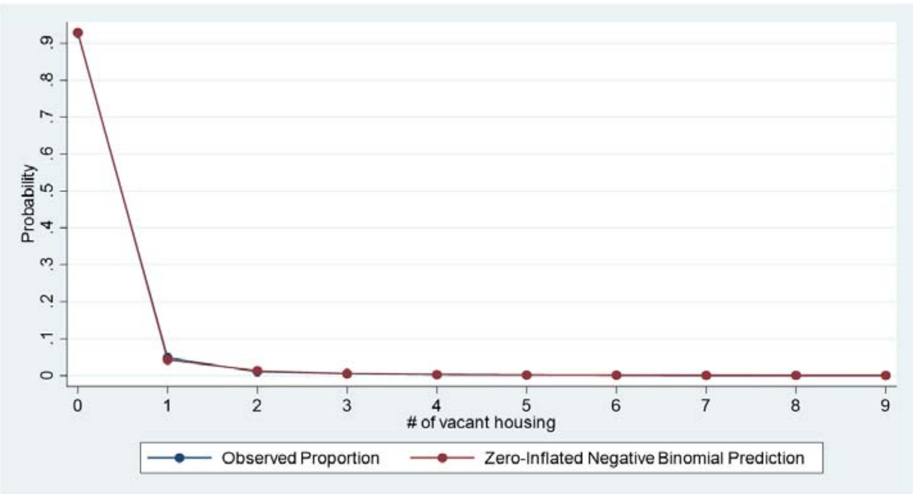

Figure 4-1. Observed and predicted values fitting graph

Table 4-1. Results of the ZINB model analysis

	Zero Inflated Model			Negative Binomial Model		
	Coef.	Exp (Coef.)	(S.E.)	Coef.	Exp (Coef.)	(S.E.)
Architectural Factors						
Housing Density	-	-	-	0.019***	1.019	(0.002)
Old Housing (%)	-0.012***	0.988	(0.002)	-	-	-
New Housing (%)	-	-	-	-0.015***	0.985	(0.154)
Apartment (%)	-	-	-	0.007***	1.007	(0.182)
Multifamily (%)	-0.028***	0.972	(0.004)	-	-	-
Low-Rise (%)	-0.020**	0.98	(0.008)	-	-	-
Detached (%)	-0.261***	0.77	(0.039)	-	-	-
Socioeconomic Factors						
Population Density	-	-	-	-0.009***	0.991	(0.001)
Average Age	-0.013	0.987	(0.017)	-	-	-
Aged Dependency Index	-	-	-	-0.001	0.999	(0.003)
Businesses	-0.005**	0.995	(0.002)	-	-	-
Employment Density	-	-	-	-0.002***	0.998	(0.000)
Urban-Scale Factors						
Area	-0.026**	0.974	(0.012)	-	-	-

Entropy Index (LUMI)	-0.763**	0.466	(0.325)	-	-	-
First-class Residential (%)	0.001*	1.010	(0.006)	-	-	-
Second-class Residential (%)	0.005	1.005	(0.004)	-	-	-
Third-class Residential (%)	0.007*	1.007	(0.004)	-	-	-
General Commercial (%)	-	-	-	0.013***	1.013	(0.001)
Semi-industrial (%)	-	-	-	0.006***	1.006	(0.002)
Natural Green (%)	0.024**	1.024	(0.011)	-	-	-
Rearrangement (%)	-	-	-	0.013***	1.013	(0.001)
Zone Dummies						
Downtown Zone	-0.116	0.890	(0.411)	0.792***	2.208	(0.110)
Northwest Zone	0.209	1.232	(0.384)	0.170	1.185	(0.104)
Southwest Zone	-0.021	0.979	(0.294)	-0.156*	0.856	(0.089)
Southeast Zone	0.734**	2.083	(0.364)	0.017	1.017	(0.136)
Constant	3.888	48.813	(0.791)	-0.043	0.958	(0.166)
Alpha					3.001	
Log likelihood				-5214.422		
AIC				10492.8		
BIC				10743.7		

Note: †: p 〈 .10; *: p 〈 .05; **: p 〈 .01;***

Chapter. 5 Verifying the results

5.1. Spatial cluster pattern (Getis-Ord Gi*) analysis

As previously discussed, to verify the ZINB analysis results, spatial cluster pattern analysis was first performed using vacant housing data for each census tract. The analysis results are shown in Figure 5-1.

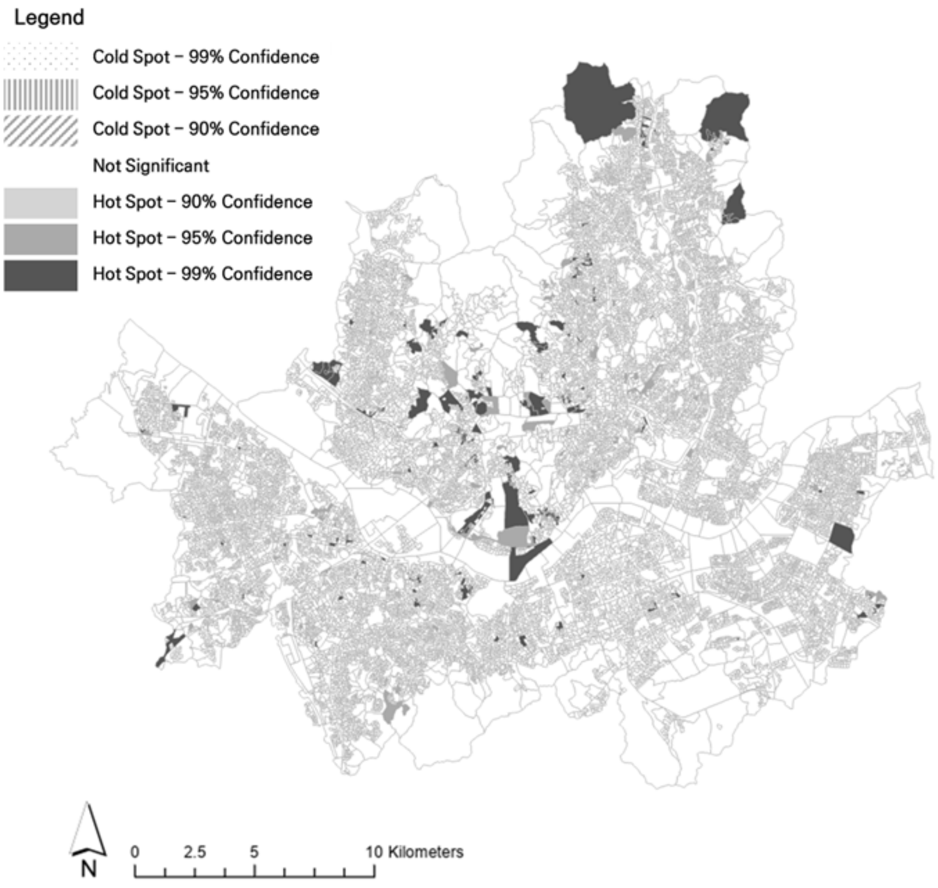

Figure 5-1. Spatial cluster pattern analysis output map

As a result of the spatial cluster pattern analysis, cold spot areas did not appear. In the case of hot spots, 444 hot spot areas with a significance level of 90% or higher were found, and 83 areas with a significance level of 99% or higher were identified.

In consideration of the amount of data that can be analyzed in STATA, hierarchical cluster analysis was performed on hot spot areas with a significance level of 99% or higher. In the hierarchical cluster analysis, 11 variables that have great influence or reflect land-use characteristics were selected among the architectural, socioeconomic, and urban-scale factors used in the ZINB model.[2)]

2) Variables used in hierarchical cluster analysis are housing density, percentage of aged housing and detached housing, number of businesses, entropy index and percentage of rearrangement area, first, second and third class residential, and general, commercial, and semi-industrial areas.

5.2. Hierarchical cluster analysis

Next, to derive the appropriate number of clusters, the dendrogram and pseudo-F values for each number of clusters were plotted as a graph. As a result of plot verification, when the number of clusters was seven, the pseudo-F value was 222.43, and the number of clusters seven was found to be a practically valid cluster. The following figure is a graph of the number of clusters and the pseudo-F value of the hierarchical cluster analysis in this study.

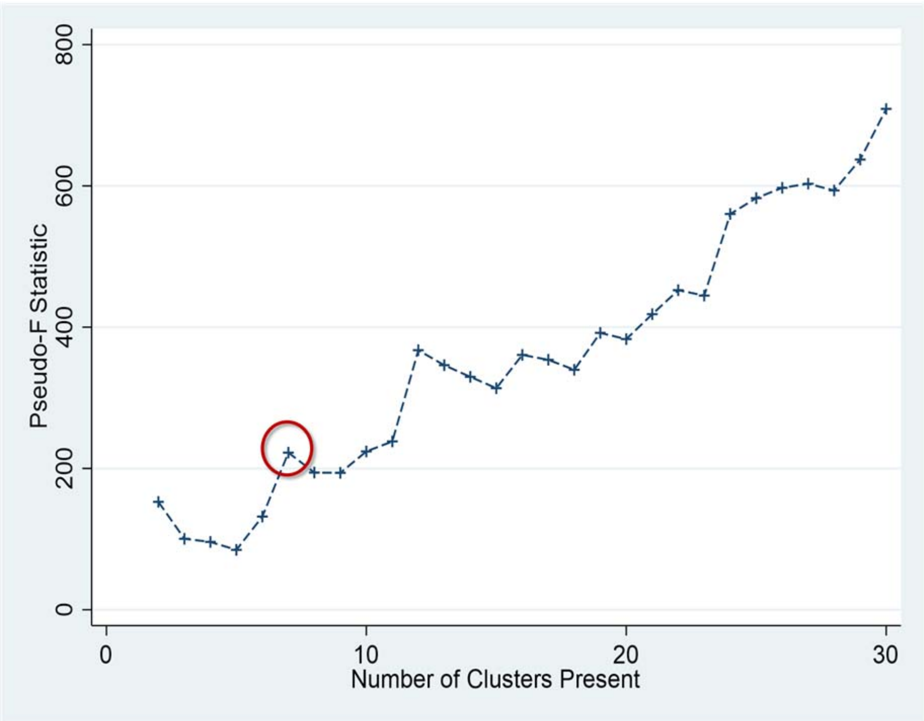

Figure 5-2. the number of clusters and the pseudo-f value graph

As a result of conducting clustering analysis with seven clusters, it was confirmed that there were 10 census tracts on cluster#1, 50 census tracts on cluster#2, and 18 census tracts on cluster#3. However, there were only one or two on cluster#4~#7 each, so they were treated as outliers. Therefore, in this study, analysis was conducted centering on cluster#1 and cluster#3. The following figure is the result of visualizing the cluster analysis results with seven clusters.

Figure 5-3. Cluster analysis results with seven clusters

The descriptive statistics for each cluster of the hierarchical cluster analysis results are summarized as follows (see Table 5-1). To summarize the overall characteristics of the results, first, it can be seen that LUM is the dominant trend in the remaining cluster#1 and cluster#2, except for cluster#3. Moreover, it was found that there was no difference between clusters in the percentage of aged housing and detached housing, which are architectural factors.

Table 5-1. Results of the cluster analysis

	Cluster						
	Cluster#1	Cluster#2	Cluster#3	Cluster#4	Cluster#5	Cluster#6	Cluster#7
Number of census tract	10	50	18	1	2	1	1
Number of vacant houses	9.80	15.50	9.11	15.00	6.50	6.00	8.00
Urban-Scale Factors							
Entropy Index (LUMI)	0.80	0.51	0.38	0.10	0.56	0.00	0.75
First-class Residential (%)	17.52	22.26	29.06	98.70	0.00	0.00	0.00
Second-class Residential (%)	36.00	37.91	63.73	0.00	49.23	0.00	36.26
Third-class Residential (%)	17.00	15.10	7.07	0.00	0.77	0.00	11.33
General Commercial (%)	14.05	2.25	0.00	0.00	24.47	100.00	50.53
Semi-industrial (%)	0.64	4.01	0.00	0.00	0.00	0.00	0.00
Rearrangement (%)	0.00	4.01	0.09	0.00	0.00	0.00	0.00
Socioeconomic Factors							
Businesses	139.00	20.96	9.50	0.00	278.00	1019.00	562.00
Architectural Factors							
Housing Density	23.73	39.19	118.81	273.09	44.79	30.83	5.65
Old Housing (%)	52.76	53.62	48.73	14.29	55.85	97.90	80.23
Detached (%)	46.34	56.90	47.80	21.02	56.08	18.01	64.74

Representative cases of each cluster can be derived through cluster visualization and technical statistics review, and reliability can be improved through the analysis of each case.

5.3. Case study of each cluster

Cluster#1 has a relatively higher mean value of LUMI than the other clusters (cluster#1 is 0.8, cluster#2 is 2.25, and cluster #3 is 0), and the mean value of general commercial area percentage is also higher (cluster#1 is 14.05, cluster#2 is 2.25, and cluster#3 is 0.00). Due to the characteristics of cluster#1, which has a high percentage of general commercial areas, the number of businesses was also 139.00, which is higher than that of other clusters (cluster#2 is 20.96 and cluster#3 is 9.50).

Therefore, based on this result, cluster#1 can be defined as a type where vacant houses are concentrated due to the LUM dominated by general commercial areas. The case sites of representative cluster#1 can be identified near Mallijae-ro, Cheongpa-dong, Yongsan-gu, and Hanti Station, Yeoksam 2-dong, Gangnam-gu, and the author verified the vicinity of Mallijae-ro as an example.

First, the layering of various data was performed on the case site and surrounding areas in Mallijae-ro. The site was found to have a higher LUM, a larger number of businesses and a higher percentage of aged housing than other areas. The base map and data visualization results of this case are shown in Figure 5-4.

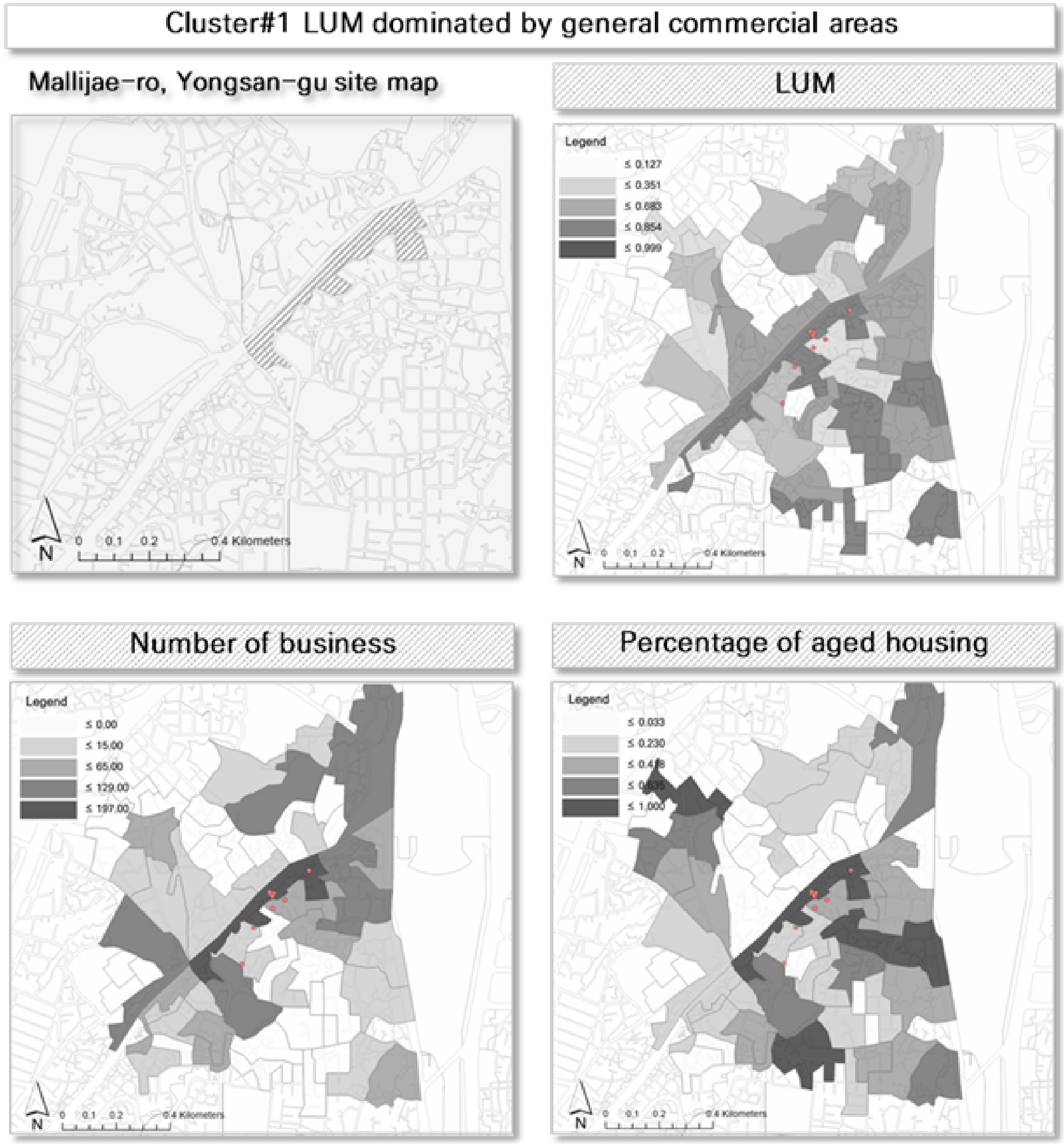

Figure 5-4. Cluster#1, Mallijae-ro site study

Next, cluster#2 shows the median value of three clusters with a LUMI. In particular, cluster#2 has a relatively high percentage of semi-industrial area of 4.01, compared with other clusters (cluster#1 is 0.64 and cluster#3 is 0.09). Along with this, cluster#2 is the only one among the three clusters that shows that the mean values of all variables in the urban-scale factor are greater than zero, so it can be defined as a case in which the middle level of LUM has been performed for various land-uses. Due to these characteristics, more than half of the census tracts selected as vacant housing hotspots belong to cluster#2 (50 of the 82 census tracts are in cluster#2).

The representative sites of cluster#2 are near Yeongdeungpo-gu Office Station in Dangsan 1-dong, Yeongdeungpo-gu, Jangseungbaegi Station in Dongjak-gu, and Sajik-dong in Jongno-gu. The author verified the data in the case of Yeongdeungpo-gu

As a result of layering various data on the Yeongdeungpo-gu site and surrounding areas, the site showed a significantly higher percentage of aged housing than other areas, and the percentage of detached houses and average age were also very high. The location of the site and the data visualization results are shown in Figure 5-5.

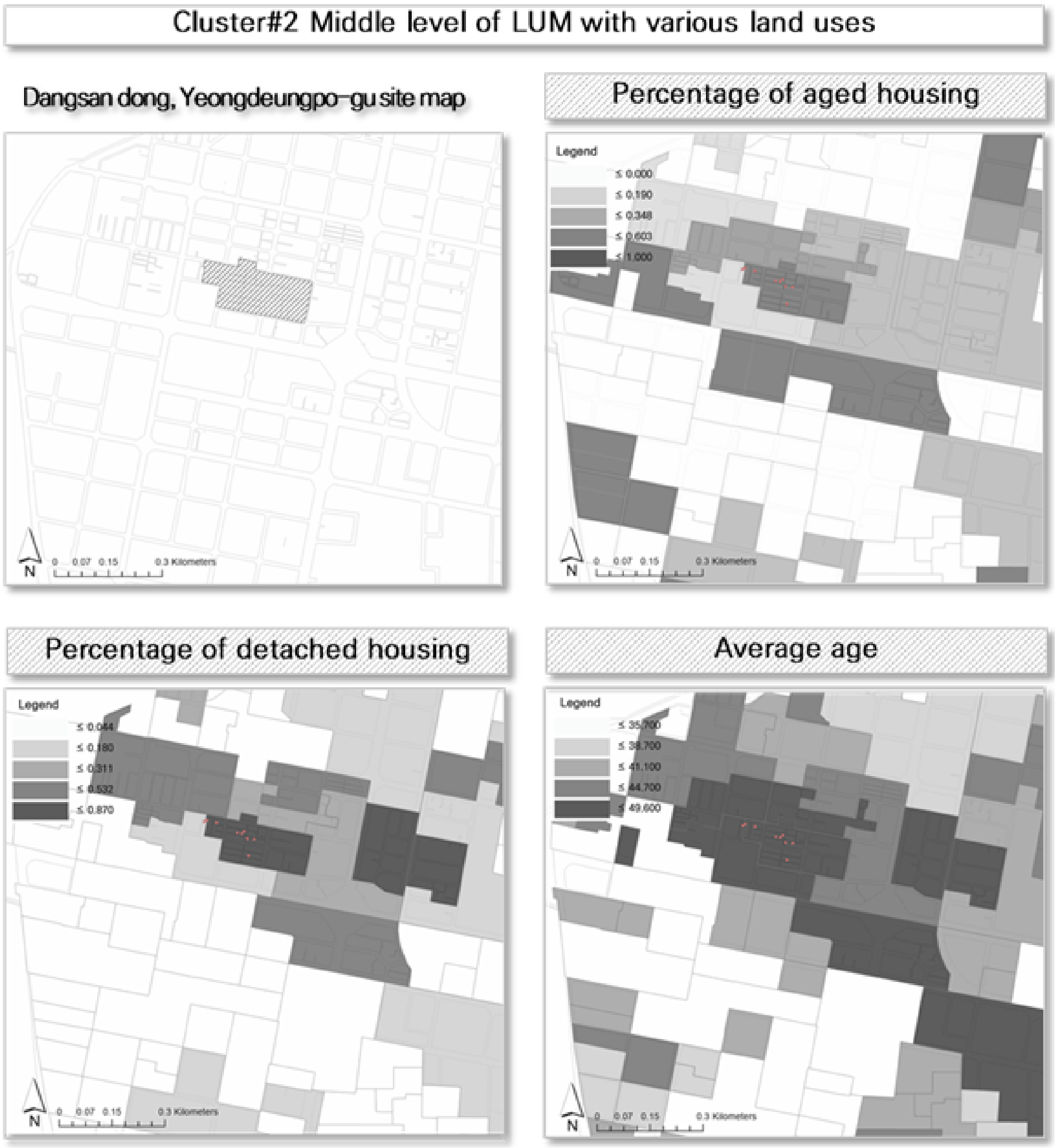

Figure 5-5. Cluster#2, Yeongdeungpo-gu site study

Last, cluster#3 has a LUMI of 0.38, the smallest value among the three clusters. In particular, cluster#3 has a relatively high percentage of second-class residential areas of 63.73 compared with other clusters (36.00 for cluster#1 and 20.96 for cluster#2). The housing density was also 118.81, which is overwhelmingly high among the three clusters (23.73 for cluster#1 and 39.19 for cluster#2). Therefore, cluster#3 may be defined as a type in which old residential areas have dominant regional characteristics. According to the characteristics of the residential areas, the number of businesses was also 9.5, the lowest among the three clusters (139.00 for cluster#2 20.96 for cluster#3).

Representative sample sites of cluster#3 include near Samyang Station in Suyu 1-dong, in Gangbuk-gu, and Omokgyo Station in Sinjeong 2-dong, Yangcheon-gu. In this present study, the vicinity of Samyang Station in Suyu 1-dong, Gangbuk-gu, was verified as cluster#3.

As a result of layering the site and its surrounding area with various data, the site was found to have higher housing density, a higher multi-family housing percentage, and the number of businesses was zero. The following figure shows the location of the site and the data visualization results.

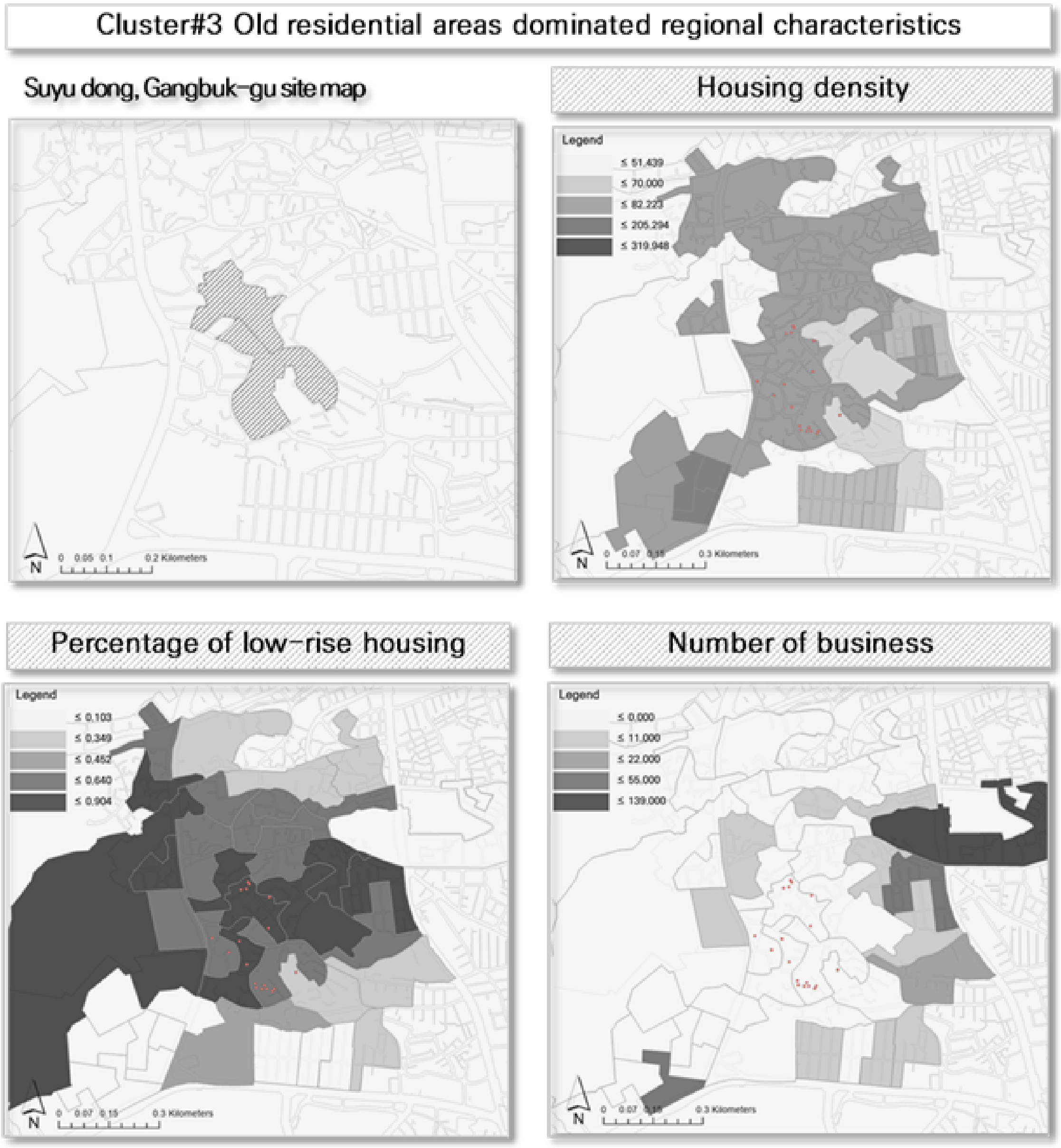

Figure 5-6. Cluster#3, Samyang Station site study

5.4. Organize ZINB analysis and verification results

Based on the ZINB analysis results, hotspot analysis, clustering analysis, and eyeballing were conducted. Through cluster analysis and verification of each of the sample sites, the cluster types of vacant housing in Seoul could potentially be largely organized into three types: a LUM of general commercial areas, a LUM of various uses excluding general commercial areas, and an old residential area.

In particular, through clustering analysis, it was possible to potentially confirm the possibility of vacant houses due to the LUM of non-residential uses, as well as vacant houses in old residential areas, which have been discussed extensively. As a result, it can be interpreted that the research hypothesis of this study is partially supported based on the results of the ZINB model analysis and hotspot-clustering analysis through verification.

Chapter. 6 Conclusion

6.1. Discussion

The purpose of the present study was to empirically examine how zoning and LUM, which are key land-use planning tools, are correlated with vacant housing in Seoul, South Korea. To overcome the MAUP of most previous studies, the author set up data at the census tract level to minimize such potential problems. The ZINB model estimated the probability of being a zero-vacant housing group and the number of vacant housing units of the non-zero group regarding land-use characteristics, such as the entropy index and the percentage of each land use as question predictors, controlling for other factors that may affect a vacant housing occurrence.

The ZINB results showed that LUM is positively correlated with housing vacancy, supporting the hypothesis that vacant housing occurrence rates tend to be higher in mixed land-use areas than in single-use areas. The coefficients of other variables also supported this tendency: the percentages of general commercial areas and semi-industrial areas, where LUM is widely allowed or even promoted and the businesses are densely located, are positively correlated with housing vacancies. In contrast, first- and third-class residential areas and natural green areas, where LUM is limited, are negatively correlated with housing vacancies, which shows that housing units are less likely to be vacant in tranquil residential environments. Zone dummies also supported this interpretation, as the downtown zone, where commercial areas and LUM are concentrated, is positively associated with housing vacancies. These results were in the same context as the verification of the ZINB analysis results through hotspot analysis and clustering analysis.

These findings imply that stable living conditions are correlated with vacant housing. Although previous studies have generally supported LUM in promoting urban vitality, LUM may play a role as an aggravating factor against the stable and tranquil living conditions of a neighborhood (Lee and Ahn, 2007; Seasons, 2014; Wu et al., 2018). This can be explained in relation to the "successful neighborhood" characteristics suggested by Alexander (1977). Successful neighborhoods are separated from other neighborhoods by clear boundaries and have features that restrict access to outsiders (Alexander, 1977). When a neighborhood's boundaries are blurred due to LUM and increased traffic from outsiders, stable and tranquil living conditions can deteriorate. Therefore, the results illustrate the countervailing effect of LUM, which may increase the number of vacant housing units while boosting urban vitality. In terms of the residential environment, LUM interferes with tranquil living conditions, which may lead to an increase in the number of vacant housing units.

Another interpretation is that commercial-based LUM blocks are generally high-density environments with narrowly pitched tall buildings that are disadvantageous to the daylight conditions of residential buildings (Kim et al., 2012; Jun and Yang, 2014). Therefore, unlike a single-use residential area, an LUM area may be relatively unsuitable for residential use, which can be explained in relation to the occurrence of vacant housing.

This can be seen in the same context as the relationship between the occurrence of vacant housing unit and LUM with general commercial or semi-industrial areas of cluster#1 and cluster#2 derived through cluster analysis. In fact, as a result of visiting cluster#1 and cluster#2 sample sites that are directly related to the research questions of this present study, the author was able to face the problem between the degree of LUM and settlement.

In general, commercial and semi-industrial areas, there is no regulation on the gap between buildings according to urban planning guidelines, so it is virtually only 0.5 m, the minimum interval in South Korea. In particular, these areas were very inconvenient to use vehicles due to the narrow street, which did not take into account the traffic volume, parking demand, and walking in the neighborhood, as blocks were divided a long time ago. The lot division also had a lot of underlots and low road access rates, making it difficult to use for reasonable land use (see Figure 6-1)

Figure 6-1. Cluster#2 and #3 sites exploration image ①

In addition, it was possible to see a number of newly developed places by combining the under-lots in cluster#1 and cluster#2 with these negative characteristics. There were many new developments in general commercial and semi-industrial areas, such as officetels, living accommodations, and urban living houses, and most of them considered only extreme profit maximize without regulations on sunlight and density and public value applied in residential areas.

In the case of Yeongdeungpo-gu, the newly built urban living house completed in 2018 was still being as unsold, and the neighborhood facilities divided into one or two stores on the ground floor were also vacant.

The vacant housing data used in the present study did not count the vacant houses newly created in this way, but it can be predicted that more vacant houses were created in cluster#1 and cluster#2. The reason why vacant houses in these clusters are continuously mass-produced is that parking environments for officetels, living accommodations, and urban living houses are not applied as residential standards, and the access roads are very narrow. In particular, urban living housing is expected to have a potentially negative impact on neighborhood settlements, as it eases the criteria for parking lots and provides incentives.

In addition, Mallijae-ro, the sample site of cluster#1, has also been designated as a general commercial area along the boulevard in the past. This shows an irrational form of land use by designating general commercial use along the boulevard without considering the lot and block.

In the case of cluster#2, materials companies and steelworks were mixed with a residential area due to the characteristics of the semi-industrial area. In some areas, it was confirmed that the odor of steelworks at a fatal level was very severe in the settlement environment of the neighborhood (see Figure 6-2).

Figure 6-2. Cluster#2 and #3 sites exploration image ②

It was confirmed that the vacant houses not only occurred due to expectations for redevelopment of old residential areas, but also the possibility that vacant houses could occur depending on the characteristics of each class residential areas. As a result of the ZINB analysis, in the case of type first- and third-class residential areas, there was a significant negative relationship with the occurrence of vacant houses, but in the case of second-class residential areas, the results were statistically insignificant.

This can be seen more specifically in the cluster analysis. In the case of cluster#3, which has the dominant characteristics of old residential areas, the percentage of second-class residential areas was very high compared with first- and third-class residential areas, and showed very high characteristics compared with other clusters.

Unlike the characteristics of a first-class residential area that is managed as a calm residential area centered on detached houses under a strict system and a third-class residential area that is managed as an apartment-oriented residential area, a second-class residential area can be interpreted in terms of the lack of systematic management as a residential area.

In particular, until recently, the seven-story height regulation had been applied to second-class residential areas under the Seoul Metropolitan Government ordinance, making it difficult to maintain or develop decent housing. In this context, it can be potentially interpreted that the occurrence of vacant houses in different patterns depends on the detailed land use of residential areas.

6.2. Policy implications

This present study suggests the potential disadvantage of LUM, which is one of the most widely applied urban planning techniques. For example, the Seoul Metropolitan Government and the MOLIT are implementing urban housing supply plans via LUM and high-density development for Seoul to stabilize the housing market. However, the present study shows the need to reexamine this plan to prevent the potential negative effects of housing supply in mixed land-use areas. More deliberate and sophisticated approaches to land use are needed in the current process of urban planning to mitigate the side effects of high-density, mixed-use developments.

In addition, strict guidelines and management of government officials are required in the process of building officetels, urban living houses, and living accommodation facilities that are used for residential purposes in areas where LUM is recommended or dominant. Rather than just a residential facility for owners' maximum profits, government officials should be directly or indirectly involved in building activities to improve the poor urban environment, induce public contributions, and improve the settlement environment of the neighborhood.

In addition, it is necessary to improve the institutional ambiguity of second-class residential areas and to consider the overall operation of second-class residential area systems.

Ultimately, urban planning and policymakers should provide measures to maintain a stable and tranquil living environment in high-density urban areas while preventing and managing long-term vacant housing and vacant

6.3. Limitations

Although this study provides insight into the influence of LUM on the occurrence of vacant housing via detailed census tract-level analysis, it has limitations, especially regarding securing census tract-level socioeconomic data. For example, land value and income data are strictly managed in South Korea due to concerns that personal information can be disclosed if census tract-level data are open to the public. If more data at the census tract level become available, it will be possible to identify the complex causes of housing vacancy more specifically and accurately at the urban-scale level.

In addition, the author conducted a cross-sectional analysis of the status of vacant housing in 2019. For this reason, there is a limitation in tracing the changes in the number of vacant housing units at each location. If time-series data on vacant housing can be obtained, it will be possible to identify the causes of vacant housing, accounting for temporal changes. Overcoming these limitations, future studies that consider the comprehensive living conditions of LUM areas will lead to various implications and solutions for resolving urban problems, such as vacant housing.

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국문초록

혼합토지이용이 빈집을 줄이는데 기여하는가? : 서울의 용도지역과 엔트로피 지수를 활용하여

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본 연구는 대도시의 빈집 발생 요인을 탐구하고 도시계획적 특성이 빈집 발생에 미치는 영향을 알아보는 것에 목적을 두고 있다. 국내의 경우 농촌 뿐만 아니라 대도시에서도 빈집 증가가 빠르게 일어나고 있어 도시적 차원에서의 빈집 발생에 대한 고찰이 필요한 시점이다. 특히 도시계획과 빈집 발생의 접점을 찾는 과정으로 여러 도시계획이론 등을 검토하면서 지역의 혼합토지이용 정도와 빈집 간의 관계에 주목하였다.

빈집문제를 다루는 선행연구는 도시쇠퇴를 배경으로 그 결과로서 빈집문제를 다루는 연구, 광역적 차원에서 빈집 발생 현상을 조망하는 연구, 빈집과 관련한 제도적 고찰, 빈집 활용방안 제안, 빈집 발생요인 분석 등 크게 5가지로 나눠 정리할 수 있었다. 이 중 대다수 빈집 발생요인 연구의 경우 빈집이 단일한 요인에 의해 발생하는 것이 아니라 복합적인 원인에 의한 결과로 해석하며, 건축적 특성과 사회경제적 특성의 틀 속에서 빈집 발생 요인을 진단하고 있었다.

따라서 본 연구는 선행연구 검토를 통해 현재 가장 작은 행정통계단위인 집계구 단위로 데이터를 구축하여 보다 정밀한 결과를 도출하고자 했다. 이와 더불어 독립변수 특성을 고려해 영과잉음이항 회귀분석을 분석모형으로 삼았다. 이를 기반으로 종속변수는 집계구 단위 빈집 수, 독립변수는 주택부문, 사회경제적부문, 도시계획부문변수로 분석의 틀을 구축하였으며, 특히 도시계획변수의 경우 서울의 주요 용도지역을 집계구 단위로 비율을 산출하고 엔트로피 지수를 활용한 혼합토지이용지수, 정비구역비율 등을 적용하였다. 추가적으로 본 모형의 결과를 검증하기 위하여 계층적 군집분석과 공간적 군집패턴 분석을 활용하여 결과의 타당성을 높이고자 하였다.

분석 결과 혼합토지이용은 빈집 발생에 양(+)의 영향을 미치는 요인으로 나타났으며, 혼합토지이용이 타 용도에 비해 권장되거나 허용되는 일반상업지역, 준공업지역 역시 빈집 발생에 양(+)의 영향을 미치는 요인임을 확인할 수 있었다. 반면 제1종, 3종일반주거지역과 자연녹지지역비율은 빈집 발생에 음(-)의 영향을 미치는 요인으로 나타났다. 이러한 결과는 후속으로 진행한 계층적 군집분석과 공간적 군집패턴 분석에서도 유사한 경향을 확인할 수 있었다.

이를 토대로 모형 분석결과에 대해 3가지 시사점을 도출할 수 있었다. 우선 빈집 발생이 상대적으로 용도순화된 정온한 정주환경에서 덜 발생한다는 점으로 해석할 수 있었다. 두 번째는 혼합토지이용으로 인한 지가 상승 등의 후속 효과로 빈집이 발생한다는 해석이 가능하다. 마지막으로 혼합토지이용이 일어나는 도시공간이 도시형태적으로 정주하기 부적합하다는 해석이 가능하다.

주요어 : 빈집, 용도지역제, 혼합토지이용, 엔트로피 지수, 영과잉 음이항 회귀분석
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