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The Impacts of Locational and Neighborhood Environmental Factors on the Spatial Clustering Pattern of Small Urban Houses: A Case of Urban Residential Housing in Seoul

Myung-Cheul Shin, Gwang-Mun Shin and Jae-Su Lee *

Department of Real Estate, College of Social Sciences, Kangwon National University, Kangwon-do 24341, Korea; smcmoin1@naver.com (M.-C.S.); taiger7878@gmail.com (G.-M.S.)
* Correspondence: jslee25@kangwon.ac.kr; Tel.: +82-33-250-6831

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Abstract: Small housing has gained prominence in the housing market due to substantial shifts of both population and household structures in Korea. The study aims to examine the spatial clustering pattern of urban residential houses (URHs) in terms of the spatial statistics, and analyze the impacts of both locational and neighborhood residential factors on the formation of the spatial clustering pattern in the Seoul metropolitan area. It is found that the URHs represent a significant spatial clustering pattern based on the census tracts. The hotspots are mostly found in the outskirts of Seoul, where the development of small houses has been concentrated for ten years. Also, both locational and neighborhood residential factors have significant effects on the hotspot formation of the URH. The hotspots are more likely to be found in areas having many available sites for development, high demand for habitation, and high expected profits from developing small residences. Another significant factor is access to public transit, amenities, and employment centers. Therefore, it is necessary to design a rent subsidy program for potential residents and to encourage the development of housing in nearby hotspots with relatively lower land values. It is also important to establish policies and strategies for planning the housing supply and managing the residential environment in low-rise residential areas.

Keywords: Urban Residential Housing; small housing; spatial clustering pattern; hotspot; one-person household; low-rise residential area; neighborhood environment; Seoul metropolitan area

1. Introduction

Due to the steady increase of unmarried and lately married households, the number of persons per household has been consistently declining in the Seoul metropolitan area (SMA). The ratio of single and two-person households to the total number of households was 33.3% in 2000, 46.7% in 2010, and 54.1% in 2015, showing a continuous growth. It is projected to increase to 67.95% in 2035; therefore, it is reasonable to anticipate that the demand for small houses will increase correspondingly [1]. Many urban areas around the world have also experienced substantial changes in both population and household structures. Due to changing trends and growing demand, small housing has attracted attention in the housing market [2].

In response to surging demand for small urban houses, shrinking residential stability, and increasing burden of housing expenses of single and two-person households in Korea, the government revised the Housing Act and introduced the Urban Residential Housing (URH) program at the end of 2009. The URH represents studio-type housing, and row housing and multi-household housing in a complex with less than 300 households constructed in urban areas Specifically, a dwelling unit of studio-type housing shall not exceed 50 m^2, while it is equipped with an independent bathroom and kitchen; both row housing and multi-household housing in a complex can be built up to five floors. It aimed to secure residential stability, residential amenities in the community, and to provide a plentiful supply of affordable small housing. The number of urban residential houses (URHs) permitted for construction in the SMA from 2009 to 2017 was 11,187 buildings and 192,638 dwelling units. The total number of URH permitted between 2009 and 2017 was 11,372 buildings based on the data provided by the Seoul Metropolitan Government (SMG); 185 buildings that were deemed redundant were not included. Since the introduction of the new housing program in Seoul, most researchers have agreed that it has significantly contributed to meeting the demand for housing for small households. However, it has been argued that housing policies and strategies need to be established to enhance the quality of residential and living environments. It has also been claimed that the housing policies are required to alleviate the burden of rents and improve the housing affordability for the households [3].

More than three quarters of total URH buildings and two thirds of total dwelling units were permitted in the general residential zones, which means that the URH has mostly been built in low-rise residential areas. In terms of the zoning system in Korea, it includes type 1 and type 2 exclusive residential zones, and type 1 and type 2 general residential zones with a limit of seven floors. They are classified as low-rise residential areas in this study when compared with high-rise residential areas, in which high-rise apartment buildings are mostly located in the SMA. It is therefore expected that the location of the housing is correlated to the spatial distribution of low-rise residential areas. Maeng et al. [4] claimed that the age of low-rise houses within the low-rise residential areas in Seoul is 26.3 years on average, and the proportion of small houses with an area of less than 60 square meters is 57.0 percent, performing a crucial role as the main places supplying small urban residences. However, from 2010 to 2016, the majority of total households residing in houses slated for demolition have occupied homes in the low-rise residential areas. During the same period, the supply of low-rise houses amounted to 51.9 percent of total housing supply [5], indicating that the quantity of small residences may be declining, threatening the residential stability of single and two-person households.

A number of studies have analyzed the characteristics and the effects of the small houses on their neighborhoods, or investigated the pricing mechanism and affordability and suggested policy implications [3,6–16]. Also, earlier studies have focused on analyzing the residential characteristics and the residential satisfaction factors of single and two-person households as the primary consumers of small urban residences [13,17–21]. They helped enhance our understanding of the factors influencing small houses, and the effects of locational and environmental factors on their prices. However, little research has been found on where they are concentrated and developed, what factors affect the spatial clustering patterns of small urban residences, how small houses influence the surrounding neighborhoods, and what can be suggested for reforming relevant policies and encouraging the provision of small urban residences.

This study aims to examine the spatial clustering pattern of the URHs in terms of spatial statistics and analyze the impacts of both locational and neighborhood residential factors on the formation of the hotspots of URH in the SMA. This research can contribute to suggestions on urban planning and urban regeneration policies to boost the development of urban small houses and revitalize decrepit residential areas. To investigate the spatial clustering pattern of the houses, a spatial database on URH permits has been established using the Geographic Information System (GIS) application.

The next section of this paper reviews the relevant studies regarding spatial clustering patterns and URHs and small-scale developments. Section 3 of this paper elaborates on the methodology, including hotspot analysis and logit analysis. Section 4 presents the results and interpretations of the development characteristics, the spatial clustering patterns, and the impacts of locational and neighborhood residential factors on the formation of hotspots in Seoul. The final section offers conclusions and implications.

2. URH Program and Literature Review

2.1. Overview of the URH Program

The URH program has been introduced to promote the supply of small urban houses by providing numerous legal, institutional, and financial incentives as shown in Table 1. The program relaxes the separation distance of the URH to the adjacent buildings by half according to the building code. It lowers the number of parking space requirements to a half parking lot per residential unit, compared to one parking lot per residential unit of an ordinary multi-family house. This is mainly related to the results of many studies arguing that one- and two-person households residing in small urban homes are favor public transportation and non-motorized modes of transport [3,9,12,13]. In addition, the URH can be approved up to seven stories based on the building code, although an ordinary multi-family house can only be built up to four stories.

The institutional supports applied to the URH program vary depending on the number of residential units approved on the site. Small development projects containing no more than thirty units of the URHs are provided with more incentives because almost all URH projects are categorized as being small development projects. They include simplified and time-saving permission procedures and construction inspections by the local government. The Housing Act also stipulates that landscaping and community service facilities for senior citizens, administration and management works, and inhabitant meetings should be secured on development sites with more than thirty residential units. However, development projects with less than 150 residential units under the URH program are exempt from, or subject to significantly relaxed enforcement of, the requirements to provide landscaping and community service facilities. In addition, the development projects for the URH units can benefit from financial support. They qualify for low-interest loans from the National Housing Fund or the Housing and Urban Fund, which have been revised since 2015 and were established to encourage the supply of affordable small to medium-sized residential units.

Table 1. Summary of legal, institutional, and financial incentives for URHs.

	URH Program	Ordinary Multi-Family House
Building code	• The distance between the URH and adjacent buildings is 0.25 times the height of the URH. • The number of parking space requirements per residential units is 0.5. • Maximum number of building stories that can be approved is 7.	• The distance between a multi-family house and adjacent buildings is 0.5 times the height of the house. • The number of parking space requirements per residential unit is 1.0. • Maximum number of building stories that can be approved is 4.
Institutional support	• The permission and inspection procedures are simpler and quicker in small projects with less than 30 units. • Both landscaping and community service facilities are not required in projects with less than 150 units.	• Conventional permission and inspection procedure is required. • Both landscaping and community service facilities are compulsory the projects with more than 30 units.
Financial support	• Developers qualify for loans from the National Housing Fund, or currently the Housing and Urban Fund, for no less than 70 percent of the total construction cost. • Developers can get these loans with relatively low interest rates.	• Do not qualify.

2.2. Review of Relevant Studies

Over past decades, many countries and cities around the world have experienced substantial shifts in both population and household structures. It is noteworthy that the proportion of elderly people to the total population has consistently increased; the number of single households has also increased, while the average number of residents per household has reduced [22]. However, the average size of a new house has been enlarged since the 1970s. People living alone have different needs from residential structures and different environmental attributes from typical families [7]. Combined with the growing burden of housing expenses due to soaring housing prices and rents in recent years, the structural changes urge us to reexamine current housing policies and planning.

Although the issue of small housing has recently received attention, relatively few studies can be found. Geffner [9] explored the benefits and challenges of alternative housing typologies (AHTs), including accessory dwelling units and micro-apartments in many cities in the United States. It was argued that small housing has gained prominence in the housing market due to changing national trends and the benefits of AHT development. On the contrary, people on the other side contended that it might have negative impacts on adjacent communities: higher density, lack of parking spaces, and an influx of undesirable populations. It was also suggested that current land use regulations based on the zoning codes hindered small housing developments. They included density regulations, parking requirements, lot and unit size limits, open space requirements, and mixed land use regulations [8,23].

According to previous studies, the advantages of small housing can be summarized as affordability, sustainability, and flexibility [9]. Affordability indicated that small housing is more affordable for low- and moderate-income households because of their small size and lack of residential amenities [24]. Small houses are considered affordable by design, which is opposite to what is affordable by subsidy [25]. Studies of diverse case areas found that small houses rented for less than typical residences in total, even though they have higher rents per unit area. It is also claimed that they have played an important role in securing affordable housing units and lowering housing costs citywide by increasing the total supply of small residences [6,7,10,23,24].

Sustainability implies that the small housing projects could contribute to a higher density of existing single-family neighborhoods, which could result in lower automobile dependence, better walkability, and better access to public transportation [9,26,27]. The White House [28] encouraged local governments to approve the development of high-density and multi-family housing in order to accommodate the growing populations in urban centers. Greenhouse gas emissions can also be reduced by enhancing energy efficiency and reducing automobile dependence in urban areas [22,29,30]. Flexibility suggests that small housing can meet the demands of a new generation of small households. Some studies found that small houses could allow many current residents to live alone, including elderly people, while relieving the burden of high housing costs [7,8,17].

Evans [2] examined the preferences and concerns around integrating small houses into urban communities located in the southeastern region of the United States. Using a visual preference survey, it was investigated how small houses should be located and what design elements would be preferred. It was found that projects specific to the small housing development and the small homes in a traditional design style were prioritized. The respondents were concerned about the potential negative effects of small houses on the surrounding property values in their communities.

Numerous studies have focused on the rents and the residential environment of the URHs in Korea. Lee and Lee [3] found that while the URH has increased rapidly within a short period, high rents compared to the income levels of potential residents have aggravated the burden of housing costs as well. Therefore, they claimed that the public's role in this system improvement should be to argue for better affordability and support, as well as a management plan for small urban houses considering their locational characteristics. Park [11] found the supply and vacancy of URHs are significantly related to their prices. Lee and Seong [12] argued that the URH plan has contributed to the increase of small houses, particularly in general residential zones and subway station-oriented areas. However, considering their high rents, the public must help alleviate the burden for residents.

Lee et al. [13] reported on the lack of residents' evaluations on the affordability and the residential environment, as the policies of the URH placed an emphasis on the efficient provision of housing. According to their survey, residents have high satisfaction regarding the internal environment (e.g., security and privacy), but relatively lower satisfaction with the external environment (e.g., parks and neighborliness), suggesting the need to improve the residential environment [31]. Lee et al. [14]

examined the effects of location factors of the URHs upon rents. They stated that mixed development policies on affordable medium-sized sites accessible to public transportation should be encouraged.

Won and Lee [15] paid attention to how the rents of the URHs were determined in Seoul using the spatial hedonic price model. They reported that factors such as net residential area and accessibilities to subway and public facilities exerted positive impacts on rents [32]. However, access to parks had no impact on rents, suggesting that one and two-person households were unwilling to put a premium on activities in open spaces. By examining the development characteristics of the URH, Shin and Lee [16] asserted that a proliferation of small-scale developments within the low-rise residential areas may result in the deterioration of the residential environment, including insufficient public facilities, breach of privacy, and more crime. Therefore, a comprehensive management plan should be made in response to expected harmful consequences.

An increase in single and two-person households and the demand for small residences are closely related, and there have been many academic achievements in Korea on this issue. Yi and Lee [19] examined the spatial characteristics and the residential environments of densely populated residential areas by the types of single households. They concluded that their residential environments were more impoverished than the average in Seoul. They stated that the public efforts to improve the residential environment in the areas were required, however, this could be a driver to augment the prices of the small urban houses. Having examined the distribution pattern of single households in Busan, Choi et al. [21] confirmed that the residential environment of one-person households was not good due to the mix of residential and nonresidential zones. They mainly resided around the downtown area, universities, and subway stations.

Lee and Lee [18] maintained that although the number of single and two-person households has been increasing, the housing stock for two-person households lacked compared to the housing stock for single households. They suggested that housing policies should consider social mix in terms of social integration due to the residential diversity of two-person households, according to their age and income levels. Lee and Yang [33] argued that it was necessary to consider a plan to encourage the provision of small urban houses in the residential areas around major centers in Seoul. Park et al. [34] examined how the different characteristics of one-person households affect housing consumption. It was found that when the number of one-person households increased, consumption of small rental houses increased; however, this was only limited to one-person households with mid to high-income ranges. After investigating the factors of single and two-person households on selecting their housing tenure, Joung and Oh [20] argued that the residential stability should be supported to resolve the issues regarding the low marriage and low birth rates of the young generation, since the housing costs played a crucial role in their decision-making.

Most studies have focused on either the effects of locational and environmental elements on the housing prices or the impacts of the attributes of the residential environment and the residents on the residential satisfaction and preference. They helped us understand what benefits the small houses could give to our communities, what factors significantly affect the rents of the small houses in terms of affordability, and what elements are more important for potential residents in terms of residential environment. However, little research has yet been accomplished on what factors have impacts on the locational pattern of small houses, even in Korea. Few empirical studies are available on the influences small housing may have on the surrounding community.

This study has significance in that it expands the scope of analysis to the entirety of Seoul rather than limited case areas to generalize our insight, and it examines the spatial clustering pattern of the URH over the decade using GIS and spatial statistical methods. It also differs from existing research in that it analyzed the impacts of locational and neighborhood residential factors on the formation of the spatial clustering pattern of the URH.

3. Methodology

3.1. Hotspot Analysis

When areas with a similar variation of quantity in spatial data, such as land and housing prices, neighbor each other, a spatial autocorrelation pattern is likely to exist. Tobler [35] has claimed that although everything is correlated to everything else, the elements closer to each other are more closely correlated than the others located farther away. One of the most distinguished characteristics of spatial data is to show the spatial autocorrelation. A spatial pattern analysis determines whether spatial data displays a specific and significant spatial arrangement. Identifying the spatial pattern is crucial since it provides fundamental information about the processes affecting their formation. There are multiple methods of measuring spatial autocorrelation using spatial data. Among them, the I index suggested by Moran [36] and the G index proposed by Geary [37] are generally used. Moran's I statistic is classified into the global statistic and the local statistic. The global Moran's I measures similarities between local attribute data and possesses a value between −1 and 1. However, it cannot distinguish between a hotspot, in which large values are clustered, and a coldspot, in which small values are clustered. In contrast, the G-statistic can distinguish between spatial concentrations of large and small values [38].

Using the statistics of Getis-Ord Gi* or Local Indicators of Spatial Association (LISA), a specific location's spatial clustering patterns and the changes can be identified. Mainly, Getis-Ord General G (General G) and Getis-Ord Gi* (Gi*) are used for the hotspot analysis in this study. General G is a global index representing the spatial autocorrelation as a single value. Using the z-test method, it tests a null hypothesis that a variable of spatial data is not spatially clustered.

Gi* calculates the z-values of the basic unit of analysis within an entire area. If the z-value of a specific unit is high and the p-value is less than the significance level, the null hypothesis is rejected. A hotspot is identified in a unit of analysis, where the z-score is statistically significant and positive. The greater the z-score is, the more intensive the spatial clustering of high values or hotspots. On the other hand, a coldspot is determined in a place where the z-score displays a statistically significant and negative value. The smaller the z-value is, the greater the spatial clustering of low values or coldspots [38–40]. The equation is as follows.

$$G_i^*(d) = \frac{\sum_{j=1}^{n} \omega_{i,j} x_i - \overline{x} \sum_{j=1}^{n} \omega_{i,j}}{SD\sqrt{\frac{\left[n \sum_{j=1}^{n} \omega_{i,j}^2 - \left(\sum_{j=1}^{n} \omega_{i,j}\right)^2\right]}{n-1}}},\ all\ j; \tag{1}$$

$$\overline{X} = \frac{\sum_{j=1}^{n} x_j}{n}, \quad SD = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\overline{X}\right)^2}$$

where i, j indicate unit of analysis; x_i, x_j are the attribute value of i and j; $w_{i,j}$ is the spatial weight between i and j; and n is the number of the unit of analysis.

In this study, the basic spatial unit for analyzing the spatial clustering pattern is the census tract presented by Statistics Korea. Using GIS techniques, the permission data of the URHs between 2009 and 2017 are converted to spatial data based on land parcel. By spatially joining the number of households of the URHs in Seoul, it has been aggregated by each census tract where it is located. The number of census tracts of the SMA suggested by Statistics Korea is 19,153 units, and the spatial clustering pattern has been analyzed using 19,061 tracts, excluding the tracts only belonging to the urban natural parks and the Han River.

The spatial clustering pattern analysis using Gi* examines if a census tract presents a statistically significant high or low attribute compared to the adjacent areas within a radius from a central census tract. First, it is necessary to decide an adequate distance for determining a neighbor, as well as a statistical confidence level. A distance band should be established to include at least one neighbor from the central unit of analysis. Based on some empirical studies, the distance showing the maximum spatial autocorrelation becomes the reference for determining it. We used the "Generate Spatial Weight Matrix" function from the ArcGIS program to perform the simulation. This is a method that examines the point at which the spatial autocorrelation is maximized by starting at 200 m linear distance from the center of each census tract and incrementing by 10 m until the point is determined. The statistical confidence level is set at 95%.

3.2. Logit Model

The logit model is used to analyze the impacts of locational and neighborhood residential factors on the spatial clustering pattern of the URHs. A logit model is a special form of regression model used when the dependent variable is in a nominal scale. It is applied when a dependent variable only results in either 1 or 0, such as in the cases of home or car ownership.

In the logit analysis, the ratio of the probability of an event occurring to the probability of not occurring is called the odds ratio. It indicates how many times the possibility of success due to a choice is higher than the possibility of failure. Therefore, the effect that the independent variable exerts on the dependent variable, in the case of a variable's odds ratio being 1, means that the difference in odds between the comparative groups is not meaningful. However, an odds ratio greater than 1 reveals that the odds of an event happening compared to the odds of it not happening increase rapidly, and if it is smaller than 1, it implies the opposite [38,41].

If x is an explanatory variable and $\pi(x_i) = P(Y = 1|x_i)$ in the logit model, the model can be defined in the linear relationship as follows [29]. In the equation, the odds increase by $\exp(\beta)$ for one-unit increment in x, which indicates that $\exp(\beta)$ is the odds ratio of the independent variable [41].

$$\log it[P(Y = 1|x_i)] = \log it[\pi[x_i]] = \ln \frac{\pi(x_i)}{1 - \pi(x_i)} \tag{2}$$

$$\log it[\pi(x_i)] = \beta_0 + \beta_1 x_1 + \cdots + \beta_i x_i;\ \pi(x_i) = \frac{\exp(\beta_0 + \beta_1 x_1 + \cdots + \beta_i x_i)}{1 + \exp(\beta_0 + \beta_1 x_1 + \cdots + \beta_i x_i)}$$

Table 2 presents the names, definitions, and data sources of both dependent and explanatory variables in this research. Two types of dependent variables are considered to estimate different logit models. Whether a place is a hotspot of the URH or a non-hotspot incorporating a coldspot and an insignificant spot is considered as a dependent variable in the first logit model. Another logit model takes account of a hotspot versus a coldspot as a dependent variable.

The independent variables of the model have been limited to those considering data available at the census tract, centering on the results of previous studies. The potential factors affecting the formation of the spatial clustering pattern can be classified as the locational factors and the neighborhood residential attributes. The locational factors are composed of accessibility to public transport, accessibility to public facilities, and accessibility to jobs, as well as the land price and the proportion of low-rise residential area. Public transport accessibility considers both subway and bus accessibility; public facility accessibility includes both college and amenity accessibility; job accessibility covers the number of jobs in the tract; the land value encompasses average land value appraised in 2017 and the rate of appraised land value change during the past five years. In addition, the neighborhood residential attributes consider the density of young people in their 20s and 30s divided by the total area, the proportion of the number of single households to total number of households, and the proportion of the number of houses over 30 years in age to total number of houses.

Table 2. Definitions and data sources of variables.

Variable			Definition	Data Source
Dependent var.	Hotspot1 Hotspot2		1 indicates hotspot, 0 indicates non-hotspot 1 indicates hotspot, 0 indicates coldspot	
			Explanatory var.	
Locational factor	Accessibility to public transport	Subway accessibility	The number of subway stations in a census tract	https://data.seoul.go.kr/
		Bus accessibility	The number of bus stations in a census tract	
	Accessibility to public facilities	College accessibility	Shortest distance from the center of a tract to the gate of nearby college (km)	Google map
		Amenity accessibility	Shortest distance from the center of a census tract to nearby amenity (km)	www.nsdi.go.kr/
	Accessibility to jobs	Number of jobs	The number of employees in a census tract in natural logarithm	https://sgis.kostat.go.kr/
	Land value	Average land value	Average appraised land value in a census tract in 2017 (1000 Korean Won (KRW))	https://data.seoul.go.kr/
		Rate of land value change	Average rate of appraised land value change between 2013 and 2017 (%)	
	% of low-rise residential area		Proportion of type 1 and 2 exclusive and general residential zones to total area (%)	https://sgis.kostat.go.kr/
Neighborhood residential factor	Density of young population		The population in the 20s and 30s divided by total area in natural logarithm	
	% of single household		Proportion of single households to total households (%)	
	% of deteriorated house		Proportion of houses over 30 years to total houses (%)	

4. Results

4.1. The Supply and Distribution Pattern of the URH

The URH plan was introduced into the revised Housing Act of May 2009. From 2009 to 2017, the number of permitted URHs in Seoul was 11,187 buildings and 192,638 dwelling units, as shown in Figure 1. The number of permitted URHs was relatively high in 2012 and 2015: 1894 buildings and 35,014 units in 2012, and 2317 buildings and 35,344 units in 2015. However, the number has declined sharply since then, especially in 2014 and 2017. The building scale of small houses is determined by the land area and the floor area ratio given under the National Land Planning and Utilization Act. Therefore, since the size per house and the number of residential units can vary according to building plans, the number of permitted buildings and units are not exactly proportional.

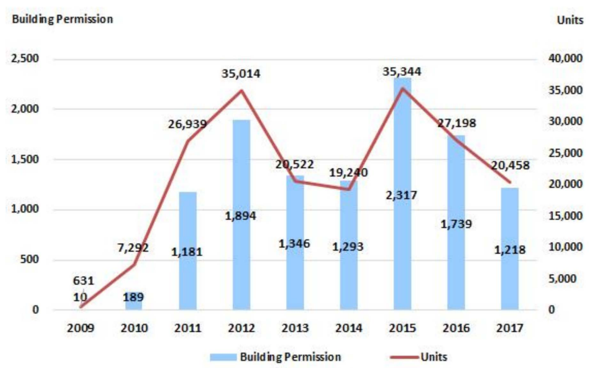

Figure 1. The number of permissions of the URH by year.

Although the permission of the URH is based on the parcel, for the sake of spatial clustering pattern analysis, permitted locations were converted to spatial information using GIS techniques. Figure 2 illustrates the locational information of all permitted URH buildings in the SMA since 2009. The URHs are more concentrated in the outskirts of Seoul compared to conventional central business districts (CBDs), such as the Downtown, Gangnam, and Yeongdeungpo districts, and even within the same district, they are concentrated within specific places. The CBDs are mostly designated as commercial zones with concentrations of large business and commercial structures, where major corporations and supporting service industries have a priority to be located compared to residences, such as URHs. Thus, there is no advantage to them occupying the downtowns in terms of locational competitiveness. Also, natural settlements without development plans have been distributed around the downtown areas for a long time. They are irregular in parcel shape and lacking in infrastructure, which results in many constraints for developing small urban houses.

The outskirts, except for the inner areas in SMA, have been developed deliberately with urban development plans since the 1960s to address the issue of an insufficient supply of residential areas due to rapid industrialization and urbanization. Many of them were developed for single and multi-family houses, with infrastructure such as roads and parking spaces [42]. The number of permitted URHs is found to be dominant in the general residential zones in Seoul. It is likely to be due to the deterioration of low-rise residential areas, where single and multi-family houses had been developed since the 1960s. It seems that URHs have been mainly built to reconstruct the deteriorated low-rise residential areas in Seoul. This will be examined later in the study.

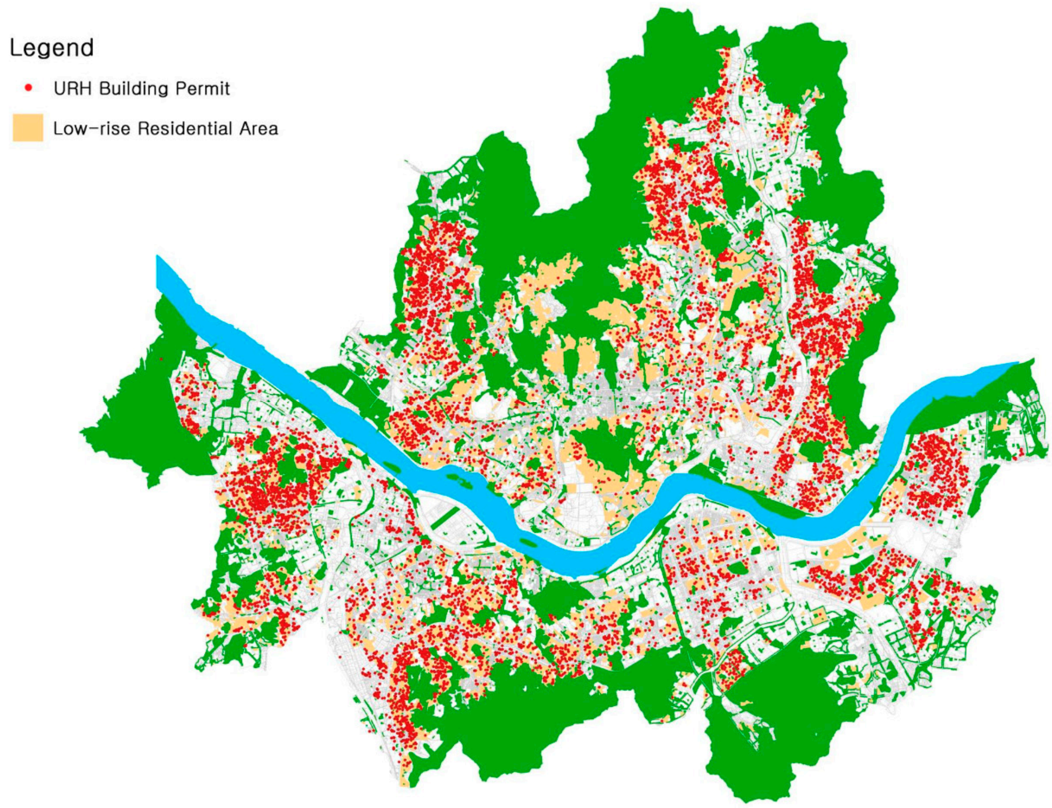

Figure 2. Distribution of the URH permits and the low-rise residential area in Seoul in 2017.

Descriptive statistics of the permitted URH buildings that was converted to spatial data is presented in Table 3. The land area is 720 m^2, and the building area is 390 m^2 on average, displaying typical characteristics of small-size urban housing development projects. The number of permitted buildings within the residential areas is 8561 cases (76.7%), and the average number of floors is 5.9, indicating that most of them have been permitted upon the low-rise residential zones.

Table 3. Descriptive statistics of permitted URH in Seoul.

	Land Area (1000 m^2)	Building Area (1000 m^2)	Total Floor Area (1000 m^2)	Parking Lot	Housing Unit	No. of Floors
Average	0.72	0.39	1.44	20.95	34.36	5.87
Standard deviation	38.23	20.91	75.93	1107.08	1815.47	1.89
Minimum	0.00	0.00	0.02	0.00	2.00	2.00
Maximum	10.97	11.75	18.75	482.00	299.00	31.00
Sum	4040.40	2209.95	8024.21	116,993	191,863	-

4.2. Spatial Clustering Pattern of the URH

In order to determine an optimal distance for the spatial clustering pattern analysis, it is crucial to consider that at least one spatial unit should be included from a spatial unit of analysis. One method applied in this study is to explore the distance from the centroid of a census tract with the reference distance of 200 m and increments of 10 m. Through the simulation, we can investigate the distance that the z-value is maximized. The result, as can be seen in Figure 3, show that at 240 and 350 m, the spatial autocorrelation is maximized.

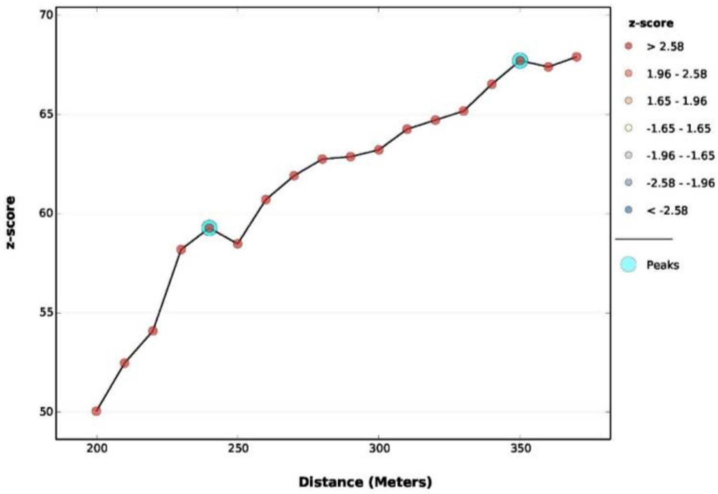

Figure 3. Simulation result showing the optimal distance being set.

From the analysis, as can be seen in Table 4, the z-score at 350 m is larger than the value at 240 m. The optimal distance was finally set at 350 m in this research to analyze the spatial clustering pattern, while including more adjacent spatial units.

Table 4. Summary of the global clustering pattern analysis.

Distance	Observed General G	Expected General G	Variance	Z-Score	*p*-Value
240 m	0.19836	−0.00005	0.00001	58.48452	0.0000
350 m	0.16621	−0.00005	0.00001	67.71605	0.0000

The result of the spatial clustering pattern analysis is shown in Figure 4. Among a total of 19,061 census tracts subjected for the analysis, there are 2962 hotspots and 1805 coldspots. It can be seen that large hotspots are formed in Gangseo-gu and some parts of the Yangcheon-gu in the southwestern subregion, Dongdaemun-gu and Seongdong-gu in the northeastern subregion, Eunpyeong-gu in the northwestern subregion, and some sections of Jungnang-gu in the northeastern subregion in the metropolitan area. The hotspots can also be observed in Gangdong-gu, Gangnam-gu, Gangbuk-gu, and Yeongdeungpo-gu.

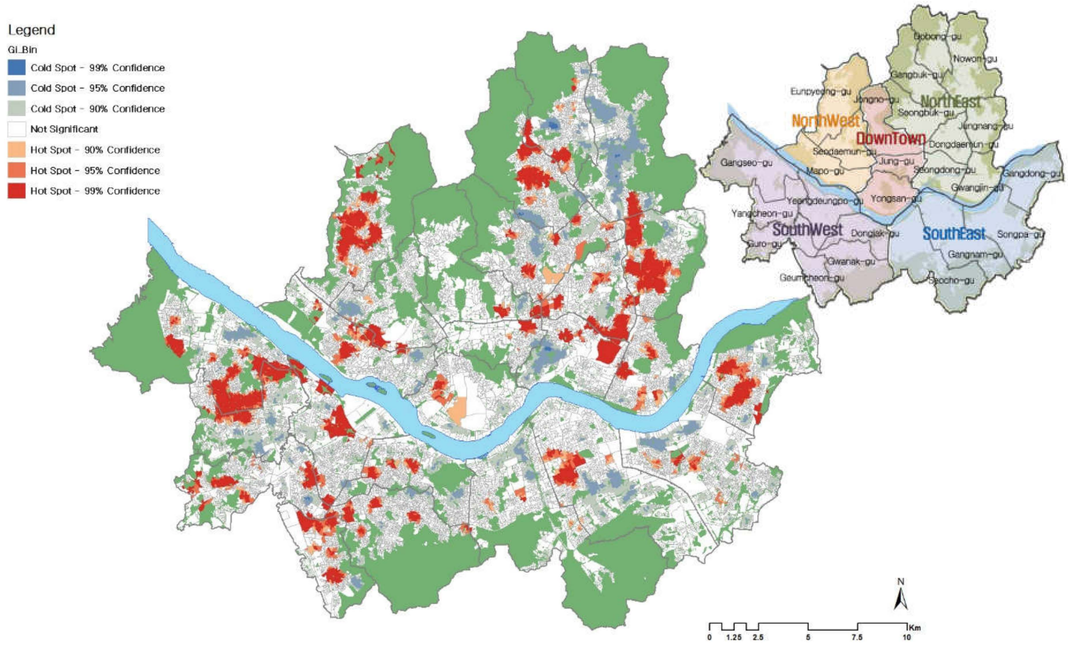

Figure 4. Local clustering pattern of the URH in Seoul (D = 350 m).

4.3. The Impacts of Factors on the Hotspot

Table 5 presents descriptive statistics of the explanatory variables for estimating the logit models. They were established to analyze the impacts of factors on the spatial clustering pattern of the URH in the SMA. As noted earlier, we consider two dependent variables with which different logit models are specified. The dependent variable of the first model is whether a place becomes a hotspot or a non-hotspot of the URH, including a coldspot and an insignificant tract. Another logit model takes account of a hotspot versus a coldspot as a dependent variable. The number of census tracts of the SMA suggested by Statistics Korea is 19,153 units, and the spatial clustering pattern has been analyzed using only 19,061 tracts, as explained earlier.

Table 5. Descriptive statistics of explanatory variables.

		Logit Model 1				**Logit Model 2**			
		Mean	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
Locational factor	Subway accessibility	0.43	0.72	0.00	7.00	0.49	0.77	0.00	7.00
	Bus accessibility	14.12	7.48	0.00	97.00	14.61	7.02	0.00	47.00
	College accessibility	1.63	1.10	0.04	7.27	1.55	0.97	0.06	5.06
	Amenity accessibility	0.57	0.34	0.00	2.67	0.57	0.34	0.01	2.67
	Number of jobs	3.35	2.30	0.00	11.05	3.45	2.20	0.00	10.23
	Average land value	3000.48	2113.36	24.60	36,960.00	2867.49	1718.01	31.50	17,315.50
	Rate of land value change	18.11	10.41	−68.00	477.63	18.82	10.57	−63.33	311.33
	Low-rise residential area	25.91	32.30	0.00	100.00	28.27	33.05	0.00	100.00
Neighborhood residential factor	Density of young population	9.21	0.84	3.88	12.51	9.40	0.66	4.80	12.51
	% of single household	29.28	17.58	2.26	91.10	31.42	18.13	2.55	89.06
	% of deteriorated house	15.75	24.82	0.00	100.00	11.58	19.32	0.00	100.00
No. of observation		15,237 in total Hotspot = 2874 Non-hotspot = 12,363				3740 in total Hotspot = 2874 Coldspot = 866			

Note: Model 1 only considers 15,237 census tracts in total. This excludes 92 tracts covered by natural parks and the river, and 3824 tracts with missing values for any one of the explanatory variables.

The results of estimating the logit models incorporating the URH hotspots in Seoul are presented in Table 6. They include the result dividing the dependent variable into hotspots and non-hotspots, covering both the coldspots and others, and the result distinctively separating the dependent variable into hotspots and coldspots.

Table 6. Results of the logit models.

Variable		Logit Model 1 ((Hotspot = 1, Non-Hotspot = 0))					Logit Model 2 ((Hotspot = 1, Coldspot = 0))				
		β	Std. err.	Wald		Exp(β)	β	Std. err.	Wald		Exp(β)
Constant		−8.907	0.421	446.866	**	0.000	−7.330	0.984	55.475	**	0.001
Locational factor	Subway accessibility	0.251	0.030	67.610	**	1.285	0.348	0.084	17.075	**	1.416
	Bus accessibility	0.003	0.003	1.140		1.003	−0.045	0.008	36.652	**	0.956
	College accessibility	0.026	0.021	1.516		1.026	0.251	0.056	20.052	**	1.285
	Amenity accessibility	0.163	0.064	6.481	*	1.177	0.854	0.175	23.929	**	2.350
	Number of jobs	0.245	0.015	275.014	**	1.278	0.478	0.031	235.720	**	1.612
	Average land value	-1.39×10^{-4}	0.000	82.164	**	1.000	-1.18×10^{-4}	0.000	12.758	**	1.000
	Rate of land value change	1.344	0.223	32.326	**	3.833	5.494	0.744	54.580	**	243.344
	Low-rise residential area	0.886	0.069	164.856	**	2.427	3.556	0.204	303.443	**	35.007
Neighborhood residential factor	Density of young population	0.628	0.041	239.548	**	1.874	0.437	0.094	21.506	**	1.548
	% of single household	1.459	0.141	106.548	**	4.303	5.185	0.389	177.950	**	178.576
	% of deteriorated house	−0.915	0.132	48.273	**	0.400	−0.804	0.263	9.370	**	0.448
No. of obs.		15,237					3740				
Cox and Snell R^2, Nagelkerke R^2		0.082, 0.132					0.345, 0.521				

Note: * $p < 0.05$, ** $p < 0.01$.

While focusing on the result of the first logit model, we can describe how both locational and neighborhood residential factors influence formation of the URH hotspots as follows. First, between the two variables of accessibility to public transportation in the locational factor group, subway accessibility only represents a significantly positive impact upon hotspot formation. At the end of 2017, the subway lines consisted of line 1 to line 9, with six metropolitan connecting routes and one light rail line in the SMA, which adds up to 16 lines and approximately 681 stations. It indicates that with higher accessibility to public transportation, especially subway accessibility, the probability of being a hotspot becomes higher, by catalyzing the development of small houses suitable for catering to the needs of transit-oriented single and two-person households. However, bus accessibility is not statistically significant. It suggests that having many bus lines available for residential areas does not guarantee the active development of small urban houses. On the other hand, the second logit model shows that bus accessibility is found to be significantly negative. It implies that having many bus lines in the residential area may exert adverse effects on hotspot formation, e.g., pollution, noise, and accidents, which discourages the development of URHs.

Second, amenity accessibility has a positive influence on hotspot formation. It means that the more available amenities exist in the residential area, the more it will induce the development of URHs, leading to a hotspot. However, college accessibility is statistically insignificant, which indicates that the development of small urban houses for students around campuses has not yet been optimized. On the other hand, the result of the second model suggests that accessibility to colleges exerts a significantly positive effect. There is a total of 95 colleges in the SMA. The second result implies that there is a possibility that the development of URHs for students is concentrated around campuses. It also found that accessibility to jobs acts positively on the hotspots of small urban houses. This indicates that URHs have been developed with concentrations around the downtowns, having high employment accessibility in Seoul. Higher demand of young single and two-person households for small urban houses to enhance employment opportunities and accessibility to workplaces results in the concentration of URHs.

Third, the two variables regarding land value are both statistically significant; however, they have adverse effects. Average land value shows a negative yet minute influence on the hotspot formation of small urban residences, meaning that the higher the average land value is, the more it acts as an obstacle to the development of the URH. This can be understood because high land value increases the cost of housing development, while lowering the economic validity. On the other hand, the rate of land value change exerts a substantial positive impact on the hotspot formation of small urban houses. Our expectation of development profits gets higher in the areas with a high rate of increase in the land value, which promotes the development of URHs, including financial and institutional incentives. They are consistent with the outcomes of the second logit model.

The proportion of low-rise residential areas also displays a positive effect on shaping the hotspots. As the ratio of low-rise residential areas grow higher, it becomes more likely that URHs will be densely developed in areas in which a hotspot of small urban houses exists. According to Shin and Lee [16], both high-density and high-rise developments have not been permitted in Seoul where the number of floors in the low-rise residential zone has been stipulated by the planning ordinance. URHs have been mostly developed in general residential zones, helping to confirm that they are closely linked with low-rise residential areas, as shown in Figure 2.

Fourth, although the three variables in the neighborhood residential factor group are all statistically significant, they show different impacts on the hotspot formation of URHs. First, the density of the young population positively influences formation of hotspots. A high percentage of residents in their 20s and 30s indicates that the demand for small urban residences is high. In the areas where the major consumer group dominantly resides, the development of URHs is more likely to be concentrated, leading to a hotspot. The ratio of single households also plays a positive role in creating a hotspot. In the residential areas with a high number of single households, there is a high demand for small residences for them, and the potential for small residences to be developed is high to meet the demand. Lee and Seong [12] claimed that the proportions of single households in their 20s and 30s were 25.7% and 25.0%, respectively; therefore, the higher the ratio of single households, the greater the likelihood that URH development is promoted.

The proportion of deteriorated houses has a significantly negative effect on hotspot formation. It was initially expected that the higher the ratio of decrepit housing, the greater the demand for new housing development would be, resulting in a hotspot of small urban houses. However, it can be disputed by two findings. The first is that the old residential areas with a high ratio of decrepit houses are more frequently inhabited by three- and four-person households and aged households than by single and two-person households. They do not have a high percentage of small urban housing, and elderly households do not favor new developments replacing the existing houses, which results in a negative relationship between them. The second reason is that the ratio of decrepit houses and the supply of URHs are in a reciprocal relationship. When a URH is built in an area in which decrepit houses are largely located, the proportion of decrepit houses declines naturally. The lower the supply of new small houses in a residential area is, the more likely it is that decrepit residences are maintained, resulting in a high ratio of decrepit residences.

Finally, in terms of comparing the odds ratio between the explanatory variables in the first model, that of the proportion of single households is the highest. The rate of land value change, the proportion of low-rise residential area, and the density of the young population are also relatively high. It indicates that these variables have a comparatively high magnitude of impact on the hotspot formation of URHs. The ratio of single households and the density of the young population are positively correlated with the demand for small urban houses. The rate of change in land value means a greater expected profit for housing developers. The ratio of the low-rise residential area indicates the site in which small houses can be developed. In other words, it is more likely that the URH hotspots are in areas where there are many sites for development, high demand, and high expectation of profits from the URHs. In addition, the higher the accessibilities to subways and amenities, and the more opportunities for employment, the more likely the area is to be developed for small urban housing.

5. Conclusions and Implications

It has been a decade since the introduction of the URH program that aimed at securing residential stability, improving amenities in residential environments, and providing affordable small urban housing for single and two-person households. Focusing on the URH in Seoul, this research intends to analyze the development characteristics and spatial clustering patterns of URHs. The study also aims to examine the impacts of various locational and neighborhood residential factors on the hotspot formation of URHs and to propose policy implications. The major findings of this study can be summarized as follows.

First, the number of permissions for URHs from 2009 to 2017 was 11,187 buildings and 192,638 residential units. The URHs are more frequently distributed in the outskirts compared to the conventional downtowns and are mostly located in the general residential zones. This is mainly because they play a major role in renewing low-rise residential areas that have been deteriorated during the urbanization process from the 1960s onwards in SMA.

Second, the URHs represent a meaningful spatial clustering pattern when they are aggregated by census tracts as the spatial unit of analysis. The hotspots for URHs are found to be similar to the areas in which the housing developments have been concentrated for ten years. However, the places in which high-rise and multi-family houses (such as apartments) are mainly observed are more likely to be the coldspots.

Third, both locational and neighborhood residential factors have significant impacts on URH hotspot formation in Seoul. Among the locational factors, accessibility to subway stations, amenities, and jobs play significantly positive roles for building up a URH hotspot. Variables regarding land value significantly influence hotspot formation. Average land value shows a negative effect; however, the rate of land value change displays a strong positive impact on hotspot formation. The proportion of low-rise residential areas has a strong influence on forming hotspots, implying that URHs are likely to be concentrated in low-rise residential areas in Seoul. Among the neighborhood residential attributes, both the density of the young population and the ratio of single households significantly contribute to the concentration of URHs.

On the other hand, the proportion of decrepit houses shows a negative effect on hotspot formation. To summarize, the URH hotspots are more likely to be built in areas having many available sites for development, high demand for habitation, and high expected profits from development of housing. It is also important to secure higher accessibility to subways, amenities, and employment centers.

Some policy implications can be suggested as follows. Above all, the places with distinct spatial clustering patterns of small urban houses, such as areas adjacent to subway stations and employment centers, are expected to have higher rental costs compared to other places. This means that single and two-person households residing in Seoul are more likely to live in areas with relatively higher rents. Thus, it is necessary to propose a rent subsidy program in order to increase affordability for single and two-person households. It is also needed to consider a policy to encourage the development of URHs in nearby hotspots with relatively lower land values.

Second, URHs have mostly been developed in low-rise residential areas in the SMA, i.e., the general residential zones with sites available for development. The pressure toward the development of URHs is expected to continue in these areas in Seoul, mainly due to the relaxation of building codes and institutional support. However, development projects for URHs in the SMA have only been based upon individual lots, which suggests that they do not consider providing public amenities and infrastructure, mainly due to economic feasibility. The community plans established by both the metropolitan and the local governments do not take them into account. Thus, it is expected that the residential environment will deteriorate due to the lack of roads, parks, and parking spaces. Therefore, it is crucial to establish policies and strategies for planning the housing supply and managing the residential environment in the low-rise residential areas.

Third, the fact that the URH hotspots in Seoul are meaningfully influenced by the land value, the rate of land value change, and accessibility to amenities indicates that the clustering pattern of small urban houses relies on regional characteristics. Therefore, it is necessary to establish detailed planning criteria and management guidelines considering the features of supply and demand for small urban housing in these places. It is further required to consider establishing a comprehensive plan for each autonomous borough, including regulations and incentives for floor area ratio, standards for parking lots, and improvement of the residential environment.

This research only pays attention to the spatial clustering pattern and the factors affecting the pattern of URH locations in Seoul. More research is required on how small urban houses are spatially expanded and concentrated in urban areas, and how the accumulation of small houses influences the surrounding communities in terms of the residential environment and satisfaction. More studies are also needed on how the rents of small urban houses are determined and what factors affect the residential choice of single and two-person households.

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