

## Article

# Spatial Analysis of Abandoned Houses and Their Influencing Factors in South Korea

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**Abstract:** The number of abandoned houses is rapidly growing across South Korea. The increasing number of abandoned houses is directly linked to a wide range of problems in communities, such as apprehension about crimes. This study aimed to analyze the variables that affect housing abandonment empirically. First, we analyzed the status of housing abandonment in various regions based on the addresses of the abandoned houses. Second, we identified the spatial characteristics of abandoned houses through spatial autocorrelation analysis. Third, we selected variables based on the literature review and analyzed the factors affecting housing abandonment through spatial regression analysis. Lastly, we aimed to explore the correlation between regional characteristics and the occurrence of housing abandonment, and to derive the factors influencing housing abandonment. This study found that abandoned houses were more likely to occur mainly in areas with environmentally vulnerable features. In this study, neighborhood environmental factors that promoted the occurrence of abandoned houses were derived by considering the neighborhood-level unit of analysis.

**Keywords:** abandoned houses; spatial characteristics of abandoned houses; environmentally vulnerable places



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## 1. Background and Purpose of the Study

The number of abandoned houses is rapidly growing across South Korea. According to Statistics Korea, the number of abandoned houses nationwide increased from 980,000 in 2018 to approximately 1,518,000 in 2019, which accounted for about 8.4% of the total number of houses [1].

The increasing number of abandoned houses is directly linked to a wide range of problems in communities, such as apprehension about crimes [2], escalation of fear among local residents, high likelihood of an old abandoned building collapsing, high risk of fire or arson [3,4], growing concern about public sanitation due to the accumulation of trash [5], diminishing cityscapes, and people's aesthetic views. Against such a backdrop, the central and local governments are taking a greater interest and expending more effort in actively maintaining abandoned houses and minimizing the social cost resulting from the growing number of abandoned houses.

The causes of housing abandonment vary, making it hard to pinpoint one particular factor. Therefore, it is necessary to determine regional characteristics. Currently, housing abandonment in Korea is observed almost everywhere, regardless of the population fluctuation [6]; thus, studies are underway to identify the causes of housing abandonment and to establish preventive measures.

In response to the recent increase in abandoned houses, the central and local governments have strived to establish and improve policies related to housing abandonment. To maintain and manage abandoned houses and properties in rural villages, the government passed the Rearrangement of Agricultural and Fishing Villages Act in 1994 and the Act on Promotion of Improvement of Rural Housing in 1995. As the number of abandoned houses began to increase in urban areas, pre-existing laws were revised into the Building Act in 2016. In 2017, the government passed the Special Act on the Maintenance of

Abandoned Houses and Small Houses, which led to each local government's enactment of ordinances related to housing abandonment. The Special Act on the Maintenance of Abandoned Houses and Small Houses represented the first enactment of law as a measure to systematically manage abandoned houses, and was significant in that it intended to not only recognize housing abandonment as an urban problem, but also to efficiently counter this problem. Nonetheless, the law has its limitations in resolving the fundamental problem due to its emphasis on the implementation of small-scale housing maintenance projects through demolition [7].

This study approached this issue from a systematic and comprehensive perspective, with the intention to empirically analyze the variables that affect housing abandonment by examining such occurrences as spatial phenomena. To this end, we established the following objectives. First, we aimed to analyze the current status of housing abandonment in various regions based on the address data of the abandoned houses. Second, we aimed to identify the spatial characteristics of abandoned houses based on spatial autocorrelation analysis. Third, we aimed to select variables based on the literature review and analyze the factors affecting housing abandonment through spatial regression analysis. Lastly, we aimed to explore the correlation between regional characteristics and the occurrence of housing abandonment, and to derive the factors influencing housing abandonment. Based on the results, it was possible to extract potential concentration zones of abandoned houses. Outlining potential problem areas is expected to help form a sustainable community and result in preventive measures to counter the effects of factors that lead to the abandonment of houses.

## 2. Methods

### 2.1. Scope of Study

In this study, we selected the entire province of Gyeongsangnam-do in South Korea as the spatial scope of the research. As a temporal scope, we selected the number of abandoned houses between 2017 and 2019 (6021 houses in 2017; 7843 houses in 2018; and 11,966 houses in 2019). With regard to the scope of the research content, we decided to analyze the variables that affected the abandonment of 11,966 houses between 2017 and 2019. In this study, the term “abandoned house” refers to a private family house that has been abandoned for over a year. To acquire data on abandoned houses, we used the data collected by 18 local governments on the addresses of abandoned houses in Gyeongsangnam-do. The data from Statistics Korea included abandoned apartments that were on the market for sale. Apartment vacancy is caused by unsold housing. However, abandoned detached houses have various implications and can adversely affect the entire community. Therefore, factors that lead to detached houses being abandoned to form a sustainable community warrant urgent investigation. Considering that vacant apartments are generally intended for sale, we decided such vacancies differed from those of private family homes.

### 2.2. Method of Study

In this study, we analyzed the distribution of abandoned houses and the variables affecting the occurrence by using a spatial regression model on 11,966 abandoned houses in 308 submunicipal-level divisions (eup, myeon, and dong) and 18 municipal-level divisions (cities and counties) in Gyeongsangnam-do.

First, we examined the distribution of abandoned houses to understand the reality of housing abandonment. We constructed data by transforming the addresses of abandoned houses into spatial variables. Based on this, we checked the distribution and the regional clustering of housing-abandonment phenomena. We identified the exact locations of abandoned houses using the geographic information system (GIS) program and identified the degrees of dispersion using a heat map.

Second, we used the main variables that were selected, after determining the status of an abandoned house, by setting a buffer centering on the boundary to measure the distance

between the spatial variable and the abandoned houses. To measure the distance between the main variable and the abandoned houses, we used the GIS program.

Third, to identify the variables affecting the occurrence of housing abandonment, we performed a spatial regression analysis. Because abandoned houses and the surrounding areas can have mutual influence, spatial autocorrelation can be detected. We used the spatial regression model to increase the reliability of the statistical estimations because general regression models do not take autocorrelation into account and can produce distorted results. Prior to the analysis, we measured Moran's I and local indicators of spatial association (LISA) to determine the presence of spatial autocorrelation and its goodness of fit with the spatial econometrics model. After reviewing the ordinary least squares (OLS) regression model, spatial lag model (SLM), and spatial error model (SEM), we selected SEM as a suitable research model. To analyze the spatial regression model, we used GeoDa software shown as Figure 1.

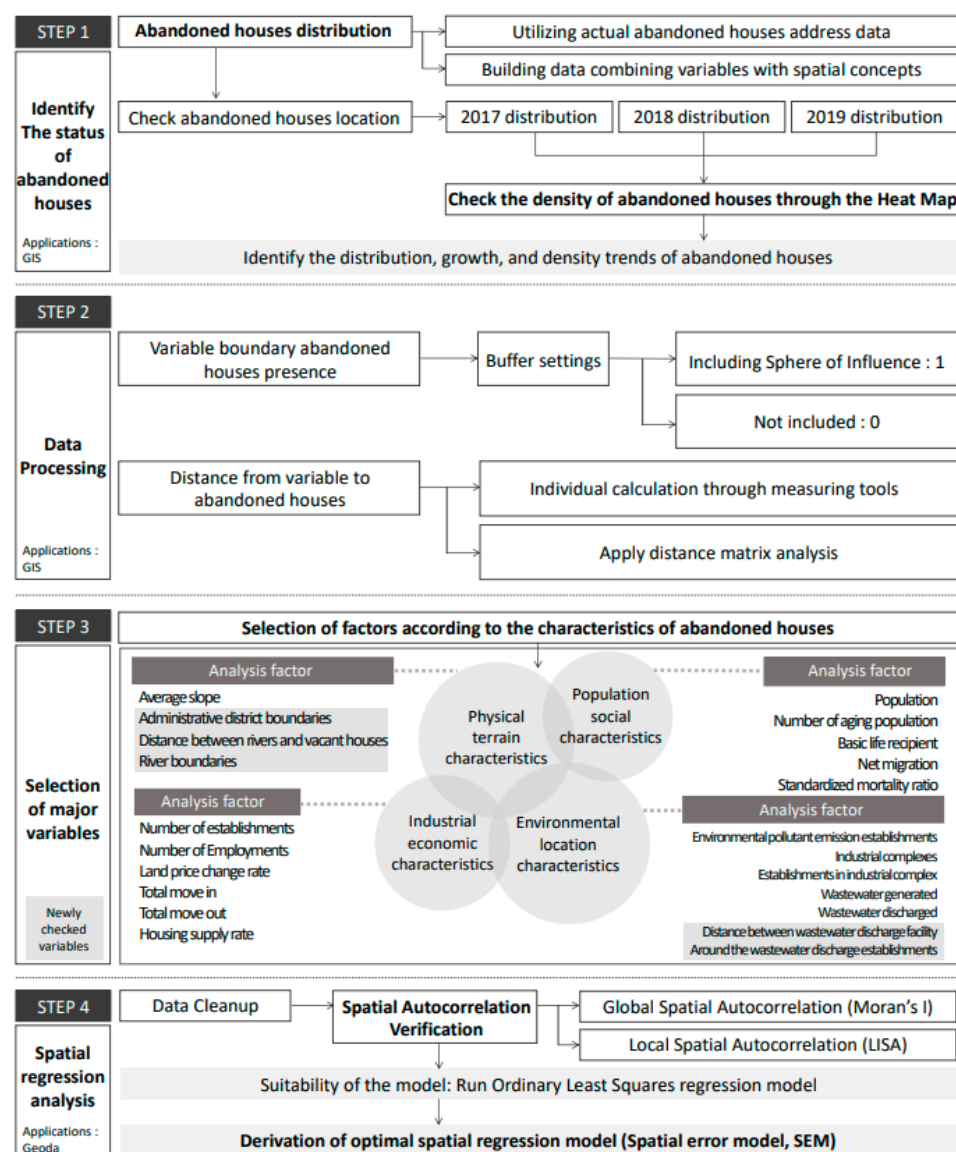


Figure 1. Study method and flowchart.

### 3. Literature Review

#### 3.1. Study of the Housing Abandonment

Housing abandonment may result from the imbalance between supply and demand due to the oversupply of housing [8,9]. When the supply of housing exceeds the demand, consumers filter the housing options. This improves the quality of housing, slowly neglecting low-competitive housing in this process. When new housing is supplied in a large quantity with no change in demand, not only the housing with low marketability, but also defective and deteriorated housing also will become abandoned. Such a phenomenon is not limited to one region [10].

Sociodemographic factors are often mentioned as major causes of housing abandonment. A decrease in population is later manifested in a decrease in the demand for housing within a region. In the same vein, we can examine the population structure of a large proportion of older people who have difficulty maintaining their homes. In the absence of a successor after their death, their houses may become abandoned. Moreover, population structure and lifestyles also change with time, and people nowadays do not prefer to live in old downtown areas. Such change is another cause of housing abandonment [11–13].

Some studies examined the physical and environmental characteristics as causes of housing abandonment. The physical deterioration and structural hazards of the residential building inhibit the usability of the building, discourage the homeowner from maintaining the property, and lead to the abandonment of the building [8]. Housing also becomes abandoned due to environmental defects such as confined building lots and crumbling infrastructure. Many unauthorized buildings in run-down urban districts in Korea are highly likely to be abandoned because there are limitations in terms of remodeling, demolition, and expansion [10]. Similarly, spatial and structural characteristics are also mentioned as causes of housing abandonment. The likelihood of a house becoming abandoned increases when the accessibility is poor due to a high elevation, a steep slope, or long distances to facilities in the neighborhood such as elementary schools and convenience stores.

#### 3.2. Study of the Causes of Housing Abandonment

Housing abandonment is not the result of one particular factor, but instead is attributed to multiple reasons.

Morckel [14] and Immergluck [15] studied crowded spaces and their patterns, reporting a high probability of housing abandonment in areas packed with low-income and impoverished groups of people. They asserted that housing abandonment has a cluster effect, since it is often also observed in neighboring areas with a high rate of housing abandonment. Silverman et al. [4] studied the distribution pattern of abandoned houses in Buffalo, NY, USA, and carried out a simulation by placing hospitals, colleges, and universities on the outskirts of the area with a high ratio of housing abandonment. The result of the simulation showed that the placement effectively controlled the dispersion of housing abandonment by encouraging public and private investment in the area. Jung and Jun [16] analyzed the spatial pattern and autocorrelation of increasing housing abandonment across Korea over 10 years, from 2005 to 2015. Using a spatial lag model, they discovered that 40.6% of housing abandonment in one area was attributed to the increase of housing abandonment in a neighboring area, and that the rate of housing abandonment increased when there was a decrease in the ratio of women of childbearing age, elderly population, new housing, and new housing supply.

Bassett et al. [17] found the cause of housing abandonment in economic and social factors in the region. To identify the variables that affected housing abandonment in Flint, MI, USA, they created three categories for the variables that affect the depreciation of real estate and the property owner's decision making as follows: economic institutional, social cultural, and environmental physical variables. Based on the results of their analysis, they asserted that the main causes of housing abandonment include race, closure of schools, change in the neighborhood, and large debt. Molly [18] reported that housing abandonment is affected by an increase in the unemployment rate, poverty of the household, and

foreclosures. Kamata and Kang [19] conducted a comparative analysis on the regional characteristics attributed to housing abandonment in Japan and Korea by examining the condition of housing abandonment in terms of nationwide, major city, urban, and rural areas. Unlike Japan, housing abandonment was observed less in areas with a large number of women of childbearing age, great fluctuation in population, and a high number of businesses and employees. As for Japan, the construction of new housing was found to affect the increase of housing abandonment. Kim and Kim [20] categorized the types of housing in Gwangju Metropolitan City, Korea, and analyzed the effect of population and housing variables on the change in the housing abandonment rate. The results of their analysis revealed that the rate of housing abandonment increased in the area with a greater number of run-down houses, a larger population of older adults, and a higher number of young adults. They mentioned share-house and multifamily housing as a cause of increases in housing abandonment. Lee's [10] study investigated the cause of housing abandonment in a microscopic space of administrative and neighborhood units in the original urban center of Incheon Metropolitan City, Korea, by extracting the variables that affected housing abandonment and examining the impact of each variable. The result of a multilevel regression analysis showed the following: housing abandonment was influenced by the site area, shape, and proximity to major roads among the housing variables in Level 1; the slope and the ratio of houses in designated urban redevelopment areas among the neighborhood variables in Level 2; and the ratio of older adults living alone among the region variables in Level 3. In doing so, the author proved that the residents' vulnerable socioeconomic status and the housing market condition caused people to abandon their houses. Kim et al. [21] also categorized regional characteristics in terms of nationwide, urban, and rural areas and analyzed the impact of regional characteristics on housing abandonment. The result of the analysis revealed the following: in urban areas, housing abandonment was influenced by population, the ratio of older adults, the ratio of women of childbearing age, the building age, and accessibility; while in rural areas, housing abandonment was influenced by population variables, building age, and the number of businesses. In the nationwide area, a wide variety of factors contributed to housing abandonment. They concluded that the speculated determinants for housing abandonment greatly varied from one region to another. Lee and Lim [22] selected 258 submunicipal divisions in Jeonju Metropolitan City and in urban–rural complex areas in Jeollanam-do and Jeollabuk-do provinces in Korea, and analyzed the variables of housing environment that affected housing abandonment in terms of economic, social, and environmental factors (i.e., safety, public sanitation, convenience, and comfort). The results of the analysis showed that housing abandonment was affected by the ratio of recipients of the National Basic Living Security Allowance, the ratio of the elderly population, and the ratio of houses older than 30 years. Noh and Yoo [23] used the data from Statistics Korea and analyzed the variables of housing abandonment in the nationwide area, Seoul Metropolitan Area, five metropolitan cities, and provincial regions. They discovered that an increase in the new housing ratio and the old housing ratio was found to influence the housing abandonment in all areas. By contrast, an increase in the number of households and employees exerted the reverse impact on housing abandonment throughout the country. The housing sale price index had an impact only in the metropolitan area and in the five major metropolitan cities, while the increased ratio of the elderly population had an impact only in the provincial regions.

Several scholars viewed physical and environmental factors as the main cause of housing abandonment. A well-known study conducted by Sternlieb et al. [24] examined the environmental and behavioral variables that affected housing abandonment in Newark, NJ, USA, and argued that the occurrence of housing abandonment was attributed to many social variables and some physical variables, such as building maintenance, the ratio of abandoned houses in the area, and the status of residence. Scafidi et al. [25] asserted that the physical housing condition determines the likelihood of housing abandonment. Morckel [5] analyzed the impact of neighborhood condition on housing abandonment in Columbus and Youngstown, OH, USA, and argued that the characteristics of a neighborhood, such as



physical condition, housing market, and gentrification, affected housing abandonment, with each characteristic having a different impact depending on the region. Hiller et al. [26] identified many cases of housing abandonment in an area with a large elderly population in Philadelphia, PA, USA, and asserted that the structure or the scale of houses and sites, physical and functional defects, and the location of houses impacted housing abandonment.

Kim et al. [7] analyzed the effect of neighborhood variables on housing abandonment in 16 districts in Busan, Korea. The results of the analysis revealed that housing abandonment was more likely to occur in areas with a low-density general population and a high-density elderly population, and that were far from major commercial districts and large-scale retail stores, and far from the highway interchanges. To identify the area-specific variables influencing the occurrence of housing abandonment, Kim et al. [27] selected 424 dongs in Seoul as the target area and added the variables related to redevelopment or reconstruction, in addition to those related to the decline of the region. The results of the analysis revealed that there was a comparatively higher number of dongs where housing abandonment was affected by the variables related to the urban redevelopment project and the variables related to the decline of the local industry. Park and Oh [28] analyzed the spatial pattern and causes of housing abandonment in Daegu Metropolitan City, Korea, using socioeconomic and physical characteristics of individual buildings. The logistics regression analysis results revealed that the probability of housing abandonment increased when the building was characterized by a small area, was situated on a low floor level, was old, was located in a redevelopment area, had a low rate of population growth, and had a low ratio of the elderly population.

There have been efforts in policy and research to resolve the problem of housing abandonment. The Korean government recognizes the seriousness of the problem, and is working to improve government-level abandoned house management policies and systems. In 2017, the “Act on special cases concerning unoccupied house or small-scale housing improvement” was enacted, and each government-enacted ordinance related to abandoned houses. Nonetheless, most research about abandoned houses is based on aggregated data considering the unit of city, county, and district, or data on abandoned houses from Statistics Korea. Because overlapping variables were used in the analyses, the research was limited in identifying the exact cause of housing abandonment. In fact, there are various causes, and one specific variable cannot be blamed for housing abandonment. Therefore, it is necessary to scrutinize other factors by focusing on regional characteristics.

Based on the review of previous studies, we discovered a wide array of causes of housing abandonment, including demographical, social, economic, and personal variables. In this study, we took into account the environmental characteristics as a probable cause of housing abandonment, and examined the environmental and geographical characteristics in depth, distinguishing this study from other related studies.

#### **4. Distribution of Abandoned Houses in Gyeongsangnam-do**

##### *4.1. Distribution and Density of Abandoned Houses*

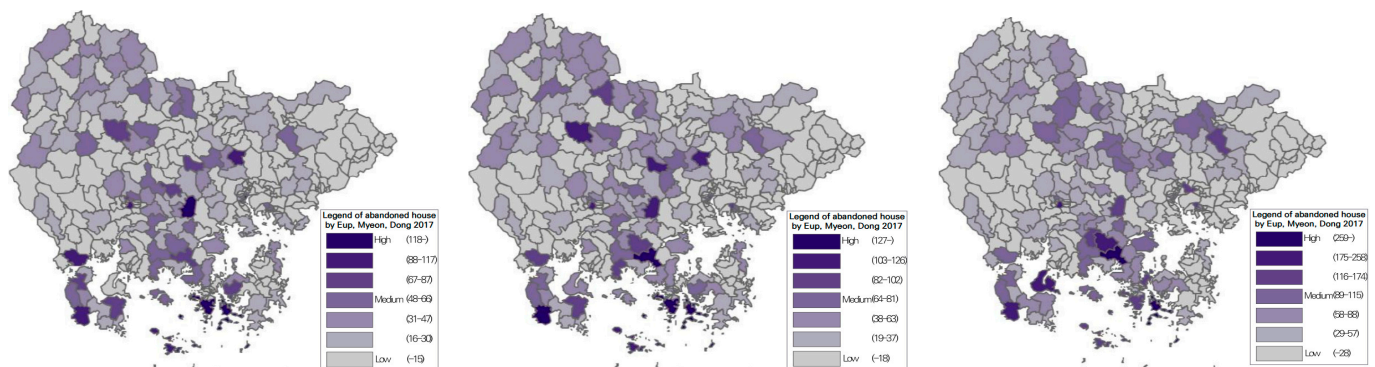
The number of abandoned houses in Gyeongsangnam-do steadily increased from 6021 in 2017 to 7843 in 2018 and 11,966 in 2019. To check the condition of housing abandonment, we analyzed using the unit of submunicipal divisions shown as Table 1.

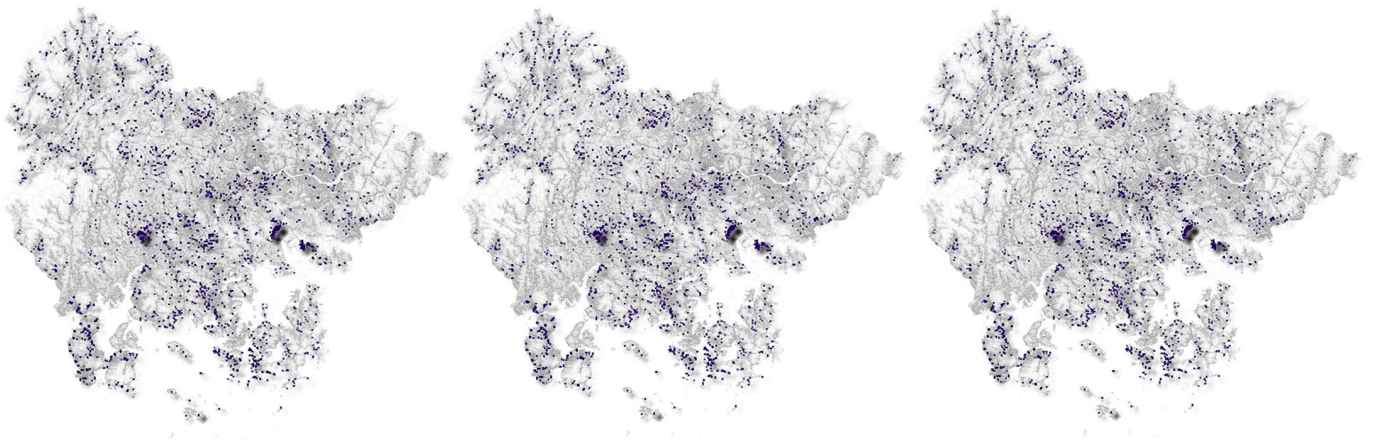
**Table 1.** Abandoned houses in Gyeongsangnam-do.

| Administrative Division | 2017             |  | 2018             |  | 2019             |  | Changed Ratio of Abandoned Houses Compared to the Previous Year |
|-------------------------|------------------|--|------------------|--|------------------|--|---|
|                         | Number of Houses | Ratio of Abandoned House to Total Number of Houses | Number of Houses | Ratio of Abandoned House to Total Number of Houses | Number of Houses | Ratio of Abandoned House to Total Number of Houses |   |
| Changwon-si             | 858              | 0.257  | 986              | 0.287  | 1250             | 0.353  | 1.1   |
| Jinju-si                | 903              | 0.786  | 967              | 0.814  | 1180             | 0.949  | 2.3   |
| Tongyeong-si            | 545              | 1.111  | 725              | 1.419  | 1278             | 2.314  | 2.1   |
| Sacheon-si              | 127              | 0.281  | 141              | 0.305  | 243              | 0.483  | 6.3   |
| Gimhae-si               | 143              | 0.084  | 169              | 0.097  | 282              | 0.156  | 3.4   |
| Miryang-si              | 256              | 0.556  | 411              | 0.879  | 763              | 1.591  | 1.3   |
| Geoje-si                | 251              | 0.271  | 309              | 0.317  | 384              | 0.379  | 0.3   |
| Yangsang-si             | 12               | 0.010  | 18               | 0.014  | 33               | 0.026  | 1.5   |
| Uiryeong-gun            | 111              | 0.847  | 308              | 2.293  | 656              | 4.374  | 0.8   |
| Haman-gun               | 414              | 1.473  | 533              | 1.894  | 581              | 2.036  | -0.6  |
| Changnyeong-gun         | 106              | 0.385  | 154              | 0.558  | 259              | 1.004  | 1.2   |
| Goseong-gun             | 472              | 1.993  | 700              | 2.927  | 1394             | 5.638  | 2.0   |
| Namhae-gun              | 455              | 2.049  | 583              | 2.594  | 959              | 4.170  | 1.9   |
| Hadong-gun              | 162              | 0.810  | 190              | 0.927  | 310              | 1.430  | 3.3   |
| Sancheong-gun           | 117              | 0.704  | 170              | 1.019  | 325              | 2.187  | 1.9   |
| Hamyang-gun             | 214              | 1.177  | 323              | 1.768  | 501              | 2.568  | 0.6   |
| Geochang-gun            | 306              | 1.155  | 414              | 1.523  | 462              | 1.659  | -0.6  |
| Hapcheon-gun            | 569              | 2.463  | 742              | 3.192  | 1106             | 4.682  | 1.1   |
| Total                   | 6021             | 16.411   | 7843             | 22.825   | 11,966           | 35.998   | 1.3   |

Source: aggregated data from cities and counties in Gyeongsangnam-do by year.

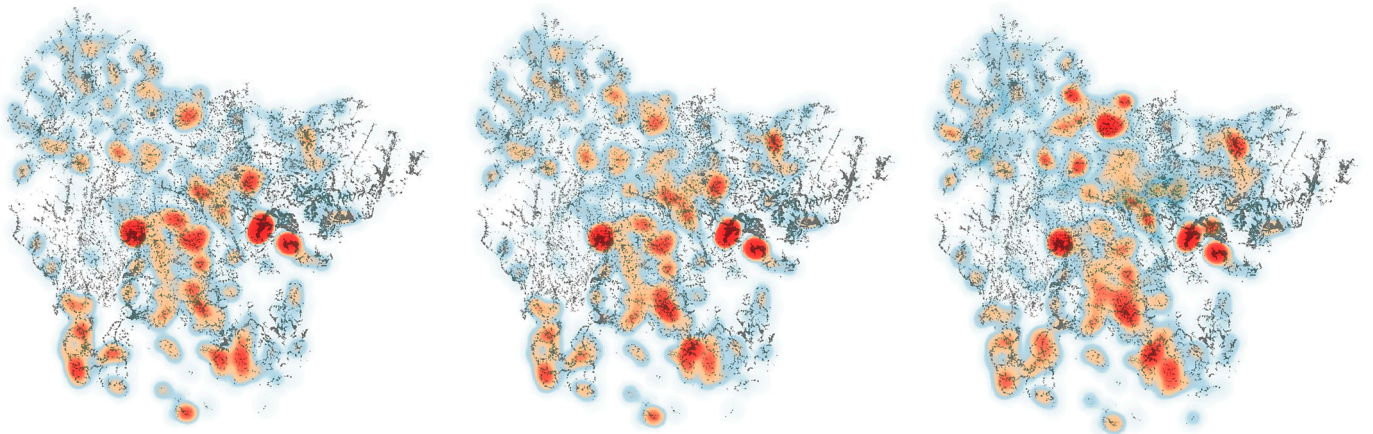
As of 2017, there were many abandoned houses in areas with large populations, such as Jinju-si (903) and Changwon-si (858). However, the ratio of abandoned houses to the population was higher in rural areas, in the order of Hapcheon-gun, Namhae-gun, and Goseong-gun. Abandoned houses increased in 2018, mainly in the areas with a high number of abandoned houses such as Changwon-si (986) and Jinju-si (967). In 2019, there were many abandoned houses in Goseong-gun (1394), Changwon-si (1250), and Tongyeong-si (1278). In Goseong-gun and Hapcheon-gun, there were areas where the ratios of abandoned houses to the total number of houses and to the existing number of abandoned houses were both high. We also observed that many cases of abandoned houses were mainly located in the western region in Gyeongnam province, where the general population was decreasing rapidly and the ratio of the elderly population was high. As such, the number of abandoned houses continued to rise, particularly in rural areas, where they remain abandoned unless demolished (Figures 2 and 3).

**Figure 2.** Abandoned houses in submunicipal divisions in Gyeongsangnam-do (2017–2019).



**Figure 3.** Locations of abandoned houses in submunicipal divisions in Gyeongsangnam-do (2017–2019).

After analyzing the location of abandoned houses (Figures 2 and 3) and the density (Figure 4), we observed the following trend. Figure 4 shows how densely abandoned houses were in the area. In 2016, the degree of density was not serious, but it was found that the degree of density increased as time progressed. In 2017, housing abandonment was occurring in areas with large populations such as Jinju, Changwon, and Kimhae; in 2018, it gradually spread to the surrounding areas; and in 2019, it spread to the entire Gyeongnam province. Such dispersion can be interpreted as additional housing abandonment in the same neighborhood as opposed to in new areas. In particular, we observed that housing abandonment occurred mainly in underdeveloped areas such as boundaries between two administrative districts, the vicinity of a river, and on steep slopes.



**Figure 4.** Clusters of abandoned houses in submunicipal divisions in Gyeongsangnam-do (2017–2019).

#### 4.2. Data Construction and Variable Selection

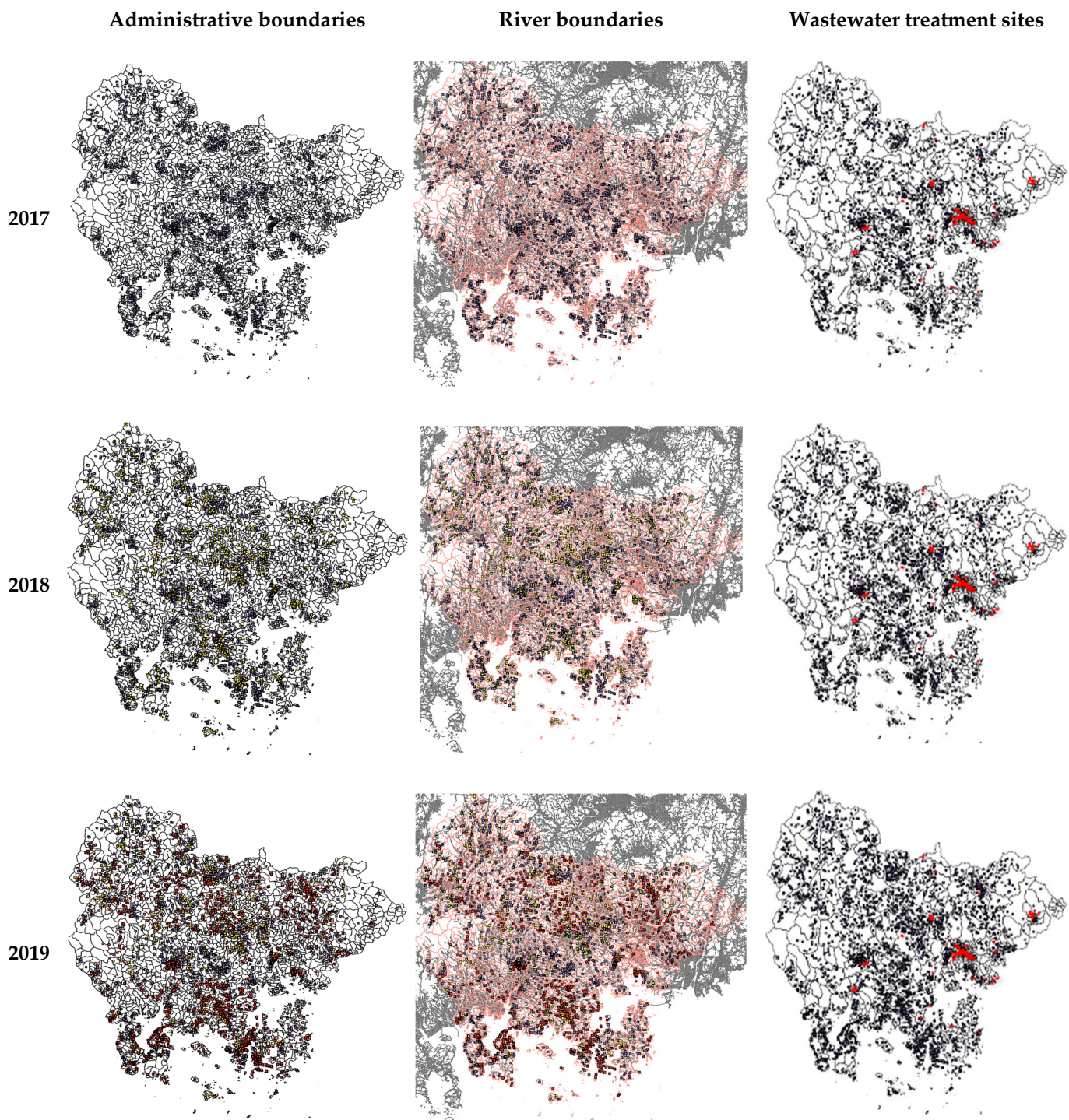
##### 4.2.1. Data Construction

We constructed data to examine the correlation of housing abandonment with major variables such as boundaries of administrative divisions, river boundaries, and the vicinity of a wastewater treatment facility.

Prior to the analysis, we identified the locations of abandoned houses in such locations. We found that housing abandonment continued to increase year after year in the boundary areas of administrative divisions and at river boundaries. As for areas with wastewater treatment facilities, there were a total of 11 areas, including Miryang-si, Yangsan-si, Gimhae-si, Changwon-si, Jinju-si, Sacheon-si, Goseong-gun, Tongyeong-si, Geoje-si, Changnyeong-gun, and Haman-gun. It was difficult to determine whether there was a concentrated distribution of abandoned houses in the vicinity of wastewater treatment facilities in 2017.



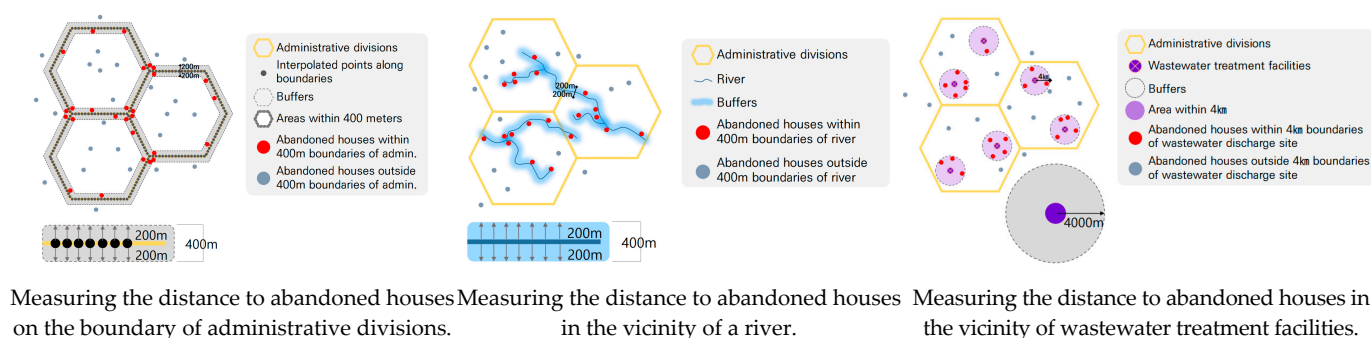
In 2018 and 2019, however, it was clear that the phenomenon of housing abandonment increased in 11 areas with wastewater treatment facilities, as shown in Figure 5.



**Figure 5.** Abandoned house distribution according to spatial information.

To determine whether these environmental conditions exerted a statistically significant effect on the increase in housing abandonment, we analyzed housing abandonment in the neighboring areas.

First, to identify the presence of abandoned houses in the boundary areas of administrative divisions or river boundaries, we created 200 m buffers on either side of the administrative divisions and rivers, thus drawing 400 m buffers as shown in Figure 6.



**Figure 6.** Method of data construction and measurement.

We determined the presence of abandoned houses in the neighborhood based on the neighborhood unit model introduced by Perry [29–33]. Neighborhood environment is a major factor influencing housing. Pedestrian and area scale can be define within 400 m from the residence suggested by Perry’s neighborhood model and the New Urbanism planning technique. The detailed physical area that defined the neighborhood range is different for each researcher. The research defined according to the researcher’s operational definition method is as follows. Ahn [30] suggested that an appropriate distance for commuting to educational facilities and the physical range forming a local community was 800–1200 m. Meanwhile, In the studies of Barton [31], Boarnet [32], and Cervero and Duncan [33], the range of 400–800 m is generally defined as a reference walking distance in a residential area. In particular, the study of Kim and Anh [34] suggested that it is necessary to establish a spatial plan focusing on the physical environmental characteristics of the pedestrian area within 400 m in order to improve the satisfaction of the residential environment. In this study, the physical environment characteristics of the neighborhood were measured by limiting the minimum distance unit to 400 m among the diversity of these limiting distances, and this was reflected in the empirical analysis.

In the areas with wastewater treatment facilities, we measured the distance to the addresses of abandoned houses. Prior to measuring the distance, the results of the review of previous studies to establish the radius of the sphere of influence around the wastewater discharge plant were as follows. According to the results of the detailed environmental measurement report of the Yeongpoong Seokpo smelter conducted by the Daegu Regional Environment Agency, a national environmental impact investigation agency, a survey was conducted in an area within a 2 km radius of the surrounding area in 2014 and 2015 [34]. However, since it was difficult to obtain relevant data, the survey was conducted on farmland and schools within a radius of 4 km in 2016. Kim [35] and Park et al. [36] analyzed soil contamination by setting a radius of 4 km to find out the cause of damage to a forest. In this way, not only the Ministry of Environment, but also several researchers studied environmental pollution issues, and was found that most of the pollution levels were measured based on the 4 km radius of the environmental pollution target site. In this study, based on previous studies, the radius was set to be within 4 km.

To check the influence of being in the vicinity of a wastewater treatment facility, prior to measuring the distance, we reviewed previous studies and found that the National Survey on Environmental Impact defines 4 km as the vicinity. Accordingly, we identified abandoned houses within a 4 km radius before measuring the distance from wastewater treatment facilities to abandoned houses [34–36].

#### 4.2.2. Selection of Variables

Before performing an empirical analysis of the factors causing housing abandonment, we selected the variables. Previous studies covered numerous factors, which were roughly subdivided into characteristics related to demographics, industry and economy, physical topography, and environmental location. In multiple studies, the demographic variables related to aging, low birthrate, population decrease, population density, population of



young adults, net migration, recipients of the National Basic Living Security Allowance, household change rate, average number of household members, density of elderly population, ratio of elderly population, and ratio of women of childbearing age were reported to influence housing abandonment.

Industrial and economic variables that affected housing abandonment were related to land price, income, and industry revitalization, such as the number of businesses, the number of employees, business growth rate, manufacturing growth rate, official land price, housing sales index, apartment sales price, financial independence, and local tax collection per capita.

Physical topographic variables that affected housing abandonment were summed up as topographical factors such as elevation and slope, and accessibility-related factors such as distances from stations, community centers, elementary schools, cultural facilities, convenience facilities, and highway interchanges.

Characteristics of environmental locations that affected housing abandonment were found to be residential environment-related factors such as building density, road width, and other facilities. They were particularly related to the degree of deterioration, such as the ratio of old houses and the age of the buildings. In addition, neighborhood environment factors such as the status of the redevelopment area or the number of abandoned houses in the neighborhood affected housing abandonment. The supply and ratio of new housings, which can be categorized as housing supply factors, also influenced housing abandonment. Among the environmental location variables, individual housing factors such as floor area, building levels, structure, land use, and the size and shape of the building lot also affected housing abandonment.

Based on the previous studies and the constructed data, we selected the following variables for this study. As demographic characteristics, we selected population [19,21,22,27,28], population of the elderly over 65 [16,21,23,28,37], the number of people receiving the National Basic Living Security Allowance [22], net migration [16,27], and standardized mortality ratio. As characteristics of industry and economy, we selected the number of businesses [7,19–21], the number of employees [19,23], fluctuation rate of land price [21,37], housing supply ratio [16,20], and total in-migration and total out-migration as the variables that affected housing abandonment. As characteristics of physical topography, we selected average slope [10], presence of abandoned houses on the boundaries of administrative divisions, distance from a river to the abandoned houses, and presence of abandoned houses in the vicinity of a river. As characteristics of environmental location, we selected the following variables: number of businesses discharging pollutants, number of industrial complexes, number of businesses in the industrial complex, amount of wastewater generated, amount of wastewater discharged, distance to abandoned houses in the vicinity of a wastewater treatment facility, and presence of abandoned houses in the vicinity of a wastewater treatment facility.

A total of 22 variables were selected, as shown in Table 2. We selected these variables based on the prediction that housing abandonment was more likely to occur in areas with slow industrial and economic activities due to increases in the elderly population, death rate, and out-migration in areas with poor environmental and topographical conditions due to being located on the boundaries of administrative divisions or rivers or in the vicinity of a wastewater treatment facility.

**Table 2.** The selected variables.

| Classification                          | Variable  | Source of data   |
|---|---|--|
| Dependent variable                      | Number of abandoned house   | Aggregated data individually surveyed by public of Gyeongsangnam-do local governments      |
| Independent variables                   | Presence of abandoned houses on the boundaries of administrative divisions      | GIS buffer analysis (based on 400 m)   |
|   | Distance from a river to the abandoned houses                                   | GIS distance measurement   |
|   | Presence of abandoned houses in the vicinity of a river                         | GIS buffer analysis (based on 400 m)   |
|   | Average slope   | Korea National Spatial Data Infrastructure Portal  |
|   | Number of businesses discharging pollutants                                     | KOSIS, Environmental statistics: eup, myeon, dong (2019)                                   |
|   | Number of industrial complexes  |  |
|   | Number of businesses in the industrial complex                                  |  |
|   | Amount of wastewater generated  |  |
|   | Amount of wastewater discharged   |  |
|   | Distance to abandoned houses in the vicinity of a wastewater treatment facility | GIS buffer analysis and distance matrix  |
|   | Presence of abandoned houses in the vicinity of a wastewater treatment facility | GIS buffer analysis (based on 4000 m)  |
|   | Population  | KOSIS, Regional statistics: eup, myeon, dong (2019)  |
|   | Population of the elderly over 65   |  |
|   | Number of people receiving the National Basic Living Security Allowance         |  |
|   | Net migration   |  |
|   | Standardized mortality ratio  | Gyeongsangnam-do Regional Health Care Basic Statistics Collection: eup, myeon, dong (2019) |
|   | Number of businesses  | KOSIS, Economic statistics: eup, myeon, dong (2019)  |
|   | Number of employees   |  |
| Characteristics of industry and economy | Fluctuation rate of land price  | Ministry of Land, Infrastructure and Transport: individually announced land price (2019)   |
|   | Housing supply ratio  | KOSIS, Housing statistics: eup, myeon, dong (2019)   |
|   | Total in-migration  | KOSIS, Regional statistics: eup, myeon, dong (2019)  |
|   | Total out-migration   |  |

## 5. Results and Discussion

### 5.1. Analysis of Variables Affecting Housing Abandonment

In studies done by Jung and Jun [16] and Lee [37], it was argued that the ratio of abandoned houses across the country and the growing ratio of abandoned houses have spatial correlation, and that housing abandonment in a neighboring area can have an impact on the increase of housing abandonment in an area. As a prerequisite for conducting a spatial autocorrelation analysis to determine the suitability of a spatial econometrics model based on the findings of previous studies, we defined spatial proximity and tested for global and local spatial autocorrelation. The spatial weights matrix was divided into contiguity measures based on spatial alignment and distance measures based on direct spatial relationships. In this study, we created the spatial weights matrix using queen-based contiguity, which refers to the contiguity in sharing a common border or a common corner. To determine the similarity among the abandoned houses, we measured the global spatial autocorrelation. The results revealed Moran's I statistics of 0.979 at a 1% significance level,



and the distribution of abandoned houses in Gyeongsangnam-do showed a very strong spatial autocorrelation, as shown in Figure 7 and summarized in Table 3.

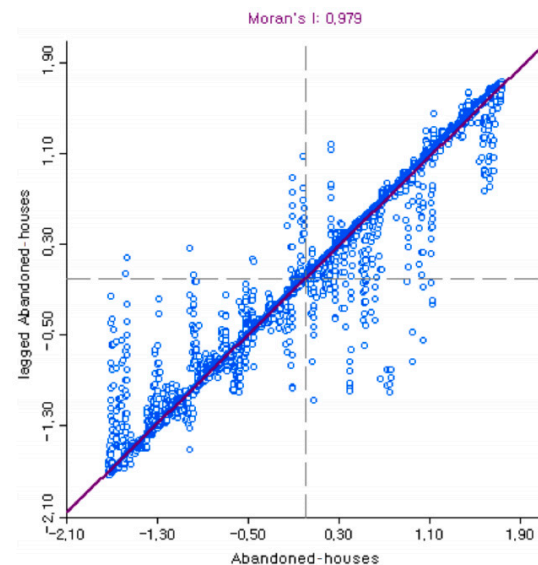


Figure 7. Global Moran's I summary.

Table 3. Moran's I test results.

|                        |          |
|------------------------|----------|
| Moran's Index          | 0.9793   |
| Expected Index         | −0.0001  |
| Mean                   | 0.0000   |
| SD                     | 0.0049   |
| z-value                | 198.1169 |
| Pseudo <i>p</i> -value | 0.001    |

Next, to test for the local spatial autocorrelation, we calculated the LISA statistics, and found clustered maps of abandoned houses showing hot and cold spots, within a 1% significance level. We found local patterns of spatial autocorrelation in the regions. Local Moran's I statistics showed the detailed patterns of spatial clustering that manifested similar measurements centering on a certain area. Hot spots had high data values similar to those of the abandoned houses in the neighborhood, whereas cold spots had low data values similar to those of the abandoned houses in the neighborhood.

Figure 8 presents a LISA cluster map that shows the pattern of spatial autocorrelation of the housing abandonment in Gyeongsangnam-do. The identified hot spots were mainly counties such as Geochang-gun, Goseong-gun, Namhae-gun, Sancheong-gun, Hadong-gun, Hamyang-gun, and Hapcheon-gun. These areas are rural areas with a small population, and the elderly tend to live there. It was found that rural areas with many occurrences of abandoned houses had a high impact on the occurrence of abandoned houses in each neighboring area. The identified cold spots were mainly clustered in urban areas such as Geoje, Gimhae, Sacheon, Jinju, Changwon, and Tongyeong. It was a type of cluster in which the number of abandoned houses is small, and at the same time, the number of abandoned houses is also small in adjacent areas. The results of this analysis showed that the distribution of abandoned houses was spatially concentrated and had spatial autocorrelation, as in previous studies.

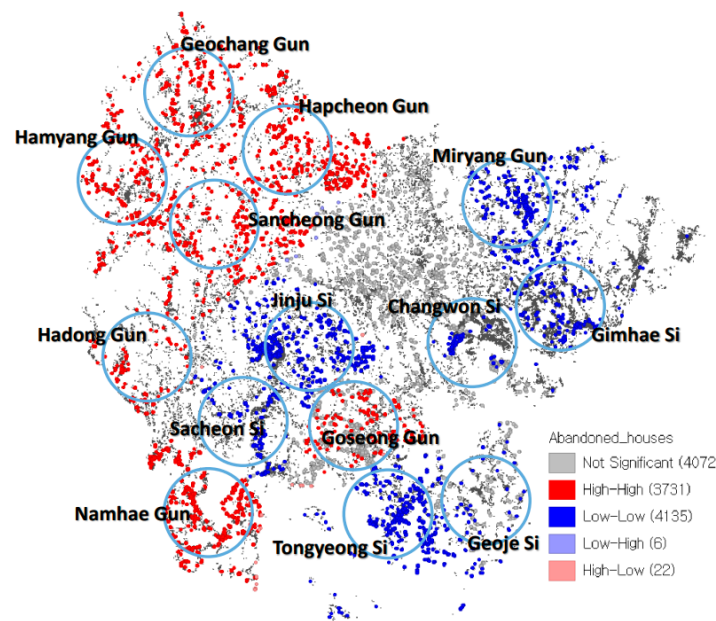


Figure 8. LISA cluster map.

### 5.2. Result of Analyzing the Factors Influencing Housing Abandonment

We discovered the spatial autocorrelation for the distribution of abandoned houses. Thus, we selected SEM, because the model was found to be most suitable after testing its multicollinearity, goodness of fit, and explanatory power. The analysis results are shown in Table 4.

Table 4. Model estimation results.

| Classification                            | Variables   | Spatial Error Regression Model (SEM) |
|---|---|--------------------------------------|
| Spatial effects                           | $\lambda$ (Lambda)  | 0.91 ***                             |
|   | Constant  | −13.875 ***                          |
| Characteristics of physical topography    | Presence of abandoned houses on the boundaries of administrative divisions      | 13.437 ***                           |
|   | Distance from a river to the abandoned houses                                   | −0.001 *                             |
|   | Presence of abandoned houses in the vicinity of a river                         | −3.917 **                            |
|   | Average slope   | 6.037 ***                            |
| Characteristics of environmental location | Number of businesses discharging pollutants                                     | 0.088 ***                            |
|   | Number of industrial complexes  | 2.023                                |
|   | Number of businesses in the industrial complex                                  | 0.300 *                              |
|   | Amount of wastewater generated  | 2.097 ***                            |
|   | Amount of wastewater discharged   | 2.177 ***                            |
|   | Distance to abandoned houses in the vicinity of a wastewater treatment facility | −0.001 **                            |
|   | Presence of abandoned houses in the vicinity of a wastewater treatment facility | 3.048 *                              |

Table 4. Cont.

| Classification                            | Variables   | Spatial Error Regression Model (SEM) |
|---|---|--------------------------------------|
| Characteristics of population demographic | Population  | −0.005                               |
|   | Population of the elderly over 65                                       | 0.049 ***                            |
|   | Number of people receiving the National Basic Living Security Allowance | 0.044 ***                            |
|   | Net migration   | −0.011                               |
|   | Standardized mortality ratio  | 0.383 *                              |
| Characteristics of industry and economy   | Number of businesses  | −0.042 ***                           |
|   | Number of employees   | −0.002                               |
|   | Fluctuation rate of land price  | −8.971 *                             |
|   | Housing supply ratio  | −0.001                               |
|   | Total in-migration  | 0.029 ***                            |
|   | Total out-migration   | 1.132 ***                            |

Note: \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ .

First, we examined the physical and environmental factors in depth. The effect of a location's environmental characteristics on housing abandonment was found to be significant under the following circumstances: a high number of businesses that discharge pollutants, a high number of businesses within an industrial complex, a larger amount of wastewater generated, a larger amount of wastewater discharged, closer proximity to a wastewater treatment facility, and being located in the vicinity of a wastewater treatment facility. Under these circumstances, housing abandonment was more likely to occur and cause further housing abandonment in neighboring areas. This indicated that the likelihood of housing abandonment can increase when the deterioration of surrounding environment worsens. With regard to the variables related to topography, we found that the cases of housing abandonment increased when the houses were located on the boundary of administrative divisions and in the vicinity of a river. The closer the house was to a river, the more likely it was to be abandoned. Lee's study finding showed [10] that houses on a steep slope were likely to be abandoned. To sum up, poor topographic locations increased the likelihood of housing abandonment.

Next, we examined demographic factors. Similar to findings in previous studies by Kim and Kim [20] and Lee and Lim [22], we found that population of the elderly over 65, the number of recipients of the National Basic Living Security Allowance, and adjusted death rate had significant effects on housing abandonment. It appeared that houses became abandoned because the increase in the population of the elderly residents and poverty-stricken residents lowered the demand for housing and inhibited the vitalization of the area. It was found that a 1% increase in the death rate due to aging or other reasons increased housing abandonment by 0.38%.

Finally, we examined the effect of industrial and economic characteristics on housing abandonment, and found that housing abandonment was significantly affected by the number of businesses, fluctuation rate of land price, total out-migration, and housing supply ratio. The number of businesses had a negative correlation with housing abandonment. In other words, the increase in the number of businesses prevented the occurrence of housing abandonment. Since the number of businesses was a significant factor, we expected that the number of employees would generate the same result. However, it was found to be insignificant, as had been reported by Kamata and Kang [19] and Jung and Jun [16].

## 6. Conclusions

Since the residential location environment and regional characteristics are closely related, it is necessary to make an effort to understand the vacant houses that occur

naturally in the process of idle housing in the local context. Against this background, this study looked at the effect of regional characteristics on the occurrence of abandoned houses from various angles, focusing on the cause of the occurrence of abandoned houses in Gyeongsangnam-do.

First, the spatial error model showed a better goodness of fit through spatial effect. This indicated that the distribution and occurrence of housing abandonment had spatial correlation, forming spatial clusters with similar areas and becoming impacted by the factors influencing housing abandonment. Therefore, it seems necessary to take into account regional characteristics in enacting additional ordinances and implementing management policies in areas where abandoned houses are concentrated. Second, the physical and environmental factors that this study investigated in depth were found to have an impact on the increase of housing abandonment. To be specific, we found that housing abandonment was very likely to occur with houses that were located in areas with poor environmental conditions or poor accessibility, such as in the vicinity of rivers and wastewater treatment facilities, near boundaries of administrative divisions, and at the boundaries of rivers. As for housing abandonment in the areas with poor environmental and topographic conditions, it is imperative to establish measures to demolish them, except for redeemable cases for redevelopment or residential purposes through remodeling, reconstruction, or expansion. Currently, due to the status of abandoned houses that constitute private property and the infringement of private property, it is not easy to demolish or remodel the abandoned houses that wreak havoc on the neighboring area. Abandoned houses that negatively affect the surrounding area should be turned into public lots or maintained to prevent them from diminishing the landscape and land value. Based on this, local governments need to not only decide the order of priority for maintaining abandoned houses based on wide and diverse perspectives, but also establish detailed policies and strategic plans. A number of studies have confirmed the following as methods to support the activation of abandoned houses. First, establishment of a field-based survey and information-sharing system; second, establishment of an abandoned house maintenance plan and provision of a support system; third, the promotion and spread of pilot projects related to abandoned house maintenance; fourth, policies related to laws and systems, such as establishing a system foundation for abandoned houses [23,38,39].

Third, with regard to demographic, industrial, and economic factors, we found that the houses in areas with a large elderly population were likely to be abandoned. It seems necessary to ensure constant monitoring and follow-up studies on such areas, because the population of the elderly is likely to increase steadily.

This study's limitation was that we selected abandoned houses among private homes.

Apartments often experience temporary vacancies due to unsold housing, so when the economy recovers, vacant houses tend to be resolved naturally. Unlike apartments, detached houses are mostly abandoned houses, so once they become vacant, they are often left as abandoned houses until they are demolished. The vacant houses left in this way adversely affect the surrounding area in ways involving accidents and crimes, so they are left as a problem to be solved at the local government level, even though they are private property. In future research, in order to look at the housing market as a whole, it is necessary to expand the study to not only single-family houses, but also apartments and other houses. It is necessary to verify the need to solve the problem of abandoned houses differentiated by housing type by deriving factors for the occurrence of vacant houses for various housing types. These results are judged to be helpful in establishing a comprehensive housing policy in relation to the abandoned house problem. In follow-up studies, it is necessary to present differentiated solutions for housing abandonment by extracting the factors that affect different housing types.

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