pISSN: 1226-7147, eISSN: 2383-9171
https://doi.org/10.17208/jkpa.2025.08.60.4.24

Check for updates
Journal of Korea Planning Association Vol.60, No.4 (2025)
대한국토 · 도시계획학회지 「국토계획」 제60권 제4호 pp.24-37

Special Issue

Analysis and Classification of Population Changes in Urban Centers and Peripheries for Regional Adaptation to Population Decline*

Choi, Hye-rim**

Abstract

The purpose of this study is twofold: to analyze differences in the spatial structure of regional population decline between urban center and periphery and to develop a typology that can serve as a foundation for regionally tailored spatial policies. To this end, the study classifies South Korea's 250 municipalities into six types based on population change patterns observed separately in urban centers and peripheries. The analysis then compares changes in residential conditions—such as the proportion of newly built housing and the rate of housing price change—and economic activity, measured by changes in the number of businesses and employees, across the six types. A Kruskal–Wallis H test is conducted to assess statistically significant differences. The results indicate that, in some types, population changes are misaligned with trends in residential or economic indicators between urban center and periphery. In particular, some types exhibit deepening functional imbalances or increasing disconnections between industrial and residential functions. Based on these findings, the study derives policy implications tailored to each type and suggests that the proposed framework can contribute to developing adaptive strategies for addressing population decline.

Keywords Population Decline, Spatial Structure, Central Place, Compact-Network, Typology

Ⅰ. Introduction

1. Background and Purpose of the Study

In recent years, population decline driven by low birth rates and population aging has emerged as a pressing global issue. South Korea is no exception: since 2020, the registered population has entered a declining trend, marking four consecutive years of reduction. However, unlike the national average, the Seoul metropolitan area continued to grow until 2020, with its population surpassing that of non-metropolitan regions in 2019—a gap that has since widened further. These trends of depopulation and regional imbalance are exerting significant influence on the socioeconomic structure of the national territory (Yoon and Lee, 2019).

As these changes unfolded, the need for low-growth management and a paradigm shift in territorial planning became increasingly evident (Park et al., 2013; Lee et al., 2018; Kim, 2020). In response, the Ministry of Land, Infrastructure and Transport announced the Fifth National Territorial Plan in December 2019, marking a paradigm shift from development-oriented planning toward a management-centered approach, reflecting the realities of population decline and slow economic growth. This shift was further institutionalized in December 2023 through revi-

* This study was prepared by reorganizing the research outcomes conducted as part of a preliminary study at the Korea Research Institute for Human Settlements (Im–Eunsun et al., 2024, Development of a Simulation Model for Spatial Structure Changes in the Era of Population Decline, Sejong: KRIHS).

** Researcher, Korea Research Institute for Human Settlements (chr1142@krihs.re.kr)

sions to the Urban and County Master Plan Guidelines, which discouraged excessive population projections and over-designation of urbanized land, instead introducing more detailed classifications of urban types based on demographic trajectories. For areas identified as experiencing population decline, the guidelines explicitly recommended establishing a compact and networked spatial structure.

As part of this shift, recent national spatial and urban policies have emphasized regionally differentiated strategies to respond to population loss. The Urban and County Master Plan, in particular, promotes a compact-network model that concentrates activity around regional urban centers while reinforcing connectivity with periphery. Consequently, a growing body of research has focused on typologizing population decline using local demographic, social, and economic characteristics and proposing corresponding policy measures.

However, most existing studies are limited by their reliance on overall population changes, without accounting for the spatial structure between center and periphery within a region. Some have even shown discrepancies between areas identified for policy intervention and those actually in need. Although a more granular spatial analysis that differentiates between urban center and periphery is crucial for implementing compact-network strategies, such approaches remain underexplored.

The objective of this study is to emphasize the need for spatial policies that consider intra-regional population change, particularly from a compact-network perspective. Specifically, the study aims to: 1) classify population change types by analyzing demographic trends separately in urban center and peripherys, 2) analyze variations in the number of businesses, employees, housing units, and housing prices by type, and 3) derive policy implications tailored to each type.

Unlike previous research, this study conducts a nationwide analysis to propose comprehensive policy directions. It distinguishes itself by shifting away from a binary view of population growth versus decline and instead offers a nuanced, structure-oriented approach that takes into account the spatial relationships between center and peripheral areas. Furthermore, it identifies the limitations of aggregate population analyses and highlights the necessity for customized spatial strategies that reflect localized demographic realities. The findings are expected to contribute to the development of more appropriate and adaptive spatial policies for the era of population decline.

II. Review of Theory and Prior Research

1. Studying Population Change and Decline

Since the onset of modern society driven by scientific and technological advancements, demographic transition theory has emerged to explain shifting population dynamics. The theory describes a transition from a regime of high birth and death rates to one characterized by low fertility and mortality, signaling a shift from traditional to modern demographic systems.

However, in the latter half of the 20th century, many societies began experiencing patterns that deviated from the classical demographic transition model. This shift gave rise to the concept of a "second demographic transition," marked by persistently low fertility rates below replacement level, an aging population, and decoupling between marriage and childbirth. Unlike the earlier model, this phase does not assume a new equilibrium between births and deaths, but rather anticipates ongoing demographic instability. As a result, scholars have emphasized the need to mitigate population decline through immigration and other policy interventions.

What makes population decline particularly urgent in the modern context is its strong association with local socioeconomic challenges and regional decline. For instance, during Germany's post-industrial restructuring in the late 1990s, the phenomenon of "urban shrinkage" emerged as cities faced population loss and economic stagnation. In 2014, American economist Harry Dent introduced the concept of the "Demographic Cliff," linking economic slowdowns to the shrinking population of prime consumers aged 45-49 (Dent, 2014). These developments prompted not only demographic research but also urban and regional planning studies addressing population decline.

In particular, the need for regionally customized strategies has led to research efforts that classify regional population decline into distinct types and suggest tailored policy responses (Chun and Chun, 2016; Yim, 2018; Choi and Park, 2020).

One group of studies has focused on demographic indicators. For example, Yim (2019) analyzed small and mid-sized non-metropolitan cities using overall population growth rates and identified three types—growing, stagnant, and declining—highlighting growing disparities in both quantitative and qualitative dimensions of population change. Kim (2019) employed k-means clustering to classify regions nationwide into categories such as growth, low growth, at-risk of decline, and declining. The study found that changes in population structure—not just total population size—play a critical role in regional decline, suggesting the need for early interventions. Lee and Han (2021) proposed typologies based on natural population change (births minus deaths), social change (in- versus out-migration), and total change, concluding that demographic characteristics must inform policies such as employment, housing, and infrastructure provision, and that a finer spatial unit is required. Min and Choi (2023) incorporated the concept of the "facto population" into a typology of all basic municipalities in South Kroea, identifying regional types based on daily population fluctuations and mobility patterns to better reflect actual demographic dynamics in policy.

Other studies have incorporated broader regional characteristics, including socioeconomic and locational factors. Lee et al. (2023) applied latent class analysis to classify municipalities at risk of extinction, using local extinction risk index combining demographic, economic, and social indicators and regional condition indicators. Jang (2023) developed typologies by incorporating variables such as local extinction risk indices, access to cultural and healthcare services, and land price changes, emphasizing the importance of urban regeneration strategies tailored to each region. Jeong and Lee (2022) included both demographic indicators and changes in local fiscal self-reliance, identifying 89 population-declining municipalities and arguing that metropolitan-scale responses are more effective than fragmented local efforts. Ribant and Chen (2020) studied 367 shrinking cities in the United States, categorizing them based on population size, geography, and commuting patterns, and found that even within shrinking cities, considerable variation exists.

Ding et al. (2022) investigated urban shrinkage across the Yellow River Basin in China, identifying multiple types and modes of shrinkage based on population change patterns and socioeconomic factors, and analyzing the key drivers behind these dynamics. They emphasized that differentiated shrinkage trjectories require tailored governance strategies rather than uniform policy measures.

Zhang et al. (2023) analyzed urban growth and shrinkage in China by integrating demographic, economic, and spatial dimensions, and proposed a four-quadrant model that classifies cities into multidimensional types. Their study underscores the value of combining multiple indicators to capture the complexity of urban change, aligning closely with approaches that integrate both analysis and typology.

Mabon et al. (2024) examined the former coal-mining city of Yubari, Japan, to explore how urban shrinkage can serve as a catalyst for transformative climate adaptation. They found that planned urban contraction, community-led environmental management, and engagement with third-sector organizations can create opportunities for resilience building, even under severe demographic and fiscal constraints.

Notably, Je (2018) also conducted on-site fieldwork, revealing that in many cases, the areas receiving policy intervention differed from those actually in need. This mismatch resulted in "blind spots" where social welfare support was lacking, underlining the importance of precise targeting within cities and counties.

2. Spatial Structure Analysis and Center Classification Research

In the early 20th century, urban ecologists and geographers introduced several models to explain urban spatial structures, including the concentric zone model by Burgess (1926), the sector model by Hoyt (1939), and the multiple nuclei model by Harris and Ullman (1945). While the concentric model conceptualized the city as comprising zones radiating from the central business district (CBD)—such as transition zones, low-income housing, middle-class residential areas, and commuter zones—the multiple nuclei model suggested that cities evolve from a monocentric to a polycentric spatial structure as they grow.

These models illustrate how urban population growth, land use change, and transportation development collectively shape spatial forms (Im et al., 2006), implying that the efficiency of urban spatial structure is closely tied to city size (Davoudi, 2003; Halbert et al., 2006).

Within these frameworks, the concept of the "urban center" has emerged as a key element in spatial structure. Initially, the center was defined as a hub for distributing goods and services to surrounding areas, while the hinterland was seen as the recipient of such flows (Christaller, 1968). More recently, however, urban centers are understood as dense nodes of human activity—concentrating employment, residence, and services (Giuliano and Small, 1991; Sun et al., 2016; cited in Kim and Lee, 2021). Research suggests that the agglomeration of major urban functions within these centers enhances the efficiency of spatial structure and fosters diverse socioeconomic activities (Kim and Woo, 2018; Kim and Lee, 2021).

Although the identification of urban centers varies depending on the researcher's approach, prior studies generally fall into three categories: density-based analysis, centrality analysis, and relational attribute analysis (Oh et al., 2018; Kim and Lee, 2021).

First, several studies have examined urban spatial structure from a density perspective. Han et al. (2008) analyzed the shift in population centers within cities with populations of 500,000 to 1 million, utilizing population density gradient functions to assess urban hollowing through temporal changes in population dispersion. Similarly, Oh et al. (2018) employed population density gradients to analyze changes in population density with distance from urban center in cities and counties across Chungcheongnam-do, identifying patterns of population decline and typologies. Other studies incorporated not only population density, but also employment and industrial density (Nam and Kim, 2017), and land price (Kim and Lee, 2013). Lee (2020) further considered Gross Regional Domestic Product (GRDP), employment by industry, and road density, and employed Moran's I statistics to conduct spatial autocorrelation and clustering analyses.

Second, other studies have approached urban spatial structure through centrality and relational attributes. Im et al. (2006) defined 25 cities and counties in Gyeonggi-do as urban areas based on average population density, and measured spatial spread and compactness using indicators such as grid-level population density, continuity of high-density development, land use mix, and centrality. Kim and An (2018) used inter-regional commuting data for the Seoul metropolitan area to conduct factor analysis and spatial autocorrelation analysis for identifying urban centers, comparing the results with existing methodologies. Kim and Woo (2018) calculated interdependence and centrality indices using origin-destination data at the city and county levels to identify key regional nodes.

More recent studies have drawn attention to the influence of everyday activities that transcend administrative boundaries, utilizing big data to identify functional urban centers. Chen et al. (2017) used satellite imagery of nighttime lights to delineate regional centers. Kim and Lee (2021) employed POI (Points of Interest) data to classify urban centers beyond official boundaries, offering insights into functional urban spaces shaped by daily activity patterns.

3. Differentiate Research

Previous urban and regional planning studies on population decline have largely focused on analyzing the driving factors behind urban shrinkage, classifying types of depopulating areas, and proposing tailored policy responses based on regional characteristics. These studies collectively suggest that various types of depopulation exist depending on demographic or socio-economic conditions, and many emphasize the importance of type-specific policy interventions. However, several studies have also noted that classifications based solely on total population change may fail to reflect actual areas requiring policy intervention within a region, potentially leading to the emergence of welfare blind spots. Despite this, few studies have directly analyzed intra-regional population changes and their implications.

In addition, previous research on spatial structures and the classification of urban centers has employed a wide range of indicators—such as population density, travel patterns, land prices, and industrial concentration—depending on the researcher's perspective. These studies reveal that urban centers can exist at multiple scales, ranging from inter-city growth poles to intra-city nodes akin to central business districts (CBDs), depending on how the center is conceptualized. While earlier studies relied heavily on administrative boundaries, more recent work has begun to utilize big data to identify centers beyond official jurisdictions. A common feature across these studies is the definition of a center as an area with high population concentration and significant interactions with its surroundings, based on both intra- and inter-regional human activity.

However, much of the existing literature stops at descriptive analyses of spatial structure or center classification. Very few studies have addressed the spatial restructuring associated with population decline, particularly from the perspective of shrinking cities. In light of these limitations, this study examines regional depopulation through the lens of intra-regional spatial disparities, distinguishing between urban centers and their peripheries.

To this end, the study categorizes local population changes by separating urban centers from periphery within each region. Unlike traditional methods based on administrative boundaries, this research employs a more granular grid-based classification system for urban centers, utilizing the National Territorial Spatial Center Map, which identifies centers across South Korea on a grid level. This approach allows for a finer assessment of on-the-ground conditions.

Beyond population changes, the study incorporates spatial structure indicators such as residential environment and economic activity. Specifically, it examines the number of businesses, employees, housing units, and housing prices to evaluate whether these indicators show statistically significant differences across the defined types. By doing so, the study aims to provide spatial policy implications beyond conventional demographic responses to depopulation. Finally, this study addresses a key shortcoming in previous research by offering nationwide insights for all 250 city and county units in South Korea, rather than focusing solely on selected case study areas. The proposed framework lays the groundwork for type-specific spatial policy strategies that reflect the diverse dynamics of population decline at both the center and periphery of each region. 〈Figure 1〉 below shows the flow of the study.

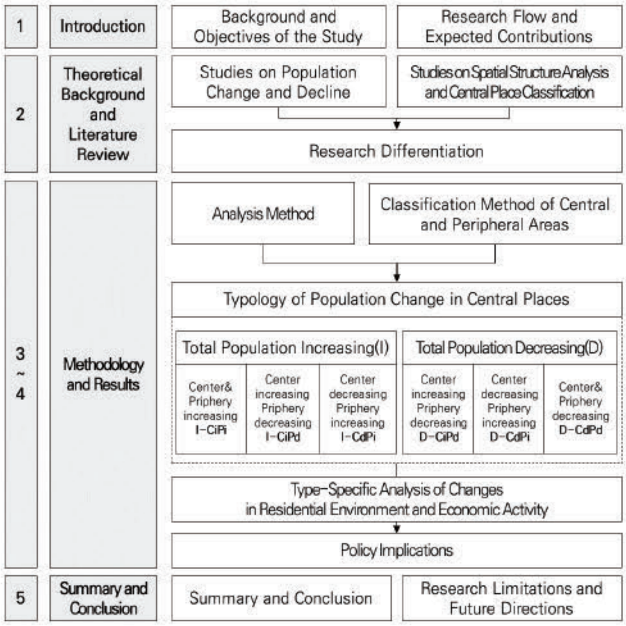


Figure 1. Flow of the study

Ⅲ. Analysis Methodology

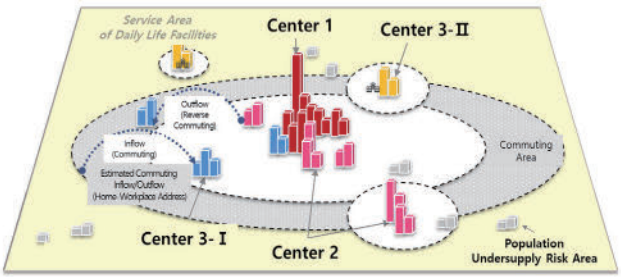
1. Analysis Methods

The preceding review of theories and prior studies has highlighted the limitations of relying solely on aggregate population change in formulating spatial strategies such as the compact-network model. Specifically, such an approach fails to adequately reflect the spatial structure of a region, particularly the internal differentiation between its center and periphery. In response, this study classifies each region into urban centers and peripheries, and further categorizes regional types based on the direction and magnitude of population change within these subareas. To move beyond administrative boundaries and capture more granular patterns of change, a grid-based classification of urban centers was employed. Specifically, this research utilized the 2024 National Territorial Monitoring Project's Urban Center Classification System, which delineates intra-regional centers across the entire country at the grid level. Using this framework, we identified six regional types according to population change trajectories in both centers and peripheries. The detailed classification criteria are discussed in Section 3.1. In addition to population trends, this study also incorporates residential environment and economic activity—two of the most frequently used indicators in measuring spatial structure, as identified in prior research. By comparing these indicators across the six regional types, we investigate how differences in residential conditions and economic vitality are distributed between centers and peripheries. Based on these comparative analyses, we derive policy implications that highlight the need for differentiated spatial strategies tailored to each type. The specific analytical procedures are presented in the following sections.

1) Classification of Urban Center and Periphery

This study employed the National Territorial Spatial center Map developed in the 2024 National Territorial Monitoring Project to classify urban centers across all municipalities in Korea. The classification criteria provided in this dataset were used to identify the urban center and periphery within each region.

The National Territorial Spatial Center Map (Ministry of Land, Infrastructure and Transport, 2024) delineates urban centers by analyzing multiple spatial indicators, including residential population density, employment density, and inflow–outflow centrality indices. Based on these metrics, the map identifies the attributes of center places and the connectivity between centers and peripheries, thereby enabling a hierarchical classification of spatial structure within regions. This classification framework offers a nuanced understanding of both the scale and functional role of urban centers, as well as their spatial interlinkages with periphery. The classification criteria from the National Territorial Spatial Center Map are illustrated in 〈Figure 2〉 below.



Classification Criteria of National Territorial Spatial Center Map	
· Center 1	More than 1,500 resident population per km^2, more than 900 workforce per km^2, and Inflow and outflow centrality indexes in the top 20% of the country
· Center 2	More than 300 resident population per km^2, more than 150 workforce per km^2, and Inflow and outflow centrality indexes in the top 20% of the nation
· Center 3-Ⅰ	More than 150 workforce per km^2
· Center 3-Ⅱ	More than 150 resident population per km^2, within a 1.5 km radius of a public service facility* * Government offices, healthcare organizations (health centers, health posts, health clinics, etc.), elementary schools, police stations (including precincts and police stations)

Source: 2024 Territoral Monitoring Report (Ministry of Land, Infrastructure and Transport, 2024)

Note: This report is not publicly available.

Figure 2. Classification Criteria of National Territorial Spatial Center Map

The classification thresholds for residential population density—1,500 persons/km^2 and 300 persons/km^2—were adopted from the United Nations' criteria for urban classification. In addition, the inflow–outflow centrality index was derived using the commuting origin–destination (OD) matrix estimated by the Korea Credit Bureau (KCB).

In this study, we defined urban centers as areas that serve both residential and employment functions, corresponding to Center Types 1 and 2 in the National Territorial Spatial Center Map. Conversely, Center Types 3-I and 3-II, which perform either residential or employment functions alone, were grouped together with other non-center and classified as the periphery.

2) Population Change Typology

To analyze intra-regional population changes between urban centers and peripheries and to classify regional types, this study examined 250 municipalities (cities, counties, and districts) across South Korea. Based on the total population change between July 2014 and April 2024, each region was first categorized as either a population-increasing region (Type I) or a population-decreasing region (Type D). Subsequently, we identified four detailed subtypes by comparing the population change in urban centers and peripheries over the same period: CiPi (Urban Center Increase – Periphery Increase): Both the urban center and periphery populations increased. CiPd (Urban Center Increase – Periphery Decrease): The center population increased while the periphery population decreased. CdPi (Urban Center Decrease – Periphery Increase): The center population decreased while the periphery population increased. CdPd (Urban Center Decrease – Periphery Decrease): Both the center and periphery populations decreased.

Notably, because the total population increases in Type I regions, the CdPd subtype cannot occur within this group. Likewise, since total population decreases in Type D regions, the CiPi subtype does not apply. Therefore, each of the two major types (I and D) contains three subtypes, resulting in six total population change types used to classify the study regions. The conceptual diagram and classification table for these intra-regional population change types are presented in 〈Table 1〉 and 〈Figure 3〉, respectively.

Table 1. Conceptual classification table of population change types

Total population change	Center (C)		Center / Periphery	
	Increasing (i)	Decreasing (d)		Periphery
Increasing (I)	I-CiPi (Center population increase, Periphery population increase)	I-CdPi (Center population decrease, Periphery population increase)	Increasing (i)	Periphery (P)
	I-CiPd (Center Ppopulation increase, Periphery population decrease)	-	Decreasing (d)	
Decreasing (D)	-	D-CdPi (Center population increase, Periphery population decrease)	Increasing (i)	
	D-CiPd (Center population decrease, Periphery population increase)	D-CdPd (Center population decrease, Periphery population decrease)	Decreasing (d)	

Note: Areas with no periphery within the region will be of the I-CiPi type, depending on whether the total population is increasing or decreasing, or categorized by D-CdPd type (15 regions in total).

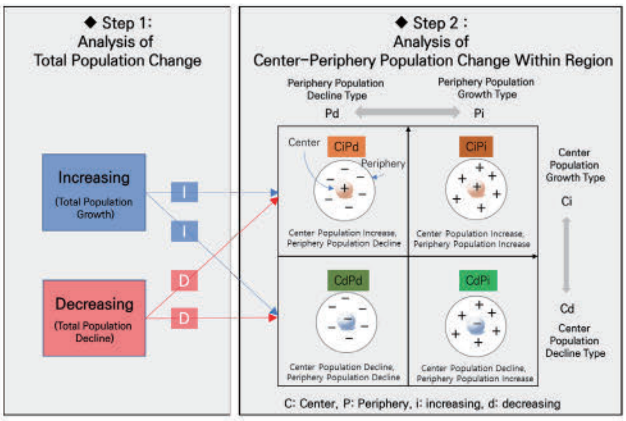


Figure 3. Diagram of population change typology in urban center and periphery within a region

3) Indicators and Methodology for Analyzing Changes in Residential Environment and Economic Activity by Type

Following the classification of regions based on population changes in urban centers and peripheries, this study aimed to examine the changes in residential and economic environments—both of which are closely linked to spatial structure—across the different types. Indicators representing the residential and economic environments were also analyzed separately for urban centers and peripheries to identify type-specific characteristics.

To select representative indicators for residential and economic change, we considered the following criteria: availability of time-series data at the grid level, spatial compatibility with the classification results, and the ability to reflect relevant phenomena. Among various candidates, four indicators were ultimately selected based on the availability of consistent grid-level time-series data:

Rate of change in the number of businesses, Rate of change in the number of employees, Rate of change in housing prices, and Proportion of newly built housing. These selected indicators are summarized in 〈Table 2〉.

To examine whether there are statistically significant differences in each indicator according to the classified types, this study employed the non-parametric Kruskal–Wallis H test. The Kruskal–Wallis H test is a rank-based non-parametric method used to determine whether there are statistically significant differences in the median values among three or more independent groups. Since the sample sizes across types were not equal, a traditional parametric test such as ANOVA was deemed inappropriate. Therefore, the Kruskal–Wallis test was applied. Following the test, Dunn's post hoc test was conducted to identify which specific group

Table 2. Indicators

Indicators	Calculation methods
Housing price change rate	((Housing price in 2023 - Housing price in 2014) / Housing price in 2014) × 100
Proportion of newly built housing	(Number of newly built housing units / Total number of housing units) × 100
Change rate in number of businesses	((Number of businesses in 2023 - Number of businesses in 2014) / Number in 2014) × 100
Change rate in number of employees	((Number of employees in 2023 - Number of employees in 2014) / Number in 2014) × 100

pairs contributed to the overall significance. To control for Type I error due to multiple comparisons, the Bonferroni correction was applied.

2. Data Sources

To analyze the population change patterns between urban centers and peripheral areas at the grid level, this study examined the availability of micro-scale spatial population data in South Korea. The investigation revealed two main sources of grid-based population data: the Population and Housing Census-based datasets provided by Statistics Korea, and the resident registration-based datasets provided by the National Geographic Information Institute (NGII). The former is available only at the census years, while the latter offers data on an annual basis since 2014 and on a semi-annual basis since 2017.

Given the study's objective of classifying types based on population change rates between two time points, the resident registration-based grid population data from NGII were adopted due to their suitability for time-series comparison. Among these, the 1 km × 1 km grid population data were selected to ensure spatial compatibility with the classification framework used in the National Territorial Monitoring Project's. The reference time points were set as July 2014 and April 2024, enabling an examination of population changes over the most recent decade.

Next, to investigate changes in residential and economic conditions by type, the availability of supplementary grid-based indicators—namely, the number of establishments, number of employees, housing prices, and housing stock—was examined. The results showed that Statistics Korea provides grid-based data on establishments and employees derived from the Census on Establishments, while housing stock data are derived from the Census on Housing. Housing price data are provided by National Geographic Information Institute (NGII). To maintain spatial consistency with the urban center classification, all indicators were used at the 1 km × 1 km grid level. While the ideal time points would align with the population change data, the most recent available data were from 2023, and thus, 2014 and 2023 data were used for these indicators. 〈Table 3〉 presents detailed information on the datasets used.

Table 3. Information on the datasets

<table>
<tr><th colspan="2">Category</th><th>Source</th><th>Spatial unit</th><th>Temporal coverage</th></tr>
<tr><td colspan="2">Population</td><td>National Geographic Information Institute</td><td rowspan="5">1 km × 1 km grid</td><td>2014.07, 2024.04</td></tr>
<tr><td rowspan="2">Residential environment</td><td>Housing price change rate</td><td>National Geographic Information Institute</td><td>2014.07, 2023.01</td></tr>
<tr><td>Proportion of newly built housing</td><td>Statistics Korea</td><td>2014, 2023</td></tr>
<tr><td rowspan="2">Economic activity</td><td>Change rate in number of businesses</td><td>Statistics Korea</td><td rowspan="2">2014, 2023</td></tr>
<tr><td>Change rate in number of employees</td><td>Statistics Korea</td></tr>
</table>

Ⅳ. Analysis Results

1. Results of Center-periphery Population Change Typology within a Region

As a result of classifying the types of intra-regional population change in urban centers across 250 cities, counties, and districts (si/gun/gu) nationwide, 72 regions were identified as experiencing overall population growth (Type I), while 178 regions were found to be undergoing overall population decline (Type D). This indicates that approximately 71.20% of municipalities in South Korea have experienced population decline in recent years.

A more detailed analysis revealed that Type 6 (D-CdPd)—where both urban centers and peripheral areas exhibit population decline—accounted for 145 regions, representing approximately 58.00% of all regions. This finding highlights that in the past decade, a majority of areas have seen simultaneous population decline in both center and periphery of the region. The spatial distribution of the six classified types of intra-regional population change between centers and peripheries is illustrated in 〈Figure 4〉 below.

A breakdown of the number and percentage of covered regions by type is shown in 〈Table 4〉. Based on the classification of regional types according to both total population change and intra-regional population changes between centers and peripheries, the following results were observed:

Among the 72 regions with an overall population increase

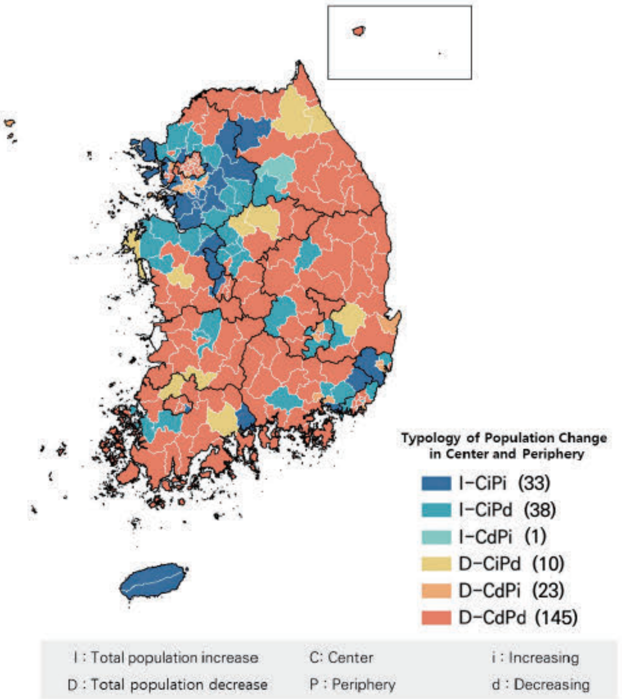


Figure 4. Distribution of population change types in center and periphery within regions

Table 4. Classification of population change types

Type	Number of regions	Region
I-CiPi Type	33 (13.20%)	Daejeon Yuseong-gu, Ulsan Ulju-gun, Sejong-si, Gyeonggi-do Suwon-si Yeongtong-gu, Gyeonggi-do Hanam-si, etc. (Total: 33 si-gun-gu governments)
I-CiPd Type	38 (15.20%)	Busan Gangseo-gu, Gyeonggi-do Uijeongbu-si, Chungcheongbuk-do Jincheon-gun, Gyeongsangbuk-do Yecheon-gun, Jeollanam-do Naju-si, etc. (Total: 38 si-gun-gu governments)
I-CdPi Type	1 (0.40%)	Gangwon-do Hoengseong-gun (Total: 1 si-gun-gu government)
D-CiPd Type	10 (4.00%)	Chungcheongbuk-do Chungju-si, Chungcheongbuk-do Eumseong-gun, Gangwon-do Yangyang-gun, etc. (Total: 10 si-gun-gu governments)
D-CdPi Type	23 (9.20%)	Seoul Jongno-gu, Seoul Gwanak-gu, Daegu Dalseo-gu, Gyeongsangnam-do Changwon-si Seongsan-gu, etc. (Total: 23 si-gun-gu governments)
D-CdPd Type	145 (58.00%)	Seoul Seongdong-gu, Seoul Jungnang-gu, Busan Busanjin-gu, Gangwon-do Sokcho-si, Jeollanam-do Shinan-gun, etc. (Total: 145 si-gun-gu governments)

(Type I), 71 regions were categorized as I-CiPi or I-CiPd, where the population of the urban center increased. Only one region, Hoengseong-gun in Gangwon-do, was classified as I-CdPi, where the urban center population decreased despite total growth.

In contrast, among the 178 regions with an overall population decrease (Type D), 168 regions were categorized as D-CdPi or D-CdPd, where the urban center population declined. Only 10 regions, including Chungju-si and Eumseong-gun in Chungcheongbuk-do, were categorized as D-CiPd, indicating urban center population growth despite overall decline. These findings suggest that, with the exception of one case, all regions experiencing total population growth also experienced urban center population growth. Conversely, except for 11 cases, nearly all regions with total population decline also saw a decline in their urban center populations.

Additionally, an examination of type distribution in recently developed new towns reveals a distinct pattern. In cases where new towns were developed between two adjacent jurisdictions—such as Naepo New Town (Hongseong-gun and Yesan-gun in Chungcheongnam-do) and Jincheon-Eumseong Innovation City (Jincheon-gun and Eumseong-gun in Chungcheongbuk-do)—the two jurisdictions were not assigned the same type. Regions with higher new town populations, such as Hongseong-gun and Jincheon-gun, were classified as I-CiPd, while regions with smaller new town populations, such as Yesan-gun and Eumseong-gun, were categorized as D-CdPd and D-CiPd, respectively.

2. Analysis of Residential Environment and Economic Activity Characteristics by Type

To examine differences in residential environment and economic activity indicators across types, and to identify the characteristics of each type, a Kruskal-Wallis H test was conducted.

According to the analysis results, as shown in 〈Table 5〉, there were statistically significant differences across the six types in the rate of new housing supply, the rate of change in the number of businesses, and the rate of change in the number of employees, both in urban center and periphery. Among these, the most distinct differences across types were

Table 5. Result of Kruskal_Wallis H

Indicators		Kruskal-Wallis H	P-value
Rate of change in housing prices	Center	8.16	0.1477
	periphery	13.554*	0.0187
Proportion of new housing units	Center	116.25***	<0.0001
	Periphery	70.692***	<0.0001
Rate of change in the number of businesses	Center	103.089***	<0.0001
	Periphery	16.411**	0.0058
Rate of change in the number of employees	Center	71.167***	<0.0001
	Periphery	18.362**	0.0025

* P < 0.05 , ** P <0.01, *** P < 0.001

observed in the changes in the number of businesses and housing units within urban center. However, the change in housing prices in urban center did not show a statistically significant difference ($H = 8.16, p = 0.1477$), suggesting that housing prices in urban center may be influenced by various external factors beyond population change.

As shown in 〈Table 6〉, the average ranks by indicator differed between urban center and periphery across the six types. Notably, the D-CdPd type recorded the highest average rank in housing price changes within peripheral areas, which contrasted with the ranking patterns of other indicators. Although not statistically significant, the housing price change in urban center also tended to rank higher in the D-CdPd type. This aligns with the results of the Kruskal-Wallis H test and suggests that housing prices are relatively less influenced by overall population change and may instead reflect external market or policy factors.

Table 6. Rank of types

Rank	Residential environment (C: center, P. periphery)			
	Housing prices (C)	Housing prices (P)	Newly housing (C)	Newly housing (P)
1	I-CiPi	D-CdPd	I-CiPd	I-CiPi
2	D-CdPd	D-CdPi	I-CiPi	I-CdPi
3	I-CiPd	I-CiPi	D-CiPd	D-CdPi
4	D-CiPd	D-CiPd	I-CdPi	I-CiPd
5	D-CdPi	I-CdPi	D-CdPd	D-CiPd
6	I-CdPi	I-CiPd	D-CdPi	D-CdPd
Rank	**Economic activity (C: center, P. periphery)**			
	Businesses (C)	**Businesses (P)**	**Employees (C)**	**Employees (P)**
1	I-CiPi	I-CiPi	I-CiPi	I-CiPi
2	I-CiPd	D-CiPd	I-CdPi	I-CdPi
3	I-CdPi	I-CiPd	I-CiPd	D-CdPd
4	D-CdPi	D-CdPd	D-CiPd	I-CiPd
5	D-CiPd	I-CdPi	D-CdPd	D-CiPd
6	D-CdPd	D-CdPi	D-CdPi	D-CdPi

In terms of the share of newly constructed housing units, types with population growth in urban center (I-CiPd, I-CiPi, D-CiPd) exhibited higher rankings in the urban center, while types with population growth in peripheral areas (I-CiPi, I-CdPi, D-CdPi) ranked higher in periphery. This suggests that new housing development is more closely associated with localized demographic trends than with total population change.

For the rate of change in the number of businesses in urban center, types with overall population growth (I-CiPi, I-CiPd, I-CdPi) generally ranked higher. However, in peripheral areas, the D-CiPd type—where total and peripheral populations are declining—ranked unexpectedly high. This may imply a spatial mismatch between industrial location and population trends, raising concerns about potential imbalances in residential-industrial alignment.

Similarly, in urban center, the rate of change in the number of employees was higher for types with overall population growth (I-CiPi, I-CdPi, I-CiPd). In contrast, periphery showed relatively higher ranks in the D-CdPd type, the most severely shrinking type, again suggesting a possible decoupling between demographic trends and employment location in peripheral regions.

To further examine which group differences drove the statistical significance, Dunn's post-hoc test was performed following the Kruskal-Wallis analysis. The Bonferroni correction method was applied to adjust for the potential increase in Type I error due to multiple comparisons. The detailed post-hoc results are presented in 〈Table 7〉.

In terms of the proportion of newly constructed housing units in urban center, the D-CiPd type exhibited significant differences from other types that shared the same overall population trend but differed in the direction of population change in the urban center. In contrast, for peripheral areas, significant differences in the share of new housing were more prevalent among types where the urban center population was increasing. Specifically, statistically significant differences were observed between I-CiPi and I-CiPd, as well

Table 7. Result of Dunn's post-hoc test (Bonferroni)

Newly housing (C)	**I-CiPi**	**I-CiPd**	**I-CdPi**	**D-CiPd**	**D-CdPi**	**D-CdPd**
I-CiPi	1					
I-CiPd	1	1				
I-CdPi	1	1	1			
D-CiPd	1	1	1	1		
D-CdPi	1.43E-07	2.15E-10	1	0.006199	1	
D-CdPd	8.1E-11	2.1E-16	1	0.010451	1	1
Newly housing (P)	**I-CiPi**	**I-CiPd**	**I-CdPi**	**D-CiPd**	**D-CdPi**	**D-CdPd**
I-CiPi	1					
I-CiPd	0.00914	1				
I-CdPi	1	1	1			
D-CiPd	0.120094	1	1	1		
D-CdPi	0.46187	1	1	1	1	
D-CdPd	3.86E-13	0.00501	1	1	0.00126	1
Businesses (C)	**I-CiPi**	**I-CiPd**	**I-CdPi**	**D-CiPd**	**D-CdPi**	**D-CdPd**
I-CiPi	1					
I-CiPd	1	1				
I-CdPi	1	1	1			
D-CiPd	0.074004	0.034327	1	1		
D-CdPi	0.00246	0.000528	1	1	1	
D-CdPd	1.94E-12	3.08E-15	1	1	1	1
Businesses (P)	**I-CiPi**	**I-CiPd**	**I-CdPi**	**D-CiPd**	**D-CdPi**	**D-CdPd**
I-CiPi	1					
I-CiPd	1	1				
I-CdPi	1	1	1			
D-CiPd	1	1	1	1		
D-CdPi	0.029666	0.005896	1	0.169228	1	
D-CdPd	1	0.422978	1	1	0.252421	1
Employees (C)	**I-CiPi**	**I-CiPd**	**I-CdPi**	**D-CiPd**	**D-CdPi**	**D-CdPd**
I-CiPi	1					
I-CiPd	1	1				
I-CdPi	1	1	1			
D-CiPd	1	1	1	1		
D-CdPi	1.68E-06	2.65E-07	1	0.082534	1	
D-CdPd	4.27E-07	1.3E-08	1	0.55994	1	1
Employees (P)	**I-CiPi**	**I-CiPd**	**I-CdPi**	**D-CiPd**	**D-CdPi**	**D-CdPd**
I-CiPi	1					
I-CiPd	1	1				
I-CdPi	1	1	1			
D-CiPd	1	1	1	1		
D-CdPi	0.004562	0.04837	1	0.649957	1	
D-CdPd	0.08074	1	1	1	0.716698	1

as between D-CdPi and D-CdPd, despite these types sharing the same total population trend.

For both urban center and periphery, the rate of change in the number of businesses showed statistically significant differences only between types, with opposing trends in total population change. Similarly, the rate of change in the number of employees revealed statistically significant differences exclusively between types with contrasting overall population trends.

3. Implications

Based on the above findings, distinct characteristics in residential environments and economic activity were identified across population change types in urban center and periphery, suggesting the following spatial policy implications:

First, both the I-CiPi and I-CiPd types exhibited high rates of newly constructed housing, business establishments, and employment in urban center where the population is increasing. However, their policy responses should differ depending on whether growth is occurring exclusively in the center (I-CiPd) or across both center and periphery (I-CiPi). In particular, I-CiPd regions show rising populations in the center but declining populations in peripheral areas, and rank relatively low in terms of peripheral housing growth. These areas require spatial linkage strategies to strengthen residential infrastructure, transportation access, and housing functions across urban center and periphery for sustainable spatial management.

Second, the D-CiPd type, where the urban center population is increasing but the periphery is declining, shows high growth rates in the number of businesses and employees in peripheral areas. This suggests that although residential conditions are deteriorating in the periphery, the industrial base remains stable or is even expanding. Such a pattern could lead to the formation of "non-residential industrial zones," where industrial activity persists without sufficient population support. If unplanned, this may result in negative externalities such as increased commuting burdens, lack of local services, and residential avoidance. Consequently, policies should focus on improving peripheral living conditions, strengthening commuting linkages to the center, and implementing integrated monitoring systems for industry-residency alignment.

Third, the D-CdPd type—characterized by population, residential, and economic decline in both urban center and periphery—was observed in more than half of all 250 municipalities examined. This type was widely distributed across the country, including in major metropolitan areas such as Seoul and Busan. Immediate policy efforts are needed to enhance urban resilience, including urban regeneration, strategic revitalization of center areas, and strengthening of interregional centrality linkages.

Fourth, in types where the urban center is declining while the periphery shows relative growth (D-CdPi and I-CdPi), the weakening or functional shift of traditional centers is evident. These regions may require targeted interventions such as reallocation of public services, mixed-use redevelopment, and designation of new local anchors. Furthermore, a polycentric planning approach that considers the formation of new centers should be explored.

V. Summary and Conclusion

This study emphasizes the importance of classifying intra-regional population changes between urban center and periphery when establishing spatial policy responses to demographic decline. By analyzing the spatial population change patterns over the past decade, we classified all 250 municipalities in South Korea into six types based on population change in the urban center and periphery. We further explored differences in residential environments and economic activities across these types to derive practical policy implications.

First, among the 250 municipalities, approximately 58% were categorized as D-CdPd, where both the urban center and periphery experienced population decline. This type included not only small and medium-sized cities in non-metropolitan regions but also major metropolitan areas such as Seoul and Busan. This finding demonstrates that population decline is no longer confined to rural or non-capital areas. Consequently, policy efforts that have focused predominantly on non-metropolitan areas must be expanded to include major cities experiencing similar trends.

Analysis also revealed a strong correlation between total population change and urban center population trends. Among the 72 regions with overall population growth, all but one experienced an increase in the urban center population. Conversely, among the 178 regions with overall population decline, only 10 maintained growth in their urban center. This indicates that urban center vitality plays a critical role in regional demographic dynamics, underscoring the need for targeted interventions aimed at sustaining population concentrations in urban center rather than focusing solely on peripheral expansion.

Furthermore, in newly developed areas such as administrative or innovation cities, total population may have increased due to in-migration. However, existing urban centers often continued to experience decline, suggesting a lack of spatial integration between new and traditional urban centers. This highlights the limitations of relying solely on aggregated population statistics and the necessity of finer-scale grid-based analysis to support spatially tailored responses.

Second, the analysis of residential and economic indicators revealed statistically significant differences across the six types in the rate of newly built housing, business establishments, and employment. However, housing price changes did not differ significantly by type, likely reflecting the influence of external factors such as speculative investment or market expectations, rather than local population demand. High housing prices, in turn, may deter in-migration or affect long-term residency, suggesting the need for housing market regulation as part of population decline countermeasures.

Notably, the rankings of each indicator varied between urban center and periphery. For example, types with urban center population growth exhibited higher ranks in urban center housing development, while types with peripheral growth ranked higher in peripheral housing development. In contrast, business and employment growth patterns diverged more sharply: while urban center business and employment growth aligned with overall population increases, some declining regions (e.g., D-CiPd, D-CdPd) still exhibited strong industrial activity in peripheral areas. This mismatch between population and industry raises concerns about the formation of "non-residential industrial zones" and suggests a need for more balanced spatial planning and monitoring in peripheral districts.

Limitations of this study include the fixed use of 1km grid units based on the National Territorial Spatial Center Map, without considering potential variation in appropriate spatial units based on region size or function. Additionally, due to data availability constraints, only a limited set of residential and economic indicators was used to interpret type-specific characteristics. Future studies should incorporate broader variables such as age structure, migration patterns, and socio-economic dynamics.

Despite these limitations, this study offers a novel perspective by moving beyond aggregate population trends and emphasizing intra-regional spatial structure through the classification of centers and peripheries. It also expands upon prior demographic analyses by incorporating environmental and economic indicators to propose differentiated spatial policy responses. The findings advocate for a dual strategy: strengthening urban center functions to retain population and improving peripheral conditions to mitigate spatial imbalance.

Ultimately, the study provides a foundation for grid-level population analysis and policy design tailored to diverse urban forms in the era of population decline. By presenting specific Compact-Network strategies for both urban center and periphery, this research contributes to the formulation of spatial policies that are both regionally customized and strategically coordinated.

References

1. Burgess, E.W., 1926. *The Urban Community: Selected Papers form the Proceedings of the American Sociological Society*, Chicago: University of Chicago Press.
2. Chen, Z., Yu, B., Song, W., Liu, H., Wu, Q., Shi, K., and Wu, J., 2017. "A New Approach for Detecting Urban Centers and Their Spatial Structure with Nighttime Light Remote Sensing", *IEEE Transactions on Geoscience and Remote Sensing*, 55(11): 6305-6319.
3. Choi, J.H. and Park, P.G., 2020. "Regional Characteristics of the Shrinking Cities in Korea and its Implication Toward Urban Policies", *Journal of the Korean Urban Geographical Society*, 23(2): 1-13.
4. Christaller, W., 1968. *Die Zentralen Orte in Süddeutschland: eine ökonomisch-geographische Untersuchung über die Gesetzmä-ßigkeit der Verbreitung und Entwicklung der Siedlungen mit städtischen Funktionen*. Wissenschaftliche Buchgesell-schaft (Reprografischer Nachdruck der 1. Auflage, Jena, 1933).
5. Chun, K.K. and Chun H.J., 2016. "A Study on the Planning Issues of Shrinking Communities for Smart Decline", *Journal of the Korean Regional Development Association*, 28(1): 1-28.
6. Davoudi, S., 2003. "European Briefing: Polycentricity in European Spatial Planning: From an Analytical Tool to a Normative Agenda", *European Planning Studies*, 11(8): 979-999.
7. Dent, H.S., 2014. "The Demographic Cliff: How to Survive and Prosper During the Great Deflation of 2014-2019", New York: Portfolio.
8. Ding, X., Zhou, Y., and Wu, J., 2022. "Types, Modes and Influencing Factors of Urban Shrinkage: Evidence from the Yellow River Basin, China", *Sustainability*, 14(15): 9213.
9. Giuliano, G. and Small, K.A., 1991. "Subcenters in the Los Angeles Region", *Regional Science and Urban Economics*, 21(2): 163-182.
10. Halbert, L., Convery, F.J., and Thierstein, A., 2006. "Reflections on the Polycentric Metropolis", *Built Environment*, 32(2): 110-113.
11. Han, S.W., Oh, S.J., and Park, B.H., 2008. "Analysis on the Changing Patterns of Population Centroid and Density in the Case of Large Cities with 500 -1,000 thousands Population", *Journal of The Korean Regional Development Association*, 20(3): 67-82.
12. Harris, C.D. and Ullman, E.L., 1945. "The Nature of Cities", *The ANNALS of the American Academy of Political and Social Science*, 242(1): 7-17.
13. Hoyt, H., 1939. *The Structure and Growth of Residential Neighborhoods in American Cities*, US Government Printing Office.
14. Im, E.S., Lee, J.Y., and Lee, H.Y., 2006. "Measurement of Urban Form in Urban Growth Management: Urban Sprawl versus Compactness", *The Korea Spatial Planning Review*, 51(4): 223-247.
15. Jang, M.H., 2023. "Study on Classification of Depopulation Areas According to Crisis of Local Extinction", *The Geographical Journal of Korea*, 57(1): 11-22.
16. Je, H.J., 2018. "Actual Conditions of Classified Types of Regional Population Decrease and the Comparison of Urban Planning Responses", PhD. Dissertation, Seoul National University.
17. Jeong, J.W. and Lee, A.R., 2022. "Analysis on the Characteristics of Areas of Population Decline by Cluster Type", *The Korean Journal of Public Administration*, 31(3): 61-87.
18. Kim, D.H. and Woo, M.J., 2018. "A Study on the Identification of Hub Cities and Delineation of Their Catchment Areas Based on Regional Interactions", *Journal of Korea Planning Association*, 53(7): 5-22.
19. Kim, H.C. and An, Y.S., 2018. "A Study on the Identification of Center of Seoul Metropolitan Area and Methodology Based on the Commuting", *Journal of the Korean Regional Science Association*, 34(2): 49-64.
20. Kim, K.Y. and Lee, Y.M., 2013. "Exploring the Urban Spatial Structure of Korean Cities Using a Land Value Function", *Journal of the Korean Urban Geographical Society*, 16(1): 99-112.

21. Kim, M.H., 2020. *Estimation Status and Implications of Planned Population in Urban Master Plans*, Sejong: Korea Research Institute for Human Settlements.

22. Kim, S.H., 2019. "A Study on Population Decline and Changes in the Population Structure in Shrinking Cities", PhD. Dissertation, Hanyang University.

23. Kim, S.J. and Lee, S.G., 2021. "Identifying Urban Activity Centers and Their Funtions using POI Big Data: The Case of Seoul Metropolitan Area", *Journal of Korea Planning Association*, 56(6): 36-52.

24. Lee, H.S., 2020. "A Study on the Urban Spatial Structure Change in Population Growth Type Local Medium Sized City: A Case of Asan-si", *Journal of the Association of Korean Geographers*, 9(2): 377-393.

25. Lee, M.J., Kim, S.G., and Kim, E.J., 2023. "A Typology of Depopulated Areas in Korea: Evaluation and Characterization by Subgroups", *Korean Journal of Urban Studies*, 23: 93-137.

26. Lee, S.J. and Han, K.H., 2021. "A Study on Analysis and Strategy According to the Type of Population Decline: Focused on Jeollabukdo", *Journal of Regional Studies*, 29(3): 21-47.

27. Lee, S.J., Min, S.H., and Cha, E.H., 2018. "Directions for Establishing Urban and County Master Plans in Response to the Era of Low Growth: Implications from the National Land Planning Evaluation System", *KRIHS POLICY BRIEF*, 667: 1-8.

28. Mabon, L., Yamagata, Y., Matsubae, K., and Hashimoto, S., 2024. "Urban shrinkage as a Catalyst for Transformative Adaptation: Insigts from Yubari, Japan", *Buildings and Cities*, 5(1): 1-18.

29. Ministry of Land, Infrastructure and Transport (MOLIT), 2024. *2024 Territorial Monitoring Report*, Sejong: Ministry of Land, Infrastructure and Transport.

30. Min, B.K. and Choi, J.S., 2023. "Characterizing Regions Based on the De Facto Population: Focusing on the Local Areas in South Korea", *Journal of The Korean Urban Management Association*, 36(4): 41-60.

31. Nam, K.C. and Kim, B.H., 2017. "The Effect of Spatial Structure and Dynamic Externalities on Local Growth in Seoul Metropolitan Area", *Urban Policy and Research*, 35(2): 165-179.

32. Oh, Y.J., Choi, J.H., and Yoon, G.S., 2018. *Spatial Policy Directions and Challenges for Chungcheongnam-do Considering Spatial Structure Changes in the Era of Population Decline*, Gongju: Chungnam Institute.

33. Park, S.H,, Jung, Y.H., and Park, G.H., 2013. "Current Status of Urban Population Decline and Urban Planning Responses", *KRIHS POLICY BRIEF*, 422: 1-6.

34. Ribant, M. and Chen, X., 2020. "A Typology of US Shrinking Cities", *The Professional Geographer*, 72(1): 152-164.

35. Sun, Y., Fan, H., Li, M., and Zipf, A., 2016. "Identifying The City Center Using Human Travel Flows Generated from Location-Based Social Networking Data", *Environment and Planning B: Planning and Design*, 43(3): 480-498.

36. Yim, S.H., 2018. "Types of Depopulated Cities and their Geographical Characteristics", *The Geographical Journal of Korea*, 52(1): 65-84.

37. Yim, S.H., 2019. "Local Small Cities's Population Reduction and the Characteristics of Their Growth and Decline", *Journal of the Korean Geographical Society*, 54(3): 365-386.

38. Yoon, J.S. and Lee, S.S., 2019. "A Study on the Urban Planning's Implications and the Governmental Policies for Shrinking City in Japan: Focusing on Location Normalization Plan", *Journal of Korea Planning Association*, 54(2): 17-32.

39. Zhang, X., Yu, S., Ding, X., Li, M., Miao, Y., and Wang, C., 2023. "Urban Growh and Shinkage with Chinese Characteristics: Evidencd from shandong Province, China", *Applied Geography*, 159: 103097.

Date Received	2025-03-31
Reviewed(1st)	2025-04-30
Date Revised	2025-07-24
Reviewed(2nd)	2025-08-08
Date Accepted	2025-08-08
Final Received	2025-08-11