

Exploring Vulnerability in Urban Areas: Housing and Living Poverty in Seoul, South Korea

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Article

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Abstract

While COVID-19 and climate change have recently had a tremendous impact on the global population, the urban poor have experienced greater suffering. The urban poor in South Korea are not immune to this social phenomenon. The current study explores urban poverty in Seoul, the capital of Korea, by considering the characteristics of housing and living poverty in Seoul. Through a data-driven approach, this study identifies how regions in Seoul form clusters and identifies the magnitude of poverty differences between regions. According to the findings, Seoul can be generally divided into two areas which clearly show the spatial dimension of socio-economic stratification. Furthermore, we find that more than 75% of Seoul is exposed to vulnerabilities. This implies that poverty is a threat to most citizens and that the poor are neighbors in their communities. In this respect, the instability of the poor caused by exposure to various types of risks indicates the instability of the living environment for all citizens.

Introduction

In recent times, the global population has faced significant challenges due to the impacts of COVID-19 and climate change. Among those affected, the urban poor have borne the brunt of these crises (Filho et al., 2019; Friesen and Pelz, 2020; Hardoy and Pandiella, 2009; Lo et al., 2022; Sanchez-Guevara et al., 2019; Tampe, 2021). South Korean society, like others, has not been immune to these social issues. The suffering of the urban poor in Korea has become a pressing concern, with the COVID-19 pandemic, natural disasters, economic deprivation, and the high suicide rate among older adults living alone emerging as significant problems (hereafter referred to as Korea). It is crucial to identify the areas in the city that are most vulnerable in order to develop and implement effective policies to address or alleviate these social problems.

While scholarly works have examined urban poverty in Korea, they have primarily focused on historical contexts and descriptive studies (Ha and Lee, 2001; Ha, 2002, 2004; Kim and Han, 2012). While these studies contribute to understanding the social contextual structure of urban poverty, they have limitations in identifying its characteristics within specific administrative units in the city, which hinders the design and implementation of poverty-alleviation policies. Although recent literature analyzes socio-economic disparities and inequalities between regions in urban areas of Korea (Han, 2022a; Han and Lee, 2022; Sohn and Oh, 2019), they have not specifically focused on the urban poor who face multiple risks in a disadvantaged urban environment. This study seeks to address this gap by concentrating on the most socio-economically vulnerable regions rather than the privileged ones. The objective is to identify the most vulnerable urban areas using a data-driven approach that examines the characteristics of housing and living poverty in urban spaces, an area that has received limited attention in the existing literature on urban poverty.

The selection of appropriate indicators that align with the research objective is crucial in conducting a data-driven study. This research focuses on exploring the characteristics of housing poverty and living poverty among the urban poor in Seoul, the capital city of Korea. By examining housing and living poverty

in Seoul, the study aims to identify the areas within the city that are most susceptible to vulnerabilities. To achieve this, the study employs principal component analysis (PCA) and clustering algorithms, utilizing extensive archived data. Through this data-driven approach, the research identifies clusters within Seoul and assesses the disparities in housing and living poverty between different regions. Ultimately, this study sheds light on the regions that are most exposed to vulnerabilities. Seoul is an appropriate setting for this analysis due to its significant population size, accounting for approximately 17% of Korea's total population, and its diverse population composition, with individuals from various regions of the country residing in the city (Ha, 2002; Kim and Han, 2012; Seo, 2007; Yu, 1990).

The results of this study demonstrate that Seoul exhibits a clear division into two main regions, with a substantial number of regions within the city experiencing vulnerabilities. This finding implies that the urban poor, who are particularly susceptible to various risks, are distributed throughout Seoul and live in close proximity to the residences of the majority of the population. The presence of instability among citizens living in poverty, resulting from their exposure to multiple risks, highlights the overall fragility and instability of the living environment for all residents in Seoul. This underscores the interconnectedness of urban poverty and its impact on the broader social fabric of the city, emphasizing the urgent need to address these vulnerabilities and create a more equitable and secure urban environment for all.

This study contributes to the existing literature by employing data-driven methods to identify vulnerable regions within an urban area. Firstly, it presents an approach to analyze the form of urban poverty by considering the characteristics of housing and living poverty within specific urban spaces. Additionally, the study proposes an algorithmic approach to classify regions using a comprehensive set of data, enabling the analysis of extensive archived data. The examination of spatial clustering patterns and differences between clusters provides insights into the vulnerabilities faced by the urban poor in Seoul, a city intricately connected to the global economy, thereby revisiting the issue of deepening spatial polarization in global cities (Sassen, 2001).

The remainder of the paper is structured as follows. Section 2 discusses vulnerabilities of the urban poor and the context of urban poverty in Seoul, Section 3 discusses data and the methodological strategy, Section 4 presents the results, classifying the regions in Seoul and identifying the form of clusters, and the Section 5 concludes with implications.

Poverty and vulnerability

The prevailing notion that poverty is solely a consequence of individual shortcomings, such as laziness or a weak will, fails to acknowledge the complex factors that contribute to poverty. Poverty is not a simple personal problem but a multifaceted social issue deeply rooted in systemic inequalities and structural constraints. While global efforts have resulted in a gradual decline in absolute poverty rates, inequality within countries has become more pronounced, exacerbating the challenges associated with poverty (Chancel and Piketty, 2021).

The COVID-19 pandemic has laid bare the severity of poverty on a global scale, further underscoring the need to address its underlying causes and implement effective social policies (Almeida et al., 2021; Béland et al., 2022; Sumner et al., 2020). The pandemic has disproportionately impacted the poor, amplifying existing inequalities and vulnerabilities. It has highlighted the interplay between poverty and other social issues, such as inadequate healthcare, limited access to education, and precarious employment. Consequently, poverty has emerged as a pressing concern that requires comprehensive strategies to promote social inclusion and reduce inequality.

In the context of Korea, the issue of income and wealth disparities has garnered significant attention since the Asian financial crisis. Studies have identified various factors contributing to poverty in Korean society, including unequal opportunities, educational inequalities, and regional disparities (Byun and Park, 2017; Han, 2022a, 2022b). These factors restrict individuals' prospects for upward mobility, perpetuating a vicious cycle of poverty, particularly within low-income communities. The concentration of unemployment, specific labor market characteristics, and inadequate social safety nets further compound the challenges faced by the urban poor (Ku, 2002; Park, 2007; Yang, 2017).

Moreover, research highlights the impact of housing inequality as a structural driver of poverty in Korea (Han, 2022a, 2022b; Kim and Kim, 2013). Wealth disparities, particularly in the form of unequal access to housing, perpetuate socioeconomic gaps and hinder upward mobility. This inequality can be transmitted across generations, leading to persistent poverty and limited opportunities for social advancement (Han, 2022b; Kim, 2017a). Consequently, individuals trapped in housing and living poverty face significant challenges in breaking free from the cycle of deprivation.

Understanding the interconnected nature of poverty, its underlying causes, and its enduring effects is crucial for formulating effective policies that address the root causes of poverty and promote social equity. By recognizing poverty as a complex social issue influenced by systemic factors, policymakers and stakeholders can work towards creating inclusive societies that provide equal opportunities for all individuals, regardless of their socioeconomic background.

Vulnerabilities of the urban poor

In recent years, scholars have increasingly recognized the importance of adopting a comprehensive and multidimensional approach when examining urban poverty. These studies, conducted by researchers such as Ashik et al. (2020), Burchi et al. (2022), Kisiąła and Rącka (2021), Meng et al. (2020), Poku-Boansi et al. (2020), Sohnesen et al. (2022), Vilar-Compte et al. (2021), and Zandi et al. (2019), aim to investigate the living conditions and circumstances of impoverished areas and their residents. By considering various dimensions of poverty, these studies shed light on the complex nature of social exclusion and isolation experienced by the poor, with spatial patterns playing a significant role in highlighting these dynamics.

Another line of research has focused on understanding the “area effects” or “neighborhood effects” within urban spaces. Scholars such as Atkinson and Kintrea (2001) and Murie and Musted (2004) have examined how social exclusion affects individuals or groups residing in specific areas, encompassing dimensions such as health, education, employment, and safety, all of which are influenced by the characteristics of the locality. These studies commonly assume that residents of impoverished areas are more likely to encounter various challenges, including social isolation, limited social networks, poor health outcomes, and heightened vulnerability to natural disasters (Cook, 2014; Kikuti et al., 2015; Lee et al., 2021; Romero-Lankao and Qin, 2011; Wang et al., 2018). Such research consistently emphasizes that the urban poor face a multitude of risks due to their disadvantaged spatial contexts.

Empirical evidence confirms the manifold risks that urban poverty poses to the urban poor, irrespective of whether they reside in the Global North or the Global South. For instance, individuals living in impoverished urban areas often encounter difficulties in accessing essential medical facilities, leading to limited healthcare services and an increased susceptibility to contagious diseases (Ewart and Suchday, 2002; Hodgetts and Stolte, 2017; Montgomery and Hewett, 2005; Tampe, 2021). Moreover, inadequate sanitation facilities, prevalent in these areas, further contribute to their vulnerability. The absence of basic amenities exposes the urban poor to higher levels of violence and perpetuates their overall deprivation, making them physically and psychologically susceptible to adverse outcomes (Ewart and Suchday, 2002; Hodgetts and Stolte, 2017; Montgomery and Hewett, 2005; Tampe, 2021).

A notable distinction arises when comparing affluent regions with their impoverished counterparts. In prosperous areas, economic resources, educational opportunities, and religious institutions foster the creation of social networks and enable access to social capital (Quillian, 2014). However, individuals residing in impoverished areas are deprived of such benefits, exacerbating their social isolation and further hindering their integration into society (Cook, 2014). This deprivation of social capital and networks intensifies the challenges faced by the urban poor, perpetuating their marginalization and reinforcing the cycle of poverty (Cook, 2014).

Additionally, the urban poor are more susceptible to natural disasters, including heatwaves, floods, and threats such as building collapses and security issues (Boateng, 2021; Crutchfield and Wadsworth, 2003; Hardoy and Pandeilla, 2009; Sanderson, 2000). Their marginalized living conditions, often characterized by inadequate infrastructure and housing, expose them to heightened risks during such events. Given the multifaceted nature of urban poverty and the numerous risks it engenders, it becomes crucial to understand the spatial patterns of poverty within urban areas.

The context of urban poverty in Seoul

As cities grow in size, residents’ socio-economic characteristics become spatially embodied, depicting society’s overall social structure (Duranton and Puga, 2000; Sassen, 2001; Soja, 2010). As of 2022, Seoul’s population was approximately 9.5 million, accounting for about 17% of the total population of Korea. Seoul is densely populated with diverse people from all over the country looking for jobs and

opportunities (Han, 2022a; Jung, 2017; Yu, 1990). In the period of rapid economic development since the 1970s, opportunities for wealth and occupations have been concentrated in the Seoul metropolitan area (Seo, 2007; Yu, 1990), which has spatially formed socio-economic stratification (Ha and Lee, 2013; Han, 2022a; Yang, 2018). In Seoul, phrases that represent specific spaces, such as *Gangnam* versus *Gangbuk*, reflect individuals' identity, social status, and class (Bae and Joo, 2020; Yang, 2018). A region where an individual lives is one of the prime factors indicate an individual's socio-economic position (Bae and Joo, 2020; Bang Shin, 2008; Sohn and Oh, 2019).

According to the Global Power City Index 2022, Seoul is ranked 7th (Institute for Urban Strategies, 2022), and according to the 2022 Global Cities Report (Kearney, 2022), Seoul is ranked 13th in the Global Cities Index. As these rankings demonstrate, Seoul is a globally competitive city, but simultaneously, high social and economic inequalities exist in this urban space (Han, 2022a). To reiterate, great wealth and the great poverty coexist in Seoul.

One study suggests "Housing poverty" and "Living poverty" as factors closely related to the vulnerabilities of the urban poor in Seoul (Cheong et al., 2012; Ha, 2002, 2004; Han, 2022a). In particular, Seoul has *Gosiwon* or *Goshiwon* (Go-si-won) and *Jiha/Banjiha* (Ji-ha/Ban-ji-ha), which are unique types of housing reflecting the housing poverty of the poor in Seoul. In Korean society, there are various factors that determine housing type, and economic status determines the threshold for selecting the dwelling type (Yi and Lee, 2014). Therefore, the cheapest and most flexible type of housing is what the most vulnerable people in Seoul are looking for. *Gosiwon* is a low-cost dwelling place where larger rooms are usually divided by thin walls and makeshift doors (Kim, 2017b). Thus, the lack of privacy in *Gosiwon* is an inevitable issue. *Gosiwon* residents tend to perceive *Gosiwon* as a temporary residence, so there is little interaction with neighbors and people are often socially isolated.

Rooms are rented on a monthly basis, and are the cheapest and most flexible form of housing in the country. Rooms are as tiny as 3.5 square meters and furnished with a desk, bookshelf, and bed. There are usually no windows, but if there are, sunlight does not filter in well. Unless an individual pays for the luxury of a private shower or toilet, the resident has to share one with many other tenants (ranging from 20 to 40). The housing fragility of this space has recently been highlighted again as many tenants contracted COVID-19 (The Korea Economic Daily, 2021) and people died in fires because of a lack of safety facilities (Kim, 2018). In a living space where contact with strangers is inevitable, individuals are exposed to many types of unpredictable risks every day.

Jiha/Banjiha refers to basement/semi-basement housing, made famous by the Oscar-awarded Korean film "*Parasite*" which vividly portrays this type of dwelling place (Kim, 2020). *Jiha/Banjiha* houses in Seoul were built intensively in the late 1980s and early 1990s. This rapid increase in the number of underground/semi-basement residences is attributable to the easing of construction standards for multi-unit dwellings in response to the sharp increase in housing prices due to Seoul's rapid increase in population. These residential spaces are characterized by low income homes, and as more than half of the houses are located underground, they are exposed to various social risks and natural disasters such

as fires, gas leaks, flooding, respiratory diseases, and pests. As recent floods resulted in many casualties in Seoul, Korean society has once again noted the vulnerability of those living in this space (Lee and Kim, 2022).

Figure 1 shows the spatial distribution of “Gosiwon” and “Jiha/Banjiha” across Seoul, where larger values are denoted by darker colors, and vice versa. According to the estimates of this study, Gosiwon and Jiha/Banjiha are distributed throughout Seoul (for detailed variable descriptions, refer to the following section). In particular, many Gosiwons are located in Gwanak-gu and Seodaemun-gu, and many Jiha/Banjiha are located in Gwanak-gu, Gangbuk-gu and Jungnang-gu.

Basic livelihood security recipients are those whose recognized income is less than 30–50% of the median income.^[1] All Korean citizens can be eligible for basic livelihood benefits based on recognized income, which is the amount calculated by considering monthly income as well as any property or debt. For example, as of 2023, assuming that a single-person household has no property or income and their recognized income is 0 KRW,^[2] the person is eligible for livelihood benefits, medical benefits, housing benefits, and education benefits because their recognized income is less than 623,368 KRW. The living income of 623,368 KRW is paid to the recipient’s bank account every month. Recently, the Seoul Metropolitan Government has announced the “Seoul-style living wage” at 11,157 KRW per hour in 2023. If an individual works 209 hours (the legal amount of working hours), they will receive 2,331,813 KRW per month based on ordinary wages.^[3] If this living wage implies a wage at which workers and their families can live above the poverty line while being guaranteed housing, education, and a cultural life, then people that receive the basic livelihood security live far below the poverty level.

Thus, these households house the people with the lowest income level face the greatest difficulties in maintaining basic living standards. Given that income is one of the important factors affecting the subjective well-being of Seoul citizens (Jin and Hong, 2022), income would not only affect economic aspects but also psychological aspects of poor people’s daily lives.

Korea’s suicide rates are the highest of all countries belonging to the Organization for Economic Cooperation and Development (OECD); suicide rates among older adults are also the highest (Jeon et al., 2017; Jones and Urasawa, 2014, OECD, 2021). In Korean society, older adults account for the largest portion of the total population in poverty (Jeon et al., 2017; Lee et al., 2013). Poverty is highly associated with suicide commitment in Korean society (Pak and Choung, 2020), and noted to be one of the most important factors influencing suicide among older adults in Korea (Cheong et al., 2012; Jeong et al., 2022). The suicide rates among older adults living alone in urban areas are higher than that of people living elsewhere in Korea (Cheong et al., 2012). Thus, if poor older adults live alone in urban areas, they are more likely to be exposed to extreme poverty and are subject to a higher risk of committing suicide or dying alone. They are therefore exposed to risks such as isolation, physical or mental health issues and economic deprivation. During the COVID-19 pandemic, poor older adults may have experienced increased deprivation and physical and social isolation. In Fig. 2, “Basic living” refers to households receiving basic livelihood security and “Old in poverty” refers to older adults living alone with reduced basic livelihood

security or low income. They live all over Seoul, but are particularly concentrated, in the southwest, north, and northeast of Seoul.

Materials and methods

Data-driven methods and data

The spatial analysis approach employed in this study revolves around utilizing data-driven methods to measure housing poverty and living poverty. Data, in this context, serve as a reflection of human behaviors, interactions, and societal dynamics (Monroe et al., 2015). Human beings reside within complex webs of relationships and activities that extend both within and beyond individual spatial units. These spatial units encompass diverse ways of life and relationships, representing the various facets of human existence.

Spatial units are constructed by individuals as active agents through social interactions, while society also plays a role in shaping these units through institutional and relational networks. Consequently, spatial divisions emerge as a result of the interplay between connection and bonding, as well as confrontation and rejection, among these spatial units. By analyzing data-driven approaches, this study aims to unveil the social relationships that underlie urban poverty and demonstrate how these relationships manifest as distinct spatial patterns.

The proposal put forth by this study suggests that multidimensional data, which capture the intricacies of social relationships, possess a discernible pattern that can be employed to measure housing poverty and living poverty among the urban poor. By understanding and analyzing these patterns, researchers can gain valuable insights into the spatial manifestations of poverty and its associated dynamics. This approach enables a comprehensive examination of the social fabric within urban areas, providing a deeper understanding of the challenges faced by the urban poor and paving the way for targeted interventions and policy measures.

A critical question for the data-driven urban housing and living poverty approach is what indicators to choose to meet the aim of study. In this regard, when collecting data, it is necessary to have a sufficient understanding of the society from which data is being collected, as the socio-economic characteristics used to analyze poverty differs according to each society. For data set that is analyzed here, the focus is on housing and living poverty.

Table 1 shows the list of variables used in the analysis of this study (see Appendix A for details). The housing poverty variable included both Gosiwon and Jiha/Banjiha housing types. The number of Gosiwons was estimated by extracting the number of Gosiwons registered in Seoul from a commercial facility dataset. Information on all commercial facilities registered in Korea are provided through OpenAPI from the public data portal, provided by the government (data.go.kr). As the data on Jiha/Banjiha housing is not directly available, we used archived registered building data disclosed by government agencies (open.eais.go.kr). The data includes the structure of all buildings registered in Korea. In this

study, the number of Jiha/Banjiha was estimated by enumerating the number of habitable basements or semi-basements of detached and apartment houses located in Seoul.

Table 1
List of variables

	Category	Variable	Explanation	N
1	Housing poverty	Gosiwon	Number of Gosiwon	5582
2		Jiha/Banjiha	Number of habitable basements or semi-basements of detached and apartment houses	202540
3	Living poverty	Basic living	Number of households receiving basic livelihood security	289518
4		Old in poverty	Number of older adults living alone with basic livelihood security or low income	124654

Note: N of Housing poverty variables are estimated values based on raw data; There are as few as 20 people and as many as 100 people living in one Gosiwon.

The living poverty variable included “Basic living” and “Old in poverty.” Basic living refers to the number of households receiving basic livelihood security. Old in poverty refers to the number of older adults living alone with basic livelihood security or low income. Both data were extracted from government statistics (stat.eseoul.go.kr). The data on housing and living poverty were collected in units of *dong* (a block), the smallest administrative unit in Korea.[4] This study applies log transformation to social socio-economic clustering data, so that the interpretive difference between social groups depends on ratios rather than absolute values (Henning and Liao, 2013).

Analysis strategy

This study classifies *dongs* for analysis of urban vulnerability based on a data-driven approach that applies the PCA algorithm, the K-means ++ clustering algorithm and visualization techniques. The extraction of implicit characteristics of variables through PCA is not simply data compression; instead, it aims to extract potential factors that can better explain data through dimensionality reduction (Gniazdowski, 2017; Hastie et al., 2009).

The strategy of extracting one principal component (PC) from either housing or living poverty features enables more efficient clustering by removing potential noise resulting from high correlation between variables. The presence of unnecessary noise in the data means that it is highly unlikely that efficient clustering is achieved. Therefore, it is necessary to create new variables by extracting potential factors that can best explain the data distribution. In addition, we can find visually and intuitively interpretable results by reducing multi-dimensional data through this approach.

K-means ++ is a distance-based clustering algorithm that is developed from K-means; its core principles are identical, except for cluster centroid initialization (Arthur and Vassilvitskii, 2007; Hastie et al., 2009). K-

means is considered to be an unsupervised learning method; it selects a cluster centroid and then the data closest to the centroid based on the Euclidean distance (Hastie et al., 2009). K-means++ (or K-means) is applied in clustering analysis based on the socio-economic characteristics of various groups (e.g., Exeter et al., 2019; Han, 2022a; Henning and Liao, 2013; Siqueira-Gay et al., 2019; Walker and Crotty, 2015). This study utilizes the silhouette score as a way to estimate K and optimize K-means++ (Kaufman and Rousseeuw, 1990). Efficient clustering indicates that the distances between different clusters are sufficiently large and that data points in the same cluster are closer. A silhouette plot provides a way to evaluate parameters visually, such as the number of clusters, as it shows measured values of how close each data point in one cluster is to data points in adjacent clusters in an intuitive, yet concise, visual manner. Besides, the approaches using map visualization enable the spatial analysis of urban poverty to visually identify spatial forms of housing and living poverty, and gain deeper insight into social structure.

To ensure its robustness, the current study shows the results from Hierarchical Clustering, which uses the Ward linkage method (Aldenderfer and Blashfield, 1984). Hierarchical Clustering begins from each data point and combines similar points simultaneously to form hierarchical clusters. Compared with K-means++, a distance-based approach, the Ward linkage method is applied in Hierarchical Clustering (Aldenderfer and Blashfield, 1984), merging clusters based on the within-group sum of squares. Unlike K-means++, the Hierarchical Clustering algorithm performs without pre-determining the number of clusters, K , and can analyze clustering results by utilizing a dendrogram, a tree-shaped structure that indicates the order in which objects are combined.

Analysis results

The PCA and clustering results are analyzed in four steps: 1) the evaluation of PCA results; 2) evaluation of how many clusters exist; 3) determining the optimal clustering and spatial structure of clustering; and 4) identifying the most vulnerable areas. The PCA results of housing and living poverty variables are shown in Fig. 3. As discussed earlier, the aim of the PCA application is to reduce the variables into two dimensions, housing and living poverty, which reflect essential characteristics of the data. As depicted in Fig. 3, PC1 in housing poverty is a new variable that explains 70.3% of the data distribution alone. PC1 in living poverty explains 99.1% of the data distribution. Each PC1, a new variable extracted through dimensionality reduction, explains about 70% or more of the data distribution. This means that the correlations of the variables are quite high and the data are distributed in similar patterns.

From the maps in Figs. 1 and 2 in the previous section, we can see the spatial structure of housing and living poverty in Seoul. We can further understand them by analyzing the clustering results. The results of the silhouette analysis of Seoul are shown in Fig. 4. The x-axis refers to housing poverty and the y-axis refers to living poverty. In this figure, we can see how the silhouette score and its shape changes as the K increases. When divided into two clusters ($K = 2$), the silhouette score is the highest (0.426). Conversely, as K increases to three (0.334), four (0.356), five (0.345) and six (0.348), the silhouette score decreases. In other words, we can see that the silhouette score drops sharply when changing from $K = 2$ to $K = 3$ and maintains a similar level thereafter. Referring to Figure A1 in Appendix A, we can confirm that the optimal

number of clusters for Hierarchical Clustering is 2 as well and *dongs* belonging to each cluster are also the same.

Looking at the optimal clustering results when $K=2$ in Fig. 5, 98 *dongs* belong to Cluster 0 and the remaining *dongs* belong to Cluster 1. In this figure, we can intuitively see that Cluster 0 outnumbers Cluster 1. That is, over 75% of *dongs* form one large cluster, and the rest form a smaller one. In Fig. 5, we can find a map visualization of the clustering result for Seoul ($K=2$). Looking at the spatial shape of the clusters, we can find that Cluster 1 is mainly located in the center around the Han River (which passes through Seoul) and in the southeast. The rest belong to Cluster 0.

Figure 6 shows the average differences between Clusters 0 and 1 of Gosiwon, Jiha/Banjiha, Basic living, and Old in poverty. On average, Cluster 0 is 1.43 times higher in Gosiwon, 1.74 times higher in Jiha/Banjiha, 5.37 times higher in Basic living, and 5.15 times higher in Old in poverty than Cluster 1. This means that regions in Cluster 0 are more vulnerable than regions in Cluster 1 in terms of housing and living poverty, and the differences are not small enough to be negligible.

Figure 7 provides insights into the results obtained from PCA, identifying 30 *dongs* that fall within Cluster 0, representing areas with the highest vulnerabilities in terms of housing and living poverty. These *dongs* are characterized by a significant concentration of residents who experience either housing or living poverty, making them particularly susceptible to the risks associated with urban environments. It is worth noting that *dongs* belonging to Gangnam-3 gu, known as one of the wealthiest and most affluent regions in Seoul (Bae and Joo, 2020; Yang, 2018), are noticeably absent from both groups. This finding emphasizes the close association between housing and living vulnerabilities and the socio-economic structures that give rise to disparities between different regions within Seoul (Han, 2022a; Han and Lee, 2022).

The absence of *dongs* from Gangnam-3 gu in both groups implies that these affluent areas exhibit relatively lower levels of housing and living poverty compared to other regions in Seoul. This observation aligns with previous research highlighting the stark socio-economic contrasts and disparities present within the city (Han, 2022a; Han and Lee, 2022). The link between socio-economic structures and housing and living vulnerabilities further underscores the importance of addressing the disparities between regions in Seoul to foster more equitable and inclusive urban development.

In summary, the results of the clustering analysis based on housing and living poverty indicators obtained through PCA reveal that the neighborhoods (*dongs*) in Seoul can be broadly categorized into two distinct clusters. These clusters exhibit significant disparities in terms of housing and living conditions, highlighting the presence of pronounced gaps in poverty levels.

The primary objective of this study is to identify specific areas in Seoul that are particularly susceptible to poverty. However, the findings indicate that more than 75% of Seoul's urban areas are exposed to vulnerabilities associated with poverty. This implies that a substantial portion of the city's population resides in neighborhoods with high levels of poverty and limited access to basic amenities and resources.

Recognizing the prevalence of vulnerabilities in the majority of Seoul's urban spaces is crucial for effectively managing various social and natural risks faced by the residents. These risks include diseases, natural disasters, deprivation, and social isolation. Identifying the regions that are most exposed to these vulnerabilities becomes an essential step in the development and implementation of policies aimed at improving the safety and well-being of urban dwellers.

The analytical approaches employed in this study provide valuable insights into identifying the most vulnerable regions in Seoul. By utilizing data-driven methods such as PCA and clustering algorithms, policymakers and urban planners can gain a comprehensive understanding of the spatial patterns of poverty and direct their efforts towards implementing targeted interventions and initiatives in the most affected areas.

Conclusions

Policies must consider that poverty is not a single-dimensional problem of economic deprivation, but a multi-dimensional problem that combines cultural, psychological, and spatial isolation. For the development and application of poverty alleviation policies, it is necessary to conduct a thorough investigation into which areas are more exposed to vulnerabilities based on consideration of the characteristics of poverty in a particular space.

The current study explored urban housing and living poverty in Seoul, the capital of Korea. We analyzed how regions are classified through extensive data and algorithms, and further looked at their spatial forms. We presented the most vulnerable areas as examples. Before stressing the broader implications, it is necessary to be clear about the empirical limitations of this analysis. Empirically, findings from this study can only be suggestive. In this study, we estimated the number of Jiha/Banjiha from the archived data as this data is not directly available. Thus, there may be some errors with the current exact numbers. However, as the data was extracted from raw data through *Python* programming in a consistent manner, we believe that the results of this study can be reliable. Follow-up studies using more reliable and extensive data can supplement the results proposed by this study. In addition, data for housing poverty only includes information on buildings and commercial facilities registered with government agencies. Therefore, data from more marginalized dwellings which were not registered may not be included. This study also does not include data on the spatial distribution of homeless people who do not have a registered residence and do not receive basic livelihood benefits. A more in-depth analysis requires an approach that incorporates ethnographical observations.

Nevertheless, this study significantly contributes to the existing literature by proposing data-driven methods to identify vulnerable regions within an urban area, taking into account the socio-economic characteristics of the specific society under investigation. The findings of this research shed light on the spatial nature of socio-economic stratification in Seoul and provide valuable insights into the implications of urban stratification, including perpetuated inequality and poverty (Soja, 2010).

The study reveals that Seoul can be divided into two distinct areas that clearly exhibit socio-economic stratification patterns. This division emphasizes how urban stratification excludes certain individuals from socio-economic opportunities, leading to persistent inequality and poverty. It is noteworthy that more than 75% of the areas in Seoul were found to be exposed to vulnerabilities, indicating a high prevalence of poverty or the presence of economically disadvantaged neighbors within communities. Such high levels of vulnerability highlight the instability faced by the less privileged segments of society and emphasize the need to address the living environment for all citizens.

In addition to the findings discussed, it is important to acknowledge the existence of a unique housing type in Seoul known as Jjokbang (Jjok-bang), which represents housing poverty (Ha, 2004). Although not included in the analysis of this study, Jjokbangs are subdivided flats that accommodate individuals who exhibit characteristics of both housing poverty and living poverty. Typically inhabited by economically deprived, socially isolated older adults living alone, these residences present permanent living conditions that are as poor as those found in Gosiwon and Jiha/Banjiha housing types. It is estimated that Jjokbangs are concentrated in areas such as Donui-dong, Changsin-dong, Namdaemun, Dongja-dong, and Yeongdeungpo-dong, and their population may exceed the approximations (about 3,500 people) reported by recent studies conducted by Seoul City in 2018 (Seoul City, 2018).

The origins of these Jjokbangs can be traced back to the aftermath of the Asian financial crisis in 1997 when a significant influx of homeless individuals sought shelter in the aforementioned areas. Despite Korea's macroeconomic recovery since the late 1990s, the lasting impact of the financial crisis is still evident among these vulnerable residents, many of whom continue to face financial hardships. While some studies have focused on Jjokbangs (Kim et al., 2015; Kwon, 2008), public support and interest in addressing this issue remain insufficient. Therefore, further follow-up studies and policy discussions are warranted to raise awareness and develop appropriate measures.

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Footnotes

1. Ministry of Health and Welfare
(http://www.mohw.go.kr/react/policy/index.jsp?PAR_MENU_ID=06&MENU_ID=06350103&PAGE=3&topTitle=)
2. At the exchange rate of 1 USD = 1,237 KRW as of January 15, 2023.
3. Seoul Labor Portal
(https://www.seoullabor.or.kr/portal/bbs/selectBbs.do?bbs_code=A1006&bbs_seq=791).
4. There are 426 *dongs* (blocks) under 25 *gus* (boroughs) in Seoul.

Appendix

The Appendix is not available with this version

Figures

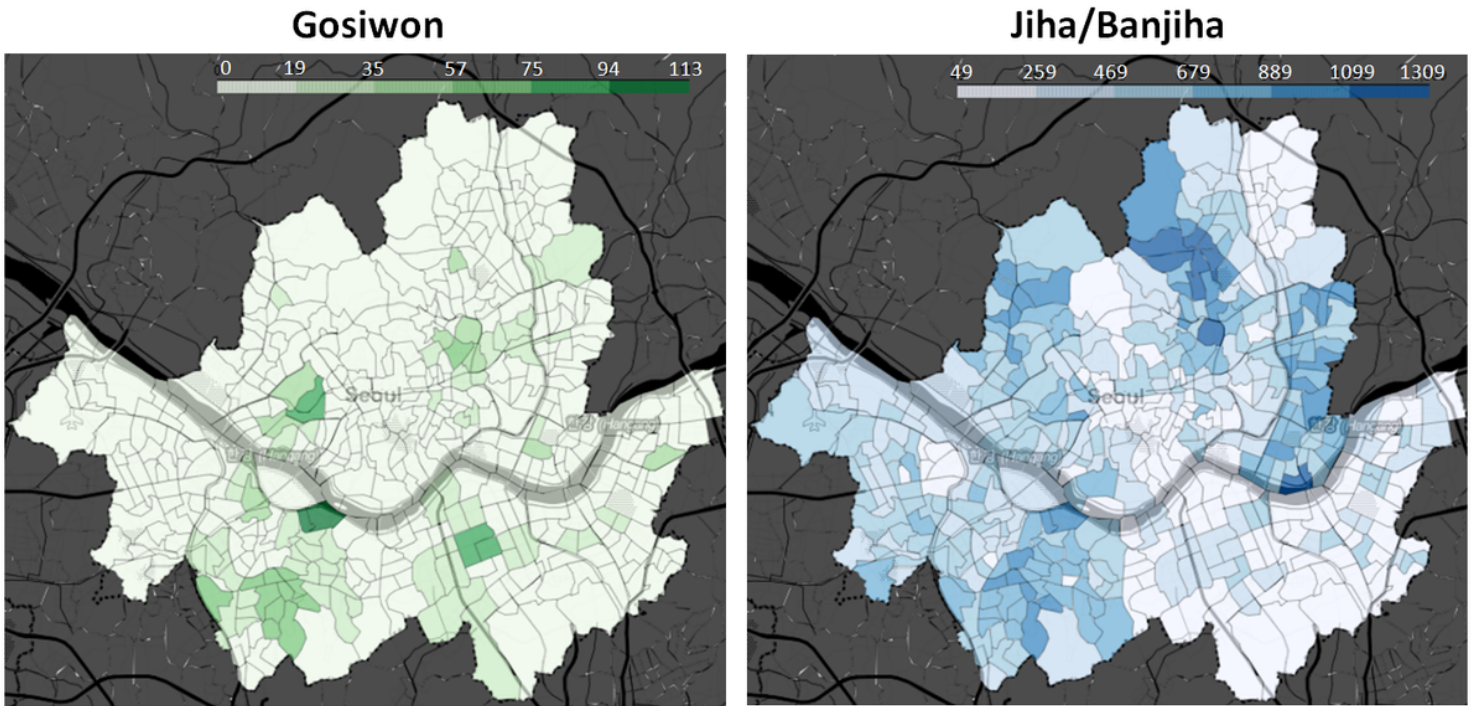


Figure 1

Gosiwon and Jiha/Banjiha map in Seoul

Note: See details in Section 3 and Appendix A.

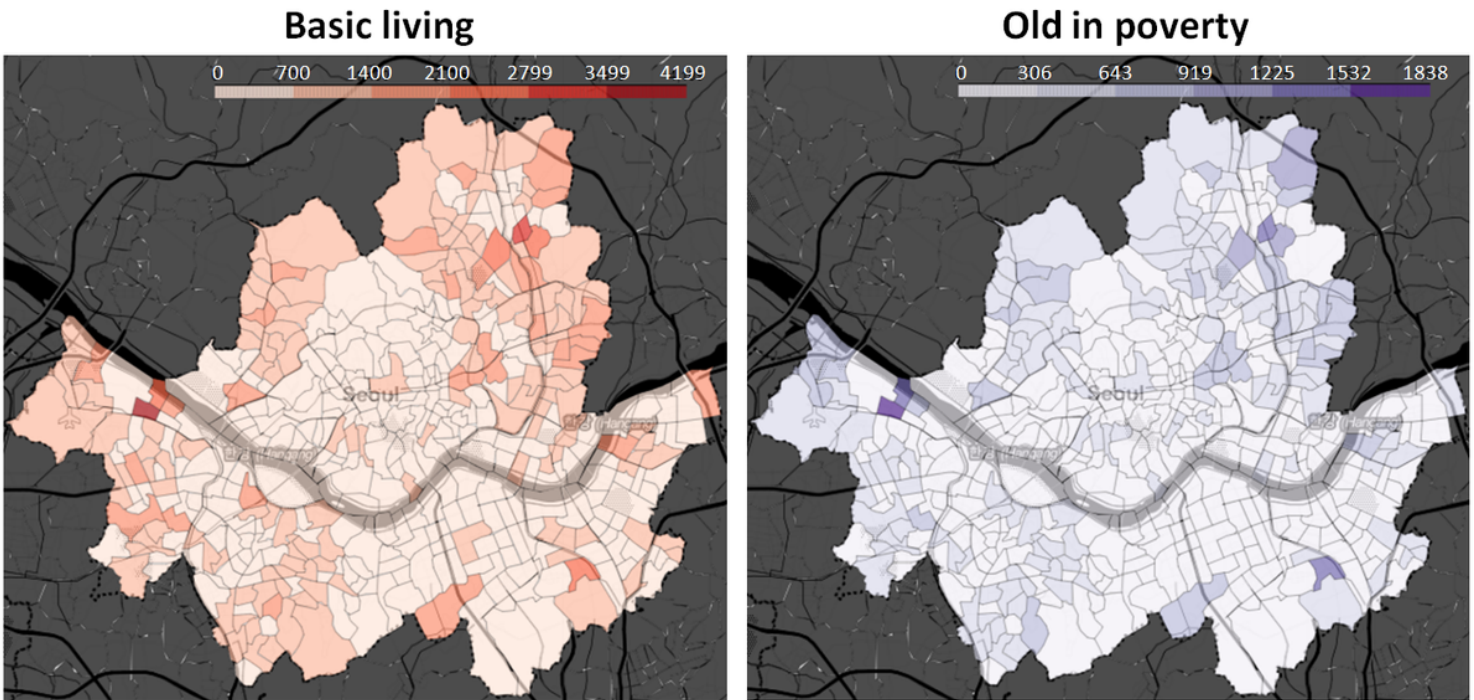


Figure 2

Basic living and Old in poverty map in Seoul

Note: See details in Section 3 and Appendix A.

Housing poverty

Living poverty

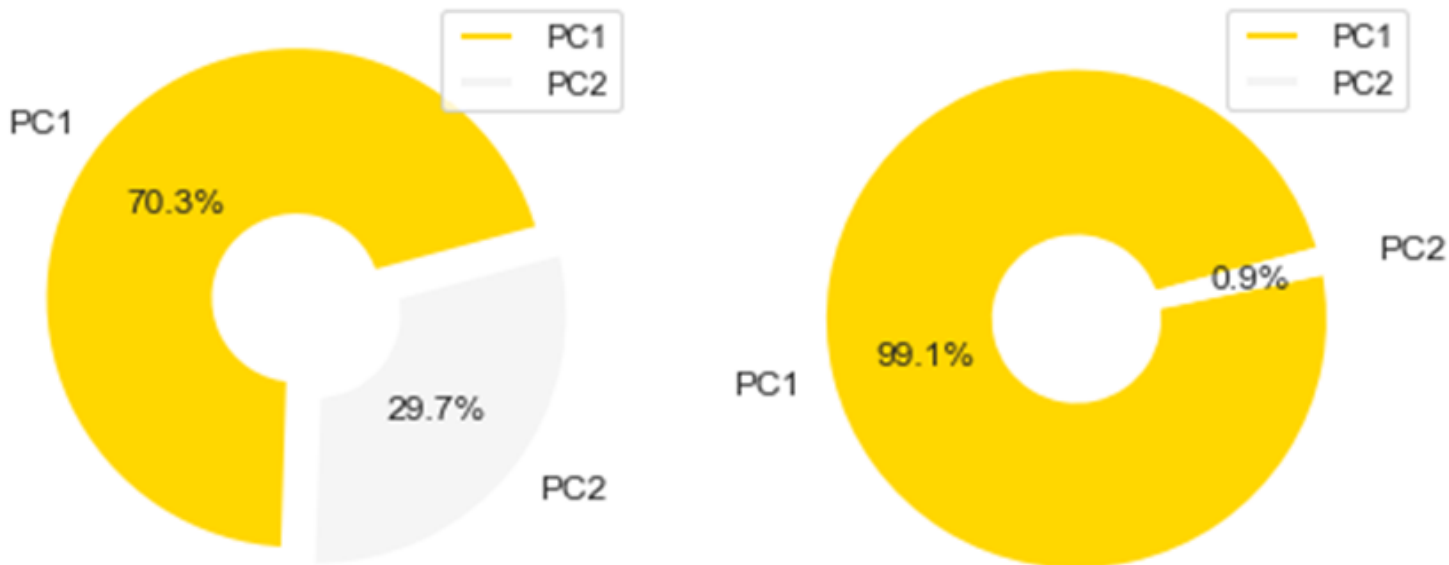


Figure 3

PCA of housing and living poverty

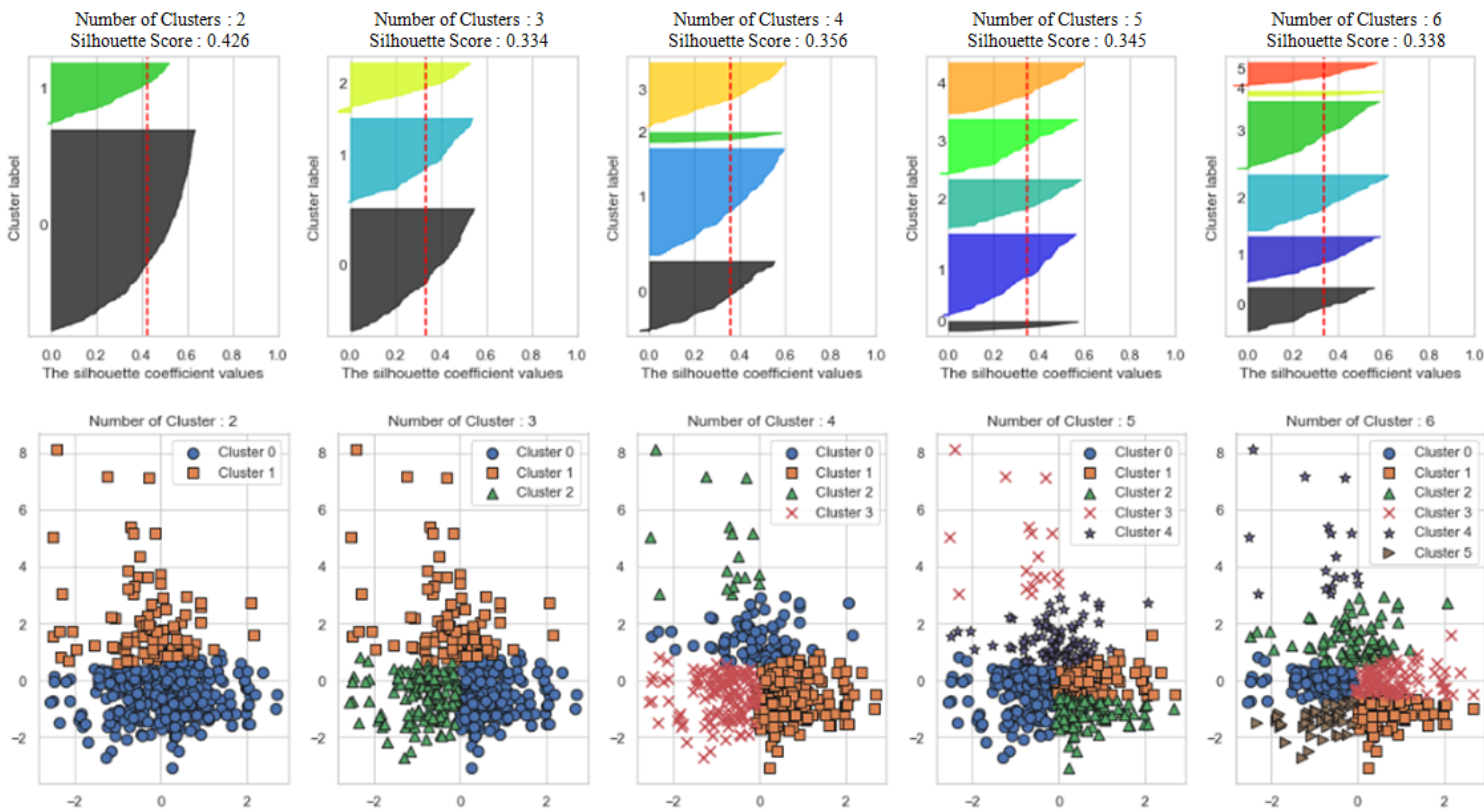


Figure 4

Clustering results

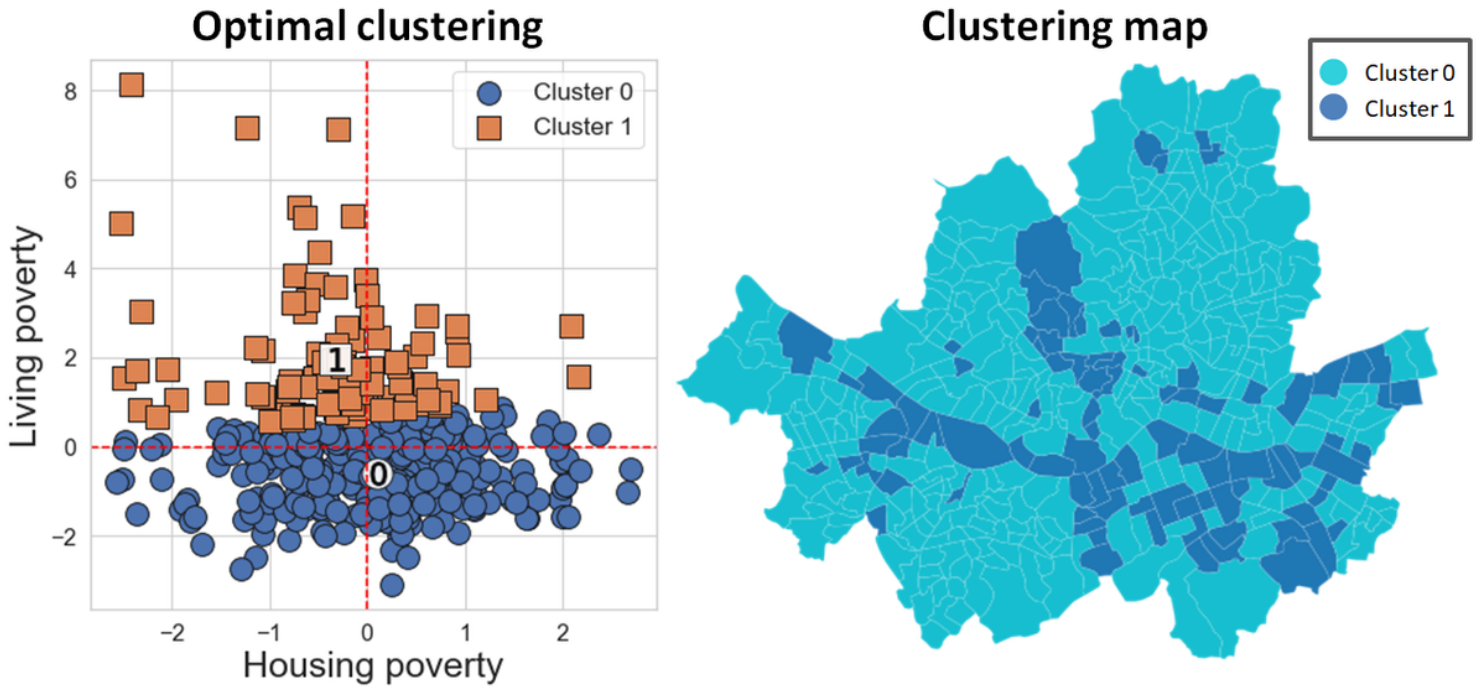


Figure 5

Optimal clustering and Clustering map

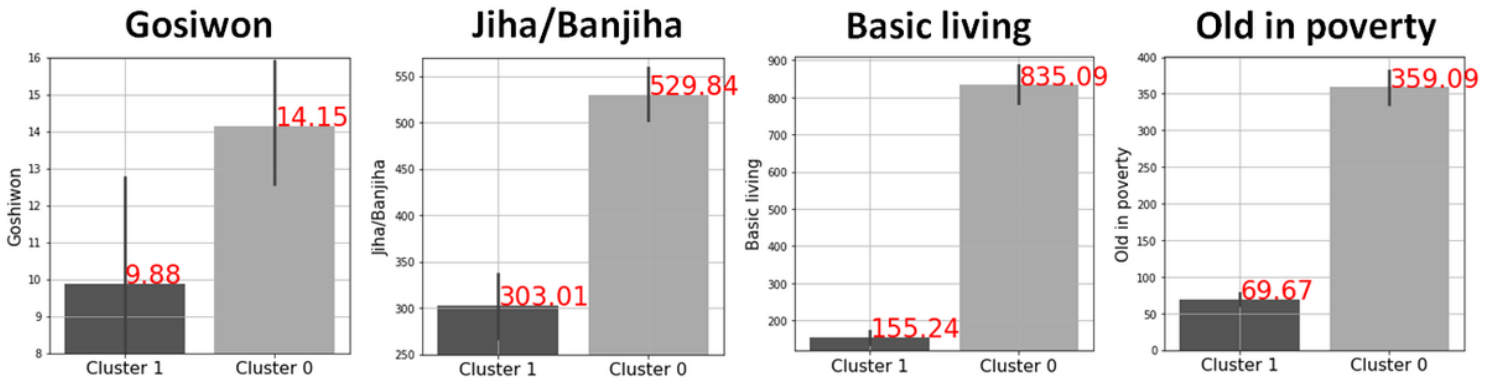


Figure 6

Poverty gap by cluster

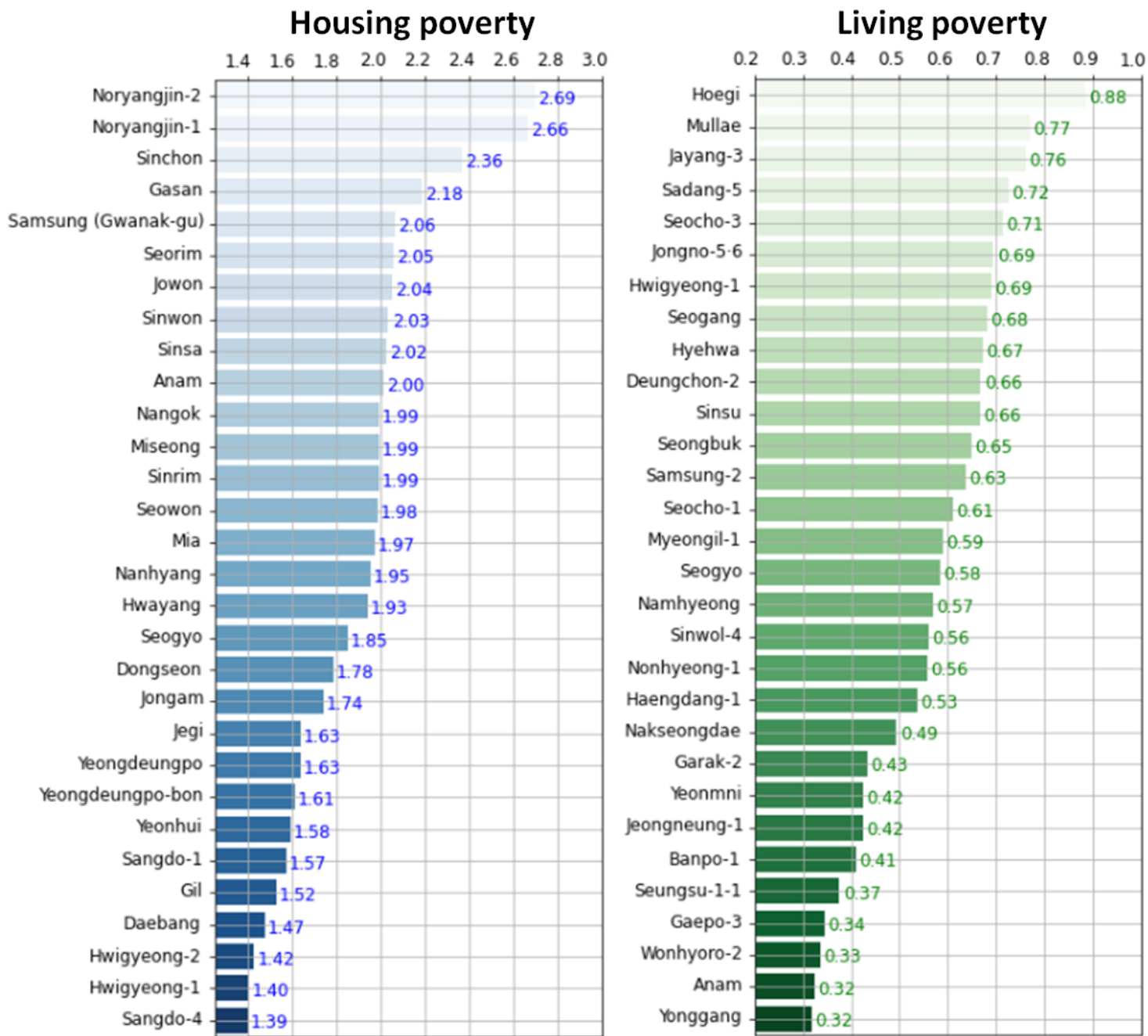


Figure 7

30 *dongs* with highest rates of housing and living poverty based on PCA