# Location Efficiency and Optimal Location of PB and PSB Using Spatial Dasymetric Mapping

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**Abstract**: The purpose of the present study is to estimate the location efficiency of police box (PB) and police station branch (PSB), using Dasymetric Mapping with house-level data. The present study selects optimal locations for additional PB and PSB, prioritizing them in consideration of their potential service population. The target area of the analysis is Seoul, the capital city of South Korea. The house-level data is rasterized in 20 by 20 meters and PB and PSB is point data, geo-coded at the ZIP code level. According to the location efficiency analysis where service areas of PB and PSB is set to a 1 kilometer radius of each of them, 89% of total population of Seoul resides within the service areas. Areas with lower location efficiency are largely located in suburban regions surrounding Seoul. Thirteen locations are found as optimal for additional PB and PSB. All of the locations satisfy the minimum serviceable population of 30,000 residents, defined by the Urban Planning Guideline of Korea. The present study concludes with some policy suggestions that can alleviate crime incidence focusing particularly on the perspectives of PB and PSB location.

**Key words** : PB and PSB, Location Efficiency, Optimal Location, Dasymetric Mapping, Seoul

## I. Introduction

Police patrolling is an important instrument for implementing preventive strategies towards the combat of criminal activities in many countries. Police patrolling is not only a way for law enforcement but also a basis for crime prevention. Police patrolling has traditionally focused on its administrative objectives aiming to know where the occurrences of crime are currently happening and to apprehend the criminals. Nowadays, however, its primary concerns have gradually moved to crime preventive measures and efforts to alleviate people's fear of crimes.

Police box (PB) and police station branch (PSB) play a pivotal role in preventing the occurrences of crime through patrolling. The location of PB and PSB has everything to do with crime prevention, in that it can decisively affect crime rates. The location of the PB and PSB has been a primary subject of research in the field of geography, urban and regional planning and police administration. For efficient crime prevention, they ought to be installed in highly-dense residential areas with maximized coverage. PB and PSB in Korea are urban planning facilities, designated by and managed based on existing urban planning laws. Despite the importance of them, however, research and analysis focused on their locations are relatively sparse. At this point of time where crime rates are steadily growing, research dealing with the locations of PB and PSB is significantly meaningful in both academic and practical perspectives.

It largely affects the accuracy of analysis results that to what degree of spatial data the population can be converted. For instance, it is recommended to increase the accuracy to use population aggregated by buildings than population of administrative regions. Dasymetric mapping is a technique well suited to this house-level analysis by explaining distribution of population in a more specific and micro level. However, there have been very limited studies using Dasymetric Mapping to evaluate location efficiency and select optimal location of crime prevention facilities.

The purpose of the present study is to estimate location efficiency of PB and PSB, using Dasymetric Mapping with house-level data. The present study also selects optimal locations for additional PB and PSB and prioritizes them in consideration of their potential service population. The target area of the analysis is Seoul, the capital city of South Korea.

The present study is organized as follows: Section II introduces the mainstreams of previous studies on crime. Section III explains variables and spatial econometric analysis method adapted in the present study. Section IV investigates the correlation between location of the PB and PSB and crime occurrence. The regional disparity of location efficiency of the facilities is also analyzed using microscopic spatial analysis, and then optimal locations for additional PB and PSB are explored. Section V summarizes the findings and implications, and discusses alternative policies and strategies to site the location of PB and PSB for effective crime prevention.

## Ⅱ. Background

Cities have been gradually expanded and overcrowded as people's standard of living has improved. At the same time, demands on public service have also grown sharply. Catching up with the increased demands on the public service, research on the provision of public services have been made in diverse fields, especially intensively in geography, regional development, urban planning and administration. Most of the research is aimed at addressing excessive concentration or unequal distribution of resources. The criteria that the research adapted to locate the applicable resource provision is focused on spatial efficiency and equity (Symons, 1971; Morrill, 1974; McAllister 1976; Bach et al., 1980). Although spatial efficiency can be thought of as being analogous to spatial equity in a broader meaning, there are distinctive differences: the former focuses on facility itself, while the latter lays stress on demands. Namely, spatial efficiency aims to achieve maximum efficiency with limited resources, while spatial equity aims to rectify spatial inequality - a social phenomenon where certain attributes among population groups are aroused in spatially uneven manner (Johnson et al., 2000).

In general, selecting public facilities location aims to maximize interaction between sources of service (supply) and service users (demand). Accessibility is the most important principle in discussing locations of public facilities, since it has characteristics of public goods such as non-rivalry and non-excludability. Public facilities ought to be distributed in the way of maximizing the use of service. That is to say, economic efficiency has to be considered in selecting public facilities location. A representative index to evaluate economic efficiency of public facilities location is accessibility with which many studies have evaluated the location efficiency of public facilities (Talen, 2003; Talen and Anselin, 1998; Tsou et al., 2005; Guagliardo et al., 2004).

Accessibility has been classified into two broad categories: revealed accessibility and potential accessibility (Phillips, 1990). While the former focuses on the practical use of the facilities, the latter deals with the extent of opportunities. Most of relevant studies adopt potential accessibility to evaluate spatial equity of facilities since they are not accessible to data which is indispensible for utilizing revealed accessibility. Accessibility is also divided into two factors: spatial factor and nonspatial factor (Donabedian, 1973). The former is based on spatial characteristics such as distance or distance of time between facilities and users, while the latter focuses on demographical attributes including income, race and gender. Most of studies have analyzed the accessibility of public facilities focusing on spatial factors; though there has recently been some analyses combining the both factors together (Wang and Luo, 2005). However, researches based on non-spatial factors are sparse, because those researches require a set of data explaining the use pattern of the facilities, which is hardly accessible.

In an accessibility analysis, the spatial level of the analysis should be decided attentively as it can largely affect the result. In analyzing accessibility to public facilities, the most important thing is to calculate the number of people to whom the individual facility can cover. If spatial data on the population of every single house is not available, it is difficult to analyze accessibility in a micro-scale manner. However, dasymetric mapping, an areal interpolation method, allows us to analyze the accessibility even when the spatial data on the population is not available. Using the method, one can analyze the population more microscopically through estimating the number of population by houses.

Diverse interpolation methods, including dasymetric mapping have developed and widely utilized by researches (Mennis and Hultgren, 2006; Mennis, 2003; Eicher and Brewer, 2001; Fisher and Langford, 1995; Goodchild et al., 1993). Dasymetric mapping is also adapted in criminology research where the incident level crime data is generally unavailable. Previous studies on crime incidents adopted dasymetric mapping to analyze spatial patterns of crime occurrences (Poulsen and Kennedy, 2004; Craglia et al., 2000; Bowers and Hirschfield, 1999).

The location of PB and PSB affects the efficiency of police patrolling and thus has effects on crime rates. A study dealing with the location of the PB and PSB is meaningful in that it can contribute to crime prevention and urban planning at the same time. However, few have dealt with the subject. The present study aims to microscopically analyze the location efficiency of PB and PSB and to select their optimal locations. The present study is also meaningful as it investigates how to select location of PB and PSB and provides discussions and suggestions that can alleviate crime incidence in real world. Although the present study only focuses on PB and PSB, the methods and discussions are expected to provide implications to researches dealing with other public facilities.

## Ⅲ. Data and Methodology

### 1. Data

As mentioned in Section II, accessibility to public facility is classified based on two types of dimension. The present study adopts potential accessibility and spatial factors for evaluating accessibility of PB and PSB. This is largely due to the inaccessibility to the data required to adopt revealed accessibility and non spatial factors. For the present study, three types of data have been constructed: point data of PB and PSB, polygon data of houses and census output areas. All of the data has been converted or constructed to a set of spatial data. The target region of the present study is Seoul, Korea, and data used in this study is as of 2010.

Locations of PB and PSB are extracted from National Police Agency, and converted into point data, geo-coded at the ZIP code level. Total 227 locations of PB and PSB are utilized in this study. To estimate population by houses, spatial data on houses is needed. It is difficult to estimate the actual population numbers, rather, it is supposed to estimate population based on the area of houses. The present study constructed separate housing data for detached houses and apartment houses. All of the housing data was extracted from polygon data of the Architectural Information System which is maintained by the Ministry of Land, Transport and Maritime Affairs, Korea.

Administrative district data has been generally used for an investigation of interregional differences. For more accurate estimation, it is recommended to use microscopic spatial data since it enables a thorough exploration of vulnerable areas, and helps to provide planners and policy makers with relevant information in a timely manner. Statistics Korea uses *dong* as the smallest spatial unit. More recently, it has changed its official spatial units to census output areas. The present study adopts the census output area to investigate the difference of location efficiency, since the census output area is of more microscopic than the traditional administrative district data.

## 2. Methodology

### 1) Dasymetric Mapping Method

Dasymetric mapping is generally regarded as an areal interpolation method (Menneis, 2003). Areal interpolation refers to the process of transferring statistical information from one set of spatial units to another one whose boundaries are compatible to the former (Goodchild and Lam, 1980). Areal interpolation is widely used in researches. Among diverse areal interpolation methods, real weighting method, pycnophylactic smoothing method, and density surface creation method using centroid are prominent (Goodchild et al., 1993; Tobler, 1979; Martin et al., 2000). The present study adopts the real weighting method which is most widely used.

$$A_i^e = \omega_r \alpha_k K_i \qquad \text{Eq. (1)}$$

$A_i^e$ refers to population estimates of the raster cell *i*. $\omega_r$ is a locally weighted factor for district *r* to which the raster cell *i* belongs, $\alpha_k$ represents estimated global coefficient for the house type *k*, $K_i$ is 1 if the house type of the raster cell *i* is *k*, otherwise 0. The locally weighted factor is estimated to control the total population of all raster cells within the district *r* for the real-world population counts of the district *r*. It can be derived using the following equation:

$$\omega_r = \frac{Actual_r}{\sum_k \sum_{i \Rightarrow r} \alpha_k K_i} \qquad \text{Eq. (2)}$$

Weight $\alpha_k$ represents weight values against absolute or relative density, which is derived using ordinary least square (OLS) regression method. Absolute values of the estimates are shown in the following Table 1. The estimates can significantly affect the quality and accuracy of the rasterization because they decide to what extent the weight is given to housing types when calculating population.

Table 1. Estimated coefficients from an OLS regression

| Housing Types | Coefficient | P-value |
|---|---|---|
| Detached Housing | 50.5501 | <.0001 |
| Apartment Housing | 216.4813 | <.0001 |

$R^2$ =0.61

The size of a raster cell which is influenced by spatial resolution (or scale) of land use map is 20 by 20 meters in this estimation. The estimated population is listed as shown in the following figure

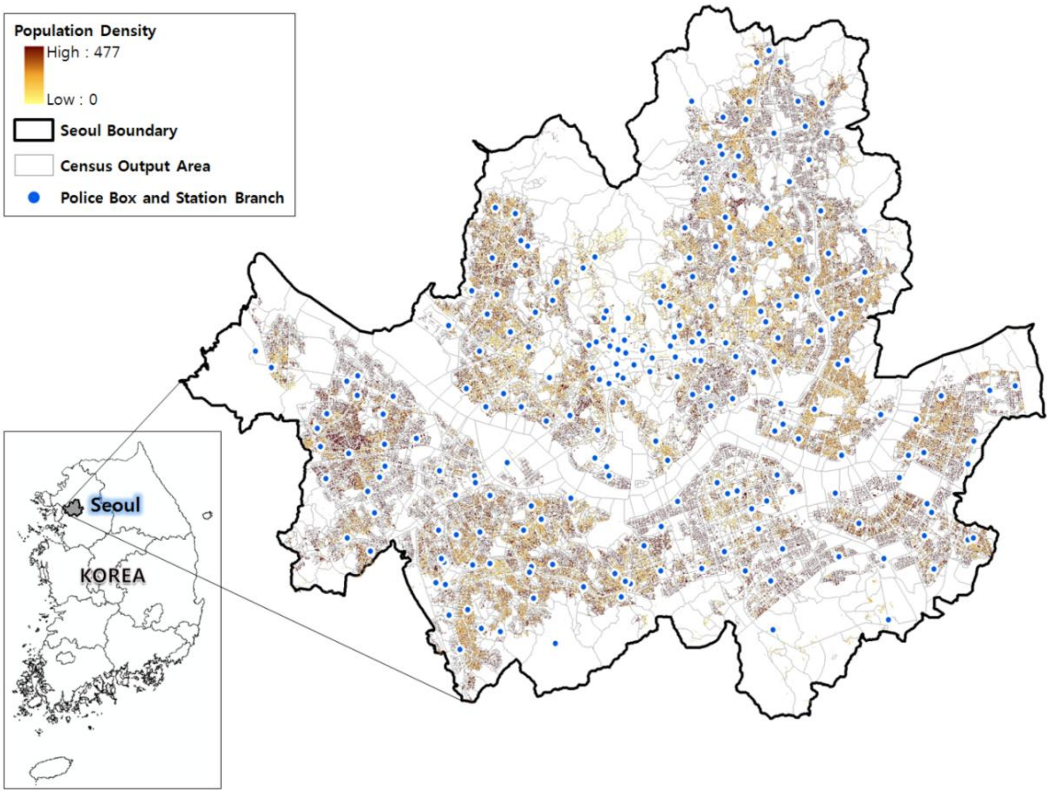



Figure 1. Locations of PB and PSB and Estimated Population using Dasymetric Mapping

2) Location Efficiency Analysis

The location efficiency of public facilities implies a maximization of service provision within given limitations and restrictions. From a point of view of service provider, high location efficiency means a large number of the service population. That is to say, when promoting crime prevention activities in regions of same size, the efficiency is expected to be higher in a region with more population than in ones with lower population. There are some problems to deal with in advance: how to standardize the quantity and quality of supplies and resources distributed to PB and PSB; how to treat service population which is serviced by two or more facilities; and how to define the extent of distance decay to apply to the accessibility analysis.

Human resources and equipments deployed to the PB and PSB differ in their numbers or quality. Even though it is reasonable to use data containing the resource status of individual PB and PSB, the present study assumes that each PB or PSB has the same resource status, due to the lack of the data.

Service areas of each PB and PSB are bound to overlap and thus the population in those areas can be offered with services from multiple PB and PSB. Even though it is reasonable to assume people in the overlap areas use a facility with better resource status, the present study takes the aggregated service population counts, based on the assumption that each PB or PSB has the same resource status.

Physical distances that a PB or PSB covers differ depending on its geographical characteristics and the resource provision status. Standard of facilities installment also differs from countries and even regions. According to the existing guidelines established in Korea, a PB or PSB can cover a population of 3,000 to 5,000 within a 700 m to 1,200 m of radius service area. Considering distribution of population in Seoul, location characteristics of existing PB and PSB, and existing guidelines for their installation, the present study applies a 1 km of distance decay which a PB or PSB can cover.

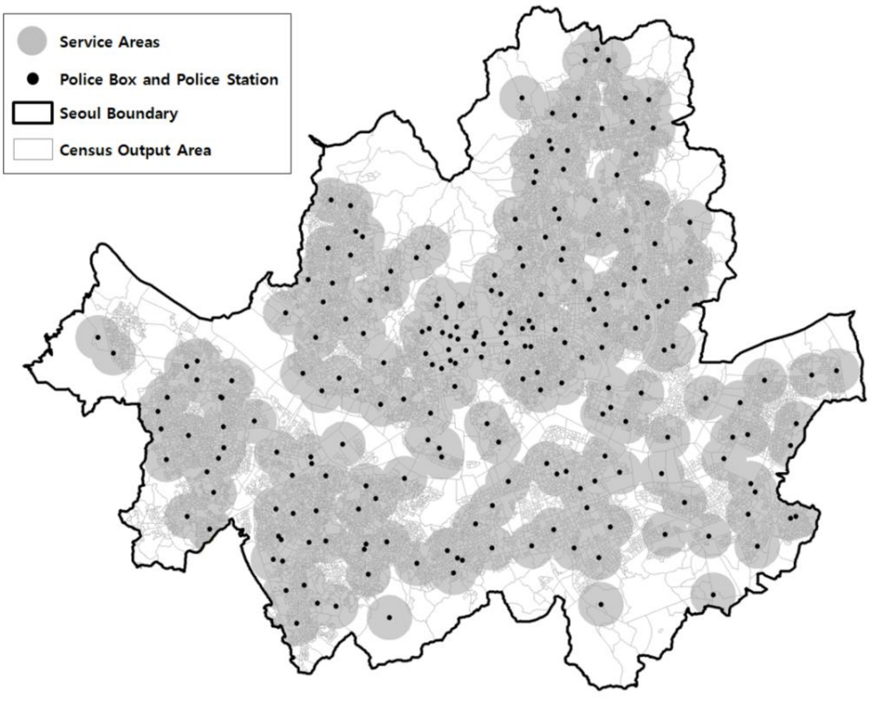



Figure 2. Service Boundaries of PB and Stations Branches (within 1km radius)

Service areas of PB and PSB should be decided with consideration of the surrounding road network conditions, since the condition can affect the police's mobility and police patrol routes are generally decided according to the existing roads. Yet, spatial data on road networks are not officially issued in Korea. Due to the absence of data, the present study analyzes the accessibility of PB and PSB using the Euclid Distance between the police facilities and housing.

As mentioned, the present study evaluates location efficiency of PB and PSB based on their accessibility through the following process. First, the present study defines a PB or PSB can cover an area within a 1 km radius of each and calculated the service areas using buffer analysis. Secondly, population within the service area of each census output area is calculated. Lastly, in order to standardize population which differs with census output areas, the ratio of population residing within the service area of PB and PSB to the total population of the census output area is calculated. The resulting population ratio is used as an accessibility index in the accessibility evaluation. The index has a value ranging from 0 to 1. The value is 1 when all of the people in the corresponding census output area are serviced by PB and PSB while 0 when they are not.

In addition, using the accessibility index of each census output area, the present study also discovers areas with high location efficiency (hot spots) and low location efficiency (cold spots) separately. Through the hot and cold spot analysis, locations whose location efficiency of PB and PSB should be preferentially improved are identified and visually represented. For the hot and cold spot clustering, the present study adopts Getis-Ord Gi* statistic which is widely used for investigating spatial concentration. The mathematical expression of the Gi* takes the following form.

$$G_i^*(d) = \frac{\sum_j w_{ij}(d)x_j - W_i x(i)}{s(i)[(n-1)S_{1i} - W_i^2]/(n-2)^{1/2}} \; (j \neq i) \qquad \text{Eq. (3)}$$

where, $x_i$ and $x_j$ is the value $x$ at location $i$ and $j$, $W_{ij}(d)$ is a spatial weights vector with values for all location $j$ within distance ($d$) of target location $i$, $W_i$ is the sum of the weights, $S_{1i}$ is the sum of squared weights, and $s$ is the standard deviation to the data in the location.

Using the *Gi**, the concentration ratio of high or low values for accessibility can be measured. The significance is judged by a Z score because the null hypothesis assumes that there is no cluster in the study area. Large Z (positive) means hot spots clustered together, while low small Z (negative) means cold spots clustered together.

### 3) Optimal Location Analysis

Each PB or PSB has to be installed in an optimal location so that its services to prevent crimes are taken in a most efficient manner. The present study defines that an optimal location is a location with a large number of population to whom services can be provided within a given distance decay factor. This point of view is in line with the Maximal Covering Location theory introduced by Church and Revelle (1974).

Many of recent analyses of location decisions have adopted the overlay analysis using geographical information systems (GIS). The overlay analysis is a spatial analysis method that investigates relationships between spatial entities or shapes belonging to each of multiple stacked layers. It can provide more reasonable, objective and unbiased approaches in deciding spatial locations based on diverse location determinants. Though, it is not compatible with microscopic spatial analysis.

At the micro scale, exploration of an optimal location for PB and PSB is performed using the local exploration method, based on raster-based analysis, since raster data allows the four fundamental arithmetic operations for multiple layers. In the present study, the optimal location of PB and PSB is analyzed in a phased manner (refer to Figure 3). The optimal location analysis process is performed utilizing ArcGIS, using data as of 2010.

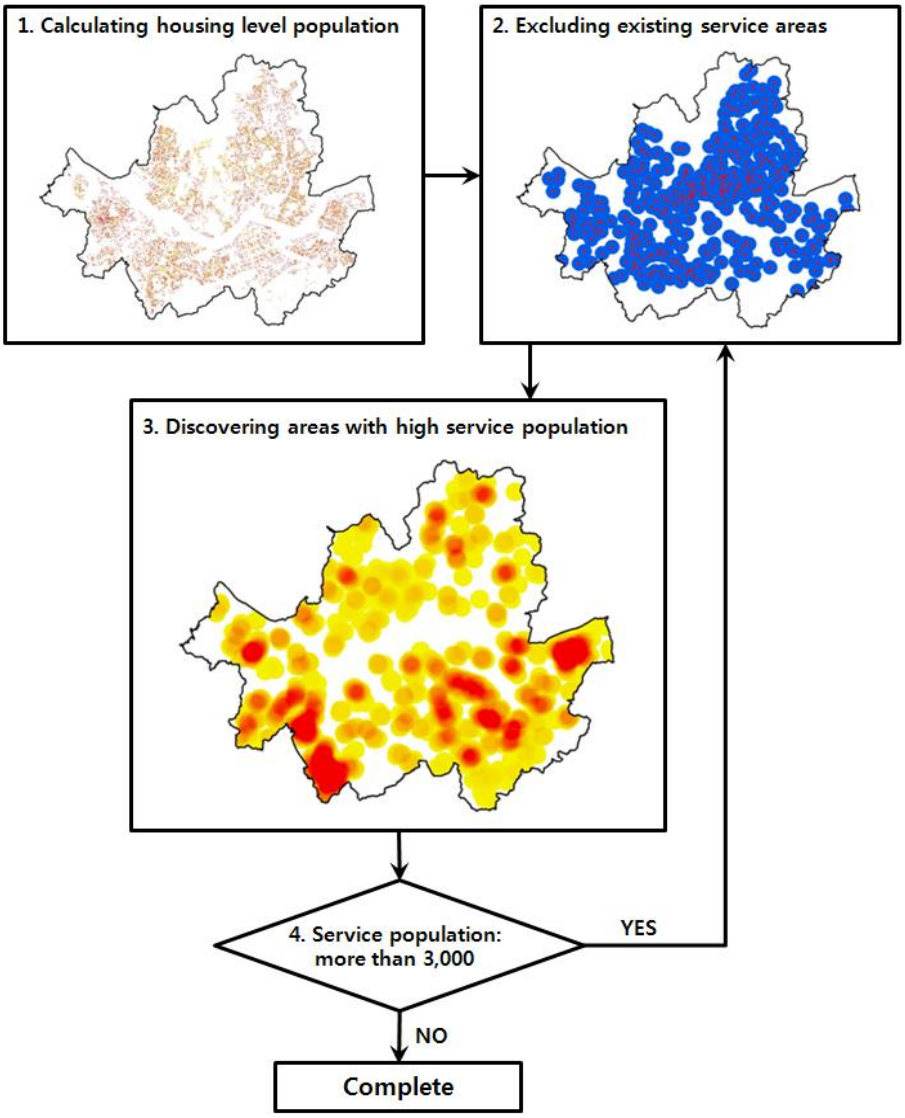


Figure 3. Phased Process of Discovering Optimal Location

In the first phase, housing-level population is calculated using dasymetric mapping. In the second phase, existing service areas of PB and PSB (within 1 km of radius of each) were excluded. The next step is to discover a location with the largest service population where a new PB or PSB can be installed. In this step, Focal Statistics is applied. Using the raster-based analysis method, population within a 1 km radius of each raster cell is calculated. In the last phase, optimal service population for a new PB and PSB is decided. The present study assumes an optimal location for a new PB or PSB has a population of at least 3,000 within a 1 km radius of service area regarding the existing guidelines on the facilities' service coverage. Considering location efficiency, areas with largest service population are regarded as preferential locations for additional installations of PB and PSB.

The analysis method adopted for optimal location analysis is very effective for a micro scale location analysis. However researches to discover optimal locations using existing methods have scarcely been made. This is probably due largely to the difficulties to construct micro scale population maps, which are indispensable for this type of spatial analysis. Hence, the result of the present study is expected to contribute to relevant body of research and the analysis methods can be adopted or applied to following researches.

## Ⅳ. Results

### 1. Incidences of Crime Occurrences in Seoul

Seoul, the capital city of Korea, has a special meaning for most people in Korea. Seoul has always been a Mecca for those who live outside it since the Yi dynasty in the 15th century. Occupying about 12% of the country's total area in 2010, the Seoul metropolitan area (hereafter Seoul) held 49.0% of the total population. In addition to the share of the population, most widely cited statistics for the Seoul dominance over the rest of the country are 48.9% of GRDP (gross regional domestic product) to the nation's GNP, 50.5% of manufacturing firms, 59.1% of the headquarters of enterprises, 65% of total loan amount, and 40.7% of universities.

Such an excessive concentration in urban region makes a lot of undesirable side effects such as pollution, poverty, and housing problems. Especially, most metropolitan cities have recently been suffered from crime in common which has become crueler, more diversified, and more intelligent. It is said that urban crime reflects gap of ability to gain spatially limited resources and spatial reactions caused by disadvantages confronted with poor environment. Furthermore, damages from crime and fear of being a victim have been recognized as one of urban diseconomy that impedes urban development. Accordingly, the realm of criminology has been widened toward preventing urban diseconomy as well as searching characteristics of crime and criminals.

In Korea, crime incidences in Seoul are higher than that of other regions. The population of Seoul in 2010 was approximately 10,312,000, which accounts for about 21% of the national population. The ratio of crime occurrence in Seoul to the nation is 19.6% (339,884 incidents) in 2010. Total incidents of five major crimes (murder, rape, robbery, burglary and violence) in Seoul were 112,103 in 2010, taking up 18.9% of total incidents.

Figure 4 shows crime incidents in Seoul. There were 330 crime incidents and 109 five major crime incidents per million capita. On the whole, the highest total crime occurrence rates were to be found in the CBD of Seoul. The sub-centers, Seodaemun, Junggu, and Dongdaemun in the north, and then Yeongdeungpo, Songpa and Seocho in the south, showed the next highest total crime rates, but the difference was considerable. On the contrary, suburban areas including Nowon, Eunpyeong and Gwanak showed relatively low total crime rates. Junggu, at 595 incidences, was highest in relation to total crime rates per million capita followed by Dongdaemun at 532 and Seocho at 515. Spatial distribution of the five major crime rates is similar to that of total crime rates. Central business districts, Seodaemun, Junggu, and Dongdaemun in the north and Yeongdeungpo in the south showed the highest five major crime rates.

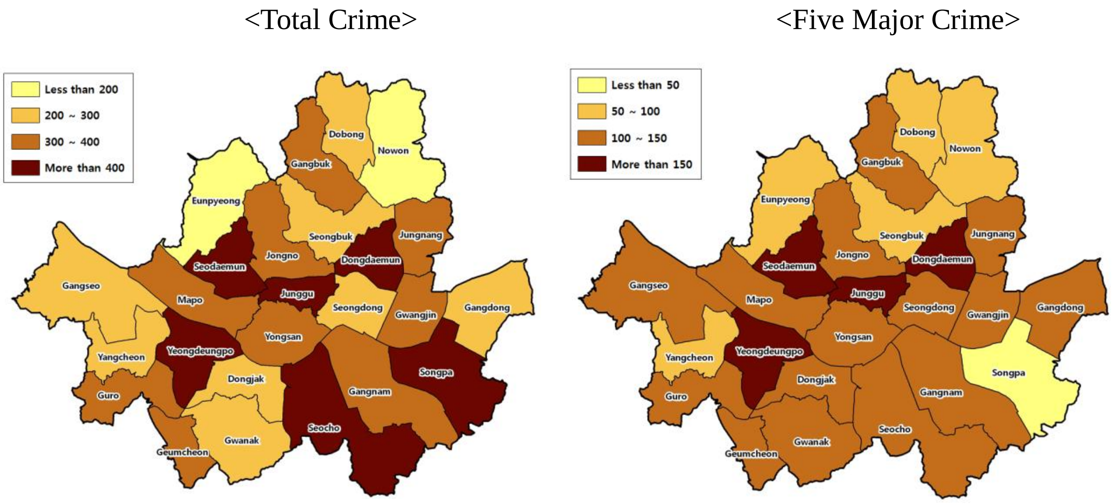



Figure 4. Crime Incidents per Million Capita in Seoul (2010)

Noticeably, most of the crime victimization happened in the center of the city. The sub-districts within CBD are prone to have higher total crime incidences and five major crime rates. The CBD has high non-resident, day-time populations and relatively small settled populations because of intensive retailing activities, government and non-government offices. Offices and entertainment spots like bars and clubs are also concentrated in the sub-centers. The mobility of the population within these areas is high as well. As the analysis results showed, the CBD is a crime-prone area. Actually, we can see a higher concentration of PB and PSB deployed within the CBD areas.

## 2. Crime Incidents & Location of PB and PSB

Table 2 showed the Pearson Product Moment Correlation between the non-serviced population and crime frequency. The analysis is performed with each Census Output Area as a minimum spatial unit. Non-Service areas represent service areas of PB and PSB covering a 1km of radius while the non-service population refers to the total number of service population within.

The results are interesting as the service areas of PB and PSB have statistical relation with none of the types of crime. On the contrary, service populations of PB and PSB have a positive relation with all of crime types excepting murder with high statistical significance. Variables with higher relation with the service population are rape (0.6950, p<0.01), theft (0.6048, p<0.01), robbery (0.6046, p<0.01), other crime (0.5409, p<0.01), Violence (0.4905, p<0.01).

The result of present study demonstrates that increasing location efficiency of PB and PSB can help prevent crime occurrence. So studies dealing with the location of PB and PSB are meaningful in both academic terms in that they can practically contribute to efficient crime prevention.

Table 2. Correlation between Crime Occurrence and Non-Service Population of PB and PSB

| | Total Crime | Murder | Robber | Rape | Theft | Violence | Other Crime | Non-Service Areas |
|---|---|---|---|---|---|---|---|---|
| Total Crime | 1 | | | | | | | |
| Murder | 0.3665* | 1 | | | | | | |
| Robber | 0.8098*** | 0.5201*** | 1 | | | | | |
| Rape | 0.8080*** | 0.3505* | 0.7399*** | 1 | | | | |
| Theft | 0.9134*** | 0.4034** | 0.7767*** | 0.7558*** | 1 | | | |
| Violence | 0.9012*** | 0.5079*** | 0.8204*** | 0.7646*** | 0.9025*** | 1 | | |
| Other Crime | 0.9849*** | 0.2971 | 0.7626*** | 0.7740*** | 0.8427*** | 0.8210*** | 1 | |
| Non-Service Areas | 0.2648 | -0.1129 | 0.1596 | 0.3361 | 0.1157 | 0.1030 | 0.3204 | 1 |
| Non-Service Population | 0.5687*** | 0.2151 | 0.6046*** | 0.6950*** | 0.6048*** | 0.4905*** | 0.5409*** | 0.5257*** |

* p<0.1, ** p<0.05, *** p<0.01

### 3. Location Efficiency

Figure 5 shows the resulted location efficiency of PB and PSB estimated by each census output area. As previously mentioned, standardized accessibility has a value ranging from 0 to 1. It is 1 when all of the population residing in the census output area is serviced by PB and PSB. So, the closer to 1 the value is, the higher the location efficiency.

According to the analysis, 89% of total population of Seoul is serviced by PB and PSB within a 1 km radius. Such ratio is by no means low. However, for more effective crime prevention, more PB and PSB should be installed. In Seoul, there are 14,711 census output areas where any population resides. Also the populations residing in 12,733 census output areas (87%)

are within a 1 km radius of any PB or PSB, while 1,288 census output areas (9%) have no serviced population.

The location efficiency is relatively higher in northern than southern areas, and in urban centers than outskirts. This is probably because population density in outskirts is lower than urban centers and the residential areas are scattered. On the other hand, we can see areas with lower location efficiency within census output areas are located in central Seoul. It is recommended to install more PB and PSB in these areas, since the population density of these areas is higher comparing to outskirt areas. In the next part, the locations for new PB and PSB will be explored and discussed.

The present study also discovers hot and cold spots of location efficiency using the accessibility index. Getis-Ord Gi* statistics are adopted to estimate the degree of cluster synchrony and resulted clusters are mapped at 1% level of significance. Analysis on spatial concentration is effective to investigate regional disparities in location efficiency in a more accurate manner, especially to distinguish spatial clusters of vulnerable areas with low location efficiency in regards to PB and branches.

<Location Efficiency> <Clustered Location Efficiency>

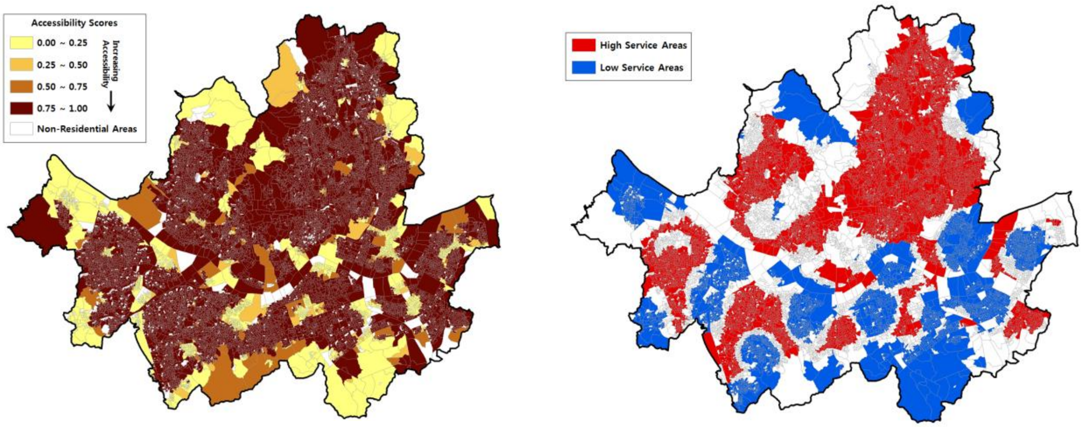


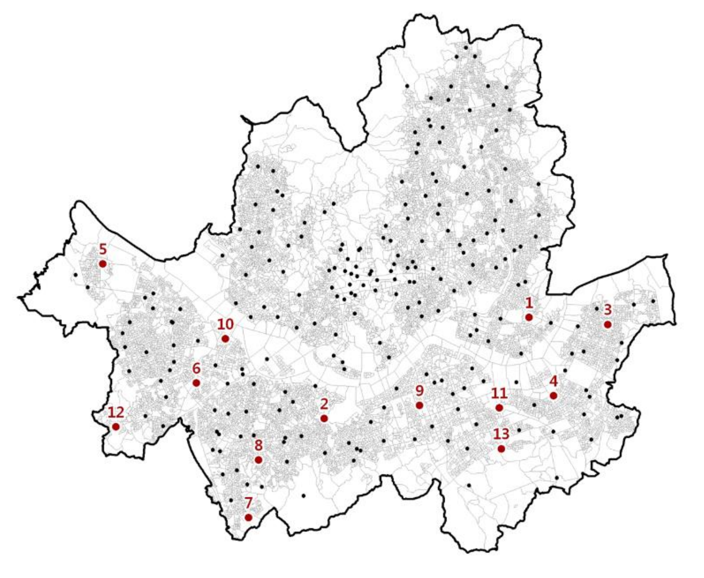

Figure 5. Regional Disparity of Location Efficiency of PB and PSB

According to the results from this analysis, areas with high location efficiency are not concentrated in certain regions but they are clustered in a scattered manner. Areas with high location efficiency are mostly found in northern Seoul while ones with lower location efficiency are located in southern Seoul. It is noticeable that many areas with low location efficiency are found in the urban centers in the southern-east and south-western Seoul which have been relatively recently developed. This means the location of PB and PSB has not been synchronized with the changes of migration trends. For example, more people migrated to new towns but additional PB and PSB were not installed to cover the increased population. So, it is highly recommendable to install additional PB and PSB, preferentially in areas with low location efficiency.

### 4. Optimal Location

Figure 6 represents optimal locations for additional PB and PSB. The optimal locations were discovered based on the existing guideline requiring a population of 3,000 being serviced within a 1 km radius of service area.

According to the analysis results, thirteen PBs and/or PSBs are required to be additionally installed in Seoul. Noticeably, all of the locations excepting ID #1 are in southern Seoul, which means the southern regions require more PB and PSB. Service population of the additional PB and PSB differs with the locations. In the location #1, the service population is the highest with 68.481 persons. Regarding that the difference of service population means the difference of location efficiency, additional PB and PSB should be installed preferentially in areas with high location efficiency. Deploying more PB and PSB in these locations is expected to actually reduce crime occurrence.




| Location ID | Service Population |
|---|---|
| 1 | 68.481 |
| 2 | 65.038 |
| 3 | 58.833 |
| 4 | 53.332 |
| 5 | 51.394 |
| 6 | 50.897 |
| 7 | 44.659 |
| 8 | 43.301 |
| 9 | 42.739 |
| 10 | 39.356 |
| 11 | 37.438 |
| 12 | 36.280 |
| 13 | 31.473 |

● Locations of Existing Facilities
● Optimal Locations of New Facilities

Figure 6. Optimal Locations for Additional PB and PSB

## Ⅴ. Conclusions

It is a major challenge for urban planners and administrators to efficiently distribute limited public facilities and resources. Considering that PB and PSB play pivotal roles in preventing crime occurrences, it is desirable to locate them in an area that maximizes their location and service efficiency. Location efficiency of a public facility is determined by its supply depending on distance decay and its demand based on the service population. It largely affects the accuracy of analysis results that to what degree of spatial data the population can be converted. With this in mind, the present study analyzed the location efficiency and optimal locations of PB and PSB in a micro scale using dasymetric mapping method.

First of all, it is found that the total crime rates and five major crime rates are high in northern Seoul. PB and PSB are concentrated in CBDs in outskirts of Seoul, a reasonable and efficient distribution for crime prevention.

Secondly, there is a positive relation between non-service population of PB and PSB and crime occurrence, with a high level of significance. It is noticeable that all of the crime types excepting murder were positively affected, which means it can practically reduce crime occurrence if the location efficiency of PB and PSB is improved.

Third, according to the location efficiency analysis based on the accessibility index where service areas of PB and PSB is defined as a 1 kilo-meter radius of each location, 89% of total population of Seoul resides within the service areas. Areas with lower location efficiency tend to be found in outskirts of Seoul. Also, the degree of clusters synchrony, upon areas with low and high location efficiency, is analyzed using Getis-Ord Gi*. Analysis results showed that areas with high location efficiency are clustered in old urban centers while many areas with low location efficiency are found in new ones. The results reflect that the location of PB and PSB has not been synchronized with the migration trends. So, it is highly recommendable to install additional PB and PSB, preferentially in areas whose location efficiency are low.

Lastly, thirteen locations are discovered as optimal for additional PB and PSB. All of the locations satisfy the minimum population requirement. The present study is meaningful in that the findings can help planners decide the PB and PSB locations. Also the analysis method adopted for searching optimal location is very attractive and useful in that it can suggest optimal locations through the micro-scale spatial exploration.

As crime in modern societies increases and becomes more brutal, effective measures to prevent crime occurrence have been intensively discussed in diverse fields. The present study focuses on the effective locations of PB and PSB as one of effective crime preventive measures. Regarding the findings that their efficient location can immediately lead to the reduction of crimes; it is required to have more and sustained interest in the location of the PB and PSB. Most of all, it is urgently needed to construct spatial data on urban settings such as road network, so that the relevant analysis can have more accurate results and reflect real world in a more practical manner.

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