

## Conference Paper

# Investigating Urban Crime Pattern and Accessibility Using Geographic Information System in Bandung City

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## Abstract

Urban crime is unplanned change from urban development processes. Understanding of urban crime is necessary for crime prevention and increase urban living quality. The geographical approach in urban crime analysis can analyze crime pattern using a geographic information system, also investigate a correlation between crime and environmental condition. This research is conducted to analyze the relationships between urban crime and urban accessibility in Sumur Bandung as the region with the highest crime in Bandung City. Urban crime pattern can be determined using geographic information systems through kernel density estimation, whereas urban accessibility is obtained via network indices methods. The correlation between urban crime pattern and urban accessibility is determined from statistical tests. The results show there is a significant positive relationship between urban crime and urban accessibility in Sumur Bandung Sub-District. Urban crime pattern is concentrated in Braga and Babakan Ciamis. Crime will increase in a more accessible area, thus crime prevention effort through physical access controlling regulation in the urban region.

**Keywords:** accessibility, GIS, urban crime pattern

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## 1. Introduction

Urban crime is unplanned change and decreases urban living quality. As a spatial phenomenon, crime analysis can be examining the relationships between crime with physical and social environmental conditions [1]. Combination of them is seen from urban morphology, where its focus on transportation network systems which create region accessibility [2]. The accessibility demonstrates human, goods, and services mobility among out-region or inter-region, although its side effect can be misused by street criminals.

Urban crime pattern generally located in areas with high accessibility levels such as commercial areas and central business district (CBD) [3]. Urban accessibility has a strong influence on urban crime. The area with high accessibility such as CBD has higher crime

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rates than other regions [4]. Also, urban accessibility has a significant correlation with crime and indicates street crime more dominant occur [5-6].

In Indonesia, Bandung City knows as a large urban area with the highest crime number after Jakarta, Surabaya, and Medan. Crime in Bandung has a concentric pattern in the middle and west of the city [5]. One of the areas with the highest crime total and crime rate in Bandung City is Sumur Bandung Sub-District. Sumur Bandung has 341 crime cases and 190.77 crime rate who dominated by property crime and street crime [7].

This research aims to determine the correlation between urban crime patterns and urban accessibility in Sumur Bandung using the geographic information system. Existing urban crime pattern is analyzed using kernel density estimation (KDE) based on annual crime data from The Bandung Police Department. Whereas, urban accessibility analysis is obtained by network indices, number of entries, access control, and road density. The relationship determined by statistic and spatial-correlation tests.

## 2. Research Method

### 2.1. Research location

Sumur Bandung Sub-District is located in Bandung City, West Java Province. Sumur Bandung has 345.5 Ha area which consists of 4 (four) urban villages such as Braga, Babakan Ciamis, Kebon Pisang, and Merdeka. Geographically, the region is located at 107° 36'14.20" E - 107 ° 37' 48.06"E and 6° 55'20.56" S - 6° 54'23.39"S. Based on The Bandung Hierarchy Service Center System Area, Sumur Bandung is a part of Cibeunying Sub-City Area Service Center (SWK).

### 2.2. Data acquisition

This research uses existing crime data from the Bandung Police Department Annual Crime Report. The data in this study is limited to property and street crime known as blue collar crime. Whereas, the accessibility refers to road network data from The Indonesia Ministry of Public Works and Settlement (PUPR RI), HOT-OSM BNPB, and visual interpretation of CNES-Airbus satellite imagery via Google Earth Pro. The road network criteria using The Law of the Republic of Indonesia No. 22 of 2009 on Road Traffic and Transportation who consists of the arterial, collector, local and environmental roads [8].

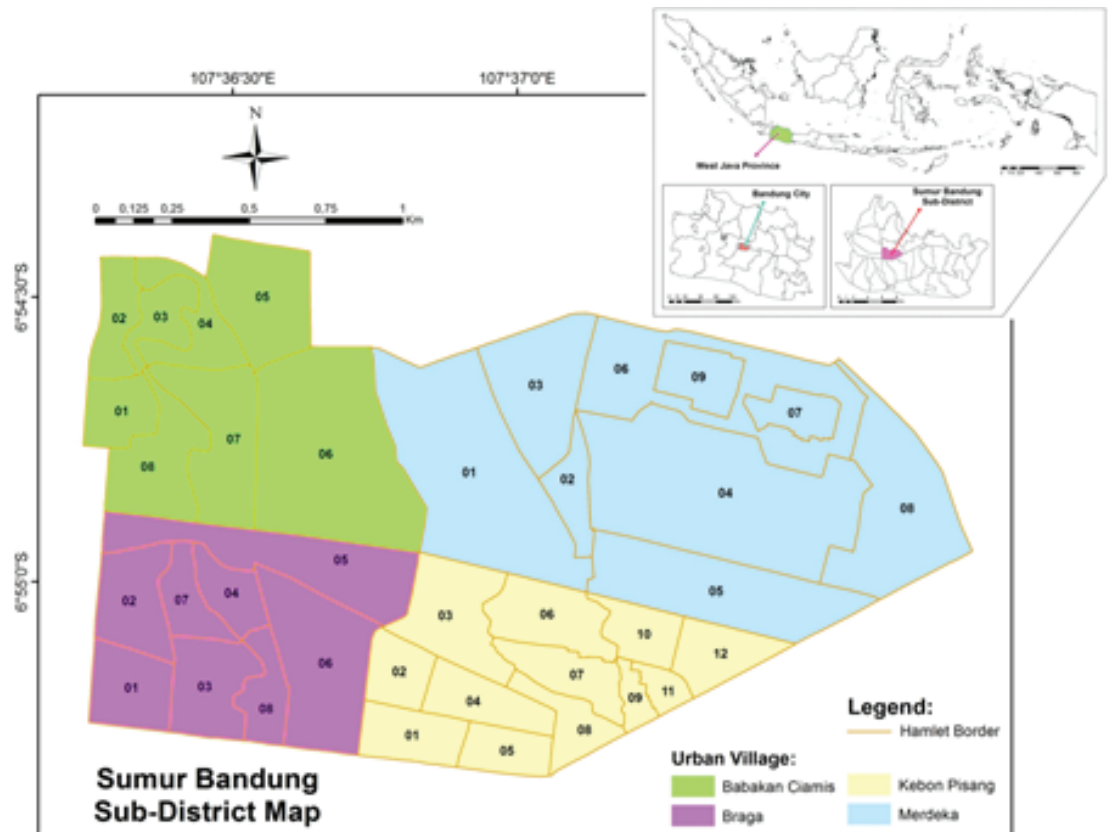


Figure 1: Sumur Bandung Location.

### 2.3. Analysis methods

Like quantitative research, the relationship between urban crime and urban accessibility is determined by Spearman correlation because each variable has an unequal data distribution. The test can indicate the significance of data and able to prove or deny the relationship. Besides that, The correlation does not require a classical assumption like statistical parametric analysis, the correlation analysis concerning equation (1).

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \tag{1}$$

Where "p" denotes the correlation value, "n" for the amount of data, and "d" is the difference value of data paired. The Spearman correlation value is significant if "p count" > "p table" and vice versa. Explanation about crime pattern analysis method and accessibility presented as follows:

#### 2.3.1. Kernel density estimation

Kernel density estimation (KDE) is a geostatistical analysis used to perform spatial interpolation based on estimating density distributions of points [9]. The KDE is widely

applied to natural or social sciences such as economics, physics and astronomy, agriculture, public health, geography, epidemiology, criminology, demography, hydrology and so on [10].

In this study, QGIS Las Palmas is chosen to determine the KDE value. Its result is validated using a geostatistical test which refers to mean error (ME), root mean square error (RMSE), and correlation coefficient ( $r^2$ ) [11]. The result uses to determine urban crime pattern in Sumur Bandung. KDE analysis is following equation 2.

$$K = \frac{3}{4} (1-t^2), t = \frac{d}{h} \leq 1 \text{ or } K = 0, t = \frac{d}{h} > 1 \tag{2}$$

Where "K" is the extrapolation (predicted) value, "t" density value, "d" distance between points in spatial dataset, and "h" bandwidth. In QGIS, bandwidth value based on standard deviation of data.

### 2.3.2. Network indices

Accessibility is closely related to connectivity; network indices method used to obtain its value. The method includes alpha, beta, gamma and eta index. To get the value of each index requires data of road number (edge) and node (vertex) [12].

The alpha index shows the ratio of edges and the number of maximum numbers possible in the network. Whereas, beta Index is the ratio of several edges to nodes. These indexes are more useful for a simple network, where no edges are involved [14]. Meanwhile, gamma index is the ratio of an actual number of edges with a maximum possible of edges and eta index shows the average of edge length in the network. These index network based on equations 3, 4, 5 and 6.

$$\alpha \text{ index} = (e - v + 1)/(2v - 5) \tag{3}$$

$$\beta \text{ index} = e/v \tag{4}$$

$$\gamma \text{ index} = e/(3(v - 2)) \tag{5}$$

$$\eta \text{ index} = l(G)/e \tag{6}$$

Where "e" represents the number of edges, "v" denotes the number of vertices and "l(G)" as the total path length (km). Alpha, beta and gamma index values range from 0 to 1, the higher value indicates the fully connected network in a region. For eta index, a decrease in value will occur when a node is added.

### 2.3.3. Number of entries, road density and access control

The number of entries defined as the number of paths which can be utilized by individuals (vehicles) to enter or exit [6]. The number of entries (turning) shows the spatial permeability in a region/area. Meanwhile, road density is the ratio between the total length of the road ( $l$ ) and width area/region ( $A$ ) who expressed in meter per square km unit (equation 7). Crime usually increases in the high road density area such as the central business district (CBD), it making public space allocation is larger and create a crime attractor for criminals [14].

$$\text{Road density} = l(A)/A \quad (7)$$

The last accessibility parameter in the study is access control. Poor access control has a role as triggers of blue-collar crime in a region. The access control is part of the crime prevention strategy in Crime Prevention through Environmental Design (CPTED), this effort can be pursued by reducing the freedom sense of person when entering a region by applying various regulations such as physical barrier (portal or gate), regulation access and security posts [15].

## 3. Results and Discussion

### 3.1. Urban crime pattern

KDE was able to know the distribution of crime on a certain radius in Sumur Bandung. Urban crime in the region is classified into 3 (three) level, i.e., high, medium, and low urban crime concentration using a natural break (Jenks optimization rule) [16]. The geostatistical validity test result shows that urban crime pattern in Sumur Bandung has ME -0.75, RMSE 6.29 and  $r^2$  0.93. The value indicates a KDE-based based crime existing model is valid. Spatial distribution of urban crime in Sumur Bandung is presented in Figure 2.

The pattern of urban crime in Sumur Bandung is clustered. High crime level located at the middle and east of Braga, it level also exist in the northern of Babakan Ciamis. Braga has hamlet (RW) with high crime vulnerability as many as four regions included RW 03, RW 04, RW 06, and RW 08. Meanwhile, Babakan Ciamis only has one hamlet (RW 05) as a region with high crime level. These areas are known as major commercial areas in Bandung City. It indicates the commercial area role as a crime generator and crime attractor [16-17]

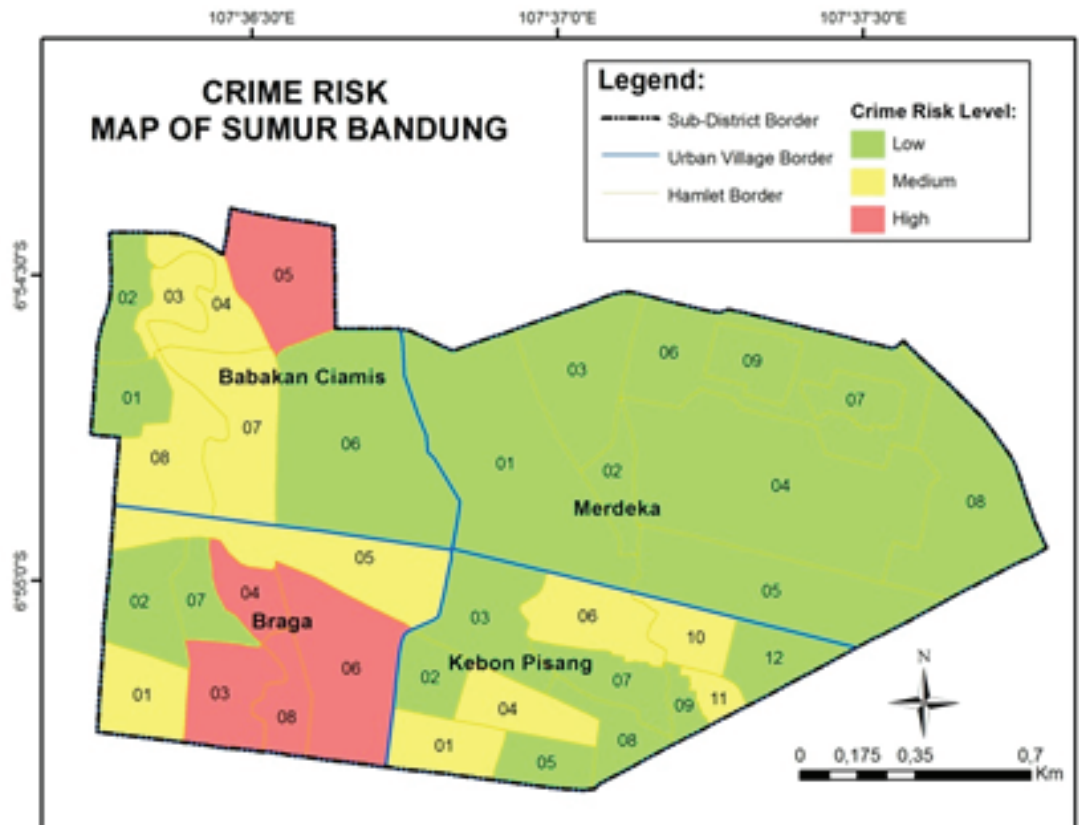


Figure 2: Urban Crime Distribution in Sumur Bandung.

Medium crime risk level areas are generally quite close to a high crime risk level. This shows that crime in Sumur Bandung occurs in a closely located to the previous incident. Overall, urban crime phenomenon in the region is clustered in the western and central part of Sumur Bandung. Thus, It is also similar to Bandung crime pattern [5].

### 3.2. Urban accessibility

Accessibility signifies interaction level to the inner and outer region in around. Better accessibility is needed to support human, goods, and services mobility [19]. Accessibility in Sumur Bandung is studied using a number of entries, network indices, access control, and road density which based on road network data. The road network system in this region is shown in Figure 3.

Sumur Bandung has 130 entries which can be accessed from another region around it through various types of roads. Hamlet (RW) with the highest number of entries owned by RW 06 Babakan Ciamis with 39 entries, then RW with the lowest number of entries is located at RW 09 Merdeka and RW 09 Kebon Pisang with ten entries. Several entries

are seen comparable with area width (Figure 4a). This condition shows the need for accessibility will increase with the extent and role of the region for others.

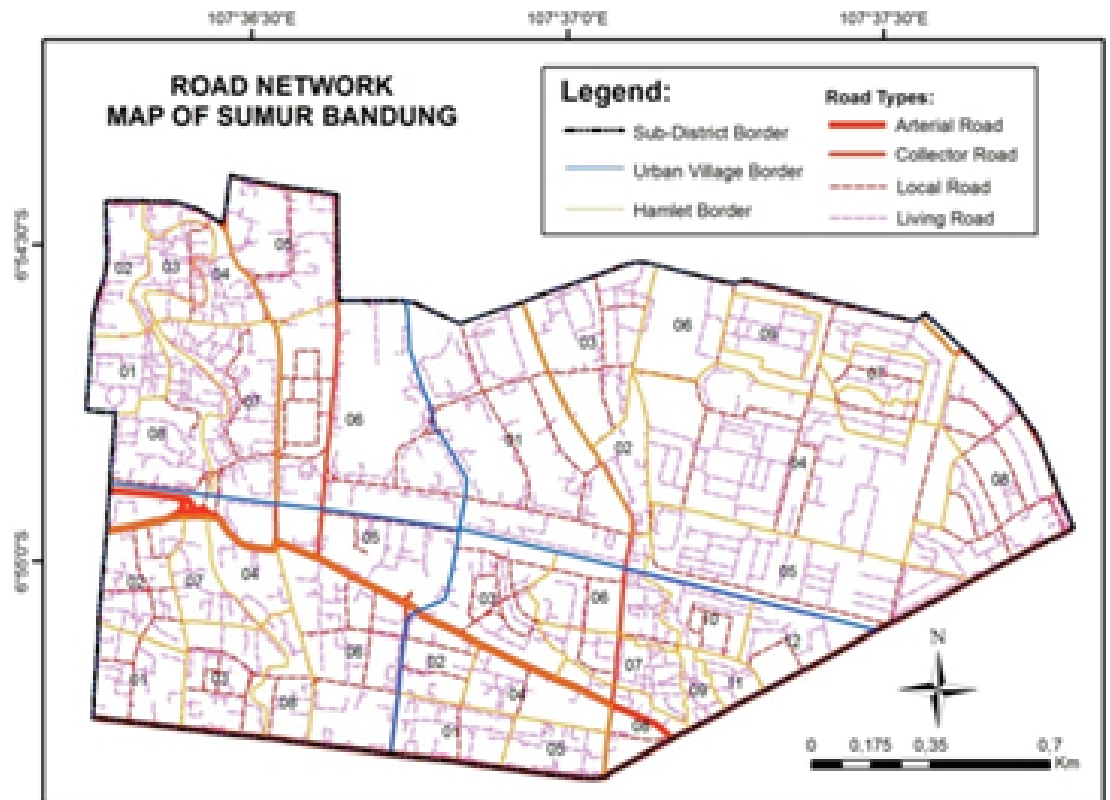


Figure 3: Road Network in Sumur Bandung.

Determining of connectivity based on several indexes requires data in the number of road segments (edge), number of intersection points (node or vertex) and length of road in the study area. Through geographic information system (GIS) technology, the data which needed to assess these index based on the road network is extracted. The data about these in each urban village in Sumur Bandung presented in table 1.

TABLE 1: Parameters of Network Indices di Sumur Bandung.

Region	Number of Entries	Node	Edge	Road Length (km)
Braga	42	362	408	24.02
Babakan Ciamis	58	552	662	29.17
Merdeka	41	497	592	46.81
Kebon Pisang	43	376	457	26.11
Sumur Bandung	130	1787	2119	108.36

Based on these data, the average of network index value in each RW included Alpha Index 0.125, Beta Index 1.203, Gamma Index 0.425 and Eta Index 0.061. Detail information about the network indices in Sumur Bandung for each RW presented at

Figure 4b. The area with high-level network indices has the spread pattern, while the area of low and medium level network indices have the clustered pattern. Areas with high network indices level spread over 6 (six) hamlet or RW. Whereas, areas with low network indices are located at the east of Babakan Ciamis and the west of Merdeka. Besides that, the eastern of Merdeka, the western of Kebon Pisang and eastern of Braga have status as medium network indices area.

Urban accessibility analysis usually using road density as the parameter [20]. Beside to causing a positive impact, the existence of roads can trigger street crime. Sumur Bandung has road density 3,145.46 m/km<sup>2</sup>. The highest road density occurs in Kebon Pisang (43,011.53 m/km<sup>2</sup>), whereas the lowest at Merdeka 33,127.39 m/km<sup>2</sup>. Distribution of road density in Sumur Bandung presented in Figure 4c. Sumur Bandung has 12 hamlets (RW) with high road density level, where 5 (five) RWs is located in Kebon Pisang. In this region, high-density RWs mostly have direct access to arterial roads. Pattern distribution of areas that have low road density is clustered in the middle of Sumur Bandung as known as the government center area [21]. Also, the low road density area usually located in large areas.

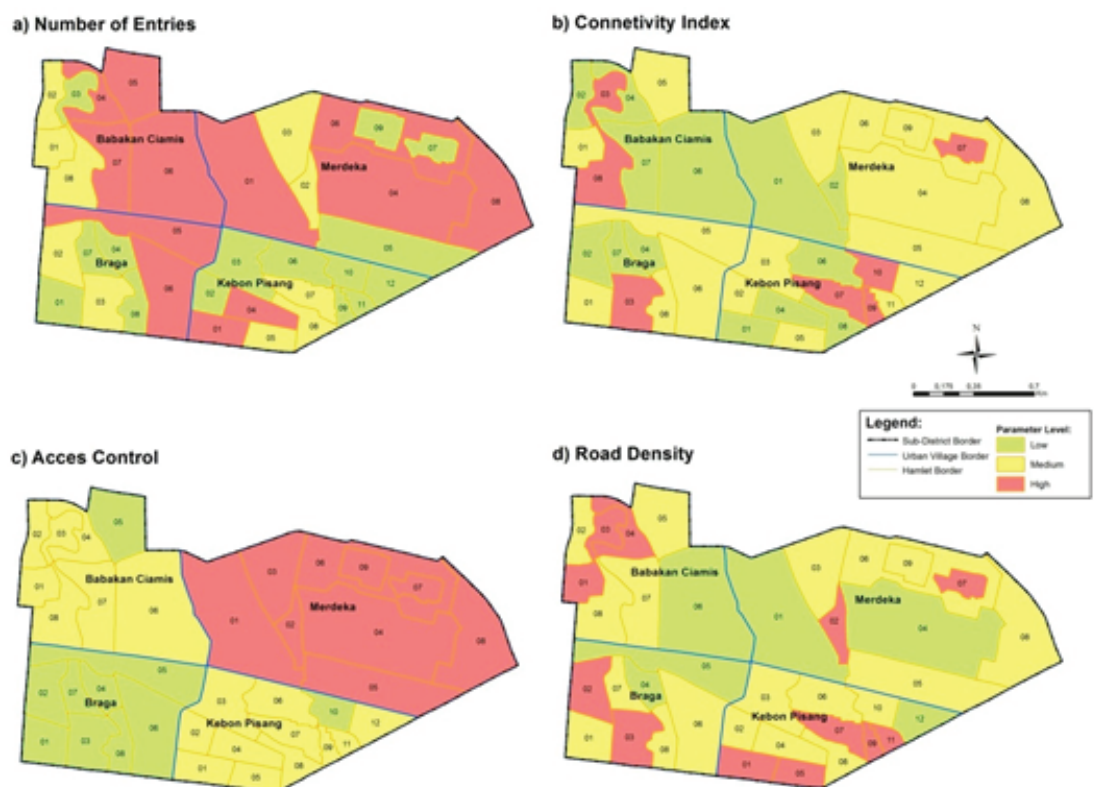


Figure 4: Accessibility Parameters in Sumur Bandung.

In a hamlet or RW unit, Sumur Bandung has portal reach 83 percent (31 RWs), and environmental security post reaches 68 percent (25 RWs). The urban village with strict



access is Merdeka which all RWs have portals and security posts. The opposite condition occurs in Braga; the portal exists in 5 (five) RWs. For a security post, only 3 (three) RWs in Braga who have portals. In Sumur Bandung, access control depends on the function of an area to another. The military area usually has very strict access with capable security guard like at RW 09 Merdeka.

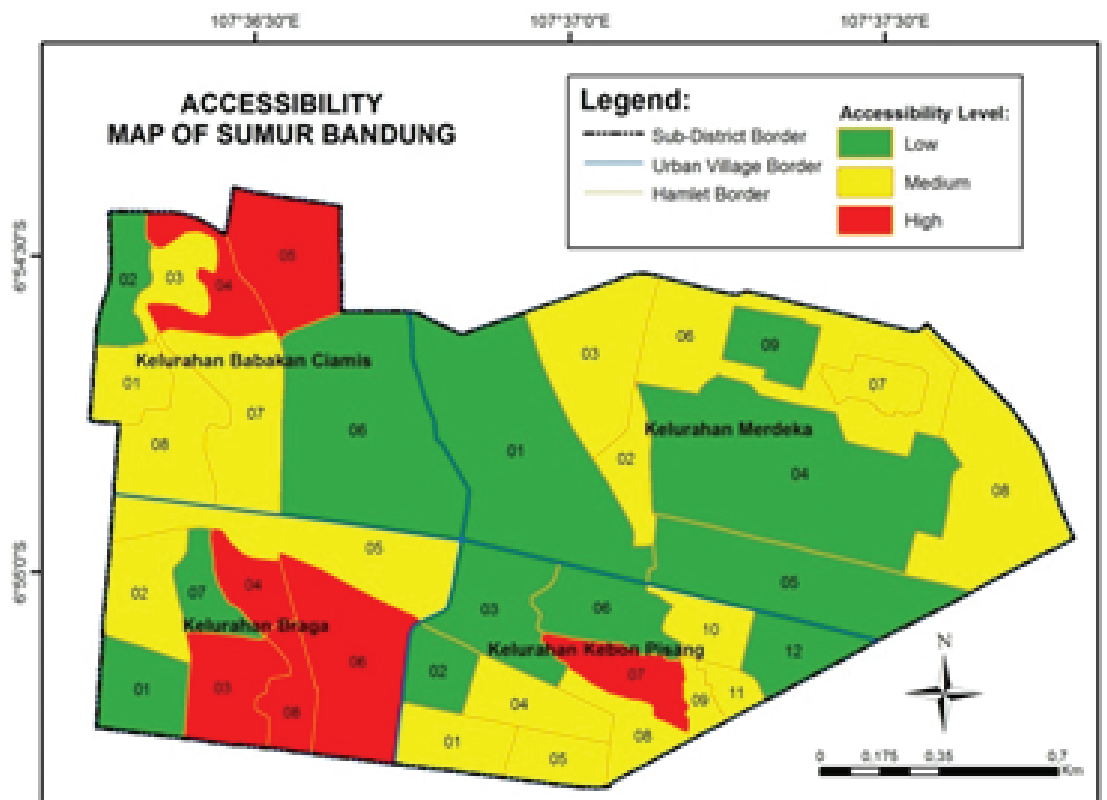


Figure 5: Urban Accessibility in Sumur Bandung.

After the four urban accessibility parameters are obtained, the values of all must be codified and summed to ease classify using a natural break (Jenk optimization rule). It generates three class levels of accessibility in Sumur Bandung, i.e. high, medium, and low class as in Figure 5. Sumur Bandung has 12 RWs with the low level of accessibility this area is clustered in the in eastern Babakan Ciamis and the western of Merdeka. Besides that, the region has 7 (seven) RWs with high accessibility level who locate closely to arterial or collector roads in the eastern part of Braga and the northern of Babakan Ciamis. The medium accessibility level shows a different pattern because 18 RWs spread in each urban village.

### 3.3. Urban crime pattern and accessibility in Sumur Bandung

Easily access often exploited by irresponsible parties to commit crimes. It occurs because of unclear boundaries between the private and public area in a more accessible region [21]. The crime pattern in Sumur Bandung tends to cluster in specific areas with good accessibility such as residential area, office area, and commercial area. Accessibility is always associated with goods and individuals mobility between places or regions through a transport network system [22]. The region accessibility is showed from the existence of the road network system which affects intraregional and interregional interactions. In addition to providing positive benefits for regional development, the high accessibility can increase crime phenomenon as known as street crime.

In Sumur Bandung, the relationship between accessibility and crime is positive, high and significant because the correlation value between them reach 0.651. The statistical test results, it's known that the Spearman correlation value or "p count" is higher than "p table" value with the level of 1 (one) percent significance who reach 0.418. It indicates the region with a high level of accessibility has higher crime risk than other and vice versa [23]. The relationship between accessibility and crime is shown in Figure 6.

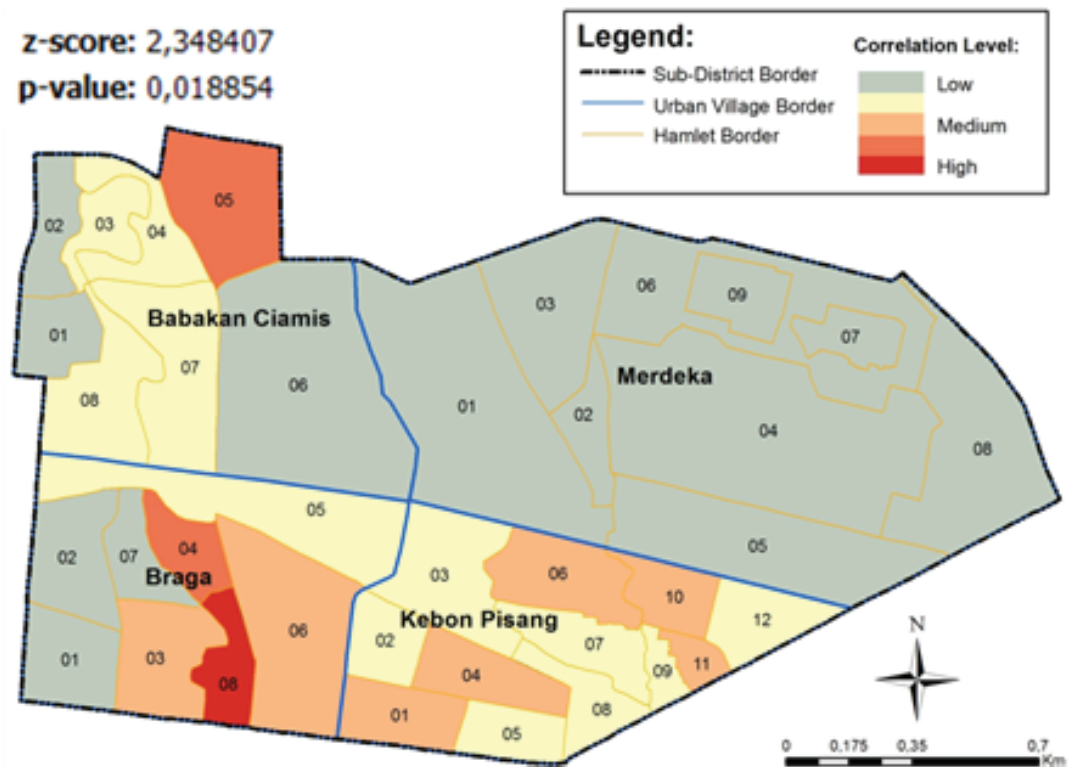


Figure 6: Spatial Correlation between Accessibility and Crime in Sumur Bandung.

The correlation between accessibility and crime is strongly caused by road infrastructure factor as a public and accessible area to anyone [24]. The perception of Sumur

Bandung people who consider that accessibility can trigger the criminals to act reach 84.38 percent is also support this statement, especially crime in the region is dominated by street crime or property crime such as vehicle theft, mugging, and pickpocketing. Spatially, the correlation has a clustered pattern with Z-score of 2.3 (Figure 6). The strong relationship between them occurs in eastern Braga, but weakly in Merdeka.

The conformable between urban accessibility and urban crime is caused by crime which occurs in closely location to the road network; the accessibility serves potential targets for property or street criminals [25]. The crime intensity will increase and follow road network system existence in a region. Thus area with low accessibility level has low crime accidents [25 – 26].

Accessibility as one of the elements of space to encouraging intraregional and interregional mobility is a necessity, thus monitoring about access is absolutely to minimize any negative impact with the spatial-temporal access controlling especially on roads which lead directly to residential, amenities and commercial area [27 – 29]. In Sumur Bandung, the access control policy should be realized because 91.24 percent of people in the region want it to improve the safety of their environment.

## 4. Conclusion

In Sumur Bandung, urban accessibility has a significant correlation with the crime pattern. Urban crime and urban accessibility have a clustered pattern in CBD and commercial area. These results strengthen the statement that high accessibility in a region can generate a negative impact on crime and accordance with routine activity theory of crime. It indicates higher level of accessibility has the role as crime generator and crime attractor. Thus crime prevention effort through physical access controlling and regulation in urban region is need. In the future, research about urban crime and environmental aspects can involve many variables such as social climate, demographic, economic and land use distribution.

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