

Mapping of Crime-Prone Areas Using Geographic Information Systems in Pematang Siantar City in 2025

Octovannes Rajagukguk¹, Eni Yuniastuti¹ 

¹Department of Geography Education, Faculty of Social Sciences, Universitas Negeri Medan, Indonesia

²Geographic Information Science Study Program, Faculty of Social Sciences, Universitas Negeri Medan, Indonesia

e-mail: octovannes@gmail.com

Received:
September 08, 2025

Revision:
October 08, 2025

Accepted:
October 08, 2025



This work is licensed
under a Creative
Commons
Attribution-
NonCommercial 4.0
International License.

Abstract

Crime is a social problem that continues to increase along with population growth and the complexity of urban activities. Pematang Siantar, the second most densely populated city in North Sumatra, faces various social challenges that contribute to a high crime rate. This study aims to map crime-prone areas and analyze the effect of population density on crime rates in 2025. The research employed a quantitative descriptive method with a Geographic Information System (GIS) approach. Primary data consisted of 302 crime cases in 2024 from the Pematang Siantar Police Department, demographic data from the Central Bureau of Statistics, and field observations of crime scene coordinates. Analysis techniques included buffer, kernel density, overlay, and simple linear regression. The results show that crime cases consisted of 191 cases of aggravated theft (63.25%), 103 cases of motor vehicle theft (34.11%), and 8 cases of robbery (2.64%). The highest distribution occurred in West Siantar (77 cases/25.50%), North Siantar (73 cases/24.17%), and Sitalasari (62 cases/20.53%), while the lowest was in Marihat (7 cases/2.32%). Regression analysis indicated that population density ($R^2 = 0.185$; sig. 0.174) did not significantly influence crime rates. This research contributes to the development of crime geography and provides a scientific basis for local government and law enforcement in designing spatial-based crime prevention strategies.

Keywords: Crime, Mapping, Population Density, Pematang Siantar.

INTRODUCTION

Indonesia is one of the developing countries with a per capita income at the lower-middle level, infrastructure that is still under development or unevenly distributed, and a human development index that remains lower compared to developed nations (Fadhil, 2020). Indonesia faces a range of issues that require attention. Almost every region faces its own unique set of problems. These various challenges, undeniably, often trigger the potential emergence of criminal acts.

As a developing country, Indonesia has a population of approximately 279 million people. Along with the progress of time, the modern era, and technological advancement, social changes occur within society. The emergence of various problems, such as social deviance, delinquent behavior, moral decline, and a decline in nationalism,

often accompanies the increasing standard of living. Current technological developments also contribute to the rise of criminal acts, in which anyone may potentially become an offender (Watrianthos et al., 2023).

Crime encompasses all actions that are against the law, whether related to taking another person's property with or without the owner's knowledge, or deliberate acts that cause physical harm (Aji, D.K., & Oktavia, 2023). Crime can be understood as deviant behavior committed by an individual within a society. It is a problem that frequently occurs across different regions and requires special attention, as it can lead to losses and negative impacts (Bahkti, Y., & Hutabalian, 2021).

The Indonesian National Police (POLRI) categorizes crimes into several

groups. Conventional crimes are those commonly occurring within society, such as murder, robbery (curas), burglary (curat), and motor vehicle theft (curanmor). Transnational crimes refer to offenses that cross national borders and have international impacts, including drug trafficking, human trafficking, and terrorism. Crimes against state assets or economic crimes encompass violations in finance and economics, including corruption, fraud, and money laundering. Meanwhile, cybercrimes are offenses committed through the internet and digital technologies, including online fraud, hacking, and the spread of hoaxes (Saputra, 2024).

Criminality is influenced by various factors, including population density and poverty levels (Adisanjaya & Nugraha, 2019). It can occur at any time and anywhere, causing both material and non-material losses to society (Ardiansyah, Y., 2021). The increasing number of criminal cases arising in different locations and at other times causes public anxiety and fear of becoming victims of crime. Therefore, information on the level of crime vulnerability in an area is urgently needed. Such information serves as a basis for anticipatory measures to improve public awareness (Dwirohayati & Sudibyo, 2020).

Densely populated areas often become centers of criminal activity. North Sumatra Province is one of the provinces in Indonesia with a high population, reaching 15,785,839 people and a density of 218 people/km². North Sumatra ranks as the fourth most populous province in Indonesia after West Java, East Java, and Central Java, which explains the frequent occurrence of crimes. This is evident from the recorded 36,635 criminal cases within a year.

Pematang Siantar is the second most densely populated city in North Sumatra, after Medan, comprising 8 districts and 53 sub-districts with a total population of 274,838 people and a density of 3,436 people/km² (Sidabutar & Sugiarto, 2025). Pematang Siantar has a high population

density accompanied by rapid workforce growth, but sufficient job opportunities do not match this. The city records an unemployment rate of 8.62% (12,795 people) and a poverty rate of 7.24% (18,960 people). These economic pressures drive some individuals to engage in criminal activities as an alternative means of survival.

To date, no specific research has been conducted on criminality or crime mapping in Pematang Siantar. Available data remain general, presented only in the form of numbers or annual graphs without spatial information showing the distribution of crime-prone areas. This indicates the need for processing crime data into more informative spatial information to support public awareness and provide a foundation for crime prevention strategies by law enforcement agencies.

Crime mapping using Geographic Information Systems (GIS) plays a crucial role in analyzing crime patterns and intensity based on vulnerability zoning. GIS technology enables the dynamic integration of spatial and attribute data, presenting them in a visually understandable format. In addition to improving the effectiveness of monitoring crime-prone areas, GIS also supports more accurate and data-driven decision-making. Based on these issues, this research aims to map crime-prone areas in Pematang Siantar City in 2025 and analyze the influence of population density on crime rates.

RESEARCH METHODS

Location and Time of Research

Research was conducted in Pematang Siantar City, situated in the central part of Simalungun Regency. Geographically, Pematang Siantar lies between 2° 53' 20" – 3° 01' 00" North Latitude and 99° 1' 00" – 99° 6' 35" East Longitude. The study focuses on Pematang Siantar City and the Pematang Siantar Police Department as the research objects, utilizing crime rate data from the city. The research was carried out in January 2025. The selection of this location was based on the consideration that Pematang Siantar

is a densely populated area with diverse social problems, making it prone to high levels of criminal activity.

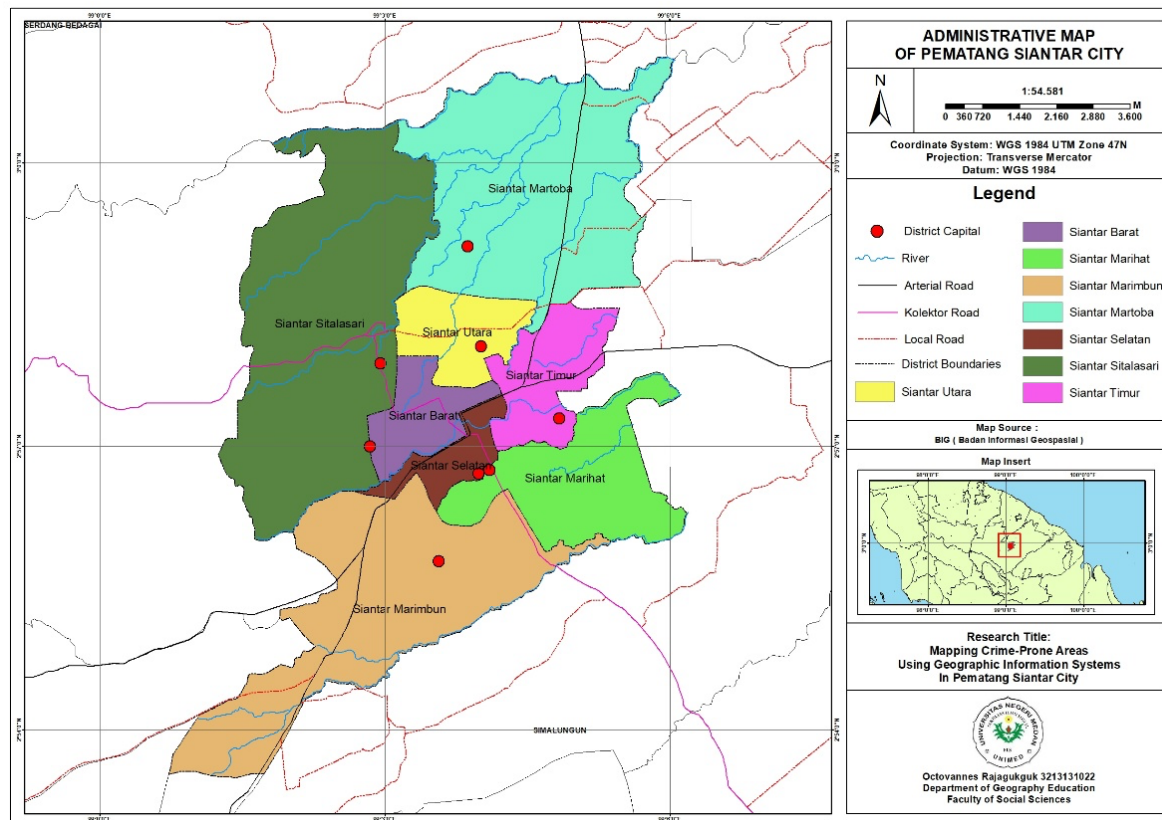


Figure 1. Research Location Map (Source: Data Processing, 2025)

Population and Sample

The population in this study was all areas with a high number of crime incidents in Pematang Siantar City in 2024. The data obtained were then processed using ArcGIS 10.8. The sample determination in this study was conducted using a total sampling technique, specifically targeting all areas with a high number of crime incidents in Pematang Siantar City in 2024.

Data Collection Technique

The data for this research were collected using the following techniques:

- 1) Observation techniques, using direct observation and recording to obtain the coordinates of each crime scene in Pematang Siantar City.
- 2) Literature study techniques, using data collection related to the title, regarding the mapping of crime-prone areas based

on population density using GIS in Pematang Siantar City.

- 3) Interviews were conducted through question-and-answer sessions with police officers from the Pematang Siantar Police Department's Criminal Investigation Unit.
- 4) Documentation was conducted to collect data in the form of crime incident reports at the Pematang Siantar Police Department in 2024.

Data Collection Tools and Materials

The tools and materials used in this research are as follows:

- 1) Tools
 - Laptop
 - Cell phone (digital camera)
 - ArcGIS 10.8.
 - Google Earth

2) Materials

- Administrative map of Pematang Siantar City
- Crime data
- Population data (Pematang Siantar City Statistics Office 2024)
- Road network map
- Crime scene coordinates from the location survey

Data Analysis Techniques

This study employed quantitative descriptive analysis techniques, using data on the number and types of crimes in each sub-district in Pematang Siantar City. The data were analyzed spatially using the Buffer and Kernel Density methods, followed by a scoring process. The results were overlaid with population data to produce a map of crime-prone areas and a map of crime rates by type of crime in 2024. The work procedures implemented in this study included:

a) Data collection

The data collected during this activity is as follows:

1. 2024 Criminal Case Data from the Pematang Siantar City Police Department
2. Pematang Siantar City Administrative Map Data

b) Processing Process

1. Crime data processing aims to determine the crime rate in an area.
2. Police location surveys were conducted to obtain coordinates for identifying and mapping the distribution of police posts and stations in Pematang Siantar City.

3. Buffers identify areas near police posts and public facilities for analysis of crime vulnerability.

4.

5. Data editing involves structured definitions that explain the relative relationships between objects.

6. Population data is calculated to serve as a parameter in determining the level of crime vulnerability. The data is scored according to the following sociodemographic criteria.

7.

8. Database construction involves organizing and combining non-spatial data into a single dataset, known as a database.

9. Data integration involves combining spatial and non-spatial data.

10. Scoring involves grouping each data item based on a predetermined score for the class.

11. Density aims to map the crime density in Pematang Siantar City.

12. Overlay data, including population density, police post distribution, and public facility locations, is processed to determine the level of crime risk in an area.

13. Simple linear regression is used to examine the relationship between population density and crime in Pematang Siantar City.

H_0 = There is no significant relationship between population density and crime.

H_a = There is a significant relationship between population density and crime.

Table 1. Police Data Criteria

No	Parameter	Category	Mark
1	Buffers for Police Stations or Stations	<250 meters	1
		>250-500 meters	2
		500-750 meters	3
		>750 meters	4
2	Buffers for Public Facilities or Crowded Areas	<100 meters	2
		>100 meters	1

(Sumber : Harries, 999)

Table 2. Socio-demographic criteria

No	Parameter	Population Density Interval	Population Density Category	Mark
		>8500	High	5
1	Population Density	2500 – 8500	Medium	3
		<2.500	Low	1

(Source: Wibisono, 2009)

c) Analysis

The analysis in this study consists of three main parts. Spatial analysis was conducted by examining maps of crime distribution and vulnerability levels to identify the influence of various parameters and determine areas with low to high levels of vulnerability in Pematang Siantar City. Statistical analysis was conducted using SPSS 25 software to measure the extent to which population size influences crime rates in each area. The vulnerability classification was determined through a scoring process for the research

parameters, which were divided into three categories: not vulnerable, vulnerable, and very vulnerable.

RESULTS AND DISCUSSION

Distribution of Crime Incident Points in Pematang Siantar City

The distribution of crime incident points for violent theft (curas), aggravated theft (curat), and motor vehicle theft (curanmor) in 2025 that occurred in Pematang Siantar City was processed from crime scene location data for Pematang Siantar City.

Table 3. Number of Crime Cases in Pematang Siantar City in 2025

Subdistrict	Curas	Curat	Curanmor	Amount	Percentage (%)
Siantar Marihat	0	4	3	7	2
Siantar Marimbun	0	8	5	13	4
Siantar Selatan	1	11	3	15	5
Siantar Barat	3	51	23	77	25
Siantar Utara	3	41	29	73	24
Siantar Timur	0	12	8	20	7
Siantar Martoba	1	10	24	35	12
Siantar Sitalasari	0	54	8	62	21
Amount	8	191	103	302	100

(Source: Reskrim Kota Pematang Siantar, 2025)

Based on data from the Pematang Siantar City Criminal Investigation Department (Reskrim), 302 crimes were recorded in 2025, including eight cases of theft with violence (curas), 191 cases of aggravated theft (curat), and 103 cases of motor vehicle theft (curanmor). These cases were spread across eight districts in Pematang Siantar City, with varying degrees of intensity.

The districts with the highest number of crime cases were West Siantar, North Siantar, and Siantar Sitalasari. West Siantar

accounted for 77 cases (25%) of the total. The dominant crime rate was theft with 51 cases, followed by motorcycle theft with 23 cases, and curas with 3 instances. North Siantar followed this with 73 cases (24%), and Siantar Sitalasari with 62 cases (21%).

The sub-districts with moderate crime rates are Siantar Martoba and East Siantar. Siantar Martoba recorded 35 cases (12%), and East Siantar recorded 20 cases (6%). Meanwhile, the sub-districts with the lowest number of cases were Siantar Marihat, Siantar Marimbun, and South Siantar.

Siantar Marihat recorded only 7 cases (2%), followed by Siantar Marimbun with 13 cases (4%), and South Siantar with 15 cases (5%).

The most common type of crime across all sub-districts was theft, accounting for 63% of total crime. This indicates that aggravated theft is the most prevalent form of crime in

Pematang Siantar City. This data distribution can provide a crucial basis for formulating effective security policies, enhancing police patrols, and identifying areas prone to crime that require additional attention from law enforcement

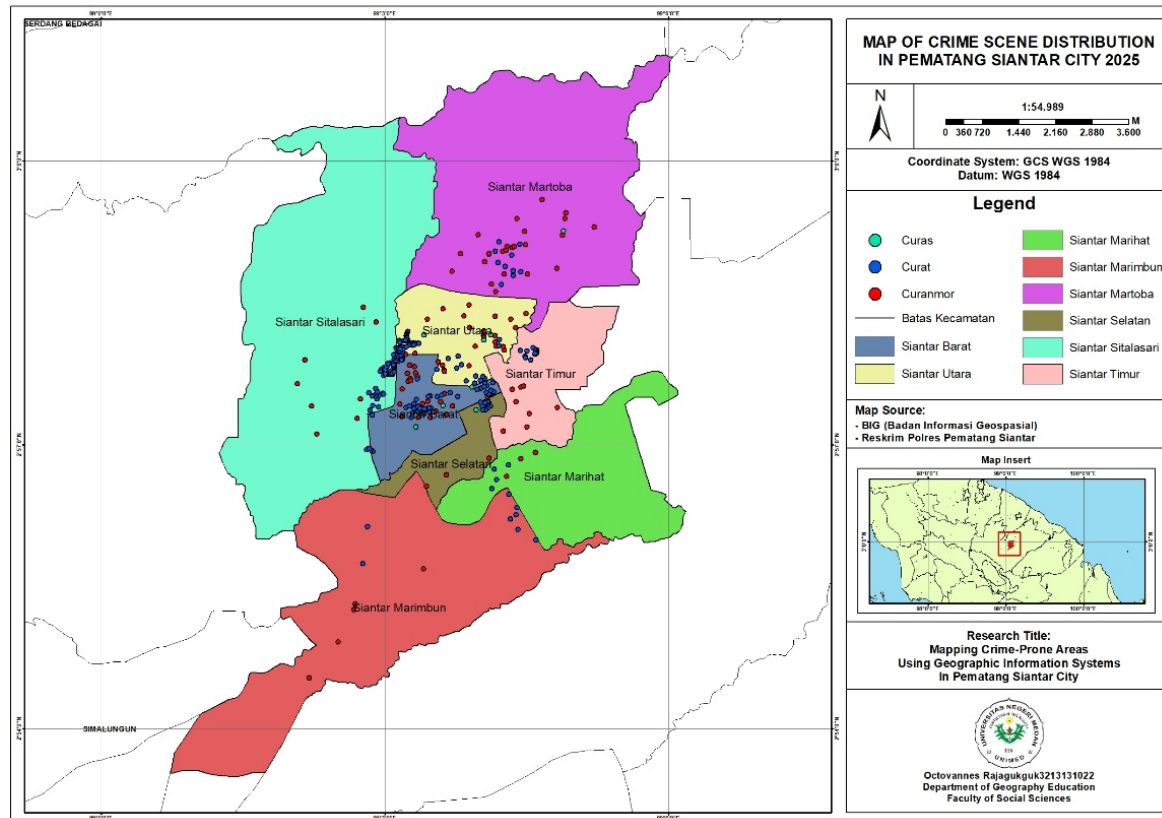


Figure 2. Map of the Distribution of Crime Points in Pematang Siantar City in 2025
(Source: Data Processing, 2025)

Population Density in Pematang Siantar City

To determine the population density of Pematang Siantar City, it can be calculated by dividing the number of residents occupying a specific area by the total area of that area.

Formula:

$$Dp = \frac{N}{A}$$

Where:

N : Total Population

A : An area

The results of the population density calculation for Pematang Siantar City, as determined by the formula, are presented in Table 4 below.

Table 4. Population Density in Pematang Siantar City in 2024

Subdistrict	Population (People)	Area (Km ²)	Population density / Km ²
Siantar Marihat	21.484	7,825	2.743,81
Siantar Marimbun	21.684	18,006	1.204,26
Siantar Selatan	17.588	2,020	8.706,93
Siantar Barat	38.249	3,205	11.934,17

Siantar Utara	50.300	3,650	13.780,82
Siantar Timur	37.041	4,520	8.194,91
Siantar Martoba	52.705	18,022	2.924,48
Siantar Sitalasari	35.787	22,723	1.574,92
Total	274.838	79,971	3.436,72

(Source: Pematang Siantar City in figures, 2024)

Based on data from the 2024 Pematang Siantar City in Figures report, the total population of Pematang Siantar City reached 274,838 people spread across eight sub-districts with a total area of 79,971 km². The average population density of Pematang Siantar City is 3,436.72 people per square kilometer. However, this density varies significantly between sub-districts, depending on their population and area.

The sub-district with the highest population is Siantar Martoba Sub-district with 52,705 people, followed by North Siantar Sub-district with 50,300 people. Conversely, South Siantar Sub-district has the smallest population, with only 17,588 people. In terms of area, Siantar Sitalasari Sub-district is the largest, covering 22,723 km², while South Siantar is the smallest, at

only 2,020 km². In terms of population density, North Siantar District has the highest density, at 13,780.82 people/km². This district is followed by West Siantar (11,934.17 people/km²) and South Siantar (8,706.93 people/km²). Meanwhile, the lowest density was recorded in Siantar Marimbun District at 1,204.26 people/km², indicating that this area is relatively sparsely populated.

To determine the level of crime vulnerability in Pematang Siantar City, a scoring system based on sociodemographic criteria is required. This data is calculated to serve as a parameter for determining and analyzing crime vulnerability maps. More detailed data can be found in the image and Table 5 below.

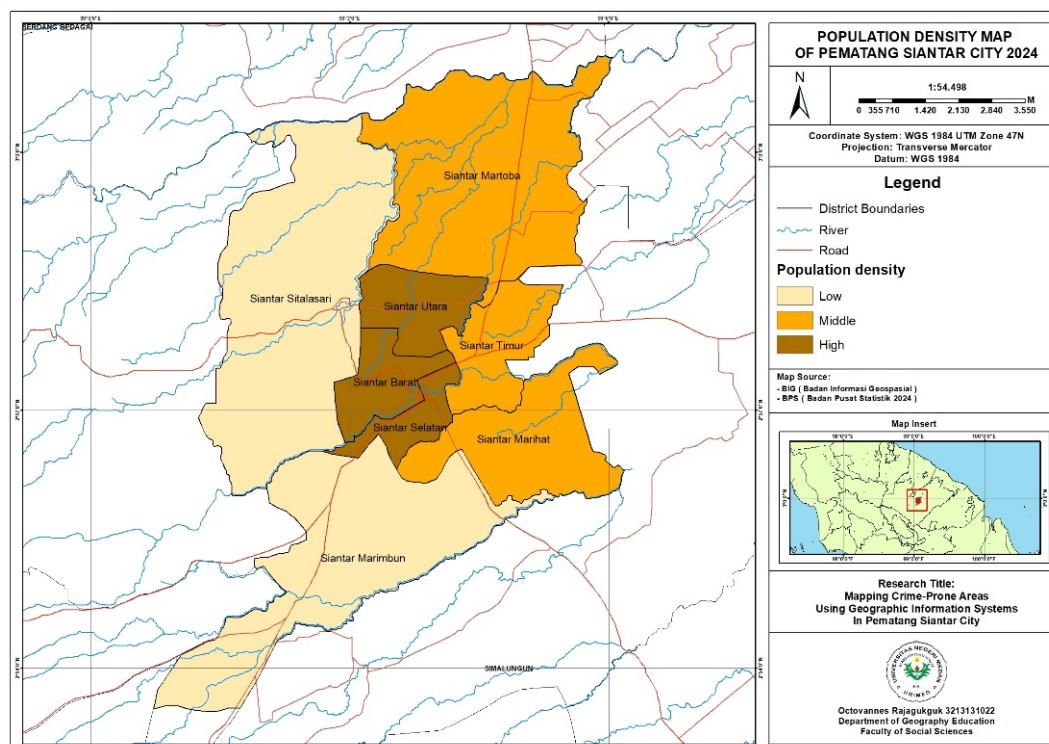


Figure 3. Population Density Map of Pematang Siantar City in 2024

(Source: Data Processing, 2025)

Table 5. Population Density per District

Subdistrict	Population density/Km ²	Area (Km ²)	Population Density Classification	Value (score)
Siantar Marihat	2.743,81	7,825	Medium	3
Siantar Marimbun	1.204,26	18,006	Low	1
Siantar Selatan	8.706,93	2,020	High	5
Siantar Barat	11.934,17	3,205	High	5
Siantar Utara	13.780,82	3,650	High	5
Siantar Timur	8.194,91	4,520	Medium	3
Siantar Martoba	2.924,48	18,022	Medium	3
Siantar Sitalasari	1.574,92	22,723	Low	1

(Source: Data Processing, 2025)

The sub-districts with high population density category include North Siantar (13,780.82 people/km²), West Siantar (11,934.17 people/km²), and South Siantar (8,706.93 people/km²), each of which received a score of 5. These three sub-districts have a relatively small area but are densely populated, resulting in a high population density. Meanwhile, the sub-districts in the medium category are East Siantar (8,194.91 people/km²), Siantar Marihat (2,743.81 people/km²), and Siantar Martoba (2,924.48 people/km²), each with a score of 3. The low category is represented by Siantar Marimbun (1,204.26 people/km²) and Siantar Sitalasari (1,574.92 people/km²), both of which received a score of 1.

In terms of area, Siantar Sitalasari (22,723 km²) and Siantar Marimbun (18,006 km²) are the largest, but both are in the low-density category. Conversely, South Siantar,

with an area of only 2,020 km², is categorized as having a high density. This indicates that the area is not always directly proportional to population density, but is more influenced by the concentration of residential activities and economic centers.

Crime Vulnerability Level in Pematang Siantar City

a) Population Density

Identification of crime-prone areas in Pematang Siantar City can be done through population density, buffer, and kernel density analysis. Scores are assigned to each parameter, followed by a classification of all parameters used. Areas with high density often indicate higher crime rates; therefore, a population density analysis is necessary. The population density classifier for Pematang Siantar City is divided into three classes.

Table 6. Classification of Crime Vulnerability in Pematang Siantar City

Population density/Km ²	An Area (Km ²)	Score	Classification	Level of Vulnerability
2.779,18	40,729	1	Low	Not Vulnerable
11.119,39	30,367	3	Medium	Vulnerable
13.780,82	8,875	5	High	Very Vulnerable

(Source: Data Processing, 2025)

The population density classification in Table 6 provides an overview of the population distribution patterns in Pematang Siantar City, which can be linked to various social aspects and regional development. Districts with high density

(13,780.82 people/km²) tend to be located in urban areas with relatively small areas (8,875 km²), which are usually centers of economic, trade, and service activities. This condition has the potential to put pressure on infrastructure and public services, as well as

increase social vulnerabilities such as traffic congestion and high crime risks. Conversely, areas with low density (2,779.18 people/km²) and large areas (40,729 km²) tend to be characterized as suburban areas or areas with predominantly non-residential functions, such as agricultural land or open spaces. Although less dense, these areas have the potential to face limited access to public facilities and basic services.

The medium category (11,119.39 people/km²) with a medium area (30,367 km²) can be seen as a transition zone between densely populated and sparsely populated areas. These areas generally experience significant urbanization and therefore require special attention in spatial planning to avoid excessive demographic pressure. Thus, this population density classification serves not only as a statistical overview but also has direct implications for urban development management in efforts to reduce the potential for crime in densely populated areas.

Further identification can be achieved by scoring each crime scene based on its distance from police stations and busy centers, and then analyzing the results using ArcGIS software with the Kernel Density method approach. This method produces a visualization of the density of incident points that represent the level of crime in an area. The results of this analysis form vulnerable zones known as hotspots, which are then visualized in the form of a crime vulnerability map. This Kernel Density-based mapping refers to the spatial distribution of incident points, thus allowing one sub-district area to be classified into several different levels of vulnerability.

The total population of Pematang Siantar City reached 274,838 people, distributed across eight districts with a total area of 79.971 km². Consequently, the city's average population density is 3,436.72 people per square kilometer. However, the distribution of population density varies significantly among districts, influenced by differences in population size and land area in each district (Yunianto, 2021).

The level of population density in a region is determined by the ratio between the total population and the size of the area, consistent with the findings of Yenny & Anwar (2021). High population densities are generally found in areas with relatively small land areas but large populations. This condition is evident in Siantar Utara, Siantar Barat, and Siantar Selatan, which, despite having land areas of less than 4 km², record densities exceeding 8,000 people/km², thus falling into the high-density category with a score of 5.

Conversely, districts with large land areas but relatively small populations tend to have low population densities, such as Siantar Marimbun and Siantar Sitalasari. In these cases, a larger area does not necessarily correspond to a larger population, as factors such as infrastructure availability, spatial planning functions, and land-use characteristics can influence residential distribution, in line with the findings of Arkan et al. (2024)[insert reference].

In the crime vulnerability analysis, population density serves as a key variable in determining the level of crime risk. Demographic data are used as a primary parameter in spatial analysis to produce zoning maps of crime vulnerability levels. The classification of density (low, medium, high) along with its scoring values can be applied as an indicator for further analyses, such as urban development planning, the provision of public facilities, or assessments of social and crime-related risks. Theoretically, areas with high population density are likely to have greater demands for public services, increased pressure on infrastructure, and more intense social interactions, which can present both opportunities and challenges in urban planning.

b) Buffer Analysis

1. Crowded Center

A buffer analysis was conducted on data from police stations and busy centers to determine the optimal distances for frequent crime. A score was then assigned to each

incident point to determine the crime rate in Pematang Siantar City. For more details, see the table and figure below.

Table 7. Buffering of Incident Points from Crowd Centers

No	Buffer	Number of Event Points	Score
1	Distance 100 M	16	2
2	Distance >100 M	286	1

(Source: Data Processing, 2025)

Based on the data analysis in Table 7, it is evident that within a 100-meter buffer from the center of the crowd, there are 16 crime

scenes, while 286 crime scenes occur outside a 100-meter radius from the center of the crowd.

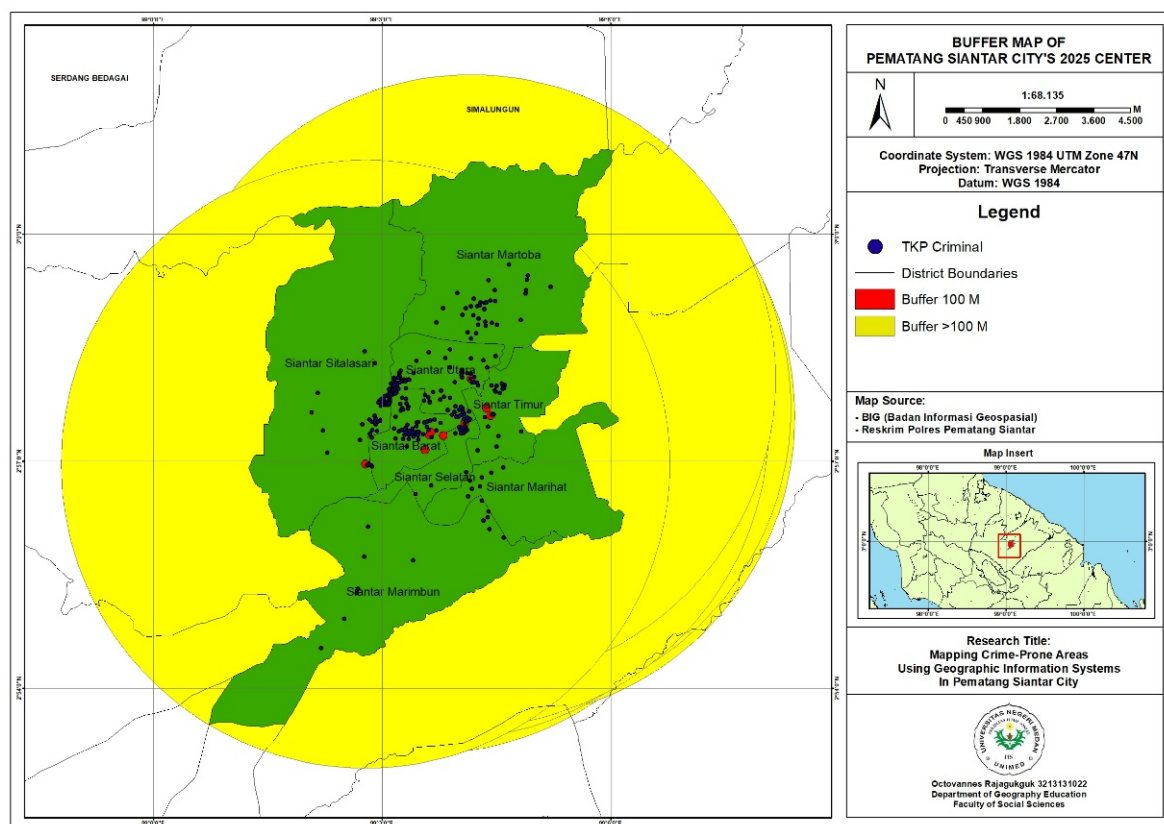


Figure 4. Buffer Distances of 100 and >100 Meters from the Center of the Crowd

(Source: Data Processing, 2025)

In total, nine busy centers were identified, including the Pematang Siantar Zoo, H. Adam Malik Field, Pematang Siantar Flower Garden, Ramayana Pematang Siantar, Suzuya Pematang

Siantar, Merdeka Suzuya Mall, Pajak Horas, Pajak Parluasan, and Rindam Morning Market. For more details, see the table and image below.

Table 8. Buffering area of busy centers

No	Crowd Center	Buffer 100 M (Km ²)	Buffer >100 M (Km ²)
1	Taman Hewan Pematang Siantar	0,031	74,2
2	Lapangan H. Adam malik	0,031	73,8
3	Taman Bunga Pematang Siantar	0,031	73,7
4	Ramayana Pematang Siantar	0,031	72,6
5	Suzuya Pematang Siantar	0,031	73,6
6	Merdeka Suzuya Mall	0,031	72,6
7	Pajak Horas	0,031	73,2
8	Pajak Parluasan	0,031	72,2
9	Pasar Pagi Rindam	0,031	72,6

(Source: Data Processing, 2025)

Based on the analysis results, the buffer area formed around the crowded centers for a 100-meter buffer ranges from 0.031 km², and for buffers greater than 100 meters, it ranges from 72.2 km² to 74.2 km². The most considerable buffer value is found in Pematang Siantar Zoo at 74.2 km², while the smallest value is in Pajak Parluasan at 72.2 km². This variation in buffer area indicates differences in the spatial reach of each

crowded center, which is likely influenced by its function, activity intensity, and the distribution of supporting facilities around it.

2. Police Station

Then, for the police station buffer, four radii were created: 250 meters, 500 meters, 750 meters, and greater than 750 meters.

Table 9. Scoring of Incident Points from Police Posts

No	Buffer	Number of Event Points	Score
1	Distance 250 M	26	1
2	Distance 500 M	49	2
3	Distance 750 M	34	3
4	Distance >750 M	193	4

(Source: Data Processing, 2025)

Based on the data analysis in Table 9, it is known that from the police post distance buffer, it was obtained that there were 26 crime scenes within a radius of 250 meters,

49 crime scenes within a radius of 500 meters, 34 crime scenes within a radius of 750 meters, and 193 cases within a distance of >750 meters.

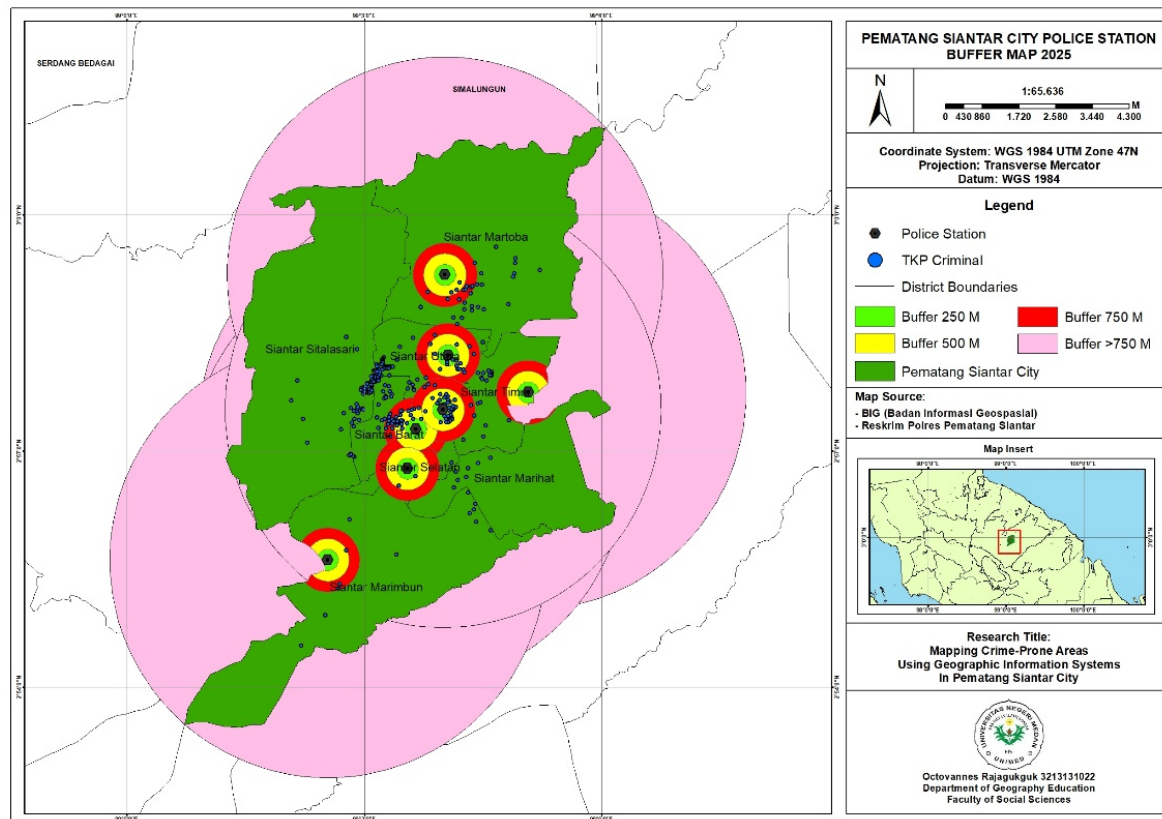


Figure 5. Buffer Map of Distances 250, 500, 750, and >750 Meters for Police Posts
(Source: Data Processing, 2025)

In total, seven police stations were identified: the North Siantar Police Station, the Pematang Siantar Police Station, the East Siantar Police Station, the South Siantar

Police Station, the Martoba Siantar Police Station, the Marihat Siantar Police Station, and the Assistant Police Post. For more details, see the table and image below.

Table 10. Police Post Buffering Area

Office Police	Buffer 250 M (Km ²)	Buffer 500 M (Km ²)	Buffer 750 M (Km ²)	Buffer >750 M (Km ²)
Polsek Siantar Utara	0,19	0,78	1,76	63,2
Polres Pematang Siantar	0,19	0,78	1,76	61,4
Polsek Siantar Timur	0,17	0,53	1,09	47,3
Polsek Siantar Selatan	0,19	0,78	1,76	55,4
Polsek Siantar Martoba	0,19	0,78	1,76	50,0
Polsek Siantar Marihat	0,15	0,60	1,36	38,3
Pos Polisi Pembantu	0,19	0,78	1,76	62,6

(Source: Data Processing, 2025)

Table 10 presents the results of the analysis of the buffer area around police posts in Pematang Siantar City, with radii of 250 meters, 500 meters, 750 meters, and greater than 750 meters. This analysis aims to determine the spatial coverage of each police station in providing security services based on its coverage distance. Based on the

data, the buffer area at a radius of 250 meters is relatively small and uniform, ranging from 0.15 km² to 0.19 km². The smallest value is found at the Siantar Marihat Police Station at 0.15 km². At the same time, the North Siantar Police Station achieves the most significant area, followed by Pematang Siantar Police Station, South Siantar Police

Station, Siantar Martoba Police Station, and the Auxiliary Police Post, all at 0.19 km².

At a radius of 500 meters, the buffer area increases to 0.53 km² to 0.78 km², with the lowest value at the East Siantar Police Station (0.53 km²) and the highest at most police stations (0.78 km²). Furthermore, at a radius of 750 meters, coverage expands further, varying between 1.09 km² and 1.76 km². The East Siantar Police Station showed the lowest value at 1.09 km², while the other six police stations reached a value of 1.76 km². Meanwhile, in the buffer category exceeding 750 meters, there is a significant variation. The smallest buffer area is at the Siantar Marihat Police Station (38.3 km²), while the largest is at the North Siantar Police Station (63.2 km²).

Generally, buffer areas exceeding 750 meters encompass a broader service area, although this varies depending on the

location and geographic conditions of each police station. These findings indicate that the larger the buffer radius applied, the broader the police service coverage. However, variations between police posts within buffers of more than 750 meters indicate differences in spatial distribution, population density, and regional spatial planning conditions that influence the reach of security services. This data is essential as a basis for planning security strategies, optimizing the distribution of police posts, and analyzing potential crime risks in Pematang Siantar City.

To determine the crime risk level in Pematang Siantar City, a buffer analysis was conducted using ArcGIS software to classify the results. The buffer analysis categorized distances from police posts into three classes. For more information, refer to the table below.

Table 11. Scoring and Classification of incident points from police posts

Subdistrict	Buffer 250 M	Buffer 500 M	Buffer 750 M	Buffer >750 M	Number of TKP	Score	Classification
Siantar Marihat	0	0	0	7	7	28	Low
Siantar Marimbun	0	1	2	10	13	48	Low
Siantar Selatan	5	8	0	2	15	29	Low
Siantar Barat	13	23	14	27	77	209	High
Siantar Utara	7	13	8	45	73	237	High
Siantar Timur	0	0	2	18	20	78	Medium
Siantar Martoba	1	4	8	22	35	121	Medium
Siantar Sitalasari	0	0	0	62	62	248	High

(Source: Data Processing, 2025)

The data processing results reveal significant variation across regions. Siantar Marihat, Siantar Marimbun, and South Siantar districts recorded relatively low numbers of crime scenes, with 7, 13, and 15 crime scenes, respectively, with scores of 28, 48, and 29. This puts these three districts in the low category. Furthermore, East Siantar District, with 20 cases (a score of 78), and Siantar Martoba District, with 35 cases (a score of 121), are categorized as moderate, indicating a medium level of vulnerability compared to other districts.

Conversely, districts with high crime rates were identified in West Siantar, North Siantar, and Siantar Sitalasari. West Siantar District recorded 77 crime scenes with a score of 209, while North Siantar ranked second with 73 crime scenes and a score of 237. Siantar Sitalasari District exhibited a different phenomenon, with 62 cases all occurring within a buffer of more than 750 meters from the police post, resulting in the highest score of 248. These three districts are categorized as high-vulnerability areas.

Overall, Table 11 shows that crime vulnerability tends to be higher in districts

with a large number of crime scenes and incidents located relatively far from the police post. This suggests that accessibility and proximity to the police post significantly influence an area's vulnerability to crime.

c) Kernel Density Analysis

1. Curas

Kernel Density analysis indicates that crime hotspots in Curas, Pematang Siantar City, in 2025 are concentrated in the city center, particularly in West Siantar, North Siantar, and a portion of East Siantar. Surrounding areas form yellow vulnerable zones, while other districts remain mostly green, indicating low vulnerability.

Table 12. Area of Crime Area of Curas in Pematang Siantar City

No	Vulnerability Class	Luas (Km ²)
1	Not Vulnerable	76,75
2	Vulnerable	2,03
3	Very Vulnerable	1,19
	Total	79,97

(Source: Data Processing, 2025)

Based on Table 12, it can be seen that areas in Pematang Siantar City are classified into three levels of vulnerability to violent theft (curas). Of the total area of 79.97 km², the majority of the area is categorized as non-vulnerable, with an area of 76.75 km². Meanwhile, areas classified as vulnerable cover an area of 2.03 km², and the area with

the highest level of vulnerability, namely very vulnerable, covers an area of 1.19 km². This distribution indicates that most areas of Pematang Siantar City are relatively safe from violent theft. However, there are still certain areas that require special attention in efforts to improve security and public order.

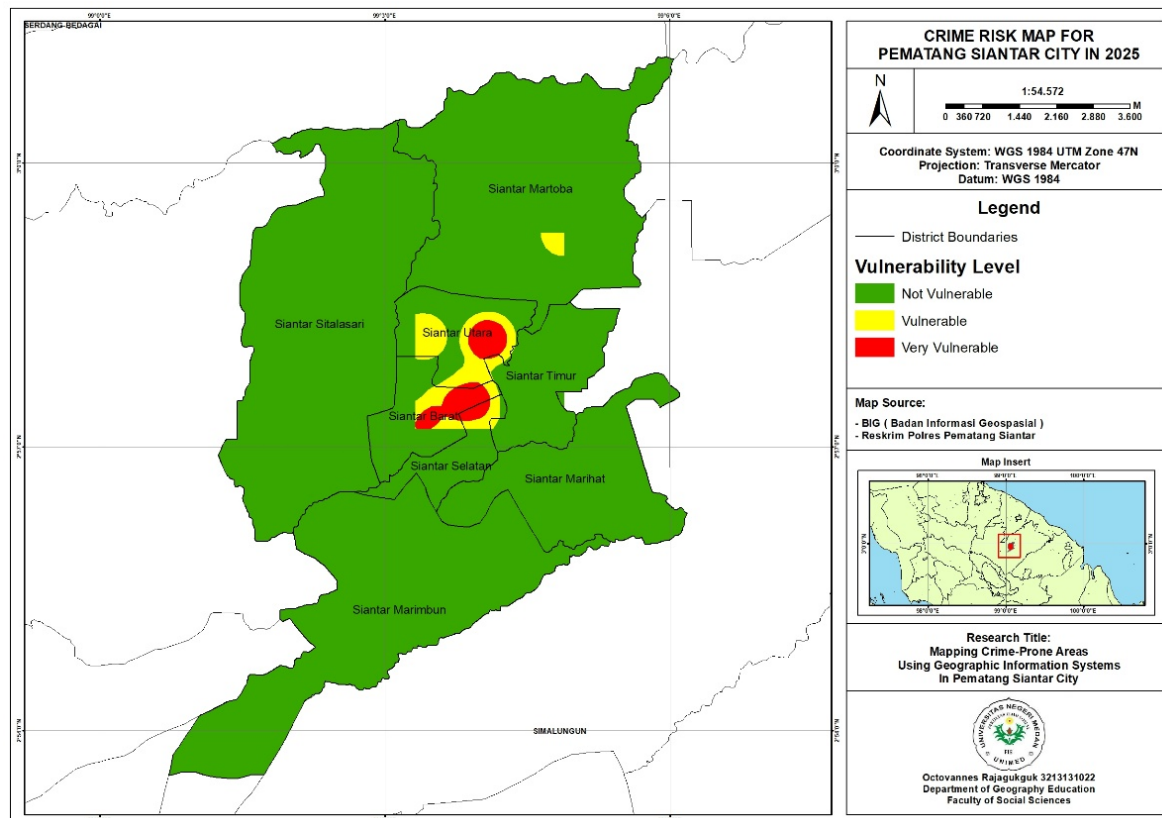


Figure 6. Map of Crime Prone to Robbery in Pematang Siantar City 2025

2. Curat

The results of the Kernel Density analysis of areas prone to theft in Pematang Siantar City in 2025 indicate that regions with the highest level of vulnerability (red) are concentrated in the West Siantar District and a small area of Siantar Sitalasari and North Siantar Districts. Areas with a high risk category (yellow) are spread around the

red zone, including parts of East Siantar, South Siantar, and West Siantar Districts. Meanwhile, most other areas, such as Siantar Martoba, Siantar Marimbun, and most of South Siantar, are dominated by the color green, indicating a low level of vulnerability or no vulnerability. For more details, see the table and image below.

Table 13. Area of Crime Area of Theft in Pematang Siantar City

No	Vulnerability Class	Large (Km ²)
1	Not Vulnerable	78,21
2	Vulnerable	1,40
3	Very Vulnerable	0,36
	Total	79,97

(Source: Data Processing, 2025)

Based on Table 13, it is evident that the non-vulnerable category dominates, covering an area of 78.21 km², while the vulnerable category covers an area of 1.40 km², and the very vulnerable category covers only 0.36 km². The total area analyzed

is 79.97 km². It can be concluded that most areas of Pematang Siantar City are considered safe from theft crimes. In contrast, areas classified as vulnerable and very vulnerable only cover a small portion of the total area.

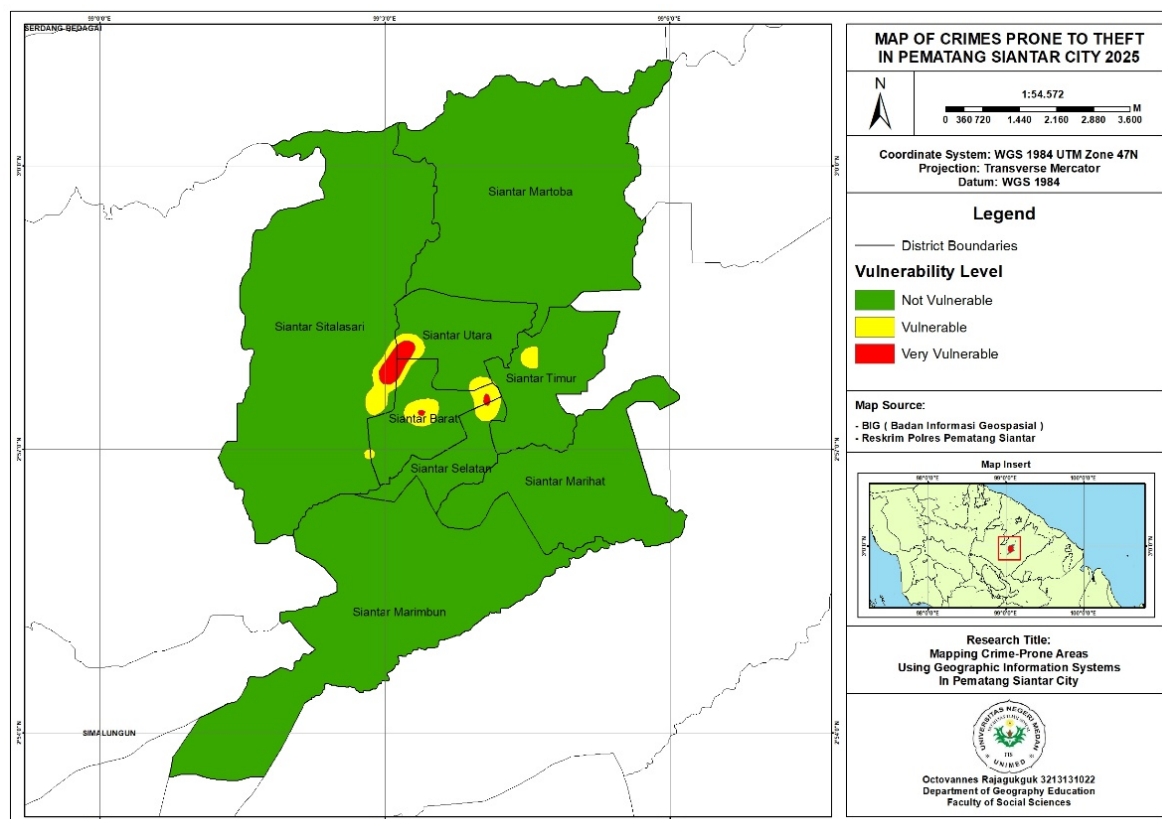


Figure 7. Map of Crime Prone to Theft in Pematang Siantar City 2025

(Source: Data Processing, 2025)

3. Curanmor

The results of the Kernel Density analysis of areas prone to theft in Pematang Siantar City in 2025 show that areas classified as highly vulnerable to motorcycle theft are concentrated in the districts of West Siantar, North Siantar, and parts of East Siantar. Areas with a moderate level of vulnerability (yellow) are widespread in

several districts, including Siantar Martoba, Siantar Sitalasari, South Siantar, and Siantar Marimbun. Meanwhile, most other areas, especially in the western and southern parts of the city, are dominated by green, indicating that these areas are less prone to motor vehicle theft. For more details, see the table and figure below.

Table 14. Area of Motorcycle Theft Crime in Pematang Siantar City

No	Vulnerability Class	Large(Km ²)
1	Not Vulnerable	66,42
2	Vulnerable	10,65
3	Very Vulnerable	2,90
Total		79,97

(Source: Data Processing, 2025)

Based on Table 14, it is evident that the majority of the total area of 79.97 km² is categorized as not vulnerable, with an area of 66.42 km². Furthermore, areas classified as vulnerable cover an area of 10.65 km², while

the very vulnerable category covers an area of 2.90 km². This distribution indicates that most areas of Pematang Siantar City have a low level of vulnerability to motorcycle theft.

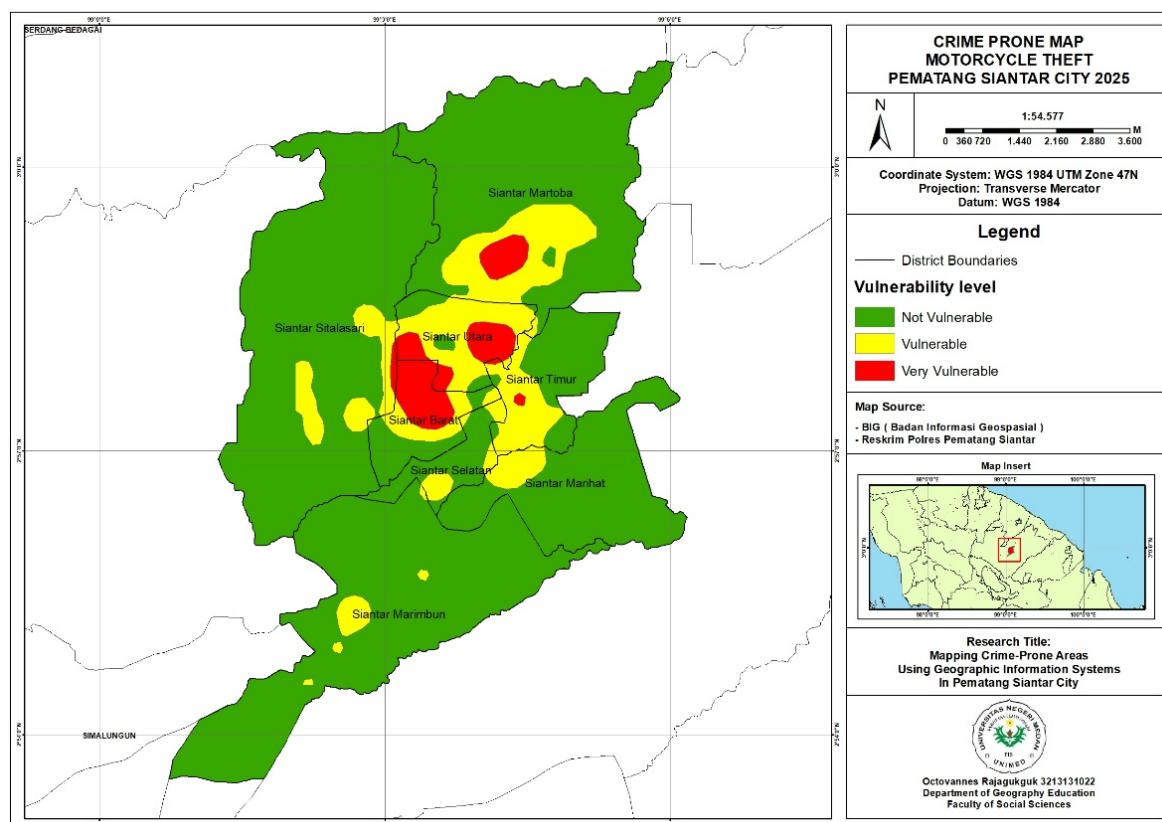


Figure 8. Map of Crime Prone to Motorcycle Theft in Pematang Siantar City 2025

(Source: Data Processing, 2025)

Mapping of crime-prone areas in Pematang Siantar City was conducted using Geographic Information Systems (GIS) technology. This map will depict the spatial distribution of crime vulnerability levels, divided into three categories: not vulnerable,

vulnerable, and very vulnerable. These categories are visually displayed through different color gradients: green for non-vulnerable areas, yellow for vulnerable areas, and red for highly vulnerable areas. For more details, see the image below.

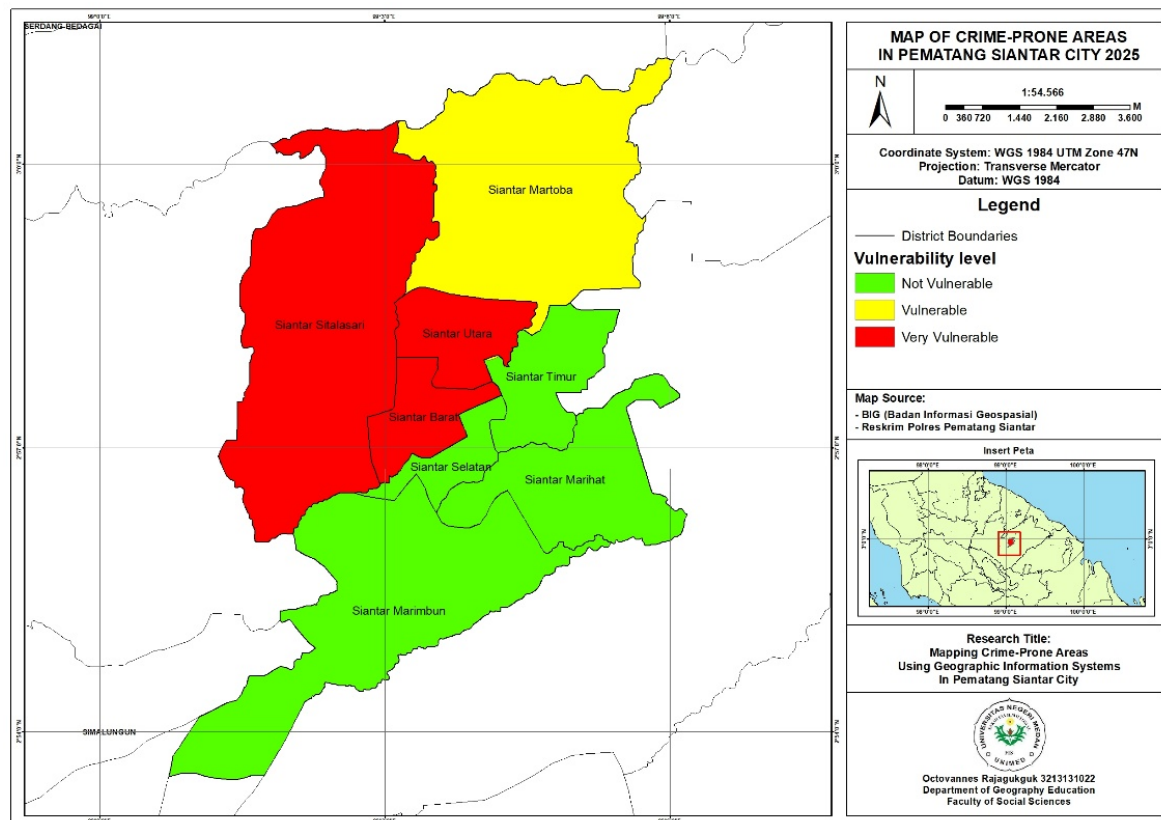


Figure 9. Map of Crime-Prone Areas in Pematang Siantar City 2025
 (Source: Data Processing, 2025)

Spatially, areas categorized as highly vulnerable include the districts of Siantar Sitalasari, West Siantar, and North Siantar. These three districts are part of the core urban area, characterized by high population density, commercial activity, and relatively high community mobility. These conditions make these areas more vulnerable to crime, particularly conventional crimes such as theft, robbery, and other crimes related to crowds.

Meanwhile, the vulnerable category includes the Siantar Martoba District. This area exhibits a significant crime rate, but not as dense as the highly vulnerable areas. Factors influencing vulnerability in this area include the presence of densely populated

residential areas and proximity to the city center. However, the intensity of economic activity is not as high as in the highly vulnerable districts. The non-vulnerable category includes the districts of South Siantar, Siantar Marihat, East Siantar, and Siantar Marimbun. These areas are typically situated on the outskirts of the city, characterized by lower population densities and relatively limited economic activity. Geographical factors and the distribution of settlements, which are not as dense as the city center, are one of the reasons for the low crime rate in this area.

Thus, this crime vulnerability map serves not only as a data visualization tool but also has strategic value in the context of

development planning and security policy. The resulting information can inform police considerations when prioritizing patrol areas, placing security posts, and developing crime prevention strategies. Furthermore, local governments can use it as a reference in designing social programs and infrastructure that focus more on improving public safety.

4. The Effect of Population Density on Crime in Pematang Siantar City

Various factors, both internal and external, influence crime in a region. The results of a simple linear regression analysis between population density as the independent variable and crime rate as the dependent variable, using SPSS version 31 software.

Table 15. Population Density and Crime Rate

Subdistrict	Population density/Km ²	Crime Rates
Siantar Marihat	2.743,81	7
Siantar Marimbun	1.204,26	13
Siantar Selatan	8.706,93	15
Siantar Barat	11.934,17	77
Siantar Utara	13.780,82	73
Siantar Timur	8.194,91	20
Siantar Martoba	2.924,48	35
Siantar Sitalasari	1.574,92	62

(Source: Pematang Siantar City Statistics Agency 2024 and Pematang Siantar City Criminal Investigation Unit)

The distribution of criminal acts in Pematang Siantar City in 2025 shows variations in crime cases across subdistricts. According to the theory of crime geography [Hartanto et al. \(2024\)](#), crime patterns tend to emerge in areas with different socioeconomic and environmental characteristics, which in turn influence varying levels of crime vulnerability across urban regions. Based on data obtained from the Reskrim Kota Pematang Siantar in 2025, the total number of crime cases reached 302 incidents, divided into three main categories: robbery with violence (curas), aggravated theft (curat), and motor vehicle theft (curanmor).

The spatial distribution of these cases reveals that certain subdistricts have higher crime concentrations, namely Siantar Barat with 77 cases (25%), Siantar Utara with 73 cases (24%), and Siantar Sitalasari with 62 cases (21%). These findings align with the theory of geographic crime concentration, which posits that environmental factors, such as population density and area characteristics, influence crime distribution ([Weisburd, 2015](#)). The most dominant type of crime is aggravated theft (curat) with 191

cases, followed by motor vehicle theft (curanmor) with 103 cases, and robbery with violence (curas) with 8 cases.

Specifically, Siantar Sitalasari recorded the highest number of curat cases (54 cases), while Siantar Utara recorded the highest number of curanmor cases (29 cases). Both Siantar Barat and Siantar Utara each recorded three instances of curas. This variation indicates differing crime intensities across subdistricts, which can be further analyzed within the framework of environmental criminology theory by [Taylor et al. \(1984\)](#) emphasizing the importance of social and ecological factors in shaping crime patterns. Consequently, this mapping provides a spatial overview of crime vulnerability in Pematang Siantar City, highlighting the need for targeted strategies that focus on high-crime areas, such as Siantar Barat and Siantar Utara, to prevent and mitigate criminal activity effectively.

The mapping of crime-prone areas in Pematang Siantar City in 2025 was conducted using a Geographic Information System (GIS) through the overlay of population density, buffers of public activity centers, buffers of police posts, and kernel

density analysis. The identification of crime-prone areas was conducted by assigning scores to each parameter. Population density analysis was performed because demographic factors are closely related to the social, economic, and security dynamics of a region. Areas with high population density often exhibit higher crime rates; therefore, a population density analysis was necessary, consistent with the findings of Sabiq & Nurwati (2021).

The buffer method was applied to determine zones of influence based on a specific distance from strategic facilities. In contrast, the Kernel Density method was used to visualize the spatial pattern of crime distribution, revealing high-density areas or hotspots. In this study, Kernel Density analysis was implemented in the context of tactical crime analysis, as described by Manik (2022) an analytical approach aimed at identifying specific patterns of certain crime types and determining locations of concentrated incidents as a basis for crime prevention planning and police resource allocation. It is important to note that for crimes such as motor vehicle theft (curanmor), aggravated theft (curat), and robbery (curas), there is no established standard for determining the predictive radius of repeat incidents. Therefore, spatial analysis was conducted by considering flexible radius settings based on the characteristics of each crime.

Figure 8 presents a spatial representation of crime vulnerability levels in Pematang Siantar City in 2025, produced using GIS with population density, kernel

density and buffer analysis. Based on the mapping results, the spatial distribution of crime vulnerability levels across the city was revealed. Pematang Siantar covers an area of 79.971 km², divided into eight districts. Districts classified as highly vulnerable include Siantar Sitalasari, Siantar Barat, and Siantar Utara. These three districts are located in the city center, characterized by high population density, intense economic activity, and high community mobility. This finding aligns with Fatkhu & Kurnia (2016) what was stated, that criminal acts most frequently occur in central or downtown areas. Such conditions create greater opportunities for crime, designating these districts as areas with the highest level of vulnerability.

Meanwhile, Siantar Martoba and Siantar Timur fall into the vulnerable category. These districts represent transitional zones between the city center and suburban areas, characterized by moderate levels of social and economic activity. Although their crime rates are not as high as those of the city center, dense residential settlements and well-connected transportation networks give these areas significant crime potential. On the other hand, districts categorized as low vulnerability include Siantar Selatan, Siantar Timur, Siantar Marihat, and Siantar Marimbun. Their locations on the city's outskirts, combined with low population densities and limited economic activity, contribute to relatively low crime levels compared to other districts.

Table 16. Input of Variable Values in Simple Regression Analysis

Variables Entered/Removed ^a			
Model	Variables Entered	Variables Removed	Method
1	Variabel Bebas ^b	.	Enter

a. Dependent Variable: Variabel Terikat

b. All requested variables entered.

(Source: Data Processing, 2025)

Table 17. Statistical t test on Simple Linear Regression

Coefficients ^a					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1	(Constant)	17.898	15.863	1.128	.302
	Variabel Bebas	.003	.002	.533	.174

a. Dependent Variable: Variabel Terikat

(Source: Data Processing, 2025)

Table 17 presents a t-statistic test that simultaneously examines the relationship between the two variables.

Hypothesis:

Ho: Population density does affect crime rates.

Ha: Population density does not affect crime rates.

Decision Making

Based on the significance value, the coefficients table shows a significance value of 0.174, which is greater than 0.05. Therefore, it can be concluded that the independent variable (X) does not affect the dependent variable (Y).

Based on the t-value: The calculated t-value is 1.543 < the t-table value of 2.447, thus concluding that variable (X) does not affect variable (Y).

Therefore, based on the analysis above, it can be concluded that population density does not have a significant impact on crime rates.

High population density is often considered one of the main factors contributing to crime rates. Areas with high population density tend to have higher levels of crime due to factors such as education levels, unemployment rates, and poverty, as noted by [Pratita & Woyanti \(2024\)](#) various studies. In densely populated areas, people interact more frequently, which increases the likelihood of social conflict and stress. As a result, high-density areas often exhibit higher crime rates, particularly crimes related to interpersonal conflict, such as acts of violence between individuals.

However, the results of data analysis conducted using SPSS to examine the influence of population density on crime rates in Pematang Siantar City show a different outcome. Based on the analysis table, the constant value is 17.898 with a standard error of 15.863, a t-statistic of 1.128, and a significance (Sig.) value of 0.302. This indicates that the constant is not statistically significant (because the significance value is greater than 0.05). Meanwhile, the coefficient of the independent variable is 0.003 with a standard error of 0.002. The standardized Beta value is 0.533, the t-statistic is 1.543, and the significance (Sig.) value is 0.174. Since the significance value is also greater than 0.05, it can be concluded that the effect of the independent variable on the dependent variable is not statistically significant.

The t-test was used to determine the significance of the relationship between the two variables. The test results show a significance value of 0.174, which is greater than the 0.05 significance level, and a t-statistic of 1.543, which is lower than the t-table value of 2.447. These findings suggest that, statistically, there is no significant relationship between population density and the number of crime cases. Overall, although the direction of the relationship is positive (as indicated by the positive coefficient value), the independent variable does not have a significant effect on the dependent variable at the 5% significance level. Therefore, the alternative hypothesis (H_0) is rejected because the p-value is greater than 0.05. In contrast, the null hypothesis (H_0) is accepted, indicating that

population density does not make a significant contribution to the high crime rate in Pematang Siantar City.

CONCLUSION

This study reveals that in 2025, Pematang Siantar City reported 302 crime cases, distributed across eight sub-districts. The predominant type of theft case was 191, followed by motorcycle theft (103) and robbery (8). The city's average population density reached 3,436.72 people per square kilometer, with the most densely populated sub-districts being North Siantar, West Siantar, and South Siantar. At the same time, Siantar Marimbun had the lowest density. Crime rates tended to be higher in the city center, particularly in the sub-districts of Siantar Sitalasari, West Siantar, and North Siantar, while the outskirts were relatively safer.

The statistical analysis showed no significant relationship between population density and the number of crimes, as evidenced by the calculated t-value (1.543) < the t-table (2.447). Thus, it can be concluded that population density is not the main factor influencing crime in Pematang Siantar City, so that other factors, such as social and economic conditions and community activities, play a greater role in encouraging crime.

REFERENCE LIST

- Adisanjaya, N. N., & Nugraha, I. G. N. M. (2019). Pemetaan Daerah Rawan Kriminalitas Menggunakan Sistem Informasi Geografis (SIG) Sebagai Upaya Pengendalian Keamanan Dan Ketertiban Masyarakat (Kamtibmas) Di Wilayah Gianyar Bali. *Jurnal Teknologi Informasi Dan Komputer*, 5(3), 277-284.
- Aji, D.K., & Oktavia, C. A. (2023). Sistem Informasi Geografis Pemetaan Analisis Daerah Rawan Kriminalitas Menggunakan Metode Jenks Natural Breaks Berbasis Web Kota Malang. *Elang: Journal of Interdisciplinary Research*, 3, 13-23.
- Ardiansyah, Y., & H. (2021). Sistem Informasi Geografis Kriminalitas di Kabupaten Cilacap. *Sainteks*, 17(2), 125.
<https://doi.org/10.30595/sainteks.v17i2.9160>
- Arkan, M. H., Levianita, M. S., Kadafi, A., Lopian, N. P., Azzahra, U., Putra, Z. A. S., Nathanael, K. H., Hakim, M. A., & Karaniya, A. S. (2024). Penurunan Pendapatan Pedagang Pasar Pondok Labu, Dampak Munculnya Marketplace. *Jurnal Ilmiah Wahana Pendidikan*, 10(12), 531-547.
<https://doi.org/10.5281/zenodo.12541384>
- Bahkti, Y., & Hutabalian, R. (2021). Pembegalan Ditinjau Dari Perspektif Kriminologis Di Wilayah Hukum Polres Jayapura. *Oxford University Press*, 649.
- Dwirohayati, D., & Sudibyo, N. H. (2020). Sistem Informasi Pemetaan Wilayah Rawan Kriminalitas Polresta Bandar Lampung Menggunakan K-Means Clustering. *Jurnal Teknika*, 14(2), 127-135.
- Fadhil, M. (2020). Analisis Tingkat Kriminalitas Di Kota Makassar Dengan Pendekatan Ekonomi. *Malaysian Palm Oil Council (MPOC)*, 21(1), 1-9.
- Fatkhu, N. M., & Kurnia, S. D. (2016). Pemetaan Daerah Persebaran Kriminalitas Curas Dan Curanmor Di Kota Probolinggo Tahun 2016 Dengan Menggunakan Sistem Informasi Geografis (Sig). *Institut Teknologi Nasional Malang*.
- Harries, K. D. (1999). *Mapping Crime: Principle and Practice* (Washington). National Institute of Justice, Office of Justice Programs, U.S. Department of Justice, Crime Mapping Research Center.
- Hartanto, D., Hamid, S., & Lubis, R. (2024). Sinergitas Lembaga Kepolisian Dalam Pencegahan Kejahatan oleh Satuan Fungsi Kepolisian Melalui Pemolisian Masyarakat Guna Memantapkan

- Pemeliharaan Keamanan Dan Ketertiban Masyarakat. *Jurnal Administrasi Publik Universitas Medan Area*, 13(1), 30–44.
- Manik, S. N. (2022). Pemetaan Daerah Rawan Kriminalitas Menggunakan Sistem Informasi Geografis (SIG) Di Kota Medan. *Universitas Sumatera Utara*.
- Pratita, K. D., & Woyanti, N. (2024). Analisis Pengaruh Pendidikan, Pengangguran, Kemiskinan, Ketimpangan Pendapatan, dan Kepadatan Penduduk Terhadap Kriminalitas Di Provinsi Jawa Timur (Tahun 2018-2022). *JEPP: Jurnal Ekonomi Pembangunan Dan Pariwisata*, 4(2), 62–70.
<https://doi.org/10.52300/jepp.v4i2.16551>
- Sabiq, R. M., & Nurwati, N. (2021). Pengaruh Kepadatan Penduduk Terhadap Tindakan Kriminal. *Jurnal Kolaborasi Resolusi Konflik*, 3(2), 161–167.
<https://doi.org/10.24198/jkrk.v3i2.35149>
- Saputra, D. C. (2024). Sistem Informasi Geografis Tindak Kriminal Di Jawa Tengah Tahun 2019 – 2021. *Jurnal Informatika Upgris*, 10(1), 47–55.
<https://doi.org/10.26877/jiu.v10i1.18133>
- Siantar, R. K. P. (2025). Jumlah Kasus Kriminal di Kota Pematang Siantar Tahun 2025.
- Sidabutar, H. S., & Sugiarto, A. (2025). Study of Urban Riverbank Area Development (Case Study: Bah Bolon River, Pematang Siantar City). *International Conference Of ...*, 2(1), 222–236.
<https://proceeding.pancabudi.ac.id/index.php/ICDSET/article/view/335%0Ahttps://proceeding.pancabudi.ac.id/index.php/ICDSET/article/download/335/286>
- Taylor, R. B., Gottfredson, S. D., & Brower, S. (1984). Block Crime and Fear: Defensible Space, Local Social Ties, and Territorial Functioning. *Journal of Research in Crime and Delinquency*, 21(4), 303–331.
<https://doi.org/10.1177/0022427884021004003>
- Watrianthos, R., Suryadi, S., Kusmanto, & Samsir, S. (2023). Pemetaan Tingkat Kriminalitas di Indonesia: Analisis Spasial dengan Pendekatan SIG pada Tingkat Provinsi. *Bulletin of Information Technology (BIT)*, 4(3), 353–360.
<https://doi.org/10.47065/bit.v4i3.861>
- Weisburd, D. (2015). The law of crime concentration and the criminology of place. *Criminology*, 53(2), 133–157.
<https://doi.org/10.1111/1745-9125.12070>
- Wibisono, A. (2009). Aplikasi Sistem Informasi Geografis untuk Pemetaan Daerah Rawan Kriminalitas di Polresta (Kepolisian Resort) Kota Surabaya Timur. *Institut Teknologi Surabaya*.
- Yenny, N. F., & Anwar, K. (2021). Pengaruh Jumlah Penduduk Terhadap Pertumbuhan Ekonomi Di Kota Lhokseumawe. *Jurnal Ekonomika Indonesia*, 1(3), 218–228.
<https://ejournal.unesa.ac.id/index.php/independent>
- Yunianto, D. (2021). Analisis Pertumbuhan dan Kepadatan Penduduk Terhadap Pertumbuhan Ekonomi. *Forum Ekonomi*, 23(4), 687–698.
<http://journal.feb.unmul.ac.id/index.php/FORUMEKONOMI>