Assessing Crime Vulnerability Levels in Balikpapan City

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Abstract

Crime significantly affects public safety and quality of life, particularly in Balikpapan City, the largest urban center in East Kalimantan, Indonesia. Despite its role as a key contributor to regional economic growth, the city faces increasing security challenges, including high rates of theft, assault, and drug-related offenses. These issues are driven by social, economic, and environmental factors, such as inequality, unemployment, and low legal awareness. The city's rapid development, if not accompanied by proper urban safety planning, may exacerbate crime risks. This study aims to assess the spatial distribution of crime vulnerability levels in Balikpapan City to support more effective prevention and policy strategies. A spatial analysis using Kernel Density Estimation was applied to identify crime-prone areas based on georeferenced crime incident data from 2022 to 2023. This method calculates the concentration of events across space to reveal patterns of crime intensity. The resulting maps classify the city into five levels of vulnerability, from very low to very high. Findings show that very high vulnerability areas are concentrated in Balikpapan City, Central Balikpapan, and South Balikpapan Districts. Surrounding areas exhibit high to moderate vulnerability, while Balikpapan Barat and parts of Balikpapan Utara show low to very low vulnerability. The results provide a spatial foundation for targeted crime prevention efforts and more efficient allocation of law enforcement resources.

1. Introduction

Crime is a persistent social issue that remains a primary concern in many regions due to its wide-ranging impacts on security, social stability, and the quality of life of communities [14]. Criminal acts such as theft, robbery, assault, and drug-related offenses have the potential to disrupt social order and diminish the public's sense of security. The term "crime," derived from *crimen*, refers to actions that deviate from prevailing social norms and may harm individuals or groups within a society [15]. In this context, crime does not merely reflect negative behavior but also indicates social pressures that contribute to insecurity. Rising crime rates can erode public trust in the existing social and legal systems. Assessing the levels of crime vulnerability in a region is therefore essential to implementing appropriate policies aimed at reducing crime, enhancing public awareness, and fostering a safe environment [4]

Balikpapan City, the largest city and a key economic growth center in East Kalimantan Province, has experienced a significant population increase. Based on the Balikpapan City Civil Registration Service in 2022, the city's total population reached 704,110. reflecting a surge compared to previous years. The rapid development of industries and infrastructure in Balikpapan has posed considerable challenges in creating a safe and comfortable environment for its residents. Although Balikpapan makes significant contributions to the oil, gas, and trade sectors in East Kalimantan, the city also faces serious security issues. According to data from the East Kalimantan Regional Police (2022), Balikpapan ranks as the second-highest region for reported crimes, following Samarinda. The increasing crime rate over recent years highlights gaps in maintaining urban security and order.

In 2019, 1,111 criminal cases were reported in Balikpapan City, with assault, theft, and drug-related offenses being the most prevalent. Reports from the Balikpapan Police Department indicate that 314 criminal incidents were recorded in 2022, encompassing various types of offenses. According to data from the East Kalimantan Regional Police (2022), Balikpapan Tengah District reported the highest number of cases, with 13 incidents in 2022, which increased to 14 by June 2023. This high crime rate negatively impacts residents' sense of security and has the potential to tarnish Balikpapan's reputation as a desirable place to live and conduct business [5].

The high level of crime vulnerability is influenced by various social, economic, and environmental factors [13]. One major factor is the social and economic inequality resulting from uneven economic growth. Poverty, unemployment, low levels of education, and limited public awareness of legal matters significantly contribute to creating conditions susceptible to crime. Another factor affecting crime vulnerability is the lack of adequate monitoring and security in areas prone to criminal activities. The rapid development of transportation infrastructure, such as highways and insufficient parking facilities, also increases opportunities for criminal acts. Under these conditions, a deeper assessment of crime vulnerability levels in Balikpapan City is crucial [6].

Therefore, assessing crime vulnerability in Balikpapan City is essential for formulating more effective strategies for crime prevention and mitigation. Crime mapping is a tool that can be used to evaluate crime vulnerability in a region. This mapping provides a clearer picture of crime-prone locations and the patterns of crime distribution, enabling authorities to allocate resources more efficiently in efforts to prevent crime.

2. Method

The method used to assess crime vulnerability levels in Balikpapan City is a quantitative approach with a spatial focus. Quantitative analysis was conducted using the Kernel Density method, facilitated by the ArcGIS software. Kernel Density is a statistical tool employed to estimate spatial density [1]. This method can be applied through ArcGIS, typically to identify distribution patterns and density within a specific area. The spatial data used in the analysis serves to determine the density of objects by inputting vector data to produce raster data. The vector data utilized consists of point features. Density measurements often have specific criteria, ranging from sparse, occasional, frequent, to very frequent. In spatial analysis, Kernel Density is widely used to analyze distribution patterns, including crime vulnerability [16].

Data collection was conducted through institutional surveys. An institutional survey involves gathering data by visiting agencies that hold the required data for the research. The target agency was the Balikpapan City Police Department, and the data collected included crime incident locations for the years 2022–2023. Crime vulnerability was assessed using Kernel Density analysis, with the input data comprising the crime incident points provided by the Balikpapan City Police Department. The crime distribution data collected is presented in Table 1.

Table 1. Crime Distribution

District	Number of Crimes
North Balikpapan	66
West Balikpapan	29
East Balikpapan	17
Central Balikpapan	81
South Balikpapan	106
Balikpapan City	168

During the 2022–2023 period, Balikpapan City District recorded the highest number of crimes among all districts, with a total of 168 reported cases. In contrast, Balikpapan Timur District had the lowest crime rate, with only 17 cases recorded during the same period. For the Kernel Density analysis, five vulnerability levels were used to ensure detailed results. The crime incident points were processed using ArcGIS software to produce a crime distribution map for Balikpapan City. Subsequently, this data was analyzed with Kernel Density, generating a crime vulnerability map with five vulnerability levels.

In the period of 2022-2023, the District of Balikpapan Kota has the highest number of crimes in Balikpapan City with a total of 168 cases. While the District of East Balikpapan has the lowest number of crimes with 17 cases. In performing kernel density analysis, 5 classes of vulnerability level were used to obtain more detailed results. The analysis were started by processing crime location points using ArcGIS software which would produce a map of crime points distribution in Balikpapan City. The distribution of points was then analyzed using the kernel density method through the arc toolbox. The detailed analysis process is visualized in the following Figure 1.
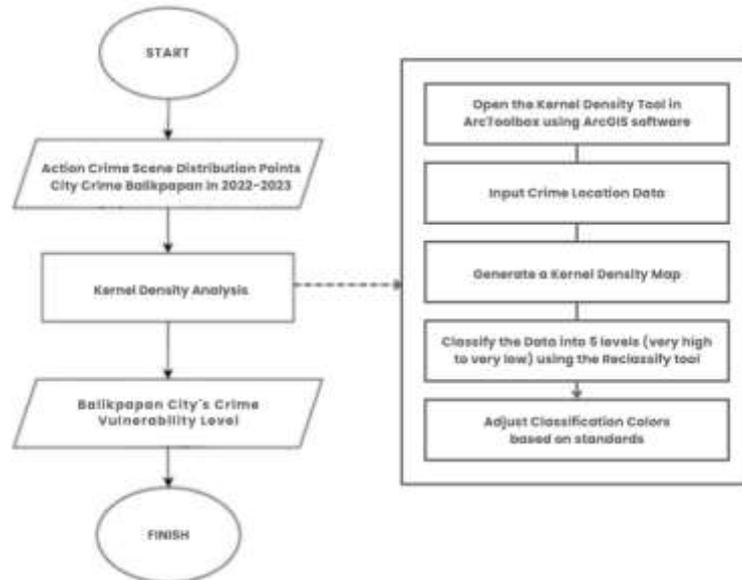

Figure 1. Analysis Framework for the Assessment of Criminality Vulnerability Level

3. Results and Discussion

The first step in conducting the analysis of crime vulnerability level assessment is to collect data on the distribution point of crime scene of Balikpapan City in 2022-2023 first as the basic material in processing kernel density analysis. Based on crime data obtained from the Balikpapan City Police Department for the years 2022–2023, a total of 467 cases were recorded. The distribution of crime locations shows that the highest concentration is in the central areas of Balikpapan City, while the outskirts tend to have fewer incidents. The types of crimes reported include vehicle theft, assault, theft, robbery, arson, forgery, bribery, adultery, rape, political crimes, abduction, murder, extortion, fraud, embezzlement, and vandalism.
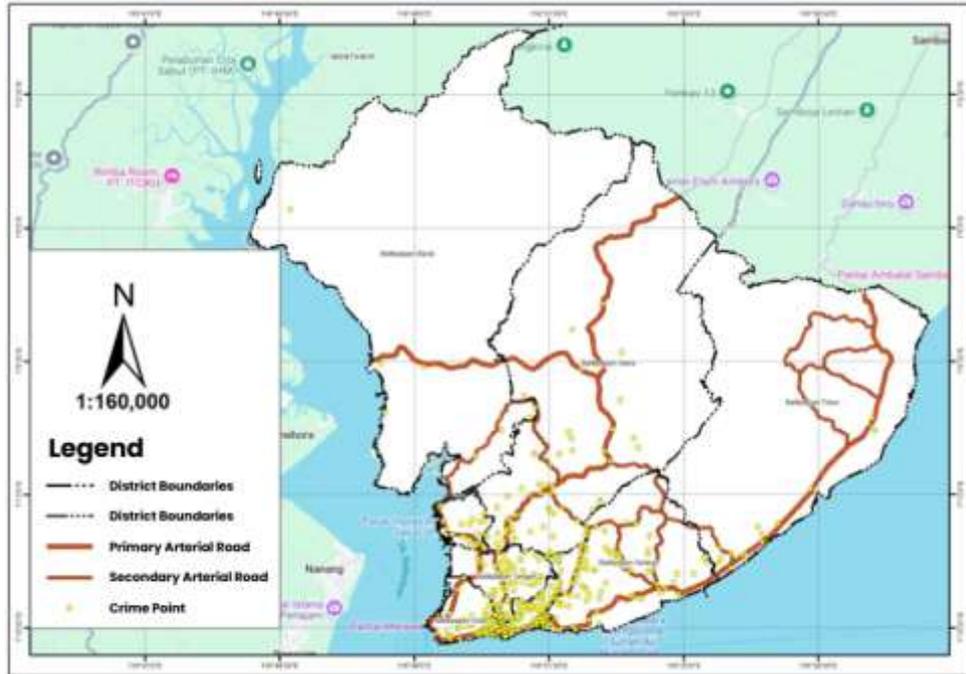
Figure 2. Distribution of Crime Locations

After obtaining the distribution point of crime scene of Balikpapan City in 2022-2023, the data is then processed using ArcGIS software with kernel density analysis tool. When the result of kernel density analysis has been processed by ArcGIS, it is then classified into five vulnerability classes: very low, low, medium, high, and very high [11]. The classification is visualized with a green to red color scheme to depict each level of vulnerability [12]. The assessment uses five levels of vulnerability: very low (dark green), low (light green), medium (yellow), high (orange), and very high (red). The crime vulnerability map of Balikpapan City for 2024 is presented in Figure 3.
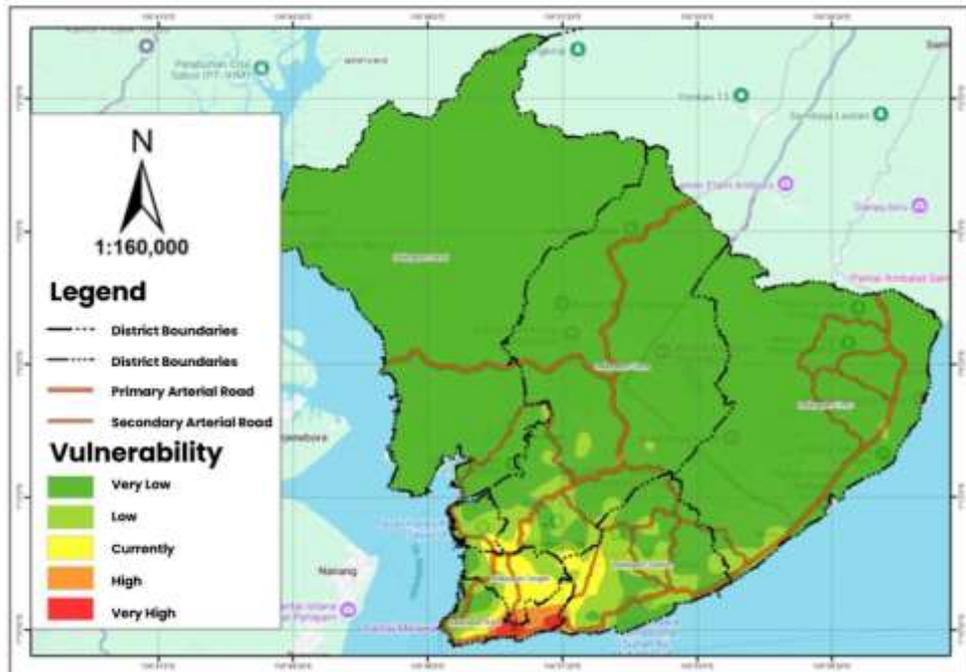

Figure 3. Crime Vulnerability Map of Balikpapan City

Based on Figure 3, the Kernel Density classification reveals that areas with very high vulnerability cover two zones in the central urban areas of Balikpapan, with a total area of 151.35 hectares. These zones are located in three districts: Balikpapan City, Central Balikpapan, and South Balikpapan, with a dominance in Balikpapan City. The high vulnerability level forms a single zone encircling the very high vulnerability areas, covering 312.77 hectares and distributed across the same three districts: Balikpapan City, Central Balikpapan, and South Balikpapan. The moderate vulnerability level spans 1,459.71 hectares and is spread across five districts: Balikpapan City, Central Balikpapan, South Balikpapan, West Balikpapan, and North Balikpapan. The low vulnerability level covers an area of 3,858.97 hectares and is found in all districts: Balikpapan City, Central Balikpapan, South Balikpapan, West Balikpapan, North Balikpapan, and East Balikpapan. Finally, the very low vulnerability level dominates with an area of 45,322.87 hectares, covering all districts. The very low vulnerability is most prevalent in West Balikpapan, where nearly the entire district is classified under this category.

Previous research on crime in Balikpapan City focused on identifying spatial distribution patterns and crime vulnerability levels before, during, and after the COVID-19 pandemic, using the Average Nearest Neighborhood (ANN) method and k-means clustering. The current study on crime in Balikpapan City reveals only minor differences compared to the research conducted during the pandemic. The earlier study categorized crime into three levels of vulnerability, while the current research uses five more detailed levels. As a result, the findings differ in terms of very high vulnerability in the current study compared to high vulnerability in the previous study. In the earlier research, high vulnerability areas were distributed across two districts: Balikpapan City and South Balikpapan. In contrast, the current study identifies very high vulnerability areas across three districts: Balikpapan City, Central Balikpapan, and South Balikpapan. This demonstrates that the inclusion of more comprehensive data—encompassing details about types of crimes, their locations, and times of occurrence—enhances the understanding of the dynamics of crime in Balikpapan City.

4. Conclusion

Based on the distribution data of crime incident locations in Balikpapan City obtained from the Balikpapan City Police Department, it is evident that crime incidents are predominantly concentrated in urban areas. A total of 467 cases were recorded, including vehicle theft, assault, theft, robbery, arson, forgery, bribery, adultery, rape, political crimes, abduction, murder, extortion, embezzlement, fraud, and vandalism. Using Kernel Density analysis with five vulnerability levels—very high, high, moderate, low, and very low. Very high vulnerability zones (151.35 ha) are located in Balikpapan City District, Central Balikpapan District, and South Balikpapan District, with the highest concentration in Balikpapan City District. High vulnerability areas (312.77 ha) surround these zones in the same districts. Moderate vulnerability (1,459.71 ha) extends to five districts, adding West Balikpapan District and North Balikpapan District. Low vulnerability (3,858.97 ha) is spread across all districts, including East Balikpapan District. The very low vulnerability category dominates (45,322.87 ha), especially in West Balikpapan District, which is almost entirely in this classification. the results indicate that areas with very high crime vulnerability form two zones in the urban regions of Balikpapan with the first zone covering Balikpapan City District and Balikpapan Tengah District. While the second zone covers Balikpapan City District and Balikpapan Selatan District. The very high vulnerability classification covers relatively smaller areas compared to other vulnerability classifications, whereas the very low vulnerability classification encompasses the widest area, spanning up to five districts.

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