Analysis of the Movement Distribution Pattern of Violent Crime in Malaysia's Capital Region-Selangor, Kuala Lumpur, and Putrajaya

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Abstract
Previous studies of violent crime have been focused on identifying hot spots areas, ignoring crime movement and distribution, particularly violent-related land use on four different time frames. Studies showed that they have used police station boundaries or sectors to detect crime hotspots without considering land use type and the distribution and movement of crime. Understanding the relationship between violent crime and land use allows stakeholders to make informed decisions about land use, urban planning, and community development projects that can help reduce crime and improve overall community safety and quality of life. The aims of this study to investigate the relationship between violent crimes, time and land use in Selangor State, Kuala Lumpur Federal Territory (KLFT) and Putrajaya Federal Territory (PFT) from 2015 to 2020 using Mean Center and Standard Deviational Ellipses (SDE). These methodologies can assist authorities such as the Royal Malaysia Police (RMP) and Local Authority (LA) to identify potential variables leading to the high prevalence of violent crime in specific locations, which can then be used by police and local authorities to collaborate, establish crime prevention initiatives, and more effectively allocate resources. This study considers four-time frames, namely midnight (12:00-6:59 am), morning (7:00-11:59 am), evening (12:00-6:59 pm) and night (7:00-11:59 pm). The main concern in this article is that the SDE and Mean Center are still being investigated for use in studies of violent crime that are related to land use and spatial temporal. The overall Direction Mean Center and SDE at evening time, has the highest area of $128,146,621.17m^2$. All SDEs are within the boundaries of Kuala Lumpur Contingent Police Headquarters (KLCPH) and Selangor Contingent Police Headquarters (SCPH) has been justify in a shape of Figure and Table in this article. However, only District Police Headquarters (DPH) Putrajaya, namely the police station in Presint 11 and 7 are not included in the analysis. Overall, police and local authorities may find it useful to employ SDE and the Mean Center technique to investigate violent crime using land use and spatial-temporal data their efforts to reduce violent crime, enhance public safety, and implement preventative measures in high-crime areas.

Keywords: Land Use, Mean Center Technique, Spatial-Temporal, Standard Deviational Ellipses Technique (SDE), Violent Crime

1. Introduction

The majority of violent crimes studies are analyzed using only hotspots that are correlated with the boundaries, ignoring crime movement and distribution, particularly violent-related land use on four different time frames. Studies by [1][2][3] and [4] showed that they have used police station boundaries or sectors to detect crime hotspots without considering land use type and the distribution and movement of crime. If law enforcement, politicians, and urban planners are to establish effective plans to prevent and respond to violent crime, they must have access to this information.

Understanding the relationship between violent crime and land use allows stakeholders to make informed decisions about land use, urban planning, and community development projects that can help reduce crime and improve overall community safety and quality of life [5][6][7] and [8]. This allows for a more targeted approach to crime prevention and intervention efforts [9][10][11][12][13][14][15][16] and [17].

This study contributes uniquely by identifying causal links between crime rates and 13 different land uses, including (1) water bodies, (2) forests, (3) industry, (4) infrastructure & utilities, (5) institutions & community facilities, (6) open areas & recreational facilities, (7) residential & housing, (8) beaches, (9) mixed development, (10) transportation & roads, (11) trade & commerce, (12) agriculture, and (13) vacant land. This study also considers four hot spot time frames, namely midnight (12:59 a.m.), morning (7:59 a.m.), evening (12:59 p.m.), and night (7:59 p.m.), which are overlaid with land used to identify violent crime activity for each land use type. It will assist us in comprehending each time frame and land use with their distribution pattern. It helps policymakers and law enforcement better understand criminal behaviors. The index crime rates in Kuala Lumpur Federal Territory (KLFT) and Selangor were marginally higher than those in Singapore. In contrast, Singapore's index crime rate in 2016 was lower at 431.3 per 100,000 residents [18].

The aims of this study to investigate the relationship between violent crimes, time and land use in Selangor State, Kuala Lumpur Federal Territory (KLFT) and Putrajaya Federal Territory (PFT) from 2015 to 2020 using Mean Center and Standard Deviational Ellipses (SDE). To improve the efficacy of preventing violent crime, this study used the police station border as the unit of analysis. This enables the police to focus more effectively on crime prevention analysis in small regions rather than vast areas, which is made possible by the deployment of smaller units [19][20] and [21]. The issue of this study is the absence of comprehensive understanding indicates that, despite significant advancements in study that link between crime and the built environment, much still needs to be learned and investigated. Further research is necessary because of the complicated nature of this link, which is influenced by several variables, including the city context, the type of crime, and socioeconomic situations [20]. The rationale for selecting Selangor, KLFT & PFT as the study area lies in their dense population, significant economic roles, diverse cultural landscape, well-developed infrastructure and

urban planning, and the potential implications of research findings for policymaking. Research conducted in Selangor, KLFT & PFT holds substantial importance for informing policy formulation and execution at both regional and national administrative levels within Malaysia.

2. Literature Review

The literature review focused on the utilization of Standard Deviational Ellipses (SDE) Technique and the Mean Center technique in examining land use and spatial-temporal dynamics of patterns in violent crime movement as well as their impact on neighborhoods. Several studies have examined the correlation between violent crime and land use [22]. One study by Bowen et al.,[23] examined the distribution of violent crime by each business/land use type and used geocode violent occurrences to determine the prevalence of violent crime by property type. Another study by Reidy et al., [24] identified community-level risk and protective correlates of several forms of violent crime. A third study by Cheng et al., [25] looked at the relationships between specific human activities and the accompanying crime trends over time and place. Hotspot analysis was also employed in a few studies to pinpoint the dynamics of robbery and violent crime hotspots [26] and [27]. The impact of greening on police-reported crime and public perceptions of safety was also investigated in a study using a randomized controlled trial [28].

In another study, SDE was used to expose the various attributes of economic distribution accurately using spatial statistical analysis [29]. Another study used hotspot analysis, Mean Center, and standard deviation ellipse to examine the changing distribution of violent crime [30]. A fifth study used Mean Center and SDE to quantify the spatial distribution of geographic elements in terms of the center [31]. Several studies used hotspot analysis to identify the dynamics of robbery and violence hot spots [32] and [33]. A report provided by the Bureau of Justice Statistics explains the process of generating geographical databases for crime analysis and law enforcement and demonstrates how SDE can effectively highlight the most densely concentrated criminal incidents on a map [34]. In a thesis project, SDE was employed to construct an ellipse representing one standard deviation from the mean center, to help identify the geographic location of a serial murderer [33]. Overall, the literature review shows that SDE and Mean Center technique are useful tools in the study of violent crime with land use and spatial-temporal dynamics.

These techniques can help identify hotspots of violent crime, measuring the spatial distribution of geographic elements, and accurately reveal the multifaceted characteristics of economic distribution. Overall, gaining a comprehensive understanding of the application of SDE and Mean Center technique in the study of relationship between violent crime with land use and spatial-temporal dynamics of violent crime is important.

3. Research Design

3.1 Study Area

The study area is in the Malaysian neighbouring states of Selangor, Kuala Lumpur Federal Territory (KLFT) and Putrajaya Federal Territory (PFT) (Figure 2). Known for its substantial economic contribution to Malaysia, particularly in the industrial and service industries, the region surrounding KLFT and PFT is located in Selangor, which is the state with the largest population. Selangor has an area of 7,950.91 square kilometers, a population of 6,994,423 people, and a density of 880 inhabitants per square kilometer. One hundred thirteen men outnumber 100 women in Selangor [35]. The largest and most important airport in Malaysia is KLFT. KLFT has a total area of 243 km^2 and a population density of 8,157 persons per square kilometer. It has 1,982,112 residents. According to [36], there were 115 more men than women (115:100). The third federal territory to take the place of KLFT in 1999, PFT has a 49.3 square kilometer area, 109,202 inhabitants, and a population density of 2,215 per square kilometer and KLFT were chosen as the study areas because they had the highest average index crime rate per 100,000 people from 2010 to 2017. It was responsible for 42.4% of all index offenses during this time [37].

3.2 Data

This study uses secondary data and adopts a quantitative approach. The information collected pertains to the violent crime dataset in Selangor, KLFT, and PFT for the period from 2015 to 2020. The Methodology Flowchart (Figure 1) visually outlines the steps from initiating research to reaching conclusions. It guides to choosing methods, collecting data, analyzing findings, and sharing results, emphasizing the importance of methodological rigor in this scientific research and inquiry. The information was provided by the Criminal Investigation Department (D4), Bukit Aman's Intelligence/Operations/Records Division. This information on violent crimes includes the incident's location, date, and time. Using ArcGIS software especially ArcMap demonstrates the significance in this study for spatial analysis [38][39][40][41][42][43][44][45][46][47] and [48]. The data is spatially analyzed and aggregated at the police station boundary level (Figure 1). This analysis uses the station border in Selangor Contingent Headquarters (SCPH), which has 87 police stations, as opposed to Kuala Lumpur Contingent Headquarters (KLCPH), which has 24 police stations, due to the vast population in Selangor, KLFT, and PFT (Figure 2) [49]. In addition, this article takes into account 13 land use characteristics, including (1) water bodies, (2) forest, (3) industry, (4) infrastructure & utilities, (5) institutions & community facilities, (6) open areas & recreational facilities, (7) residential & housing, (8) beaches, (9) mixed development, (10) transport & roads, (11) trade & commerce, (12) agriculture, and (13) vacant land, as potential influences on the pattern of violent crime (Figure 3).
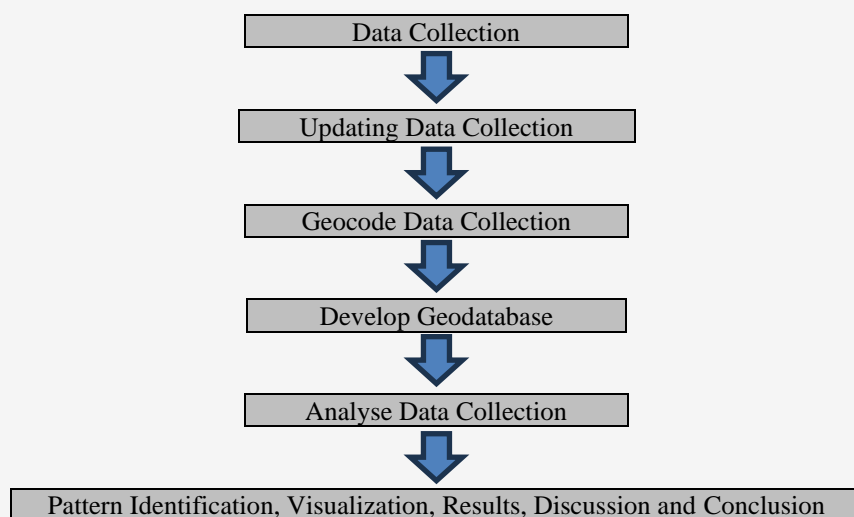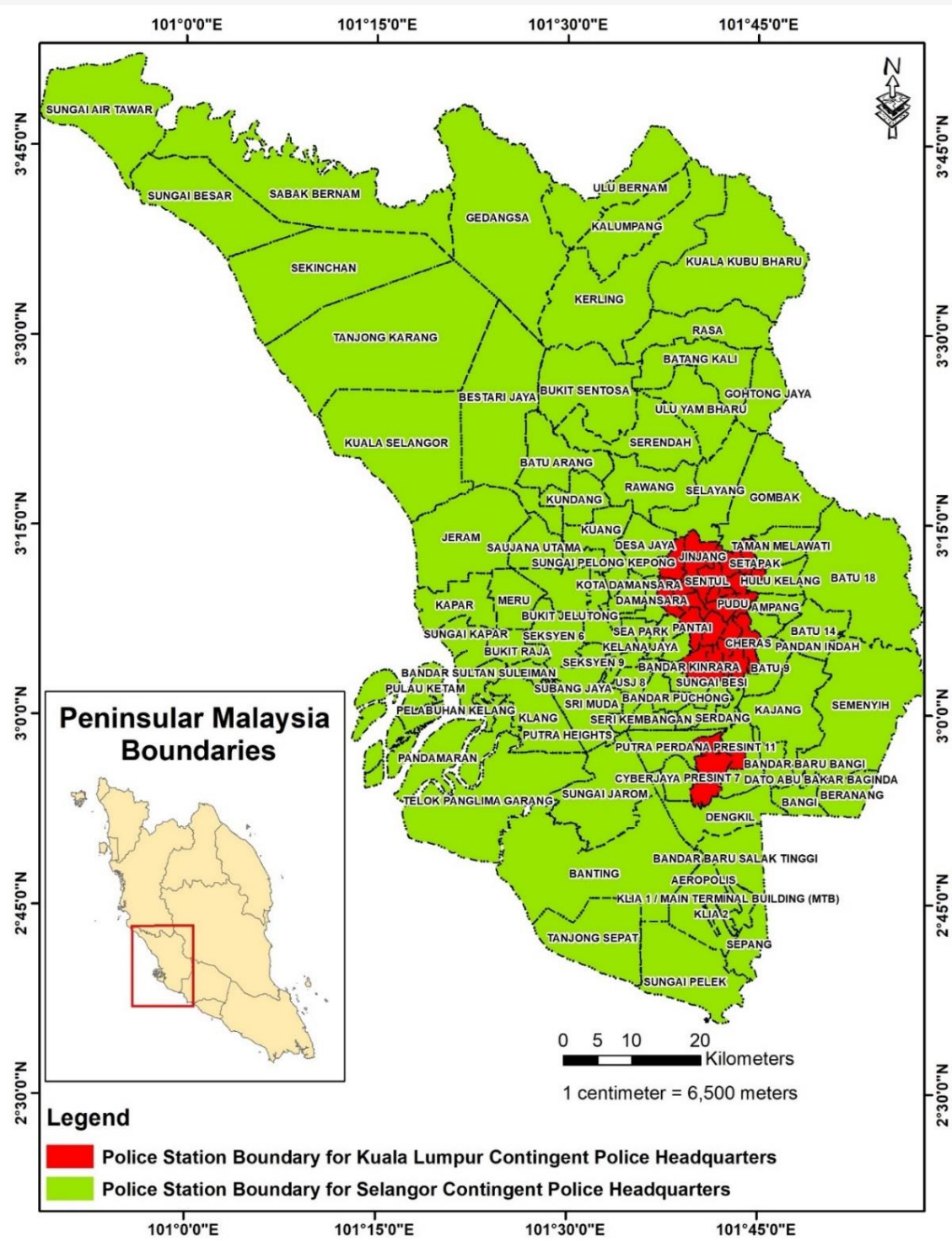

Figure 1: Methodology flowchart

Figure 2: Police stations boundary for Selangor and Kuala Lumpur contingent police headquarters [49]
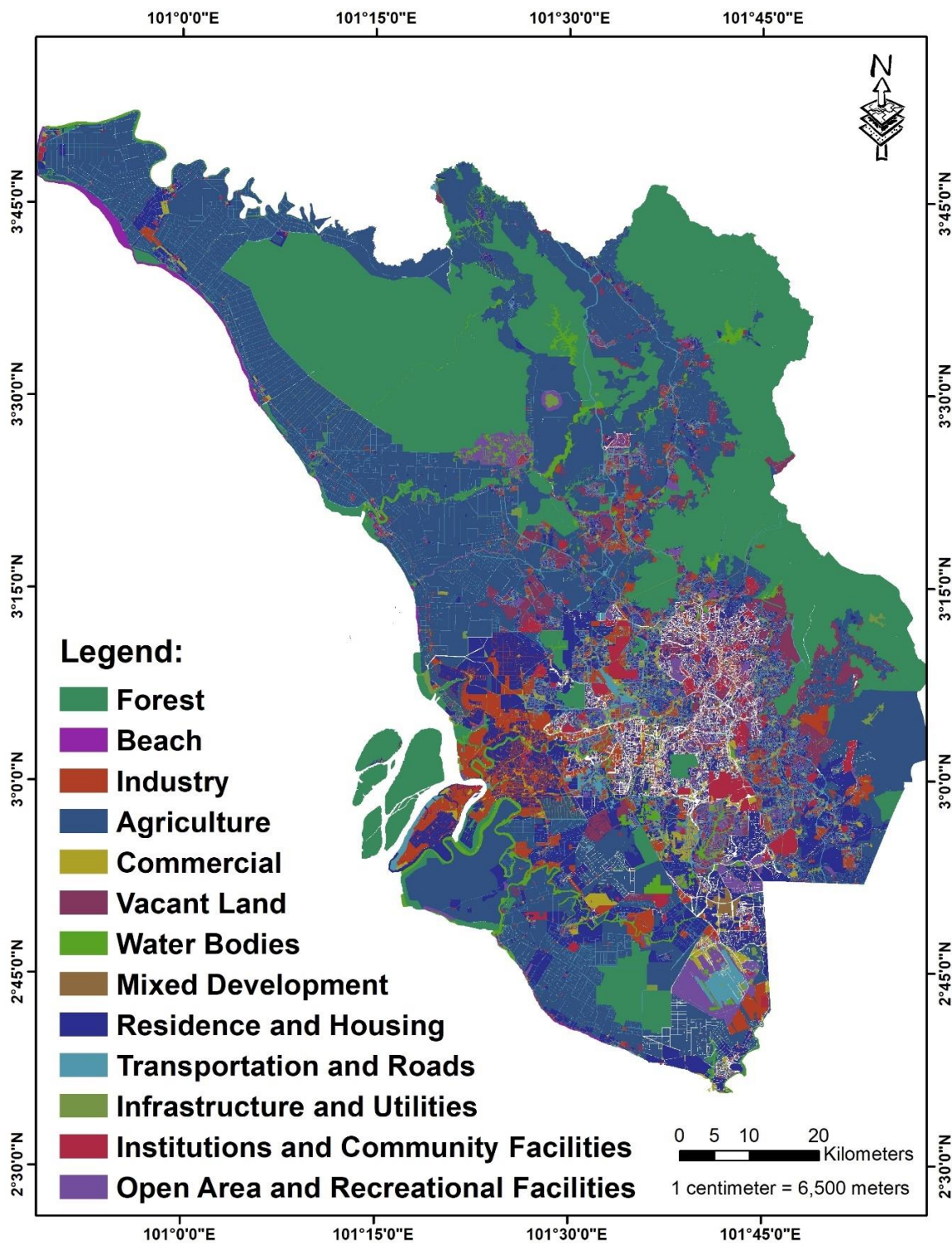
Figure 3: Land use 2018 for Selangor, Kuala Lumpur federal territory (KLFT) and Putrajaya federal territory (PFT) [50]

The 2018 land use for Selangor, KLFT, and PFT regions was gathered from the National Geospatial Centre (NGC)'s MyGDI program (Malaysia Geospatial Statistics Infrastructure) [50]. The geographical center (or pedestal center) for the crime feature set was determined using mean center analysis, and the central tendency, dispersion, and direction of flow of the geographical feature space were represented by standard deviation ellipses or ellipsoids. According to Figure 1, there are several stage in this research to be follow accordingly in order to complete this Violent Crime Analysis:

1) Data Collection:
- Obtain violent crime data from the Bukit Aman Police for the Selangor and Kuala Lumpur Contingent Police Headquarters in 2015-2020)

2) Updating Data Collection:
- Updating and identifying police station boundary data for Selangor and Kuala Lumpur Contingent Police Headquarters
- Updating information and identifying the location and address of crime
- Updating information and identifying the date of the investigation paper, the date the crime started and the date the crime ended.
- Updating information and identifying the time when the crime started and the time when the crime ended.

3) Geocode Data Collection:
- Geocoding manually
- Geocoding automatically using google sheet (geocode by awesome table and geocoding by smart monkey)

4) Develop Geodatabase:
- Developing a Crime Database (Geodata base).

5) Analyse Data Collection:
- Crime data analysis.
- The Standard Deviational Ellipses (SDE) method is used to illustrate the spatial distribution of crime within certain areas.
- Mean Center analysis, a GIS technique, examines the spatial distribution of crime incidents.

6) Pattern Identification, Visualization, Results and Discussion:
- Results and Discussion
- Conclusion

4. Spatial Analysis
4.1 Standard Deviational Ellipses (SDE)
The Standard Deviational Ellipses (SDE) method is used to illustrate the spatial distribution of crime within certain areas. It employs statistical analysis to determine the spatial variance in criminal activity and subsequently draws an ellipse to represent this variation. The size and shape of the ellipse can tell us about the locations where crime is more densely concentrated. One benefit of using SDE is that it helps us understand the spatial patterns of crime better. For example, if the ellipse is stretched in a certain direction, it means there's more crime happening in that direction. SDE can also be used to compare how crime is distributed in different regions or time periods. It can show us if there are changes in crime patterns over time. To do this, it uses the Mean Center, which is a point that represents the average location of all the crime incidents in an area. SDE calculates how far each crime incident is from this average point to figure out how offenders choose their target areas. The mathematical formula Standard Deviational (SD) for these measurements is in Equation 1 [51][52] and [53]. To understand how each crime changes over time in terms of day categories, it is imperative to know the geographic center, distribution, orientation, and direction to which each crime belongs. Therefore, a logical extension/extension of the standard distance circle that can capture the directional bias in the point distribution is the SDE [53] and [54]. To address three-dimensional data, an extended version of this formula can be applied. In order to create an ellipse or ellipsoid with the required percentage of data points, an adjustment factor scales the variance. The table below lists these correction factors [51].

4.2 Mean Center
Mean Center analysis, a GIS technique, examines the spatial distribution of crime incidents. It identifies a central point based on the average *x* and *y* coordinates of all features in the study area. This can help pinpoint areas with the highest concentration of crime incidents, aiding law enforcement and city planners in focusing their crime prevention efforts effectively. However, it's important to note that Mean Center assumes a uniform distribution of crime episodes, which may not always be the case, especially in densely populated areas. Therefore, it is recommended to use Mean Center analysis alongside other analytical methods and consider broader social, economic, and political factors that influence crime trends. Additionally, Mean Center is valuable for tracking changes in point distribution and comparing points with different characteristics [52] and [53].

5. Results and Discussion

The result of the mean center and standard deviation ellipse and land use is the point that represents the average location of all the features examined, based on their x and y coordinates. SDE measures the difference between the average distance of a feature to the mean center and the distance of a particular feature to the mean center. When applied to crime analysis, SDE can help to identify the direction in which the criminals aimed their crime. SDE is also useful for understanding the geographical center, distribution, orientation, and direction of each crime, especially when looking at how crime patterns change over time (Figures 4, 5 and 6). SDE is a way of capturing directional discrepancies in point distributions and extends the standard distance circle [52] and [53]. This means that the boundary of Setapak, Sentul and Jalan Tun Razak police stations is in the middle of the mean center, which is the focus of all violent crimes involving the boundary of Jinjang and Jalan Dang Wangi police stations, which has the highest hot spot percentage value at midnight (13.86 percent), morning (20.57 percent), evening (12.79 percent) and night (14.14 percent).

Based on Figure 4, the occurrence of mean center movement of violent crime 2015-2020 occurred at midnight and morning time involving land use residence and housing and transport and roads in Setapak Police Station Boundary, District Police Headquarters (DPH) Wangsa Maju, KLCPH. Evening time focused on land use, residential and housing involving Sentul Police Station Boundary, DPH Sentul, KLCPH. It moves towards land use type transport and roads, Jalan Tun Razak Police Station Boundary, DPH Wangsa Maju, KLCPH at night. Based on the SDE analysis at midnight time (Figures 4, 5 and 6), it shows the incidence of violent crime in Setapak Police Station Boundary which includes the northern part of the stations namely Selayang, Gombak, the eastern part (Wangsa Maju, Taman Melawati, Jalan Tun Razak and Hulu Kelang), the south (Chow Kit, Jalan Dang Wangi, Tun H. S. Lee, Pudu, Cheras, Ampang) and the West (Sentul, Jinjang, Kepong, Sri Hartamas and Pandan Indah). It involved 17 police stations, including the Setapak police station boundary (Figures 3 and 4). In the morning, it covered 14 stations including the Setapak police station boundary, surrounded by police station boundaries in the north (Gombak and Selayang), east (Wangsa Maju and Taman Melawati), south (Ampang, Jalan Tun Razak, Hulu Kelang, Pudu, Chow Kit, Jalan Dang Wangi) and west (Jinjang, Sentul and Kepong) (Figure 3).

In the evening, 19 police stations including Sentul Police Station boundary surrounded by police stations in the north (Jinjang, Selayang and Gombak), east (Setapak, Wangsa Maju, Jalan Tun Razak and Hulu Kelang), south (Chow Kit, Jalan Dang Wangi, Tun H. S. Lee, Pudu, Ampang, Pandan Indah and Cheras) and west (Kepong, Sri Hartamas, Desa Jaya and Travers). During the nighttime, 14 police stations were involved, including the Jalan Tun Razak police station boundary surrounded by police stations in the north (Setapak, Gombak and Wangsa Maju), east (Hulu Kelang), south (Ampang, Pandan Indah, Jalan Dang Wangi, Tun H. S. Lee, Cheras and Pudu) and west (Chow Kit, Sentul and Jinjang). As the daily activities of the victims change, the hotspot of violent crime is to change, as shown in Figures 4, 5 and 6, which move according to all four time periods without considering the weekday and weekend factors.

This movement of the middle center can also be attributed to advanced and growing economic development in the urban area, which has enticed rural inhabitants to migrate urban areas in search of improved income opportunities [55] and [56]. As a consequence, urban areas such as Selangor State and KLFT have evolved into both economic and criminal focal points. It becomes congested, which has a high probability of violent crime being committed. Figures 3, 4, 5 and Table 1, which show the overall Direction Mean Center and SDE at evening time, has the highest area of $128,146,621.17m^2$. All SDEs are within the boundaries of KLCPH and SCPH. The only exception in the analysis is DPH Putrajaya, specifically, the police station in Presint 11 and 7, which are not considered.

The different locations demonstrate that, depending on the distribution of violent crime points, it happens with varying values of SDE rounds. The analysis results show that the SDE for each of the four study periods is spherical [55]. In terms of the direction of the main axis of the SDE, the distribution of violent crimes is divided to the north and east with the values of the circular distance at midnight (134.282794°), morning (119.332966°), evening (128.516342°) and night (132.515833°) (Table 1). The SDE shows a change when it is more skewed and a large change occurs at midnight (134.282794°) as shown in Figures 3, 4, 5 and Table 1. This shows that there are land use factors, Residence & Housing and Transport & Roads, as shown in Figure 6.
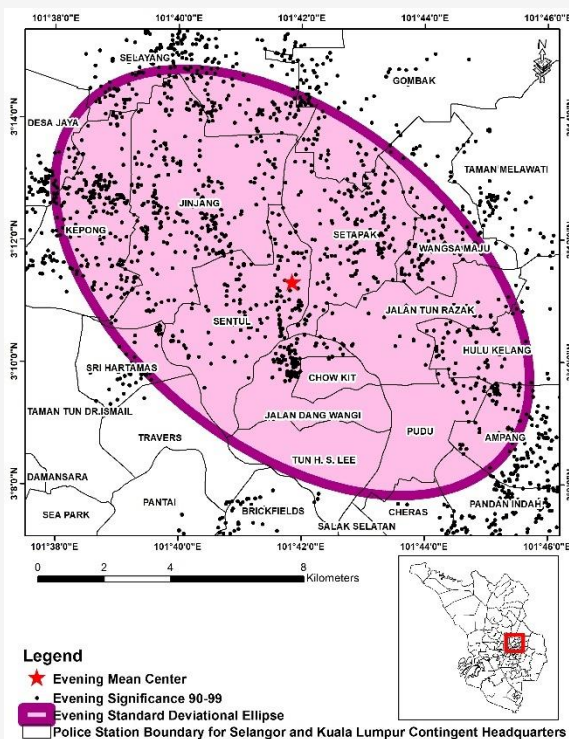
Table 1 also shows that at midnight, the location base for land use is Taman Tasek Titiwangsa near Persiaran Kuantan Road, in the morning at C.K.L. Holdings Sdn. Bhd near Desa Gombak 1 Road, in the evening is DBKL Flat near 9/48A Road, and at night is at Restoren Nelayan near Sisir Timur Road.
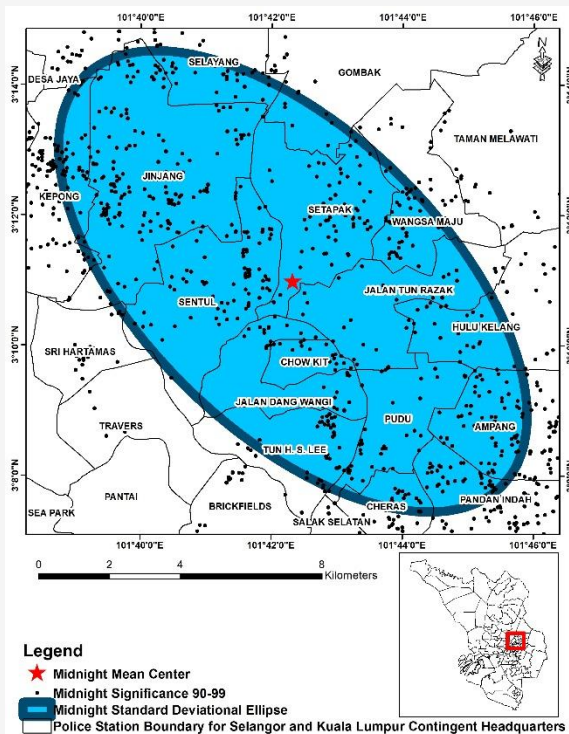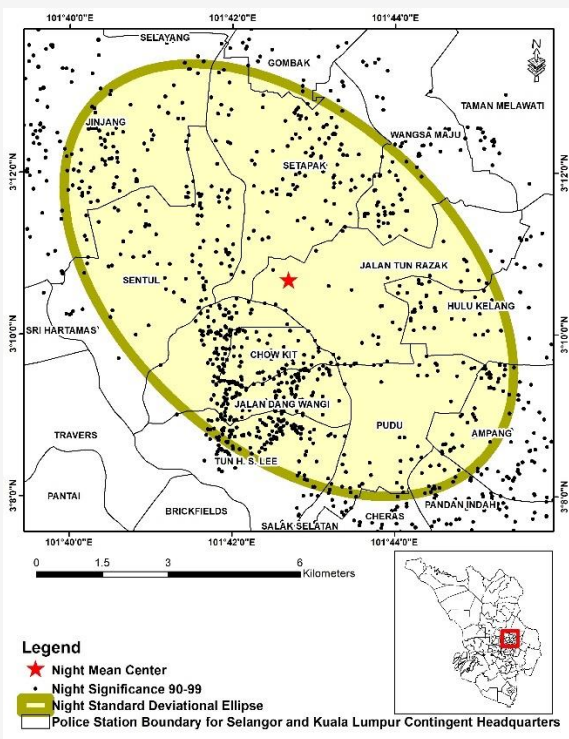
(Midnight, 12am-6.59am)
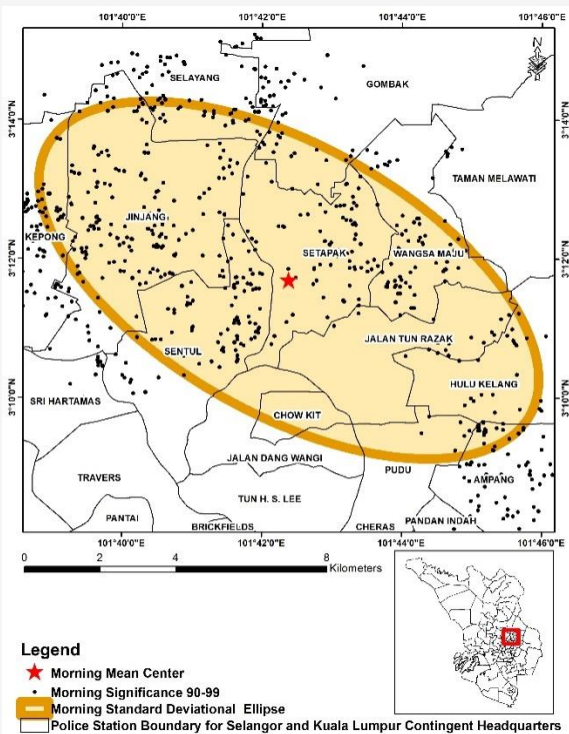
(Morning, 7am-11.59am)

(Evening, 12pm-6.59pm)

(Night, 7pm-11.59pm)

Figure 4: Mean center direction and standard deviational ellipses (SDE) of violence crime based on the year 2015-2020 according to four time frame categories
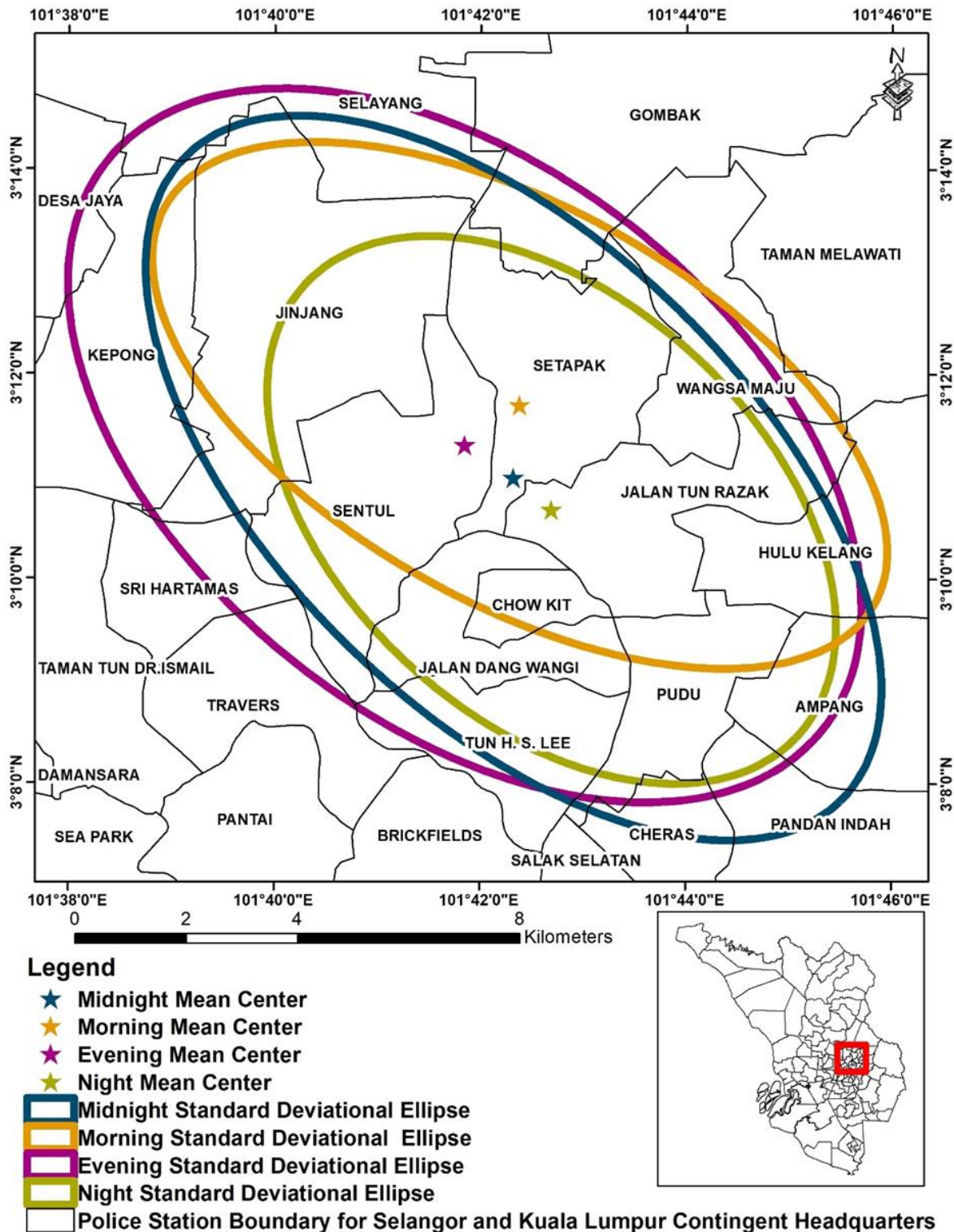
Figure 5: Direction of standard deviational ellipses (SDE) of violence crime 2015-2020 by land use according to four time frame categories
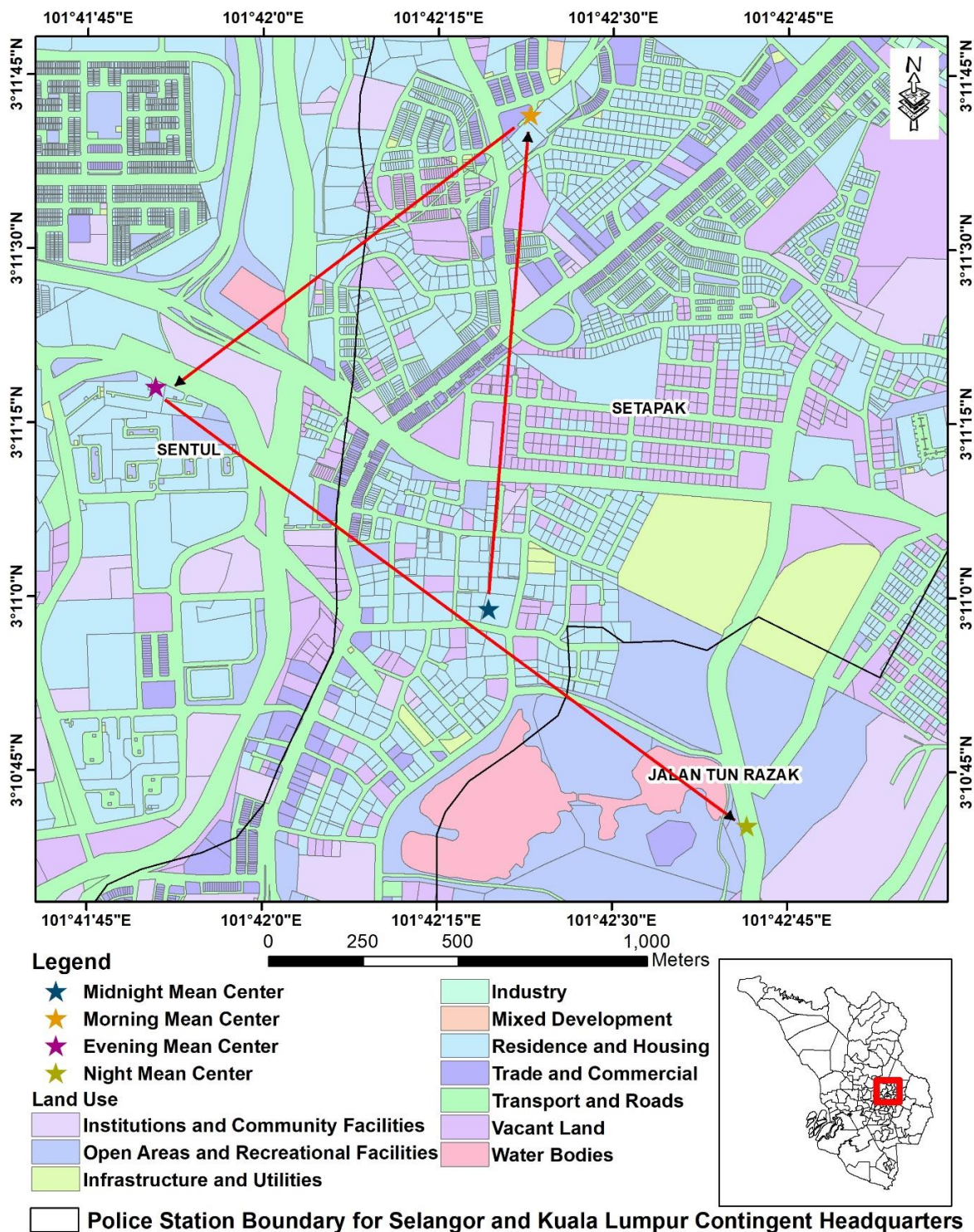
Figure 6: Direction of movement mean center of violence crime 2015-2020 by land use according to four time frame categories

Table 1: Time frame of movement mean center and SDE violence crime year 2015-2020

No.	Period	Location Name	Time Frame	Land Use Type	Stations Involved	XStdDist	YStdDist	Rotation	Area (m²)
1	Midnight	Taman Tasek Titiwangsa, Jalan Persiaran Kuantan	12 am – 6.59 am	Residence and Housing	Setapak	8268.04	4243.15	134.28	11,0205,222.14
2	Morning	C.K.L. Holdings Sdn. Bhd., Jalan Desa Gombak 1	7 am – 11.59 am	Transport and Roads	Setapak	7317.43	3559.05	119.33	81,808,763.60
3	Evening	DBKL Flat, Jalan 9/48A	12 pm – 6.59 pm	Residence and Housing	Sentul	8224.81	4959.79	128.52	128,146,621.17
4	Night	Restoren Nelayan, Sisir Timur	7 pm – 11.59 pm	Transport and Roads	Jalan Tun Razak	6011.89	3787.30	132.52	71,525,442.47

The result shows that SDE and Mean Center technique are complementary in analyzing violent crime with land use and spatial-temporal data. Spatial statistical analysis using SDE can accurately reveal the multifaceted characteristics of economic distribution [57]. Additionally, it may display the densest concentrations of criminal incidents on a map and pinpoint hotspots for violent crime [58]. The Mean Center technique can quantify the spatial distribution of geographic elements in terms of the center [59]. It can also examine the changing distribution of violent crime and identify the dynamics of robbery and violence hotspots [15][60] and [61]. By using both techniques together, researchers can acquire a more comprehensive understanding of the spatial and temporal patterns of violent crime and how they relate to land use. For example, a study could use SDE to identify hotspots of violent crime and then use the Mean Center technique to examine the spatial distribution of businesses or other land use elements in those hotspots. This could help identify potential factors contributing to the high incidence of violent crime in those areas [51] and [52]. Overall, the use of SDE and Mean Center technique in the study of violent crime with land use and spatial-temporal dynamics can provide valuable insights into the patterns and causes of violent crime. It also becomes some type of offence that can harm other people or the community [62]. Road mapping, crime mapping, and other types of disaster mapping can also be aided by GIS [61]. In the future, we also can use Terrestrial Laser Scanning (TLS) to create a detailed three-dimensional model of a crime scene [64]. It also can be use to identify the distribution of disease and archaeological site to make GIS subject more relevant [65][66] and [67].

6. Conclusion
In the study of violent crime with land use and spatial-temporal dynamics, the application of SDE and Mean Center approach can provide useful insights into the patterns and causes of violent crime. The Mean Center approach can investigate the shifting distribution of violent crime and uncover the dynamics of robbery and violence hotspots, whereas SDE can find hotspots of violent crime and depict the densest concentrations of criminal episodes on a map. Researchers can acquire a more thorough picture of the spatial and temporal patterns of violent crime and of how they relate to land use by combining both methodologies. According to the literature review, these strategies are beneficial in the investigation of violent crime through land use and spatial-temporal dynamics. These methodologies can help identify potential variables leading to the high prevalence of violent crime in specific locations, which can then be used by police and local authorities to collaborate, establish crime prevention initiatives, and more effectively allocate resources. The analysis outcomes reveal that the central hub for the distribution of violent crime cases in Selangor and KLFT primarily exists within the KLFT, notably in Police Station Boundaries such as Setapak, Sentul, and Jalan Tun Razak in Malaysia's Heartland. This finding implies a heightened concentration of violent crime cases in urban settings, particularly in densely populated towns. The directional distribution of violent crime cases also suggests a correlation with spatial factors, including location and land use. Nevertheless, further comprehensive investigations are imperative to thoroughly explore these relationships. Furthermore, this methodology provides a convenient approach for presenting data, facilitating the identification of patterns in violent crime through the mapping of dots, illustrating the evolution of violent crime over time and space, utilizing data spanning from 2015 to 2020. Consequently, this discovery holds significance in augmenting the comprehension of the Royal Malaysian Police and Local Authority regarding the dynamics of violent crime. Overall, using SDE and the Mean Center technique to study violent crime with land use and spatial-temporal data can be a valuable tool for police and local authorities in their efforts to reduce violent crime, improve public safety, and implement preventative measures in high-crime areas.

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