



# การประยุกต์ใช้การวิเคราะห์ทางสถิติเชิงพื้นที่ของอาชญากรรม ในพื้นที่สามจังหวัดชายแดนใต้ของประเทศไทย Applying Spatial Statistics Analysis to Crime Data in the Three Southern Border Provinces of Thailand

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## บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่ออธิบายรูปแบบและความหนาแน่นของอาชญากรรมใน 3 จังหวัดภาคใต้ (ยะลา ปัตตานี และ นราธิวาส) ในประเทศไทย โดยใช้ GIS และการวิเคราะห์เชิงพื้นที่ มีการรวบรวมข้อมูลเหตุการณ์ไม่สงบจากหน่วยงานรักษาความปลอดภัยและมีความเชื่อถือได้ในช่วงปี 2560 - 2563 เกี่ยวกับการยิงและวางระเบิด การลอบวางเพลิง การก่อความรุนแรงและยาเสพติด ระเบียบวิธีวิจัยแรก คือ สถิติเชิงพื้นที่จากทฤษฎีความหนาแน่นของเคอร์เนล ใช้สำหรับวิเคราะห์รูปแบบอาชญากรรมหรือจุดฮอตสปอต ช่วงเวลาการก่ออาชญากรรม และความหนาแน่นของอาชญากรรม ระเบียบวิธีที่สอง ใช้ค่าสัมประสิทธิ์สหสัมพันธ์และการวิเคราะห์การถดถอยเพื่อค้นหาความสัมพันธ์ของปัจจัยต่างๆ ที่มีผลกระทบต่อเหตุการณ์อาชญากรรม หลังจากนั้น มีการใช้วิธีการรวมข้อมูลประเภทต่างๆ ที่เกี่ยวข้องเข้าเป็นหนึ่งเดียวเพื่อวิเคราะห์ดัชนีการเข้าถึงสถานีตำรวจและด่านตรวจในพื้นที่อาชญากรรม ผลการศึกษาพบว่า 1. คดีที่ก่อมีการระบุในกลุ่มที่คล้ายกันที่มีแบบแผนและพื้นที่อาชญากรรมซ้ำเดิมหรือพื้นที่ใกล้เคียงกับที่เกิดอาชญากรรมก่อนหน้านี้ 2. ในการวิเคราะห์พื้นที่เสี่ยงสูง (จุดฮอตสปอต) พบว่าการยิงและทิ้งระเบิดที่จังหวัดยะลา มีการลอบวางเพลิงและการก่อความรุนแรงที่ปัตตานี และตรวจพบยาเสพติดที่นราธิวาส 3. ผลการวิเคราะห์ความถดถอยเชิงพหุคูณ เพื่อทดสอบสมมติฐานพบว่า มีปัจจัยอิสระ 5 ตัว ที่สามารถพยากรณ์จำนวนอาชญากรรมในพื้นที่ 3 จังหวัดชายแดนภาคใต้ได้อย่างมีนัยสำคัญทางสถิติที่ระดับ 0.05 ได้แก่ ขนาดพื้นที่จังหวัด จำนวนประชากร ความหนาแน่นของประชากรในพื้นที่ จำนวนนักเรียนที่เลิกเรียนกลางคัน และจำนวนสถานประกอบการอุตสาหกรรมในพื้นที่ เมื่อนำปัจจัยอิสระทั้งหมดมาเข้าสู่สมการพยากรณ์ ได้ค่าสัมประสิทธิ์สหสัมพันธ์พหุคูณ (R) เท่ากับ 0.392 มีอำนาจพยากรณ์ (Adjusted R Square) เท่ากับ 0.362 หรือสามารถพยากรณ์ได้ร้อยละ 36.2 ซึ่งแปลผลได้ว่า ปัจจัยทั้ง 5 ด้าน พยากรณ์จำนวนอาชญากรรมในพื้นที่ 3 จังหวัดชายแดนภาคใต้ได้ร้อยละ 36.2 ส่วนที่เหลืออาจเป็นอิทธิพลของปัจจัยด้านอื่นๆ ผลการศึกษานี้สามารถนำไปใช้เป็นแนวทางในการป้องกันและลดอาชญากรรมที่เป็นประโยชน์ต่อเจ้าหน้าที่ตำรวจในการวางแผนป้องกันอาชญากรรมในสามจังหวัดชายแดนภาคใต้ของประเทศไทยได้

**คำสำคัญ :** แผนที่อาชญากรรม; รูปแบบการเกิดอาชญากรรม; ระบบสารสนเทศภูมิศาสตร์; การวิเคราะห์เชิงพื้นที่;  
สามจังหวัดชายแดนภาคใต้



### Abstract

The purpose of this study is to describe the criminal pattern and density in three southern provinces of Thailand (Yala, Pattani, and Narathiwat) using GIS and spatial analysis. Data on disorderly incidents received by reputable security authorities between 2017 and 2020, including shootings and bombings, arson, violence, and drugs were collected. This study's approach employed spatial statistics, particularly kernel density, to analyze crime patterns- hotspots, criminal periods, and criminal density. Second, the correlation coefficient and regression analysis were performed to determine the association between various factors and crime incidents. 1. The crime scenes were located in similar cluster patterns and repeated criminal areas or in areas close to previously criminal areas, according to the study. 2. According to the analysis of high-risk areas (hot spots), shooting and bombing cases was identified at the Yala Province, Arson and Violence was identified at Pattani and Drug was identified at Narathiwat. 3. In the multiple regression analysis for hypothesis testing, 5 independent variables could predict the number of crimes in Three southern border provinces at the statistical significance level of 0.05. These 5 independent variables were district area size, number of population, population density, number of drop-out students, and number of industrial establishment. When loading all these independent variables into a predictive equation, the multiple correlation coefficient (R) was 0.392 with predictive power (adjusted R square) at 0.362 (36.2%). This means that these 5 factors could predict the number of crimes in Three southern border provinces at 36.2%. The factors with effects of relationship of crime incidents were the number of population and the number of industrial establishments. The results of this study can be utilized for guidelines in criminal prevention and reduction, they are useful for police officers in planning for criminal prevention in Three southern border provinces in Thailand.

**Keywords :** crime mapping ; criminal pattern; GIS; spatial analysis; Thailand's Three southern border provinces



## Introduction

Thailand has been experiencing insurgent occurrences in terms of terrorism and violent crimes since 2004, mainly in the three southern bordering provinces of Pattani, Yala, and Narathiwat. The year with the most events was determined to be 2017, with 529 instances accounting for 36.1 percent, followed by 2018 (440 cases accounting for 30.0 percent), 2019 (302 cases accounting for 20.6 percent), and 2020 (196 cases accounting for 13.4 percent). Daily shootings and killings of various groups of people, public bombings and bombings targeting government officials, attacks on military, police, or militia bases, clashes with armed forces to suppress or arrest insurgents, blockades and searches by officers against insurgents, and arson are all part of the events. Furthermore, there are influential organizations seeking illicit benefits, such as drug traffickers, illegal oil traders, or contraband dealers. The situations show no signs of reversal, but they have an influence on the economy and people's lives in the afflicted area (Aomjai, 2019). People and society are terrified because of the panic situation and the danger of a crisis in the area. Because of the importance of criminal problems, many approaches for preventing, solving, and decreasing violence from various parts of crimes in these areas are being researched. Apart from social and psychological aspects of crime, geographical features and crime mapping are some of the strategies that police throughout the world have found to be reliable.

Before an analysis, geographic and criminal data, such as the crime scene, incident date and time, frequency, continuity, and crime trend, were collected and shown on a computer map. Crime maps now make use of current Geographic Information System (GIS) technology to aid in crime analysis. The tendency of crimes to occur necessitates an area or location where they occur, precise causes such as family, school, or workplaces, and the area or location of the crime that may be taken into consideration to understand it and accomplish preventative techniques (Markovic, 2007). This approach seeks to investigate crime trends in connection to the environment. Because a system of geographic information was established, mapping shifted from pictures to digital data, lines, or it was represented by X and Y coordinates, resulting in a more effective comprehension of crime (Breslin, 1999). The act of dealing with geographical data via computer systems by defining descriptive data (attribute data) and information, such as position, location, frequency, height, and amount, all of which are connected to the geospatial position or coordinates, is known as geographic information systems.

As a consequence, it can more accurately record a range of criminal data and retrieve data in spatial analyses than in the past. The use of geographic information systems to the study of spatial crime relies on the spatial distribution principle to identify areas or areas with high concentrations and crime densities. This includes establishing linkages with various types of environments, whether physical, social, or economic variables, in order

to comprehend the causes of recurring crime in those areas. As a result, effective crime prevention measures are implemented in the three southern border provinces of Thailand, where problems persist.

## Methods

### 1. Study area

Thailand's southern border, including Pattani, Yala, and Narathiwat, which border Malaysia. There are 33 districts, 250 sub-districts, and 1,614 villages in the regional government. Sankalakhiri mountain, a natural boundary between the nations, is approximately 258 kilometers long. There is a 500-meter-high peak known as Kuan Mountain. It links to the Thai Gulf in the east in 330 kilometers, the Andaman Sea in the west in 144.3 kilometers, and Malaysia in the south in 500 kilometers, for a total area of approximately 10,936,864 square kilometers.

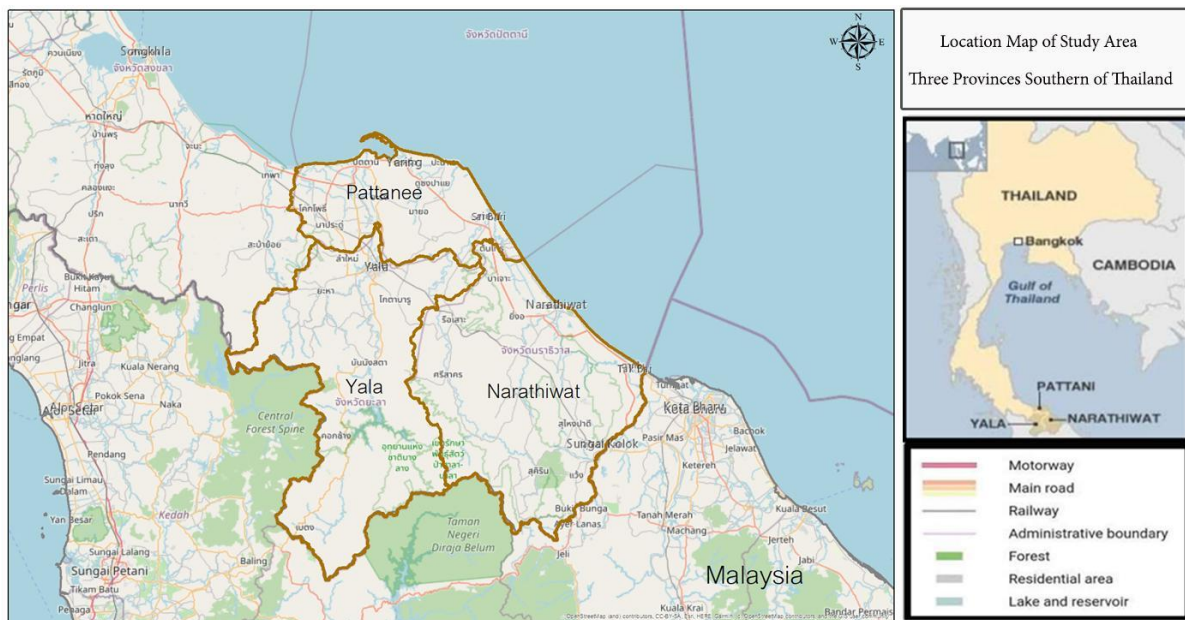


Figure 1 Study areas, Three Provinces, Southern Thailand

## 2. Data collection

### 2.1 Crime data

Based on theory and related research, one of the most interesting types of crimes to be studied is bodily injury cases, which include murder, rape, and mayhem. Many studies look at incidents involving property offenses,



and the most important cases of this type of crime include plunder, burglary, scrambling, and auto theft. The patterns, features, and density of crime cases in space and time in Thailand's three southern border provinces were investigated in this study. From 2017 to 2020, the researchers gathered data from the SMIC System of the Directorate of Intelligence, Royal Thai Army, and selected the type of crime and environmental factors of the area as follows.

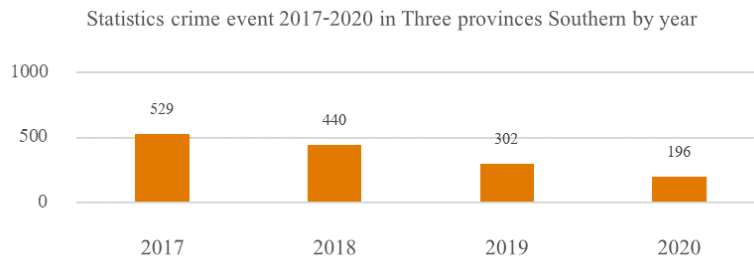


Figure 2 Statistics crime event by year

Figure 2 shows crime in the three southern border provinces from 2017 to 2020. The year with the most incidences was determined to be 2017 (529 cases accounted for 36.1 percent), followed by 2018 (440 cases accounted for 30.0 percent), and 2019 (302 cases accounted for 20.6 percent). The year with the fewest events was 2020, with 196 incidents accounting for 13.4% of all incidents.

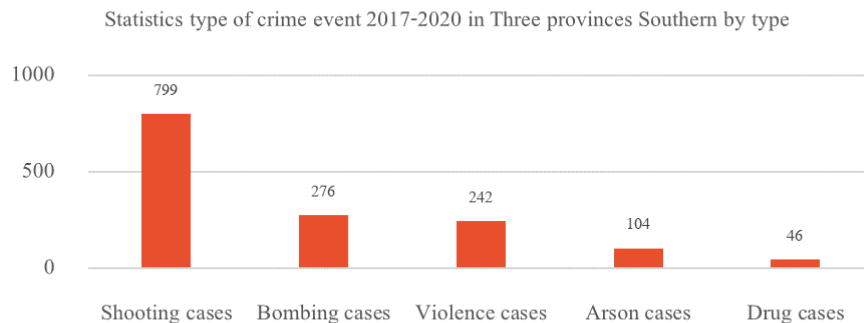


Figure 3 Statistics type of crime event by type



Figure 3 shows the types of crimes committed in the three southern border provinces between 2017 and 2020. It was revealed that the type of crime with the highest crime rates was shooting (799 cases accounted for 54.5 percent), followed by bombing (276 cases accounted for 18.8 percent), violence (242 cases accounted for 16.5 percent), and arson (104 cases accounted for 7.1 percent), respectively. Drugs had the lowest crime rate, accounting for 3.1 percent of all crimes with 46 incidents.

### *2.2 Environmental demographic factors*

According to theory and related research, (Mayhew & Binny, 2011), most studies of crime and the environment primarily focus on the distribution of crimes in the areas and deal with the physical factors of the environment of the areas, social character, economy, culture, population characteristics in the areas (Tarde, 2010), and other factors to determine spatial relationships and describe patterns in crime density and distribution. In addition to studies on crime in the areas, many researchers are interested in conducting studies in urban areas, suburbs, or even parts of cities, such as residential areas, modified city zones, and urban vacant spaces. The following are the factors influencing the physical environment of the location that the researcher chose for analysis. Data on population density, total population, number of households, number of student dropouts, industrial establishments, employees, and capital. From 1 January 2017 to 31 December 2020, data on population density, demographic environment, education, economy, and investment were gathered from The National Statistical Office of Thailand, as well as related documents, publications, and research reports, by dividing the study area into 33 districts in Thailand's Three Southern Border Provinces based on a survey conducted by the Department of Town and Country Planning.

### *3. Methodology*

3.1 Primary and secondary data were categorized and reformed into statistical units for statistical computations during data processing. The results of using Microsoft Excel and the Geographic Information System Program with prepared data originated from primary and secondary sources were presented in the form of tables, figures, and supplement figures.

3.2 In this study, the data was analyzed using the ArcGIS Geographic Information System program. The goals of the data analysis were to analyze and present crime risk areas in the three southern border provinces. In other words, for identifying crime risk areas, spatial pattern search, spatial data analysis using geographic information system applications, the use of the collect events method, spatial data analysis with overlays, and area information of residents, buildings, and the geographic environment were evaluated in order to find a spatial pattern in terms of crime locations in responsible areas.

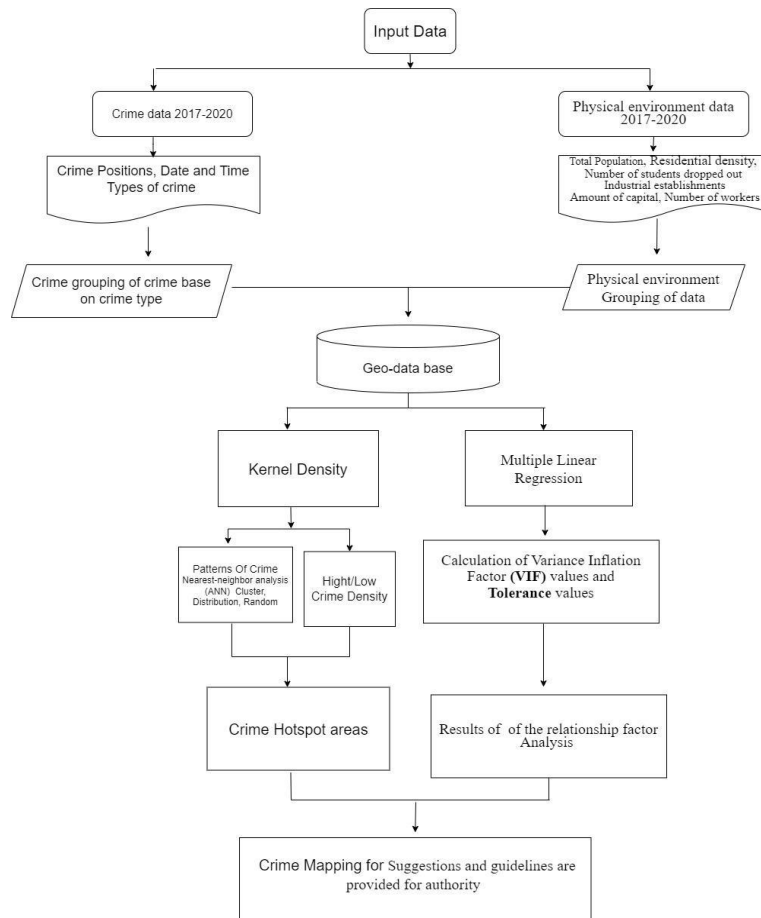


Figure 4 Flow-chart of Methodology

3.3 The tools used for time analysis of crime were Histogram Chart tool with Microsoft Excel program, geographic information system applications for analyzing spatial data of positions and times of crimes, and Geographic information system application by using Collect Events to analyze together with Histogram chart, the interpreted results display as hourly case count format, monthly number of cases, the number of cases per year, and the time of the incident for showing a map with the time of crimes in the three southern border provinces.

3.4 Geographic Information System Applications were used for Hot Spot Analysis to determine the locations, frequency, and timing of crimes in the areas. On the other hand, for identifying the highest crime scenes, the Kernel Density Estimation approach was used to determine the density of crimes based on time points. In the aggregation and point distribution measurement model, the approach is used to measure the distribution of point



data. As a result, the results demonstrate areas with a high crime density or risk of crime. The study's findings were used to interpret the density of crime sites in the three southern border provinces. In other words, areas with a higher concentration of dots have a higher crime density than areas with a lower sparse dot distribution, and the analysis results are also reported in the form of a map displaying areas with a sparse dot distribution and a high risk of crime in the areas. Kernel density estimation is a method for analyzing point patterns based on the notion of spatial quantitative analysis (Maurizio *et al.*, 2007). The results of point-pattern spatial statistics in geographical information systems are shown in raster format, and the technique concept is to compute the radius of each data point before connecting to other points at the set bandwidth distance to obtain the density. If the point radius is set to 30 m, the density among all points is computed to be 250 m. The radius and distance of the bandwidth for the analysis are determined by the users and the subject matter of the analysis. For example, in order to use the analyzing results for quick and direct prevention and correction at a specific region or area radius, the radius value for the crime density analysis should be set at around 10 - 100 m. The bandwidth distance is determined by the size of the whole area and must conform to the radius value.

3.5 Adjust the density base of each criminal case using the Function Raster Calculator in the Arc GIS application and the density conversion formula (Yiampisan & Srivanit, 2010), as stated in Equation 1. The density is set between 0.00 and 1.00. The criminal density areas were then assessed in an overview, by crime category, and by day and night in the following stage.

$$D'_{ij} = \frac{D_{ij} - D_j^{\min}}{D_j^{\max} - D_j^{\min}} \tag{1}$$

Where  $D'_{ij}$  is base density adjustment,  $D_{ij}$  is not adjustment,  $D_j^{\min}$ , the minimum density value,  $D_j^{\max}$  is the maximum density value

3.6 An analysis of the crime scene's distribution pattern. Distribution analysis of crime cases using nearest-neighbor analysis (ANN) of the spatial distribution to determine if crimes are dispersed, random, or clustered (Tantiwutthipong *et al.*, 2021). The distribution of crimes can be explained by using a Z-score between -2.58 and 2.58, where a Z-score close to -2.58 indicates a clustered distribution and a Z-score close to 2.58 indicates a dispersed distribution. Equation 2 was used to get the Average Nearest Neighbor Index:





$$ANN = \frac{\bar{D}_O}{\bar{D}_E}$$

$$\bar{D}_O = \frac{\sum_{i=1}^n d_i}{n} \quad \bar{D}_E = \frac{0.5}{\sqrt{n/A}} \tag{2}$$

Where  $\bar{D}_O$  is the mean of the distance between pairs of points closest to each other observed in space,  $\bar{D}_E$  is the mean of the distance between the pairs of the expected closest points, A is the size of the crime areas, n is the number of crimes, respectively

3.7 Using multiple regression analysis, the association between criminal events and physical environment characteristics was determined. The statistical analysis was performed using SPSS for Windows to determine the association between variables in accordance with the research hypothesis. Variables used to find the correlation include, number of crime cases in the area at the district level and physical environment of the Three southern border provinces.

3.8 Write recommendations and suggestions for government officers in criminal risk prevention or reduction. It results in effective crime prevention measures in the specific area of Thailand's three southern border provinces.

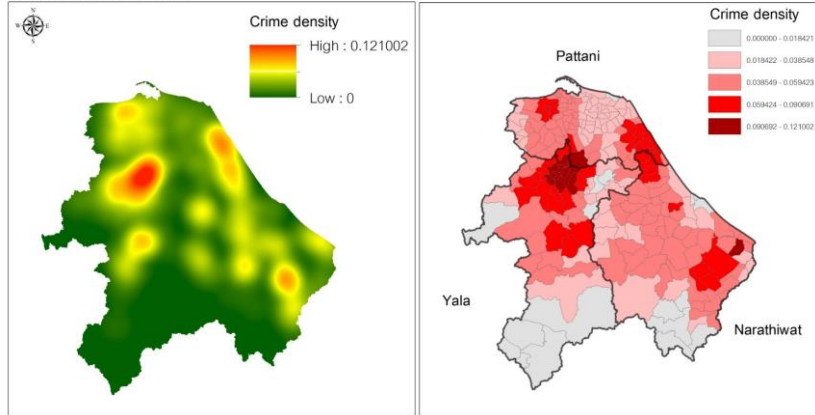
## Results

### Consideration of the pattern and density of crime cases classified by the type of the crime.

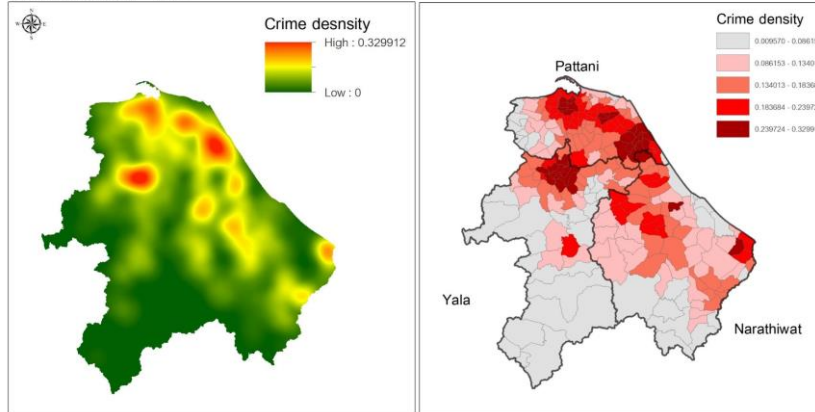
Crimes can be studied based on the density and distribution of the accident site and classified based on their features, such as the nature of the crime. In addition, criminal cases can be broken down into hourly, yearly intervals for comparison, analysis, correlation, and usage in decision-making in planning and preventing future crimes. According to the current study to evaluate crimes using the Kernel Density Estimation approach with the Geographic Information System in the area of the Three Southern Border Provinces, shooting cases were the most common, followed by bombing cases, physical violence cases, arson cases, and drug cases. The following were the findings of the data analysis:



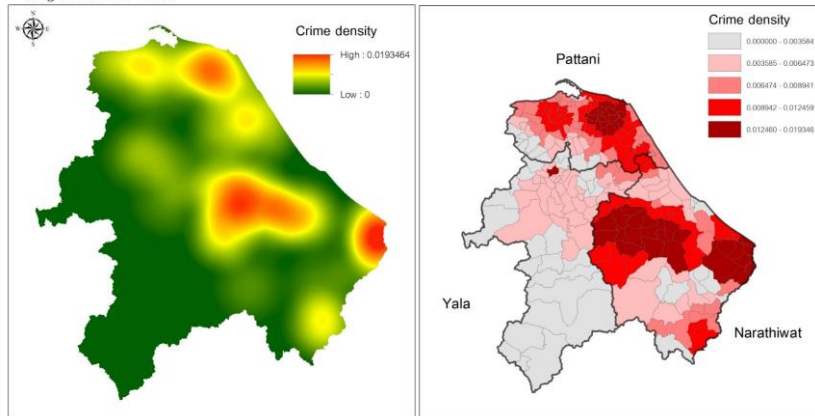
Bombing cases 2017 - 2020



Shooting cases 2017 - 2020



Drug cases 2017 - 2020



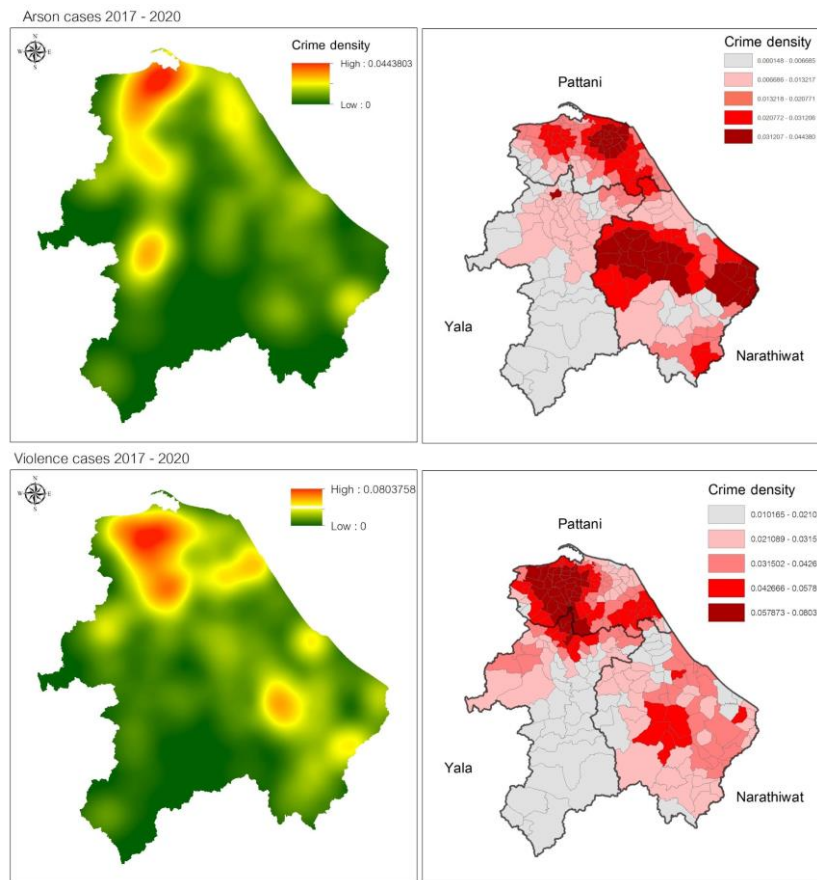


Figure 4 Crime scene and density of crimes classified by each type of crimes between 2017-2020.

*Bombing case* Bombing offenses followed a clustered pattern, with a z-score of -11.832840. The three southern border provinces had the highest density of bombing crimes on highways, minor roads, urban area roads, and officers' traffic routes. The results show that 90 of the 276 bombing incidents, or 32.60%, occurred on highways. The highest density of bombing offenses was in Satang Sub-district, Yupo Sub-district, and Thasap Sub-district, Mueang Yala District, Yala Province, with 0.1210 being the average.

*Shooting cases* The z-score for the clustered pattern of crimes is -22.617805. In comparison to other crimes, the shooting offense had the highest density of crimes in the Three Southern Border Provinces. When compared to other locations in the Three Southern Border Provinces, Satang Sub-district and Thasap Sub-district, Mueang Yala District, Yala Province, in community and city areas had the highest density of shooting crimes, with an average density of 0.3299.



*Drug cases* The current study's findings show that the crime pattern was clustered, with a z-score of -2.840185. Furthermore, Tak Bai District, Narathiwat Province, had the highest crime density in Thailand's urban and border areas. The average maximum crime density was 0.0193, with Khosit Sub-district, Kosathon Sub-district, and Nanak Sub-district, Takbai District, Narathiwat Province having the highest crime density.

*Arson cases* The arson crime pattern was clustered, with a z-score of -7.491978. The locations with the highest density of arson crimes were Baraho Sub-district, Talubo Sub-district, and Pakaharang Sub-district, Mueang Pattani District, Pattani Province, and the average highest density of arson crimes was 0.044.

*Violence cases* The violent crime pattern in the three southern border provinces was clustered, with a z-score of -10.071614. Cases of violence were commonly discovered in public areas or in blind locations. Lipa sango sub-district, Yabi sub-district, and Pulo puyo sub-district, Nong Chik district, Pattani province, had the highest density of violence crimes, whereas the average highest density of violence crimes was 0.0803.

#### Consideration of the density of crime cases classified by year

In the case of criminal density area estimate, the density of each case is taken into account using the point dispersion technique, therefore, the Kernel density estimation must be adjusted in the density base values to produce the same bases because each case does not have the same frequency (Maurizio *et al.*, 2007). Case A (drug cases) has a case frequency of 50 points, whereas Case B (shooting cases) has a case frequency of 200 points. Before being used in the crime risk area analysis of all criminal cases, the density base value of each crime must be changed to the same density value. The formula for converting densities into the same standard is illustrated.

When total crimes from 2017 to 2020 were included in Figure 5, the density of crime sites varied by year. For instance, the average highest density of overall crimes in 2017 and 2019 was in Mueang Yala District, Yala Province. In contrast, the average highest density of overall crimes in 2018 and 2020 occurred in Sai Buri District, Pattani Province. Overall, the highest crime density was found in Mueang Yala District, Yala Province, and Sai Buri District, Pattani Province. Furthermore, the trend of crime has dropped in 2020.

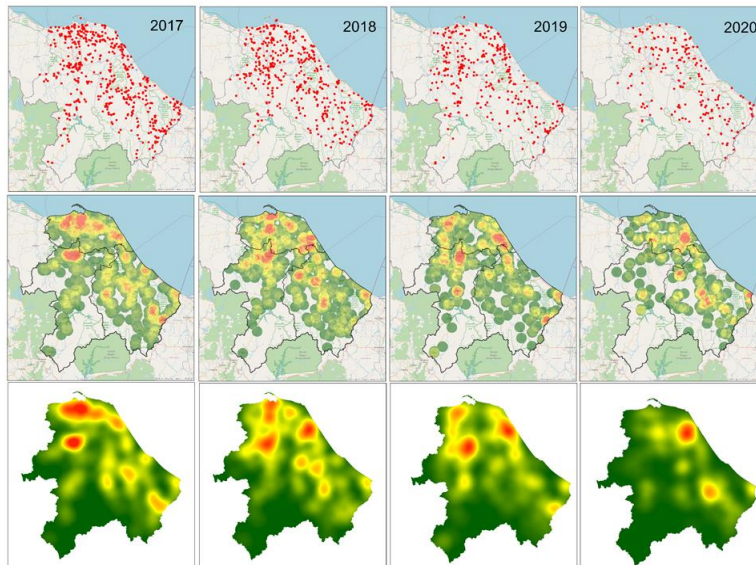


Figure 5 Pattern and characteristics of crime density between 2017 -2020.

Type	Time				Total
	Day		Night		
	06 AM- 12 AM	>12 AM – 06 PM	> 06 PM – 12 PM	> 12 PM - 06 AM	
Arson cases	27	17	22	38	104
Bombing cases	99	72	75	30	276
Drug cases	11	6	19	10	46
Shooting cases	141	179	353	126	799
Violence cases	81	82	38	41	242
<b>Total</b>	<b>359</b>	<b>356</b>	<b>507</b>	<b>245</b>	<b>1467</b>

Figure 6 Statistics type of crime event 2017-2020 in Three southern border provinces by time

Regarding to Figure 6 presenting comparison of types of crimes in the Three southern border provinces by times, arson cases were likely to happen at night, as the crime rate was highest during 12.00 AM – 6.00 AM (38 cases accounted for 36.5 percent), bombing cases were likely to happen during daytime, as the crime rate was highest during 6.00 AM- 12.00 PM (99 cases accounted for 35.9 percent), drug cases were likely to happen at night, as the crime rate was highest during 6.00 PM – 12.00 AM (19 cases accounted for 41.3 percent), shooting cases were likely to happen at night, as the crime rate was highest during 6.00 PM – 12.00 AM (353 cases



accounted for 44.2 percent), and violence cases were likely to happen during daytime, as the crime rate was highest during 12.00 PM – 6.00 PM (82 cases accounted for 33.9 percent).

### Multiple Regression Analysis

Before performing multiple regression analysis, it is necessary to confirm that the independent variables do not have a significant degree of correlation, also known as "Multicollinearity." If the independent variables have a high correlation, the relationship between the independent variables and the dependent variables obtained from the multiple regression analysis is inaccurate. As a result, the conclusion of this hypothesis test is that it is inaccurate. Because of the reasons stated above, it is necessary to assess "Multicollinearity" with each independent variable prior to performing multiple regression analysis. Multicollinearity can be achieved in two ways, as follows:

- 1) Identification of the Correlation Coefficient ( $r$ ) according to Pearson's method to study the association between independent variables. The Correlation Coefficient ( $r$ ) between independent variables should not exceed 0.800.
- 2) Calculation of Variance Inflation Factor (VIF) values and Tolerance values. The suitable Variance Inflation Factor (VIF) values should not exceed 5.000 if Variance Inflation Factor (VIF) values are more than 5.000, it indicates that the independent variables have a very high correlation with each other, while Tolerance values should be below 0.200.

**Table 1** Results of the correlation analysis between factors affecting the number of crimes

Factors	Crime	Area	Population	Population Density	Household	Student Drop out	Industrial Establishment	Employee	Capital
Crime	1.000								
Area	-0.047	1.000							
Total Population	0.511***	-0.019	1.000						
Population Density	0.233**	-0.467***	0.677***	1.000					
Household	0.411***	0.075	<u>0.957***</u>	0.679***	1.000				
Student Drop out	0.184*	-0.069	0.537***	0.361***	0.512***	1.000			
Industrial Establishment	0.426***	-0.092	0.705***	0.703***	0.742***	0.427***	1.000		
Employee	0.254**	-0.043	0.726***	<u>0.814***</u>	<u>0.825***</u>	0.330***	0.795***	1.000	
Capital	0.254**	0.161*	0.598***	0.349***	0.694***	0.303***	0.513***	0.639***	1.000

\* $p < 0.05$  \*\*  $p < 0.01$  \*\*\*  $p < 0.0$

**Table 2** The inspection of Variance Inflation Factor (VIF) values and Tolerance values with six factors.

Independent factors	Tolerance	VIF
Area	0.567	1.764
Total Population	0.291	3.440
Population Density	0.259	3.862
Student Drop out	0.696	1.438
Industrial Establishment	0.370	2.705
Capital	0.589	1.698

**Table 3** Results of the correlation analysis between factors affecting the number of crimes.

Model	Unstandardized		Standardized	t	p-value
	Coefficients		Coefficients		
	B	Std Error	Beta		
(Constant)	7.356	1.726		4.261	0.000
Area	-0.009	0.003	-0.280	-3.020	0.003
Total Population	0.000	0.000	0.812	6.279	0.000
Population Density	-0.021	0.005	-0.626	-4.567	0.000
Student Drop out	-0.008	0.003	-0.183	-2.191	0.030
Industrial Establishment	0.071	0.020	0.409	3.561	0.001
Capital	0.000	0.000	-0.122	-1.345	0.181

R = .626, R Square = .392, Adjusted R Square = .362, F=13.414, p-value = 0.000

According to Table 1, a correlation analysis of factors affecting the number of crimes in the three southern border provinces shows independent variables with a high correlation over 0.8, such as 1) population, 2) population density, 3) the number of households, and 4) the number of employment. Multicollinearity is thus applied to these factors. Furthermore, when the four components were combined with the Variance Inflation Factor (VIF) and Tolerance values from Table 2, the Variance Inflation Factor (VIF) and Tolerance values of these four factors were greater than 5.000 and less than 0.200, respectively. Based on these findings, the summary is as follows: 1) population, 2) population density, 3) number of households, and 4) number of employees have a very high correlation and multicollinearity. When the number of households and employees were removed from the Multiple Regression Analysis in Table 2, the maximum Variance Inflation Factor (VIF) was 3.440, which was less than 0.500.



However, the minimum Tolerance value was 0.259, which was higher than 0.200; so, it can be stated that the independent variables were not overly correlated or had Multicollinearity.

According to the results of Multiple Regression Analysis using Enter's technique (Table 3 for hypothesis testing, five independent factors, such as 1) province area size, 2) population, 3) population density, 4) the number of students who drop out of school, and 5) the number of industrial establishments in the area, were identified. The ability to predict the number of crimes in three southern border provinces was statistically significant at the 0.05 level. The amount of investment capital, on the other hand, was unable to predict the number of crimes in the three southern border provinces with statistical significance. When all of the independent variables were included in a predictable equation, the multiple correlation coefficient (R) was 0.392, and the Adjusted R Square was 0.362. In other words, it can forecast 36.2% of the time. In conclusion, it may be possible to forecast the number of crimes in the Three Southern Border Provinces at 36.2 according to five factors, with the remaining percentages originating from other factors.

The highest factor could predict the number of crimes in the Three southern border provinces was the population, followed by population density, the number of industrial establishments in, province area size, and the number of students who quitted from schools. The Beta values of the population, population density per area, the number of industrial establishments in the area, province area size, and the number of students who quitted from schools were 0.812, 0.626, 0.409, 0.280, and 0.183, respectively.

## Discussion

According to the results of a research study on the estimation of Kernel criminal density using a geographic information system in three southern border provinces. According to (Bourdieu, 1984), the distribution of area crimes and disorders was clustered. This indicates that the incidents occurred in repeated or close areas, but with varying criminal densities based on physical and environmental characteristics of criminal categories. In these three southern border provinces between 2017 and 2020, the maximum number of criminal occurrences was 529 (36.1%) in 2017, followed by 440 (30.0%) in 2018, and 302 (20.6%) in 2019, with the lowest number of criminal episodes being 196 (13.4%) in 2020. The maximum frequency occurred at night and was higher than during the day.

To estimate the density of Kernel crime cases, the pattern of crime geographic distribution separated by crimes with typicality, criminal behaviors depend on the circumstances of that crime was found. This is consistent with the results of the research "The kernel density estimation for crime analysis: a case study in Three southern provinces of Thailand" by (Soontorn & Hong, 2020) Drug cases, for example, found contraband through immigration, border checkpoints, and natural channels. For example, through the Su-ngai Kolok customs border; through several





natural channels such as Narathiwat Province's Tak Bai-a border area, and others. All of these correspond to the information—Subject "Drugs-the dangerous disaster and interruption hazard-in southern border provinces. The number of criminal bomb cases in Pattani, Yala, and Narathiwat provinces was almost equal, while Narathiwat province had the highest occurrences. Probably the criminal crime comes from the topographical land features of Narathiwat province itself: Contiguous Thailand-Malaysia woods and densely forested mountains cover two-thirds of the total area. A mostly flat area next to the Gulf of Thailand and lowlands on four rivers: Sai Buri, Bang Nara, Tak Bai, and Golok River, where perpetrators can easily escape and hide within this geography either by water or land. When each district was considered, the majority of the explosions occurred frequently and densely in Amphur Muang District, Yala Province. It may be the most famous of urban planning of Amphur Muang District itself, being the most beautiful town planning in Thailand. Especially the design of the 3 -tiered roundabout where the innermost round is the government agencies center and all traffic roads lead to here. However, in the terrorist's vision, cobwebs or nets connect traffic lanes to assist the perpetrators' escape. The first round tier of the town plan is the government agencies zone, the second round tier is the residence of government officials, the third round tier is schools and hospitals, and the outer zone is a commercial and residential region. As a result, this is the terrorist target area for perpetrators to commit crimes precisely and clearly designate criminal targets. The majority of physical attack instances occur during the day, in public, in living communities, and in the economic zone. The distribution of daytime criminal cases shows a densely concentrated pattern among crowded areas where various crimes are easily committed. Shooting and arson cases are generally committed at night, in public areas such as living communities zones, in a blind corner. While the crime rate remains high in the same location year after year. To assess crime-prone risk zones and determine crime statistics from 2017 to 2022, five major locations were identified as high-risk crime areas: Mueang Yala District, Sai Buri District, Yarang District, Muang Pattani District, and Kapho District.

According to the study results, the number of population and number of industrial establishments had positive relationship with the number of crimes at the statistical significance level of  $< 0.01$ . The population number had effects on the increase of crimes at 81.2%. This result is consistent with Gabriel Tarde's theory (Tarde, 2010), that urban people have more chances to imitate crimes than rural people because urban people are in more numbers and live together densely. In large cities, crime is a matter of imitation expanding to improve techniques or tricks. Furthermore, several types of crimes began in large cities with a huge population before spreading to rural areas.



The second variable of number industrial establishment in the area had effects on the increase of crimes at 40.9%. This is consistent with Henry Mayhew's theory (Mayhew & Binny, 2011), which involves map plotting on the crime incidents and determining the criminal density in each area. After a nine-year study, it was found that crimes occur more frequently in business or trade areas and in areas with industrial factories than in other areas. As a result, related agencies with responsibility for peaceful maintenance in the areas should pay attention to the increase of these two factors.

Moreover, the study concluded that the factors of population density, area sizes, and the number of drop-out students had negative effects on the number of crimes at the statistical significance level of  $< 0.05$ . These factors had an impact on the number of crimes. Population density had the biggest effect (62.6%), followed by area size (28%), and the number of dropout students (18.3%). These variables should be promoted by relevant agencies in order to reduce the frequency of crimes in the locations.

## Conclusion

In comparison to the situations in 2019 and 2020, the trend of criminal situations in the southern border areas has declined systematically and noticeably since 2017, and it is expected to get better gradually. This leads to improvements in solving criminal and disorderly problems in the three southern border provinces. As a result, the number of criminal and disorderly incidents in 2020 will be markedly lower. According to the case study, crime incidents in three southern border provinces were to create crime situations and disorders in densely populated areas or communities. Because these factors have an effect on reducing crime, related agencies should promote them by encouraging local people's participation in preventing crimes in communities and training local leaders and people to prevent crimes in the area. When the facilities such as police stations and security officers increase in the study area, the crime cases decrease in relation to the density of government sectors. Public participation should be promoted in criminal prevention by monitoring surrounding areas. Community leaders and local people should share responsibility for surveying in assigned zones to detect abnormalities. Companies or shops should have security guards patrolling around the public area, and surveillance cameras should be installed. If observing any abnormal matters, the police officers should be notified immediately. Technology should be used in operation and inspection of the police officers together with relating agencies. Therefore, these factors should be enhanced to decrease the number of crimes in the areas.



### Recommendation

1. The study should be scoped on a small scale rather than a large scale to study more details. The study should cover the physical aspects of various areas since each area has particular internal components in relation to wrongdoing and crime. As a result, studying in a small area might cover more different factors than studying in a wide area.

2. It is necessary to give importance on other factors such as societies, communities, lifestyles, cultures, or religions. These factors may help troublemakers' resistance to be stronger in the southern border provinces, and they are cited as a remarkable conflict factor by (Ninsri, 2014). In fact, the religious way plays a role in controlling some local people whereas some people are influenced by changes of external societies, purposes, political power, honor, and money which inevitably cause conflicts in communities.

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