SPATIAL ANALYSIS OF CRIME IN THREE PROVINCES, SOUTHERN THAILAND: HOTSPOT, FACTORS, AND ACCESSIBILITY

PONGSAKORN SRINARONG

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR MASTER DEGREE OF SCIENCE
IN GEOINFORMATICS
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Thailand has faced with problems of criminal and disorder situations in Three southern border provinces in Pattani, Yala, and Narathiwat since 2004 until present. In overall, such situations seem continuously violent since troublemakers still attempt to harm innocent people and fight back to the government officers in every chance. Consequently, the criminal problems in these areas are complicated with more and more violence as reported in various media. These problems cause people's fear and mental instability and they have effects on the national economy, societies, and security.

Using a map to explain the areas with criminal density can support a decision-making process of planners and police officers to plan for criminal prevention in risk areas. This study collected the data of disordering incidents from security agencies and reliable sources during 2017 – 2020 and processed them with the geography information system (GIS) by using spatial statistics for examining the criminal patterns. The purpose was to explain the criminal cases in Three southern border provinces to find out the patterns of criminal behaviors in shooting, bombing, drugs, physical violence, and arson. In addition, Kernel Density Estimation (KDE) was also used to display distribution of criminal patterns, hotspots classified according to offences, criminal periods, and criminal density in each area. After that the correlation coefficient and regression analyses were used to find out relationship of different factors with effects on crime incidents in Three southern border provinces whereas. The two-step floating catchment area (2SFCA) was used to analyze the accessibility index of police stations and checkpoints in criminal

areas. The results were presented in statistics and maps on particular issues to be explained.

The study results showed that the crime cases took place in a clustered patterned at repeated criminal areas or nearby previous criminal areas. In the analysis of high-risk areas (hot spots), shooting cases took place at the highest rate of other cases, followed by bombing cases, physical violence cases, arson cases, and drug cases. 1) The highest density of shooting cases was found at Mueang District, Yala Province in community and city areas, frequently at night during > 06 pm – 12 pm. 2) The highest density of bombing cases was found at Mueang Yala District, Yala Province at roadsides and police officers' traffic paths, frequently during daytime at 06 am – 12 pm. 3) The highest density of physical violence was found at Nong Chik District, Pattani Province in public places and blind spots, frequently during daytime at >12 am – 06 pm. 4) The highest density of arson cases was found at Mueang Pattani District, Pattani Province in the areas with buildings and workplaces, frequently at night during > 12 pm - 06 am. And 5) the highest density of drug cases was found at Takbai District, Narathiwat Province at the border areas of Thailand, frequently at night during > 06 pm – 12 pm. In overall, the least criminal and disorder incidents was found in Yala Province in comparison with Pattani and Narathiwat Provinces.

Regarding the accessibility index of police stations and checkpoints on criminal incidents, the police station which should highly servient to cope with crimes in the area was Mueang Pattani Police Station in Pattani Province, followed by Ra-ngae Police Station in Narathiwat, Ma Yor Police Station in Pattani Province, and Reuso Police Station in Narathiwat respectively. The results of this study can be used for guidelines in criminal prevention or reduction, and they are useful for police officers in planning for criminal prevention in Three southern border provinces.

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Pongsakorn Srinarong

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CHAPTER 1
INTRODUCTION

1.1 Statements and significance of the problems

Thailand has experienced the events of insurgency in terms of terrorism and violent crimes, particularly in the area of the Three southern border provinces of Thailand, namely Pattani, Yala and Narathiwat, since 2004. Over time, such violence has become more chronic and intensified due to a continuation of violence every day and every month. The events include daily acts of shooting and killing various groups of people, public bombings and bombings targeting government officials, attacks on military, police or militia bases, clash with armed forces to suppress or arrest insurgents, blockade and search by officers against insurgents as well as arson. Moreover, there are a group of influential people who seek illicit benefits, such as drug traffickers, illegal oil traders, or contraband dealers.

Such incidents regularly appear in the news. According to the statistics of security incidents, from 2004 to August, 2021, there have been a total of 21,328 unrests, on-site attacks, shootings, bombs, arson, brutal killings, weapon robbery, demonstrations, assaults, and other conflict-related incidents. In all the incidents, a total of 7,314 people were killed, 13,584 were injured, including 20,898 casualties (Deep South Watch Thailand's Situational Surveillance Center). Unfortunately, the situations show no sign to calm down, but cause an impact on the economy in the affected area as well as the life of people there. The panic situation and the danger of crisis in the area create great fear among the people and society.

These emerging damages can be financially measured such as loss of properties, loss of income, and expense on medical treatments in case of injuries. In addition, some damages cannot be financially measured such as fear, pain, agony, and death. The criminal crimes can be an indicator of urban quality of life because they directly affect safety of life and properties, and they also cause mental consequences in the forms of feeling and fear of unsafety under serious criminal situations. The government allocates a lot of budgets for crime suppression in terms of materials and equipment for criminal prevention, and increase of personnel in the justice process for

dealing with criminal problems. Therefore, effective criminal prevention is helpful in reducing social loss and loss of budgets as well as in increasing the quality of life of people in the societies.

Due to the importance of criminal problems, various techniques are studied for preventing, solving, and reducing violence from various aspects of crimes in the areas. Apart from sociological and psychological aspects of crime, geographical aspects are also studied, and crime mapping is one technique of criminal analysis acceptable for police around the world at present.

It brings together geographic and criminal data to display on a computer map before an analysis, such as the crime scene, incident's date and time, frequency, continuity, as well as the tendency of crime. Currently, crime maps have made use of the prevailing Geographic Information System (GIS) technology to assist in crime analyses. The tendency of crimes to occur requires an area or location where they take place, precise causes e.g., home, school or workplaces, the area or location of the crime that can be taken into account to understand it and achieve approaches of prevention.

Crime mapping has been formulated since the 1800s. It started with making a map on a piece of paper called "Pin Mapping", which had problems in both reading and understanding the map itself. It was therefore difficult to map an area with a wide variety of crime types as crime locations on the map can be neither increased nor decreased. Until the 1960s, computers were used to analyze and produce crime maps, known as Computerized Crime Maps. Initially, there were limitations, namely limitations of technology and problems in logical analysis. In addition, the number of map analysis personnel is limited, not to mention hardware problems that are large, expensive, difficult to use and import data. Until the 1970s, after the development of a geographic information system, more studies have begun to characterize the relationship between crime and geographical components.

This new technique aims to study crime patterns in relation to environment. This results in a more effective understanding of crime because, when a system of geographic information was developed by Breslin (Breslin, 1999) mapping has changed from images to digital data, lines, or it has been represented by X and Y coordinates. Geographic information system is the process of working with spatial data via computer systems by defining descriptive data (Attribute Data) and information, such as position,

location, frequency, height, quantity, all of which are related to the geospatial position or coordinates.

As a result, it can record a variety of crime data more accurately and can retrieve data in spatial analyses more than it was in the past. The use of geographic information systems in the study of spatial crime has a key principle of spatial distribution to identify areas or areas with high concentration and crime densities. This includes finding relationships with different types of environments, whether physical, social or economic factors, to be able to understand the causes of recurring crime in those areas. This consequently leads to effective prevention measures to tackle crime in the specific area of the Three southern border provinces in Thailand where problems persist.

1.2 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.

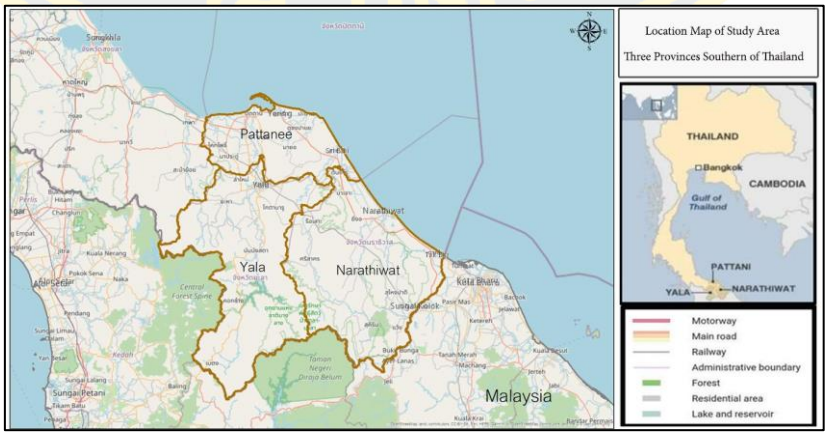


Figure 1 Study area

1.3 Research questions

1.3.1 What are the criminal patterns in each case in Three southern border provinces?

1.3.2 Which areas in Three southern border provinces does criminal density took place?

1.3.3 Which period of day does criminal density took place?

1.3.4 Which factors or variables have effects on criminal incidents in Three southern border provinces?

1.3.5 What differences of accessibility index are among the police stations and the checkpoints in each area of Three southern border provinces?

1.4 Objectives

1.4.1 To study the patterns, characteristics and densities of crimes in space and time in the Three southern border provinces of Thailand.

1.4.2 To study the spatial relationship between crime and the physical environment.

1.4.3 To study on potential to access the crime risk areas of the police stations, check-points.

1.4.4 To recommend for the government officers in prevention or reduction of criminal risks, in the Three southern border provinces of Thailand.

1.5 Scope of study

1.5.1 Study the technique and theory of the dot data dispersion measurement. As a crime occurs, there will be a point or position of a particular criminal scene, the obtained data can inform the repetition and density of the cases in the studied area.

1.5.2 Analyze the crime density in the area by using the estimation of the Kernel Density.

1.5.3 Conclude the analyzing results with the spatial relationship between crime and the physical environment on the crime density areas.

1.5.4 Analyze the potential to accessibility of police stations in Three border province southern.

1.5.5 The study area according into 33 districts in the Three border provinces southern.

1.5.6 The data of criminal during 2017 - 2020

1.6 Thesis structure

In this thesis, Chapter 1 presents the statements and significance of crime incidents in Three southern border provinces of Thailand. And a brief discussion about the topic and objectives of the study areas.

Chapter 2 provide the information about the definition of literature review on crime incidents in the Three southern border provinces of Thailand. Such the crime theory, The influence of geographic environment on crime, crime mapping, spatial statistics in the study of crime and the Two-Step Floating Catchment Area method.

Chapter 3 describes the methodology and material used in this study about spatial and temporal patterns of crime in the Three southernmost provinces of Thailand in order to: (1) Analyze and apply spatial statistics in the study of crime incidence during 2017 and 2020 using (KDE) for studying patterns and analyze crime scene density using (KDE) method. (2) Analyzing the relationship between the high crime scene and the factors in physical environment, educational environment, and economic and investment environment. (3) Analyze the extent of service and access of police stations in the Three southernmost provinces using The Two-Step Floating Catchment Area (2SFCA) method to measure the spatial accessibility of service area from a police stations.

CHAPTER 2
LITERATURE REVIEW

In this research literature applies a geography information system (GIS) for the analysis patterns, characteristics and densities of crimes and study the spatial relationship between crime and the physical environment and analysis on potential to access the crime density areas of the police officers from the police stations, check-points in the area of Three southern border provinces in Thailand. The documentary research was done on Geo-information technology, Theory of criminology, Influence of the geographic environment on crime, Spatial relationship between crime and the physical, Crime mapping, Spatial Statistics. The description is presented below.

2.1 Geographic information systems

Geo-information technology is the application of combined knowledge and technology in Geographic Information System (GIS), Remote Sensing (RS), and Global Positioning System (GPS) for various fields. For example, satellite images are useful to study crime scenes. In addition to criminal operation, this technology can be applied for land utilization, such as topography, to plan the work before going to study, and to speed up data collection in the studied areas. Global Positioning System (GPS) can be employed in field trips to locate the crime scene collection, and then, for data analysis, the gathered data are evaluated using Geographic Information System (GIS) software. The collected data divided into 2 types are as follows: 1) Spatial Data, such as data showing geographical location; and 2) Attribute Data or data describing the relationship to spatial data, such as place names, time and date of crimes. The results of the analysis can support and monitor crime-risk areas and can be applied in numerous fields.

2.2 The application of Geo-information technology for crime field

The combination of geo-information technology and criminal maps is mixed between geographic feature data and criminal data to show the maps on computers, and the maps are analyzed, such as crime scenes, time and date of crimes, continuous frequency of crimes, and the trend of crimes. Currently, criminal maps using the

function of Geographic Information Technology can interpret crimes. In other words, the occurring crimes require obvious areas or locations, such as houses, schools, universities, office buildings, areas. Consequently, the locations of the crime can be taken for understanding and for preventing crimes (Yiampisan & Srivanit, 2010)According to (Sahapattana et al., 2010), the results show that the safety of people's lives and property, and the peace of the country are important fundamental factors in the development of the country. The theft offense is a problem that arises and causes great trouble, and police officers are less able to arrest and prosecute. Therefore, the crime solving problems, especially the theft offense, should carry out the benefits of geo-information technology for showing hot spots by pointing on maps and for seeing the concentration of the crime scenes (Sahapattana et al., 2010).

2.3 The ecological theory of criminology

This theory is originated from the idea that Crimes happen because of the influence of the environment, especially communities with high density of population and areas with high increasing rate of population. The first study to observe the relationship between areas and crimes was done during the Second World War by Clifford Shaw and Henry McKey (Snodgrass, 1976). They surveyed data related to the growth of Chicago city and criminal rate of child abuse. In other words, they explained criminal problems with the facts about the occurring social changes which depend on the changes of the physical environment in communities. In that study, Chicago city was divided into 5 districts in accordance to Concentric Circle Theory of Burgess (Burgess & Bogue, 1967). With the idea of actual space supporting the theory, the techniques and methods of the study are mixed together, such as the detailed maps of the distribution of social conditions and various behavior occurring in areas. The results show that youth and child abuse cases are associated to environment conditions in each district. In other words, each district had different case rate of youth and child abuse. They concluded that case rate of child abuse was high in slum and commercial districts. Particularly, transitional zones are neighborhoods with high population dynamics, such as where colored people and foreign immigrants move in and out, commercial areas which are factories, ports, train stations, and shopping centers. The population in these areas is dynamic, so increasing or decreasing rate of population in each district is not

different. As a result, the crime rate in these neighborhoods always be high. Such facts point to the influence of the local physical characteristics of different population groups, such as immigrants, and new residences, which tends to cause crime all the time.

Later, Henry Mayhew (Mayhew & Binny, 2011) plotted on the map exactly where each crime occurred and considered which of the city's neighborhoods has more crime rates than others. After the 9 - year data were plotted, the results demonstrate that most cases occur in business or commercial and factory areas, compared to other areas. Gabriel Tarde (Chotikul, 2001) reported urban people are more likely to copy than rural people due to high amounts of people and high density of population. Crime is one thing that has been replicated to be more expanded. In other words, crime has been improved to have a sharper technique or action, especially the big cities. In addition, some crimes initially start in large cities with high density of population but later gradually expand into rural areas.

Next, Wolfgang (Wolfgang, 1957) studied in Philadelphia, Pennsylvania, and pointed that only 6.3% of children and youth did total cases, and more than half of all crimes are official evidence. On the other hand, Lander studies the same topic in Baltimore, Maryland, and found the relationship between the physical structure of the area and the rate of cases. After, this method was used to apply cases in Detroit, Michigan, and Indianapolis, Indiana, and show economic and social conditions were determined by the physical composition of the community and statistically correlated with the perpetrator's intelligence. Interestingly, the relationship was clearer If the conditions of overcrowding and uninhabitable houses including economic and social conditions are the pointers.

2.4 Influence of the geographic environment on crime

The study of environment influencing in the field of geography is the study of space consisting of various environments, especially physical environment or a possible concrete environment. The environment refers to the environment around a person whose physical body is tangible and can be used to reduce the chances of crime. National Advisory Commission on Criminal Justice Standards and Goals of the United States reported that the chance of cases can be reduced by controlling and designing a tangible environment which should be an important part of preventing crimes. In other

words, the physical environment in these studies is the physical environment of space. According to numerous studies referring Influence of concrete environment on social behavior, many research, such as (Becker & Mayo, 1971) and (Sundstrom & Altman, 1974), concluded that not only animals but also humans mark the environment to symbolize ownership rights; moreover, both of them often fight to defend their area from invaders. They show possession of territories that may be done either for themselves or for a group of which they are members. In summary, animals and humans not only inhabit the physical environment but also try to take ownership of the physical environment. For human society, such environments can be categorized according to the occupation of either individuals or groups and can be divided into 3 types as 1) primary space; 2) secondary space; and 3) public space.

Primary space refers to territory occupied and utilized by a limited number of people or groups. The areas also include controlled areas in a permanent manner. The example of primary space is residential which recognized as “personal territories” (Brower, 1965). In such areas, ownership identity is evident and public entry and exit may not be permitted unless authorized by the owner.

Secondary space means a territory in which a person or group of people can exercise their right to possess an area. Also, they can control the utilization of strangers to a certain extent although their right to possess the areas is not equal to primary space. In other words, secondary space is areas connected between primary space and public space and is known under different names, for instance the track area (Goffman, 1961), the interaction area (Lyman & Scott, 1967)and the defense area Ninsri, S. (2016). The samples of secondary space are village roads, residential alleys, the corridors in front of the room in apartments, and sidewalks in front of townhouses. Such areas are particularly important in preventing crime from constructive environments. Unlike public areas, secondary areas in a community or neighborhood are therefore required to limit free traffic. The use of the alien's secondary space must at least fall within the eyes of the inhabitants, who are like co-owners of the space.

Public space refers to the area in which the general public can legally enter. or can be used to roam freely within the scope of the regulations. Brower (Burgess & Bogue, 1967), called these areas as “Ooccupied by Society”, such as parks, train stations, airports, hospitals, and theaters. The public ways are the first public domain or

also are known as "True Highways", which are usually arranged in public areas including areas used in a temporary manner, such as general parking, corridors both inside and outside the buildings, including public toilets. Therefore, public spaces are opposite to the primary spaces because they are areas where people have the right to use or travel around and they are not in the control or possession of any particular person or group of persons.

Consequently, the physical environment of the areas or concrete environment is a form of land utilization, and humans act on the areas according to the role of that communities including areas which are also tourist cities. In general, residential areas are classified as private spaces, while commercial districts, tourist attraction (beaches, hotels, and accommodation), and public spaces (such as government offices, and temples) can be arranged in public and secondary spaces. In other words, freedom and diverse traffics of humans occur in these areas; however, some places may be restrictions on entry and exit. For unused areas where may be empty or desolate spaces, they can be classified as either public areas or a private areas.

2.5 Research and study on crime and the environment

Crime studies have long been studied by geographers. During 1830 to 1880, they used maps in teaching criminology in France, and later this technique has expanded into other European countries. The principles of the technique are rate of cases and crime change to be spotted on maps; however criminal studies have recently improved with more detail and system by geographers around the early 1970s (Herbert, 1982). Many geographers, such as Lambert, are interested in studying crime in ecology and sociology(Lambert & Jenkinson, 1970). He studied based on ecological theory by studying the area as a basis, collected information from the records of government agencies, and manually record with mapping techniques and observations, which are overall crime studies using the entire city areas. (Pyle, 1976), studied only the inner areas of large cities and found high rate of cases, compared to suburbs or surrounding cities. (Katzman, 1981), studied the increasing crimes in suburban areas, especially large cities, and the results show that the increasing crime cases were related to the increasing population of the areas. In 1872, Brown employed spatial regression analysis, and bodily harm cases were high in suburbs. Also, the phenomenon of suburban-to-

property was dense in retail and high-economic areas. In 1829, (Guerry, 2002) collected data in Paris and compared them using statistics. Serious and shocking cases and cases involving property offenses at province and district levels in France were referred in Journal “Quarterly Returns” of the French local prosecutors. By testing the hypothesis of crime due to poverty, un-education, and high density of population, analysis studies and translation and abbreviation of journals were published in “Westminster Review” issue 1833.

Guerry designed people in areas are either rich or poor using the amount of taxes that can be charged directly (Guerry, 2002). The results demonstrate that case distribution at provinces and districts in French was same. Rate of cases in some areas was very high, while those in some areas were very low. Rate of cases in some areas was at different levels. In addition, the patterns of serious and shocking cases and cases involving property offenses were different. Rate of cases involving property offenses was high in urban and developing industrial areas; on the other hand, rate of serious and shocking cases was high in rural areas (Brantingham et al., 1976).

Efforts to highlight geographic and ecological explanations of crime were a common feature of 19th century research studies and searched such rational rules. Sometimes it leads to the setting of general rules on other geographic determinants of criminology to show statistical data that bodily harm cases were common in the hot temperature period of France, Italy, and Germany. On the other hand, cases involving property offenses always occurred in cold weather period (Mannheim, 1965). Although the exact influence of geographic factors on criminal behavior is unclear, preliminary evidence suggests that rural and urban crime variability (Kaplan, 1956) is related to the following factors:

1) Population in these cities.

2) Demographic composition in relation to gender, age, and ehnicity.

3) The status and economic activity of the population.

4) Conditions and climate variations.

5) Opportunity to be educated, ethical inculcation, and the opportunity to relax.

6) Number of police officers per unit of population. measures to control the operations of law enforcement officials.

7) Policies for operating within the courts.
8) The public's problems with law enforcement.
9) The level of effectiveness of local law enforcement agencies.

2.6 Crime Mapping

Map refers to a man-made object for representing characteristics and locations of various things occurring on the earth surface in order to collect something in some areas by scaling down and using symbols to represent such object in the map. The objects on the map include the following components.

1) Natural objects such as sea, ocean, lake, rivers, mountains, and plains etc.
2) Man-made objects such as cities, villages, and transportation routes etc.

Crime refers to an action which causes trouble and damage to property, people, economic system, and society such as murder etc. A person who commits crime by the court judgment as an offender refers to as a “criminal” A crime is regarded as a social phenomenon occurring in a society. It has been something occurring in a society from the past to present and it may be exist in the future. The crime is a matter which make people fear and worried so that they cooperate to correct it for reducing its effects on the society as little as possible. The crime is also regarded as a barrier of the country development in various aspects which cause enormous social and economic loss. The criminal victims lose their properties or get injuries or damages. Meanwhile, the government loses budget for crime suppression and increase of workforce in the justice system for dealing with criminal problems in the societies in the country.

Therefore, the government officers have duties in criminal suppression, so they have to develop measures or systems for crime suppression. Accordingly, modern technology is used for suppressing crime effectively, and Royal Thai Police and its affiliated agencies need to possess sufficient knowledge and data systems about crimes in terms of crime data, data storage system, analytical system, and application of criminal data analyzing results. At present, one international acceptable technique is crime mapping.

Crime mapping refers to representation of geographical and criminal data on the computer for the analysis in such as crime scenes, time and dates of incidences, frequency, continuation, and trends of crimes (Boba, 2005). Currently, crime mapping

exploits a geographic information system (GIS) which is widely available for analyzing various matters as follows. Analysis of criminal incidences

1) Analysis of criminal patterns, criminal trends, and criminal problems
2) Analysis of information system such as local data, data of criminal records

2.6.1 Crime Mapping can be divided into 5 types

The crime mapping that is currently exploited, can be divided into 5 different types depending on the information to be presented and the purpose to be represented with the following:

Single-symbol mapping: This map relies on only one type of symbols to represent one type of physical characteristics without other physical aspects. The only one symbol type is used to represent the required points such as the locations of the police stations without representing the points of criminal incidences or other physical aspects.

Buffer mapping: The physical aspects in the map are buffered in large or small circles as set by the analyst such as setting the used GIS program and buffering around the liquor-selling service places in the responsible areas of Uttaradit Police Station. The analyst may need to compare the number of assault cases in terms of emerging frequency nearby and outside the buffered liquor-selling service places.

Graduated mapping: Colors or different sizes of symbols are used to represent numbers or physical aspect data repetitively occurring in the same areas or nearby particular areas. For example, a small circle is used to represent 1 - 3 theft cases and a large circle is used to represent 4 - 6 theft cases whereas colors are used to represent high criminal points such as red representing the area with more than 10 crimes and brown representing the points with 6 - 9 crimes.

Chart mapping: It is an option for the crime analysts to represent different values of the same variables on the same maps. For example, the data are represented for drug cases, assault cases, and trouble-causing cases at the service places etc. The usable chart mapping is in 2 types for data representation: pie chart or bar chart.

Density chart mapping: This chart represents the density by painting the police responsible areas with different density in the map. The dark colors are used to represent high crime incidences in the areas whereas the light colors are used to represent low crime incidences. The patrol police officers and administrators can be

informed the crime density in a particular area in order to find measures for crime prevention.

2.7 Functions of the Crime Mapping

Crime mapping is a process of crime analysis. At present, crime mapping is used for the following functions.

The crime mapping is a good visual tools for depicting crimes in a clearer way such as a map representing car theft cases in the last month or year.

The crime mapping enables the crime analysts to relate the data of crime cases to the geographical data in order to find the relationship between the geographical variables and the crime variables. For example, the criminal living places are related to the criminal case data in order to investigate the number of thefts at those places.

The crime mapping enables for criminal search in different places. It informs what crimes occur in particular places such as public park, malls, and educational institutions etc.

The crime mapping use the GIS for producing maps with complete geographical details in the responsible areas without repetitive production, leading to time-saving and budget-saving. Moreover, the resulting maps can be reproduced in an unlimited number.

2.7.1 Crime mapping can be used for 6 main purposes as follows.

Crime mapping for police operation: Crime mapping is used for setting the responsibility levels of the planning officers and for decision-making of the commanders. It is helpful in planning for reducing the criminal cases in the areas and in planning constabulary placement to work in cooperation with the police officers at the local police stations and check-points for the security purpose etc. In addition, criminal mapping is useful for considering crime statistics in the areas or finding causes of crimes near the scenes by using the spatial analysis technique. The techniques of critical points and density analysis enables officers to visualize the incidences and the extent of the responsible areas in an easier way, and it is helpful for reducing the number of criminal cases.

Crime Mapping for petrol: Patrol is one of the main police duties apart from arresting the suspects and controlling disorders in the responsible areas of the police stations. The crime mapping is used for obtaining ideas to solve problems, and making understanding about criminal patterns in the responsible areas. For example, with display of the crime risk areas, the police officers can inspect these areas quickly, assess the crimes in the areas more easily, and perceive the problems which cause crimes by using mapping for crime risk area analysis, crime change analysis according to time, and criminal incidence analysis. The crime mapping is developed for all police officers to understand about their responsible areas and be able to find answers from the area images and maps.

Crime mapping for investigation: This type of map displays the positions of crime scenes, disorder points, and details of different cases at daytime/nighttime or day/month/year etc. The investigation needs the collected important data for mapping different types of crimes used as guidelines for investigation or surveillance. The examples are maps of drug trafficking sources, regular criminal spots and slums. The investigation officers may use information of people under arrest warrants for mapping crimes because the addresses of offenders escaping from the responsible areas are useful information or guidelines to track and arrest the offenders.

Crime mapping for inquiry: The crime scene maps can be used in submitting opinions recommending prosecution so they must be correct. The inquiry offices can use the crime maps in offenders' conspiracy as evidences in court ruling to show planning sites or the living positions of criminals while committing crimes.

Crime mapping for traffic work: The crime maps can be used for planning traffic management effectively in placement of traffic police at various points and strict of traffic discipline. This map shows streets, alleys, junctions, or routes in the responsible areas; and crime risk routes so it can be used for analyzing the risk points of crimes on the roads or traffic routes in the responsible areas. The map information can be basic data for the project arrangement to reduce traffic accidents by related agencies or for planning prevention of traffic accidents. Moreover, the map also displays the quantity and types of crime on the traffic routes in the responsible areas and such information can be a presenting instrument on the police officers' work performance to the commanders or different agencies.

Crime mapping for relationship affairs between police and community: The crime mapping is helpful in raising the relationship between the police and the community. To make relationship with communities, social services are provided by disseminating information to people. With the crime mapping method, the information can be disseminated in the forms of crime maps, details of villains, details of crimes in communities, frequency of crimes, crime scenes, offenders' names and so on to the communities and police officers.

2.8 Spatial statistics

This study conducted the analysis for finding the areas with high crime density or risks. In such analysis, the data of the crime position were considered and displayed in a dot map. Therefore, the technique and theory of the dot data dispersion measurement can inform about the density or clarity for the spatial comparison by measuring the data dispersion Suwan, M. (1998) in 3 types:

1) central tendency measurement, 2) clustering and dispersion measurement, and 3) measurement of distance from point. In the analysis of areas with high crime density or risk, the clustering and dispersion measurement was used for measuring the dot data dispersion, and the analyzing results were interpreted about the density of the criminal points in the closed area. This means that the area with clustering dots represents the crime density higher than the area with dispersing dots. The clustering and dispersion measurement can be performed in 3 cases as follows.

1) Clusters or dispersion from the dot center or median
2) Clusters or dispersion from a specific location
3) Clusters or dispersion by considering the relation to the other nearby points

In the dot data dispersion measurement, the first two methods are the dispersion measurement of the dot median from the specific dots and the central tendency data has less chance to occur in reality. In this study, the clustering and dispersion method was used by mainly considering the relation to the other nearby points because this method has higher possibility to occur. The clustering or dispersing data can occur in every place, so the researcher presents the technique and method of

the data dispersion by considering the relation to the other nearby points. This method is effective and concrete in the data interpretation according to the data characteristics.

2.9 Hot Spot

Hot Spot means areas that are prone to disasters in different ways. For example, they may be natural disasters, such as earthquakes, landslides, floods, windstorms, disasters of human actions, such as the danger of sabotage and wars, and disasters originated both nature and humans, such as crimes, fire, forest fire, floods, and outbreaks. The extent of the damage in each time of these occurring disasters varies greatly. by region, topography, the severity of disasters, and chances of occurring disasters in each form HSE BOOKS, (Walker & Tait, 2004). Therefore, the meaning of hot spot is one of the risk areas involved in the impact. Hot spot in this present study depends on amounts of crimes, and time period of occurring crimes. The risk area can be identified by searching for the density of local crime data.

In this study, Hot Spot Analysis with geographic information systems was used to quantify spatial patterns. Data categorized in accordance to the type of crimes, crime scenes, date, and time led to the use of kernel density estimation technique. Kernel density estimation technique is a method for measuring point distribution with a geographic information system to analyze the spatial density of crimes, such as the distribution of crime scenes, time period, and areas.

2.10 Research review

In 2010, Pankeaw, P. (2010). investigated criminal data using topographical software, namely ArcView 3.3, by bring criminal data in Cha-uat District, and Mueang Nakhon Si Thammarat District, Nakhon Si Thammarat Province, between January 2003 to December 2007 for the criminal-risk area estimation. The crimes divided into5 types are as follows: 1) serious and shocking cases; 2) the case of crimes against life, body, and sex; 3) cases involving property offenses or may harm property; 4) interesting cases; and 5) cases in which the state is the victim. After that, each case was overlayed with time of the incident for identifying relationship with physical factors, land utilization, and population density. According to the relationship between identified crime scenes

and the time of the incident, the appropriate checkpoint locations were determined to reduce the criminal rate. and to find ways for criminal prevention.

Wisetsumont, T. (2013), Using geo-information technology to pinpoint the high density or risk locations of the road accidents in Prachachuen Police Station areas, the study employed density time pattern analysis function or Kernel density estimation. In other words, this technique measures the distribution of accident spots and analyzes incidents with various factors, such as areas, seasons, and time period, to identify suitable locations for drunk checkpoints along main roads, to increase traffic lights at junctions, or to adjust traffic routes in high accident cases.

(Yiampisan & Srivanit, 2010), Study was analysis of the spatial density of crimes as the case study in Phra Nakhon District, Bangkok Province between 2003 to 2007. By using the method for estimating spatial density or Kernel density estimation to measure the distribution of crime scenes, the principle is calculation of the distance between each point to determine the density, and then the density is adjusted to be in the same range. Due to different frequency of each crime case, when the density of each crime case is the same range, the calculation of Simple Additive Weighting Method (SAW) is multiplication between value of the weight of the case type and the standard density of each case type. According to the considered case type, most murder cases, and bodily harm cases, and theft and snatching cases are found in public open spaces, entertainment areas, and commercial districts, respectively. On the other hand, drug cases are found in public areas that lack surveillance. When cases were considered in accordance to time period, the results demonstrate that in 2007 the trend of occurring cases have reduced, compared to cases in 2006. When cases were considered in accordance to time period and hourly, the high density of occurring cases was between 00.01 - 06.00 a.m.

When topographical data and criminal data, such as crime scenes, time and date of crimes, are fed on geo-information technology maps, these analyzed data describe the frequency, continuity, time period, area of spatial density of crimes as well as the tendency of crimes. As a result, police officers can make the decision plans to protect re-occurring crimes in the areas.

Network Analyst tool and the 2SFCA method A network consists of line connection, generally thought as a road network or network utilization such as search

for the shortest routes, analysis for the best routes and travel time in which each component is included with attribute data for setting conditions as required. (2SFCA) method is a gravity model of spatial interaction that was developed to measure spatial accessibility demand and supply (Soontorn & HONG, 2020).

CHAPTER 3

MATERIALS AND METHODS

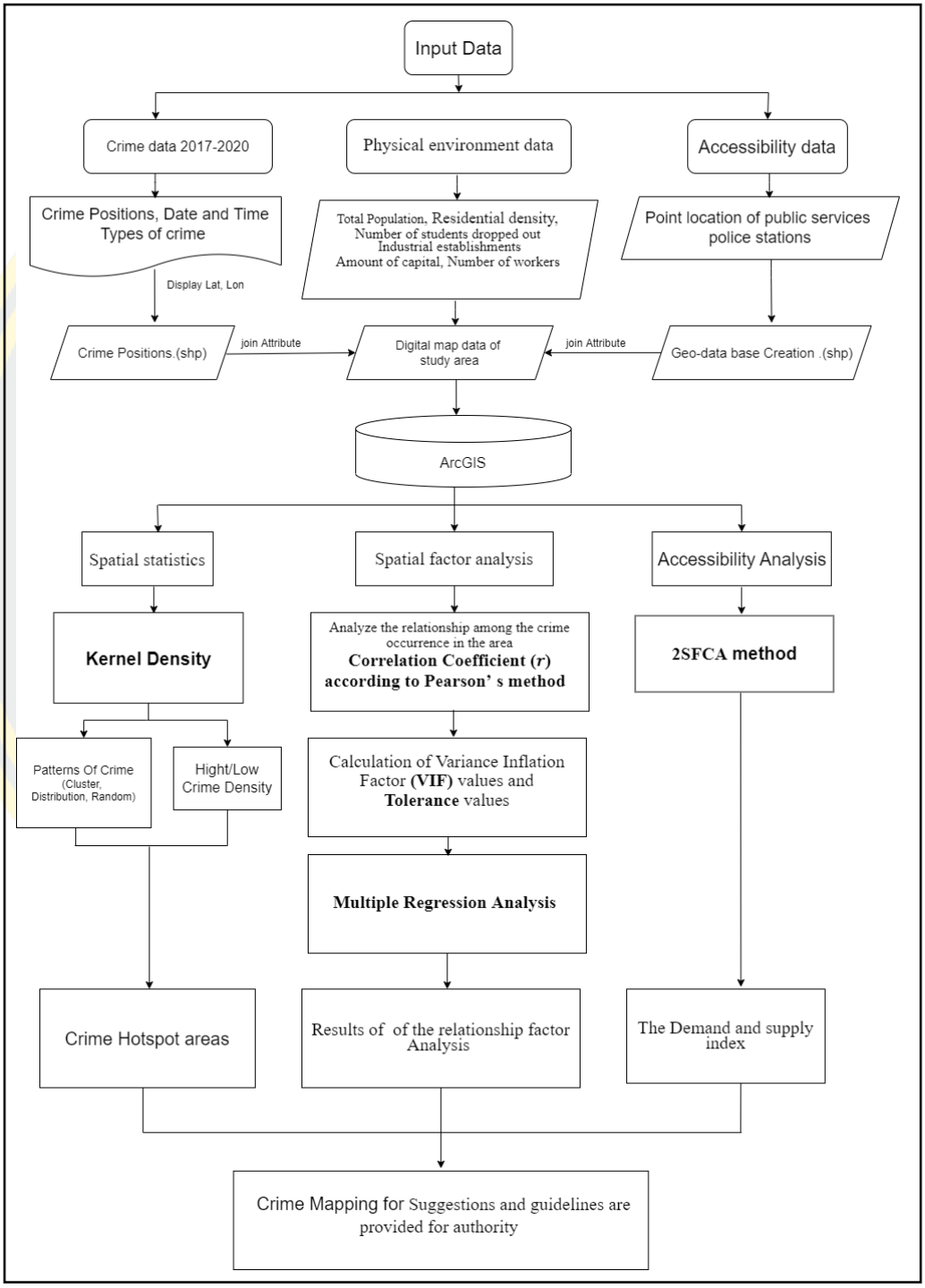


Figure 2 Workflow of study process

3.1 Type of research

This research was a spatial research with the use of secondary data to assist in analysis by concentrating on studying types of crime and criminal density during 2017 - 2020, and characteristics of the physical environment of cities by using techniques for data analysis and mapping data from Geographic Information System (GIS) to present data and process it together to explain the results.

3.2 Data collection

For this research, secondary data of Three southern border provinces was studied and the data could be categorized as follows.

1) Environmental demographic factors from the National Statistical Office of Thailand

2) Map data from the Royal Thai Survey Department

3) Criminal data from the Directorate of Intelligence, Royal Thai Army

3.2.1 Crime data

Based on the studies of theory and related research, a lot of attention to one interested type of crimes to be studied is bodily harm cases, which are murder, rape, and mayhem. Another crime which many studies investigate is cases involving property offenses, and the most important cases of this criminal type are plunder, burglary, scramble, and car theft. In this study of the patterns, characteristics, and density of crime cases in space and time in the Three southern border provinces of Thailand. The researchers gathered data from the Directorate of Intelligence, Royal Thai Army, and compiled the unrests from several sources such as trusted media from 2017 to 2020, the researchers selected the type of crime and environmental factors of the area as follows.

Table 1 Annual crime incidence cases

Year	Frequency
2017	529
2018	440
2019	302
2020	196
Total	1467

Table 2 Crime incidence types

Crime type	Frequency
Arson cases	104
Bombing cases	276
Drug cases	46
Shooting cases	799
Violence cases	242
Total	1467

Information about crimes occurred in the areas divided into types of crime, including drug, violence, shooting, bombing and arson in the southern border provinces of Thailand. Since this study focuses on studying and preparing data to prevent crimes from physical environment factors that support or push the incidents. With that, selected cases are basic crimes which are a crime involving insurgency in areas which threaten to life and affect the peaceful society.

Table 3 Example of the crime dataset

No.	Crime Type	Date	Month	Year	Time	District	Province	MGRS
1	Shooting cases	30	1	2017	12:30 AM	TAK BAI	Nara Thiwat	48 N SM 7639985176
2	Shooting cases	18	1	2017	4:00 AM	KRONG PINANG	Yala	47 N QH 4901712235
3	Shooting cases	9	1	2017	1:00 AM	BANNANG SATA	Pattani	47 N QH 5470854167
4	Arson cases	17	1	2017	3:30 AM	Bannang Sata	Yala	47 N QG 5058387440
5	Arson cases	3	1	2017	2:00 AM	NONG CHIK	Pattani	47 N QH 4390650165
6	Shooting cases	9	1	2017	2:30 AM	SU-NGAI KOLOK	Nara Thiwat	47 N RG 2814466291
7	Arson cases	1	1	2017	5:30 AM	PANARE	Pattani	47 N QH 7295859971

According to the studies of theory and related research, it can conclude that most of the 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, and other factors to determine spatial relationships and to describe patterns in crime density and distribution of each type of crimes.

In addition to the studies of crimes in the areas, many researchers are interested to conduct studies in urban areas, suburbs, or even part of the cities, such as residential areas, modified zones of the cities, and empty spaces in urban areas. The researcher selected the factors affecting the area's physical environment for analysis as follows.

Information collected from 1 January 2017 to 31 December 2020 about the population density, factors related to demographic environment, education, economy and investment by gathering from the National Statistical Office of Thailand, and

related documents, publication and research reports by dividing the study area according to the survey of the Department of Town and Country Planning into 33 districts in the Three border province.

3.2.2 Population density data

Table 4 Example of population data from registration record by Yala District

District	Area (Sq.km.)	Population			
		2017	2018	2019	2020
MUEANG YALA	258.02	169,003	170,205	170,905	171,206
BETONG	1328.00	62,523	62,572	62,643	62,473
BANNANG SATA	629.01	60,477	62,075	62,746	63,017
THAN TO	648.01	24,857	25,134	25,309	25,571
YAHA	500.00	62,259	62,818	63,455	63,819
RAMAN	516.03	94,785	96,049	96,934	97,465
KABANG	451.00	24,282	24,564	24,962	25,272
KRONG PINANG	191.00	28,477	28,909	29,376	29,376

Table 5 Example of population data from registration record by Pattani District

District	Area (Sq.km.)	Population			
		2017	2018	2019	2020
MUEANG PATTANI	96.84	132,628	134,407	136,661	137,690
KHOK PHO	339.41	68,180	68,556	68,840	68,668
NONG CHIK	231.53	79,856	81,437	82,083	81,739
PANARE	144.06	46,336	46,704	47,070	47,183
MAYO	216.14	60,333	60,950	61,619	60,946
THUNG YANG DAENG	114.97	23,983	24,350	24,733	24,966
SAI BURI	178.42	69,844	70,512	70,897	71,135
MAI KAEN	55.20	12,637	12,823	12,947	12,940

Table 5 (Cont.)

District	Area (Sq.km.)	Population			
		2017	2018	2019	2020
YARING	196.83	87,540	88,403	89,208	89,651
YARANG	183.95	89,651	94,244	94,905	94,777
KAPHO	93.82	18,452	18,590	18,817	18,917
MAE LAN	89.19	16,876	16,876	17,324	17,403

Table 6 Example of population data from registration record by Narathiwat District

District	Area (Sq.km.)	Population			
		2017	2018	2019	2020
MUEANG NARATHIWAT	305.12	125,232	126,237	126,858	124,707
TAK BAI	253.45	72,407	72,902	73,388	73,789
BACHO	171.68	54,269	54,782	55,306	55,552
YI NGO	200.50	46,016	46,513	46,819	47,108
RA-NGAE	434.58	92,366	92,892	93,531	93,558
RUESO	468.32	72,116	72,765	73,517	74,003
SI SAKHON	502.87	39,827	40,257	40,775	41,389
WAENG	374.27	53,843	54,262	54,709	54,024
SUKHIRIN	517.00	26,258	26,462	26,462	26,449
SU-NGAI KOLOK	139.43	78,576	79,058	79,167	78,412
SU-NGAI PADI	372.64	56,692	56,968	57,353	55,199
CHANAE	550.00	38,342	38,775	39,071	39,286
CHO-AI RONG	163.00	40,295	40,601	40,893	40,953

Table 7 Example of a Households data from Registration Record by District

Year	Province	District	Households
2017	YALA	MUEANG YALA	58,227
		BETONG	26,130
		BANNANG SATA	17,887
		THAN TO	9,135
		YAHA	14,269
		RAMAN	22,806
		KABANG	6,783
		KRONG PINANG	6,194
2017	PATTANI	MUEANG PATTANI	44,686
		KHOK PHO	20,144
		NONG CHIK	19,852
		PANARE	11,686
		MAYO	13,255
		THUNG YANG DAENG	5,515
		SAI BURI	17,087
		MAI KAEN	3,228
		YARING	19,570
		YARANG	21,651
		MAE LAN	4,251
2017	NARA	MUEANG NARATHIWAT	39,368
	THIWAT	TAK BAI	16,343
		BACHO	12,395
		YI NGO	11,022
		RA-NGAE	21,938
		RUESO	18,425
		SI SAKHON	10,516
		WAENG	12,705
		SUKHIRIN	8,561

Table 7 (Cont.)

Year	Province	District	Households
2017	NARA	SU-NGAI KOLOK	25,319
	THIWAT	SU-NGAI PADI	13,474
		CHANAE	9,183
		CHO-AI RONG	9,310

3.2.3 Educational data

Information collected from 1 January 2017 to 31 December 2020 about the educational institutions, number of students dropout during their studies.

Table 8 Example of a student drop-out of school by important causes and districts: academic year

Year	Province	District	School	Student	Student Drop-out of School
2017	YALA	MUEANG YALA	90	42,688	368
		BETONG	31	12,271	45
		BANNANG SATA	49	14,980	201
		THAN TO	20	4,819	8
		YAHA	45	14,949	76
		RAMAN	71	20,823	406
		KABANG	10	3,957	16
		KRONG PINANG	15	3,348	19
2017	PATTANI	MUEANG PATTANI	53	35,505	2
		KHOK PHO	62	17,451	7
		NONG CHIK	52	14,449	0
		PANARE	35	10,791	0
		MAYO	45	13,171	8

Table 8 (Cont.)

Year	Province	District	School	Student	Student Drop-out of School
		THUNG YANG DAENG	19	7,845	0
		SAI BURI	47	20,720	2
		MAI KAEN	12	2,172	0
		YARING	51	15,571	5
		YARANG	61	19,853	0
		KAPHO	13	1,918	1
		MAE LAN	13	2,110	0
2017	NARA	MUEANG	66	32,939	343
	THIWAT	TAK BAI	38	11,917	0
		BACHO	37	11,253	19
		YI NGO	34	10,300	0
		RA-NGAE	51	21,029	106
		RUESO	55	15,694	99
		SI SAKHON	24	7,606	0
		WAENG	35	11,047	113
		SUKHIRIN	17	4,200	2
		SU-NGAI KOLOK	26	16,766	179
		SU-NGAI PADI	38	8,105	110
		CHANAE	20	6,784	2
		CHO-AI RONG	22	7,691	118
		Total	1,257	444,722	2255

3.2.4 Industrial establishments data

Information collected from 1 January 2017 to 31 December 2020 about Industrial establishments, amount of capital and number of workers.

Table 9 Example of an Industrial Establishment, Capital and Employee by District

Year	Province	District	Industrial establishment	Employee (Person)	Capital (Baht)
2017	YALA	MUEANG YALA	157	4,180	4,351,000,000
		BETONG	57	1,310	2,239,000,000
		BANNANG SATA	13	551	3,175,000,000
		THAN TO	5	20	8,000,000
		YAHA	7	71	48,000,000
		RAMAN	69	564	88,000,000
		KABANG	3	26	7,000,000
		KRONG PINANG	7	22	5,000,000
2017	PATTANI	MUEANG PATTAN	266	6,067	2,256,070,000
		KHOK PHO	135	522	1,018,880,000
		NONG CHIK	72	399	3,243,360,000
		PANARE	74	196	20,240,000
		MAYO	71	224	31,100,000
		THUNG YANG DAENG	6	86	77,270,000
		SAI BURI	39	115	28,210,000
		MAI KAEN	6	19	4,990,000
		YARING	95	337	40,860,000
		YARANG	81	426	66,580,000
		KAPHO	10	24	2,590,000
		MAE LAN	24	44	2,050,000

Table 9 (Cont.)

Year	Province	District	Industrial establishment	Employee (Person)	Capital (Baht)
2017	NARA THIWAT	MUEANG NARATHIWAT	117	1,259	1,347,729,928
		TAK BAI	41	1,171	101,275,000
		BACHO	32	107	8,830,500
		YI NGO	32	321	477,813,817
		RA-NGAE	40	250	97,159,980
		RUESO	28	541	98,154,000
		SI SAKHON	7	19	7,587,000
		WAENG	17	82	329,772,000
		SUKHIRIN	7	18	1,178,000
		SU-NGAI KOLOK	58	639	350,071,320
		SU-NGAI PADI	7	53	8,685,000
		CHANAE	11	151	51,295,000
		CHO-AI RONG	14	58	5,957,000
		Total	1608	19,872	19,598,708,545

3.3 Statistics used in research

3.3.1 Analysis of general data to describe the general characteristics of the studying variables. General data was analyzed by using descriptive statistics, including percentage, and presented in tables, graphs and charts.

3.3.2 Statistical analysis by searching for correlation between variables using correlation coefficient and Multiple Regression Analysis.

3.4 Data analysis

Spatial analysis by studying patterns and characteristics of crimes in areas with high criminal intensity, including consideration of crime rate by types of crime, annual criminal rate, crime rate by time, and representing the analysis in a form of a crime density map.

The analysis process consists of spatial statistical analysis by using Kernel Density, which identifies the occurrence of crime, and calculates the crime frequency to be inputted into the attribute data of administrative areas of the Three southern borders provinces of Thailand, so that the data is obtained prior to identification of areas with high density of crimes.

Step 1: Collect the data at the scenes of interesting criminal cases. The cases should not be so complicated, but they should occur in private places relating to physical environment and have chances to occur with general people. The collected data were plotted as dots in a map through the geographical information system. Apart from collecting the map data, some other additional data relating to each crime scene were also recorded in the GIS databases. These data were date and time of incidences, crime sites, and types of criminal cases etc. These data can be utilized in various aspects for analyzing crime density and dispersion, and they can be classified according to different characteristics.

Step 2: Assess crime density areas of each case by using the Kernel density estimation in the Arc GIS tools. The main layer was determined as the criminal scenes of each case with the point radius of 30 m. The density between points was calculated in every 250 m distance (search radius = 250). The obtained result is the map displaying the density and dispersion of each criminal case together with the minimum, maximum, and average density values.

3.4.1 Kernel density estimation

The technique of Kernel density estimation is a method for analyzing point patterns under the principle of geographical quantitative analysis (Maurizio et al., 2007). In the point-pattern spatial statistics in the geographical information system, the analyzing results are displayed in a raster format, and the method principle is to calculate the radius of each data point before connecting to other points at the set distance of bandwidth to find the density. For example, if the point radius is set at 30 m, the density among every points are calculated at the 250 m. The values of the radius and the distance of the bandwidth for the analysis depend on the users and the matters of the analysis. For example, the crime density analysis need to set the radius value not too much i.e. at about 10 - 100 m in order to use the analyzing results for immediate and direct prevention and correction at a particular area or an area radius. The

bandwidth distance depends on the size of the whole area and it needs to conform to the radius value.

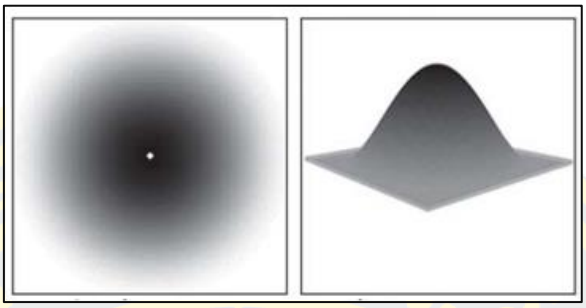


Figure 3 The radius calculation with 1-point Kernel density (Maurizio et al., 2007)

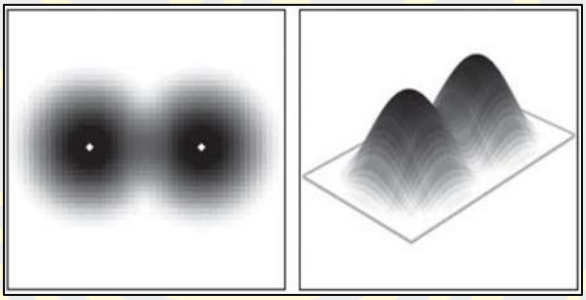


Figure 4 The radius calculation with 2-point Kernel density (Maurizio et al., 2007)

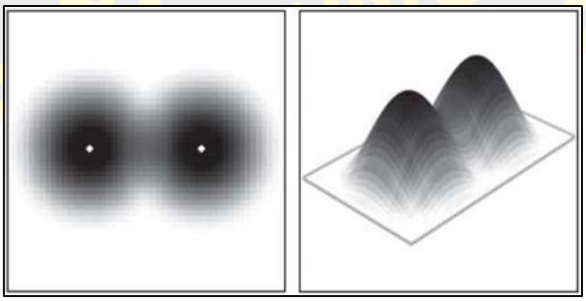


Figure 5 The density calculated from 2 data points with the set (Maurizio et al., 2007)

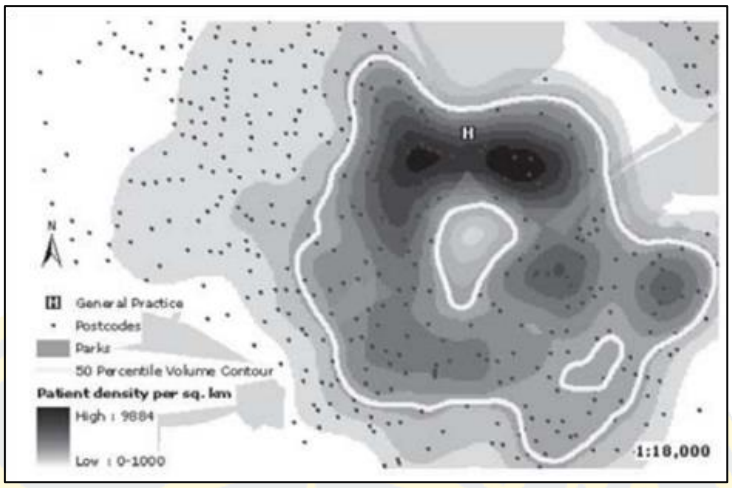


Figure 6 The density calculation of the patients dispersing in the city area in various aspects in Southwark, London by using the method of the Kernel density estimation (Maurizio et al., 2007)

Step 3: Adjust the density base of each criminal case by considering it with Function Raster Calculator in the Arc GIS program by using the formula for converting the density into the same base as shown in Equation 1. The density at 0.00-1.00. Then the criminal density areas were assessed in overview, separation by the criminal types, and separation by daytime and nighttime in the later step.

3.4.2 The conversion standardization of the crime density

In case of the crime density area estimation, the density of every case is considered by using the technique of point dispersion so the Kernel density estimation needs to be adjusted in the density base values to obtain the same bases because each case does not have the same frequency (Yiampisan & Srivanit, 2010). For example, Case A, (Drug cases) has the case frequency at 50 points and Case B, (Shooting cases) has the frequency at 200 points. The density base value of each crime has to be adjusted into the same density value before being used in the crime risk area analysis of all criminal cases. The formula for converting the density value into the same standard is illustrated in Equation 1.

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

Where

D’ij is base density adjustment.

Dij is not adjustment.

D_j^{min} is the minimum density value.

D_j^{max} is the maximum density value.

Step 4: Assess the criminal density areas in overview, separation by the criminal types, and separation by daytime and nighttime in order to facilitate the consideration to find the guidelines for crime prevention and correction. The methods are different according to each case and each period of time in order to obtain the crime density areas and crime mapping.

Step 5: Distribution analysis of crime cases by applying nearest-neighbor analysis (ANN) of the spatial distribution to see how crimes are distributed (dispersed distribution, random distribution or clustered distribution). Distribution of the crimes can be expalined by considering Z-score which has the value between -2.58 and 2.58, where Z-score close to -2.58 means clustered distribution and Z-score close to 2.58 means dispersed distribution.

3.4.3 Analysis of the distribution pattern of the crime scene

For the studies in the area of the Three southern border provinces, the spatial autocorrelation analysis supports the test of crime patterns in the studied areas. The Spatial statistical analysis, divided into 3 forms, describes of the distribution of things on Earth as 1) the clustered pattern; 2) the random pattern; and 3) dispersed pattern. Applying mathematical and statistical methods to describe the distribution characteristics in this study, data for analysis of the distribution characteristics of the violent points in the Three southern border provinces of Thailand were collected from 1 January 2017 to 31 December 2020. The Average Nearest Neighbour Index was calculated by the following equation 2:

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

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

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.

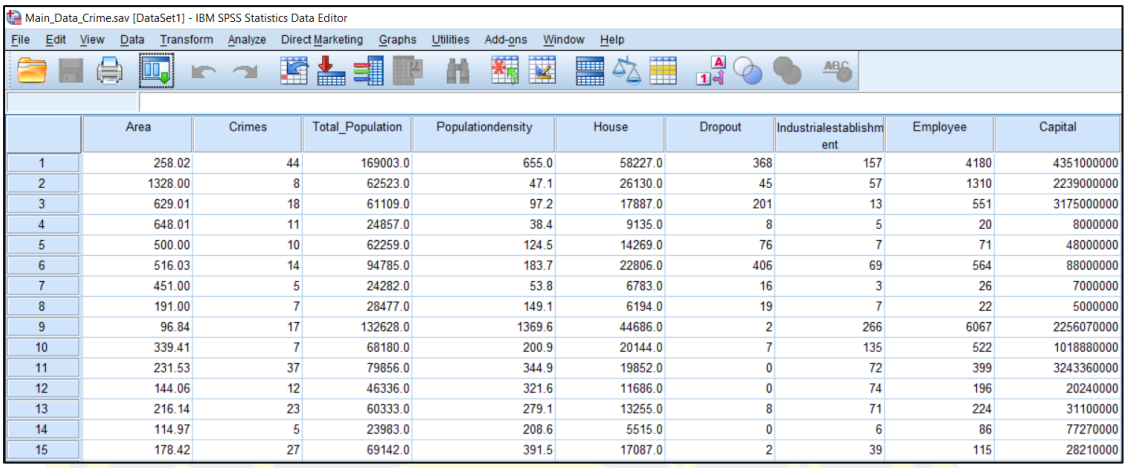
The results of the calculations show that the averages near to two crime scenes were clustered pattern. The results of the calculations show that the averages near to one crime scene were random pattern, or each area had a different distribution of points.

Step 6: In the multiple regression analysis, the relationship of criminal incidents and disorders in Three southern provinces were determined from the factors in physical environment, educational environment. The statistical analysis using SPSS for Windows to find the relationship among variables according to 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.

1) Population density and residential density in the study area

2) Educational institutions, number of students dropped out during their studies

3) Industrial establishments, amount of capital and number of workers


Main_Data_Crime.sav [DataSet1] - IBM SPSS Statistics Data Editor

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	Area	Crimes	Total_Population	Populationdensity	House	Dropout	Industrialestablishment	Employee	Capital
1	258.02	44	169003.0	655.0	58227.0	368	157	4180	4351000000
2	1328.00	8	62523.0	47.1	26130.0	45	57	1310	2239000000
3	629.01	18	61109.0	97.2	17887.0	201	13	551	3175000000
4	648.01	11	24857.0	38.4	9135.0	8	5	20	8000000
5	500.00	10	62259.0	124.5	14269.0	76	7	71	48000000
6	516.03	14	94785.0	183.7	22806.0	406	69	564	88000000
7	451.00	5	24282.0	53.8	6783.0	16	3	26	7000000
8	191.00	7	28477.0	149.1	6194.0	19	7	22	5000000
9	96.84	17	132628.0	1369.6	44686.0	2	266	6067	2256070000
10	339.41	7	68180.0	200.9	20144.0	7	135	522	1018880000
11	231.53	37	79856.0	344.9	19852.0	0	72	399	3243360000
12	144.06	12	46336.0	321.6	11686.0	0	74	196	20240000
13	216.14	23	60333.0	279.1	13255.0	8	71	224	31100000
14	114.97	5	23983.0	208.6	5515.0	0	6	86	77270000
15	178.42	27	69142.0	391.5	17087.0	2	39	115	28210000

Figure 7 The variables data set from SPSS

Before Multiple Regression Analysis, it is necessary to verify preliminary agreement that the independent variables are not in a very high degree of correlation, or namely "Multicollinearity." If the independent variables have a very high correlation, it leads that the relationship between the independent variables and the dependent variables obtained from the multiple regression analysis has an error from reality.

Therefore, the conclusion of this hypothesis testing is inaccuracy. Due to the reasons mentioned above, it is required to test "Multicollinearity" with every independent variable before Multiple Regression Analysis. The two ways for Multicollinearity are the following:

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.

Step 7: Analyze the potential to accessibility of police stations.

3.4.3 Two Step Floating Catchment Area

2SFCA is a method that was created by (Luo & Wang, 2003), to measure health care accessibility. The method has been going through several enhancements. Together, they are forming a Floating Catchment Area Methodology Family.

For the Two-Step Floating Catchment Area (2SFCA) mean is the specific case of a model in spatial relation improved to compute the spatial accessibility of service area. In addition to have vary of the advantages in a gravity model, the 2SFCA method is important to be interpreted because it essentially uses a special form of crime ratio. It is easily to complete in a GIS phenomenon (Soontorn & HONG, 2020). The 2SFCA method measures spatial accessibility like the ratio of police stations and crime cases combination of two steps:

$$R_j = \frac{S_j}{\sum_{k\epsilon\{d_{kj}\leq d_0\}} P_k} \quad (3)$$

This method focused on the catchment area and common that consists of 2 steps. For the first step, the ratio between demand and supply (R**j**) is calculated at each location of a Police stations (**j**) within the critical travel time (t) is calculated. It is calculated by dividing a number of supplies (S**j**).

$$A_i^F = \sum_{j\epsilon\{d_{ij}\leq d_0\}}$$

$$R_j = \sum_{j\epsilon\{d_{ij}\leq d_0\}} \frac{S_j}{\sum_{k\epsilon\{d_{kj}\leq d_0\}} P_k} \quad (4)$$

The second step, the accessibility of police stations (A **i**) and service opportunities per police station are calculated as the summary of the supply and demand ratio (R**j**) for all facilities that can be reached within the critical travel time by crime cases to make dicision for the accessibility (demand) index (Soontorn & HONG, 2020). The 2SFCA produces a spatial accessibility. The way to calculate is as follows:

1) The basic Floating Catchment Area method use to calculates accessibility from the demand (crime density) and supplier (Police stations).

Approached by buffer in specific distance which was 10 km. from the police stations by the following equation 5.

2) Analysis of the mean radius of the crime scene surrounding the checkpoints and police stations in the area (Near Distance).

Another type of spatial data analysis principle, another popular technique, is the function to find the neighborhood (closeness) of an object, which is in the group "Neighborhood function" type. Such a function not only answers the question of where it is but also reports whether something is close to the target object. Neighborhood function technique is composed of 1) Proximity computation; 2) Spread computation; and 3) Seek computation. In this current study, only Proximity computation was applied to analyze the average radius of the crime scenes that occurred around the checkpoints and police stations.

The well-known method of calculating Proximity computation is for creating buffer areas which are areas around the spatial data representative (points, lines, and territories) with a specified distance. The results are new data layer to show a distance away from the specified characteristics. Find the average distance (Near Distance) by the following equation:

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \quad (5)$$

Where

X_1 is the horizontal coordinate (along the x axis) of point 1.

X_2 is the horizontal coordinate (along the x axis) of point 2.

Y_1 is the vertical coordinate (along the y axis) of point 1.

Y_2 is the vertical coordinate (along the y axis) of point 2.

Analysis the previously and computed a police stations provider to crime cases ratio. Then compute the accessibility index by summing up all crime cases to police stations ratios.

Therefore, the crime and police station data are calculated in the 2SFCA form by using the formula as in equation (3) to find several police stations. Then, the demand in the police station is used for finding the efficiency to support several events and the classification by using the formula along with the equation (4) which is going to be the ratio of demand and supply crime mapping.

Step 8: Write the recommendation and suggestion for the government officers in prevention or reduction of criminal risks. It leads to effective prevention measures to reduce crime incidence in the specific area of the Three southern border provinces in Thailand.

CHAPTER 4
EXPERIMENTS AND RESULTS

According to the research results on Spatial Analysis of Crime in Three Provinces, Southern Thailand: hotspot, factors, and accessibility. The results divided into 4 parts was as follows:

4.1 Spatial data analysis

4.2 Fundamental data analysis

4.3 Statistical analysis

4.4 Spatial accessibility analysis

4.1 Spatial data analysis

The study of crimes can be considered from density and distribution of the accident site and can be classified in accordance to their characteristics, such as the nature of the crime. Also, crime cases can be broken down into hourly, daily, weekly, monthly or yearly intervals in order to compare, analyze, correlate, and use them in decision-making in planning and preventing future crimes. According to the present study to analyze crimes using Kernel Density Estimation technique with Geographic Information System in the area of the Three southern border provinces, here the results of the data analysis were as follows:

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

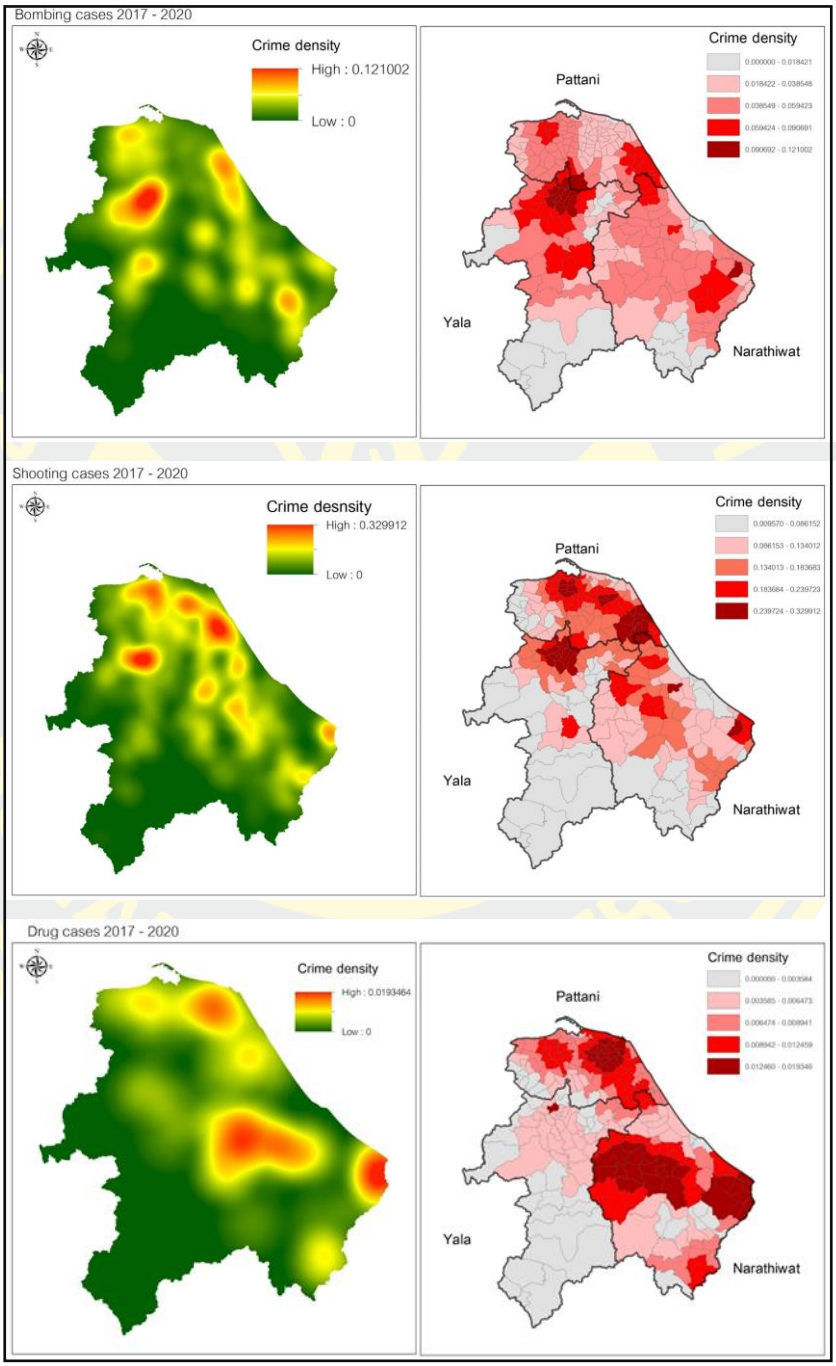

Figure 8 Crime scene and density of crimes classified by each type of crimes between 2017-2020

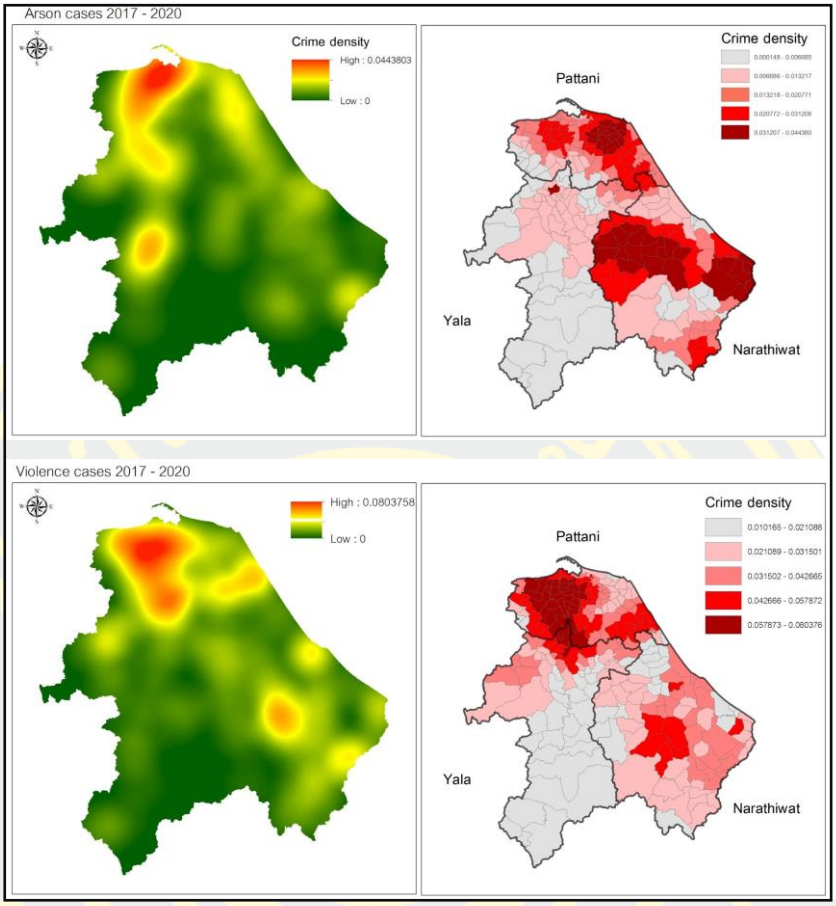

Figure 8 (Cont.)

4.1.1.1 Bombing cases.

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.

4.1.1.2 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.

4.1.1.3 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.

4.1.1.4 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.

4.1.1.5 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 sa-ngo 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.

The distribution pattern of all crime types was created using the Average Nearest Neighbor (ANN) method to calculate the distribution. As shown below, the distribution of the points is clustered pattern.

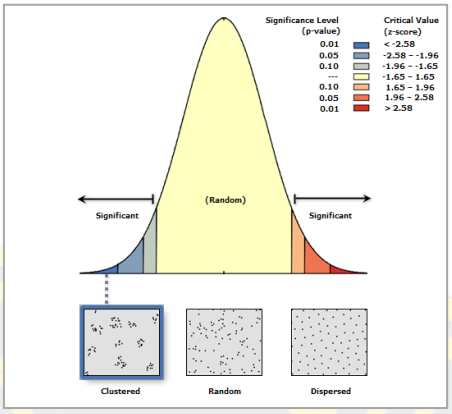

Figure 9 The result from Average Nearest Neighbor (ANN) method

4.1.2 Consideration of the density of crime cases classified by year

To measure the distribution and identify the density of the crime scenes, the principle is calculation of the distance between each crime scene which is used to determine the density. Then the density was adjusted to be in the same range which is range 0.00-1.00 (as shown in equation 1) because the crime rate of each type of crimes was different frequency. After that, the adjusted density was evaluated to determine areas with high density of crimes and was classified in accordance to time of each year.

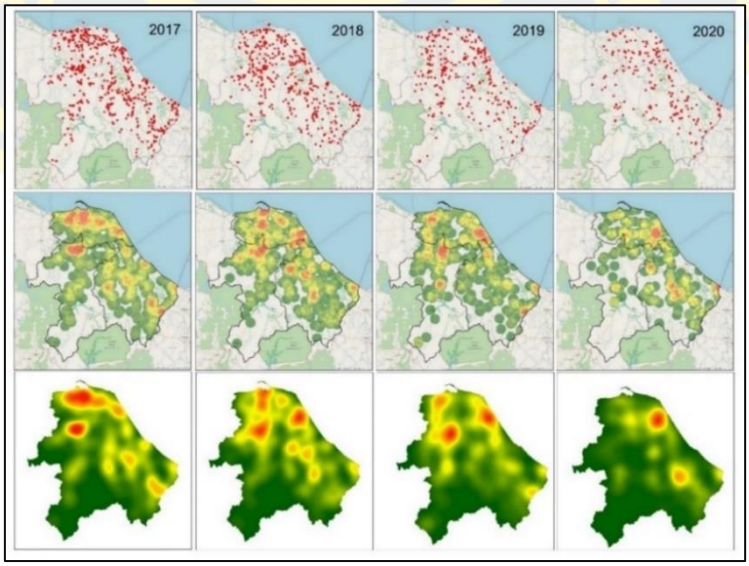

Figure 10 Crime scene and total crime density between 2017 -2020

Table 10 The top three crime scenes of the average highest crime density in the Three southern border provinces

Year	no.	Province	District	The maximum density
2017	1	Yala	Mueng Yala	1.0000
	2	Pattani	Yarang	0.9217
	3	Pattani	Mueng Pattani	0.9048
2018	1	Pattani	Sai Buri	1.0003
	2	Yala	Mueng Yala	0.9700
	3	Pattani	Kaphao	0.9564
2019	1	Yala	Mueng Yala	1.0003
	2	Pattani	Sai Buri	0.9969
	3	Pattani	Yarang	0.9173
2020	1	Pattani	Sai Buri	1.0005
	2	Pattani	Kapho	0.9852
	3	Pattani	Thung yang deang	0.8891

When total crimes between 2017 to 2020 were considered Figure 10, the density of crime scenes was different in each year. For instance, in 2017 and 2019, the average highest density of the total crimes was in Mueang Yala District, Yala Province. On the other hand, in 2018 and 2020, the average highest density of the total crimes was in Sai buri District, Pattani Province. Overall, the average crime density was mostly concentrated in Mueang Yala District, Yala Province, and Sai buri District, Pattani Province, shown in (Table 10). Furthermore, in 2020 the trend of violent crime has decreased.

4.1.3 Consideration of the pattern and density of crime cases classified by the time

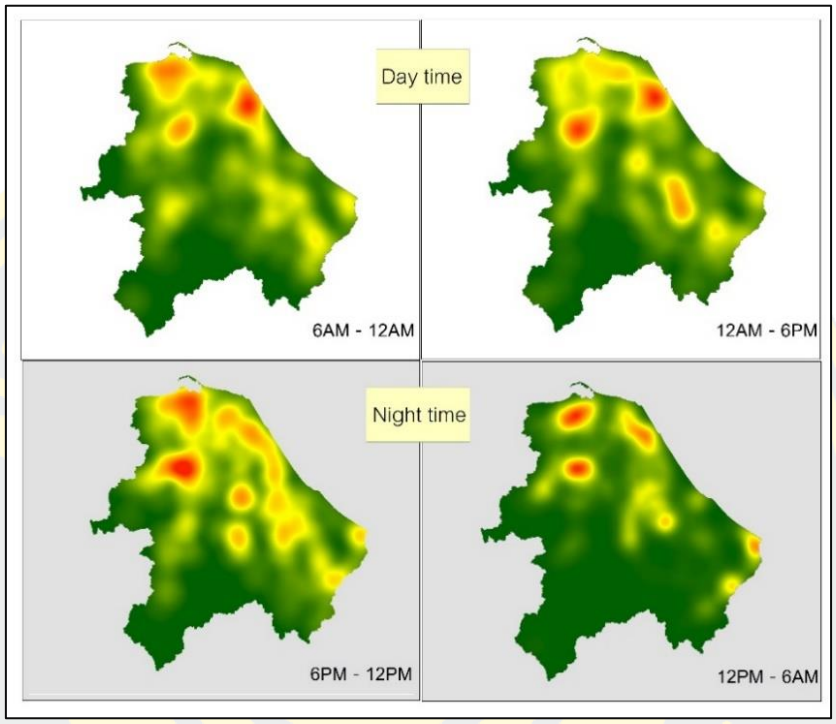

Figure 11 Crime scene and crime density classified by 6-hour intervals

When total crimes separated into every 6 hours were considered Figure 11, the results demonstrate that the time of the highest density of crimes was between 6 to 12 p.m., and the density of crime scenes between 6 to 12 p.m. was higher than that between daytime. Compared to other time, the lowest density of the total crimes was between > 12 p.m. to 06 a.m.

4.2 Fundamental data analysis

4.2.1 Crimes in the Three southern border provinces during 2017-2020

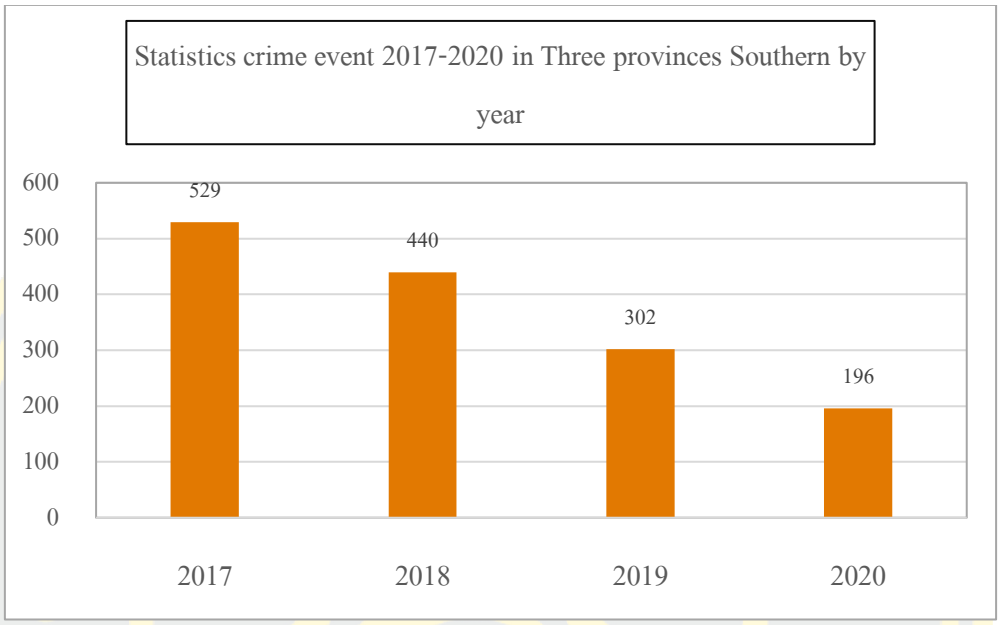

Figure 12 Statistics crime event by year

Figure 12 shows crimes the Three southern border provinces during 2017-2020. It was found that the year with the highest incidents was 2017 (529 cases accounted for 36.1 percent), followed by 2018 (440 cases accounted the for 30.0 percent) and 2019 (302 cases accounted for 20.6 percent) respectively. The year with the lowest incidents was 2020 which had 196 cases accounted for 13.4 percent.

4.2.2 Types of crimes during 2017-2020

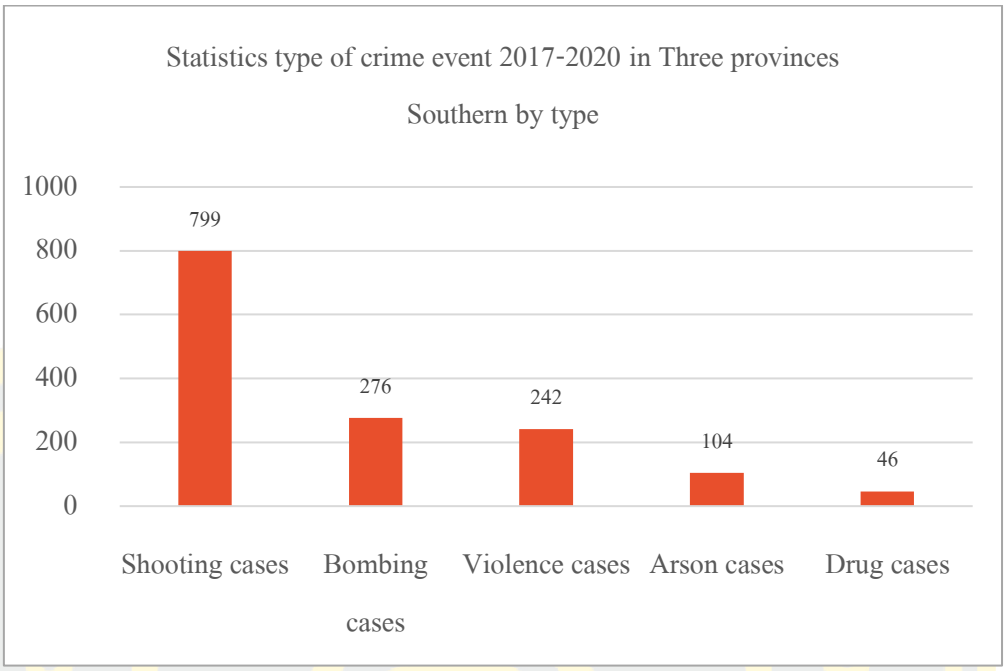

Figure 13 Statistics type of crime event by type

Figure 13 shows crimes in the Three southern border provinces during 2017-2020 categorized by types of crimes. 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. The type of crime with the lowest crime rates was drug which had 46 cases accounted for 3.1 percent.

4.2.3 Time of day of crimes during 2017-2020

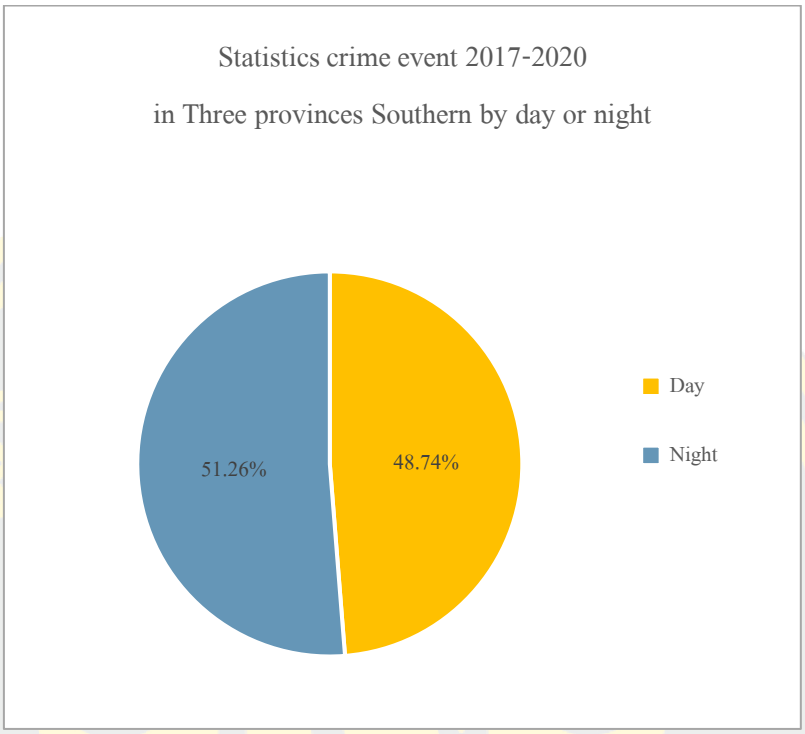

Figure 14 Statistics crime event by day or night

From Figure 14 presenting crimes in the Three southern border provinces during 2017-2020 classified by time (day or night), nighttime crimes were more frequent than during daytime. More specifically, there were 752 crimes during nighttime which accounted for 51.26 percent, where there were 715 crimes during daytime which accounted for 48.74 percent.

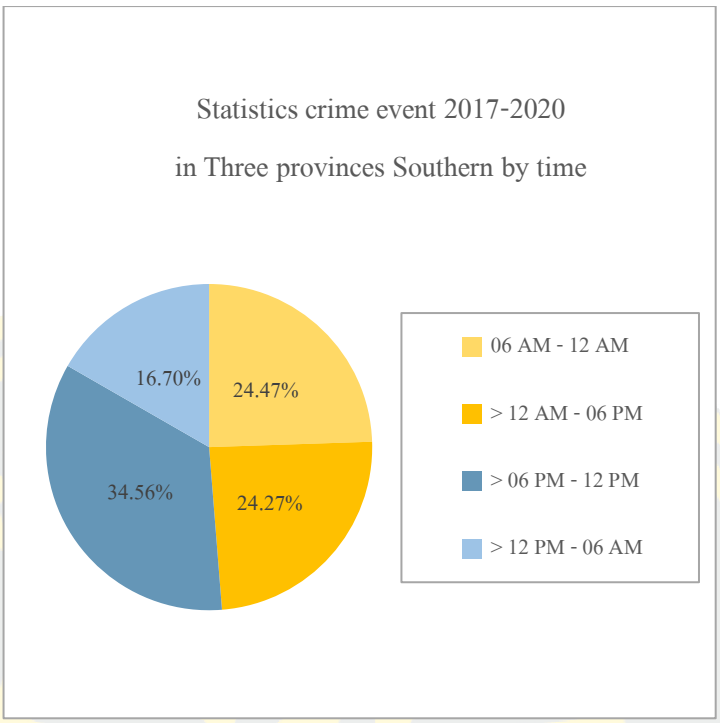

Figure 15 Statistics crime event by time

When considered crimes in the Three southern border provinces during 2017-2020 divided into four periods of time as follows:

1) Daytime: 6.00 AM - 12.00 PM and 12.00 PM - 6.00 PM
2) Nighttime: 6.00 PM - 12.00 AM and 12.00 AM - 6.00 AM

The information was derived as shown in Figure 15. From Figure 16 which presents crimes in the Three southern border provinces during 2017-2020 classified by time, the duration with highest incident rates was 6.00 PM - 12.00 AM (507 cases accounted for 34.6 percent), followed by 6.00 AM - 12.00 PM (359 cases accounted for 24.5 percent) and 12.00 PM - 6.00 PM (356 cases accounted for 24.3 percent) respectively. The duration with the lowest incident rates was 12.00 AM - 6.00 AM which had 245 cases accounted for 16.7 percent.

4.2.4 Locations of crimes during 2017-2020

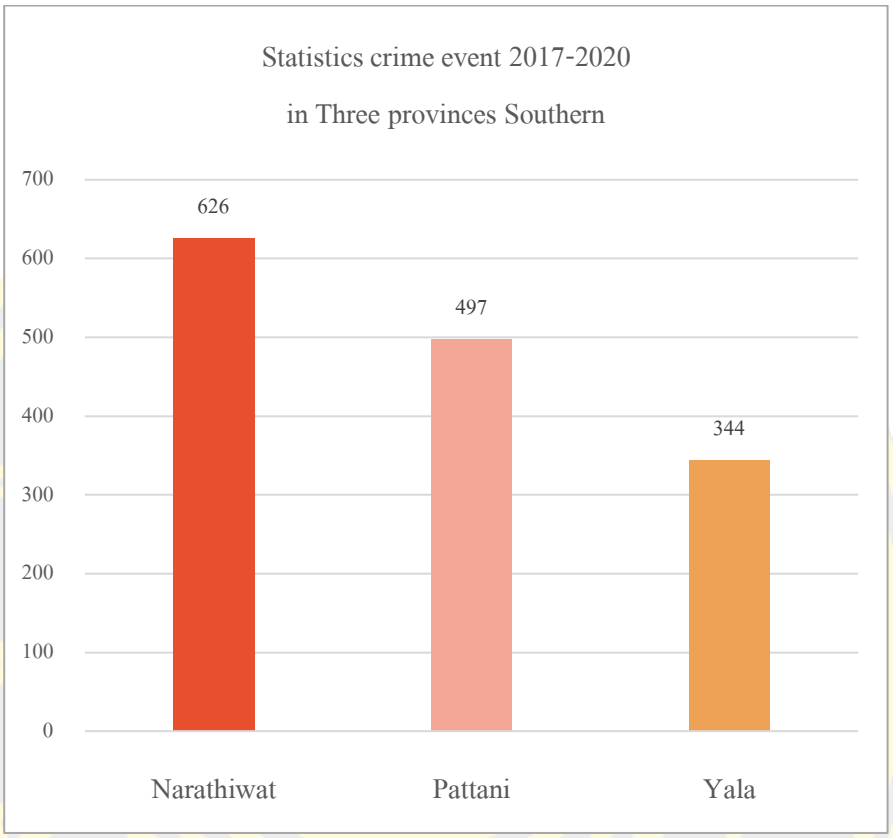

Figure 16 Statistics crime event 2017-2020 in Three provinces Southern

From Figure 16 showing crimes in the Three southern border provinces during 2017-2020 classified by provinces, the provide with highest incidents was Narathiwat (626 cases accounted for 42.7 percent), followed by Pattani (497 cases accounted for 33.9 percent) and Yala (334 cases accounted for 23.4 percent). When considered the crimes in the area of Narathiwat which was the province with the highest crime incidents, we knew more about crimes classified by districts as shown in Figure 17.

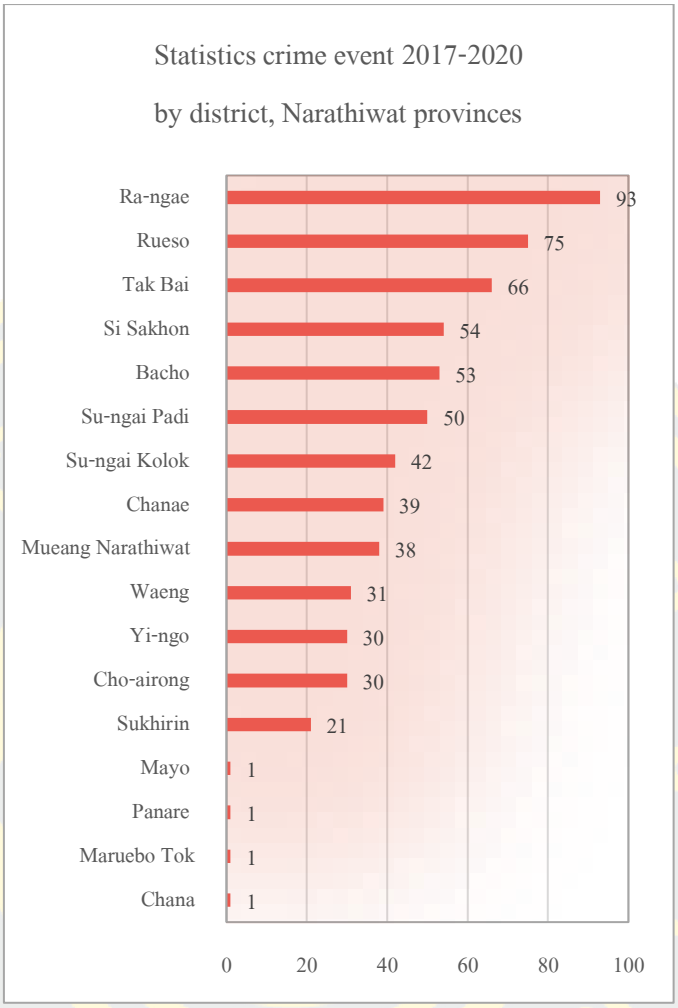

Figure 17 Statistics crime event 2017-2020 by District, Narathiwat provinces

Referred to Figure 17 depicting classification of crimes in Narathiwat Province by districts during 20170-2020, it was found that the district with the highest crime rates was Ra-ngae (93 cases accounted for 14.9 percent), followed by Rueso (75 cases accounted for 12.0), Tak Bai (66 cases accounted for 10.5 percent), Si Sakhon (54 cases accounted for 8.6 percent), Bacho (53 cases accounted for 8.5 percent), Su-ngai Padi (50 cases accounted for 8.0 percent), Su-ngai Kolok (42 cases accounted for 6.7 percent), Chanae (39 cases accounted for 6.2 percent), Mueang Narathiwat (38 cases accounted for 6.1 percent), Waeng (31 cases accounted for 5.0 percent), Cho-airing (30 cases accounted for 4.8 percent), Yi-ngo (30 cases accounted for 4.8 percent), and Sukhirin (21 cases accounted for 3.4 percent) respectively. The district with the

lowest crime rates was Chana, Maruebo Tok, Panare and Mayo which had 1 case (accounted for 0.2 percent) each.

When compared the types of crimes in the Three southern border provinces each year, province and time, the results were as follows.

4.2.5 Comparison of types of crimes each year

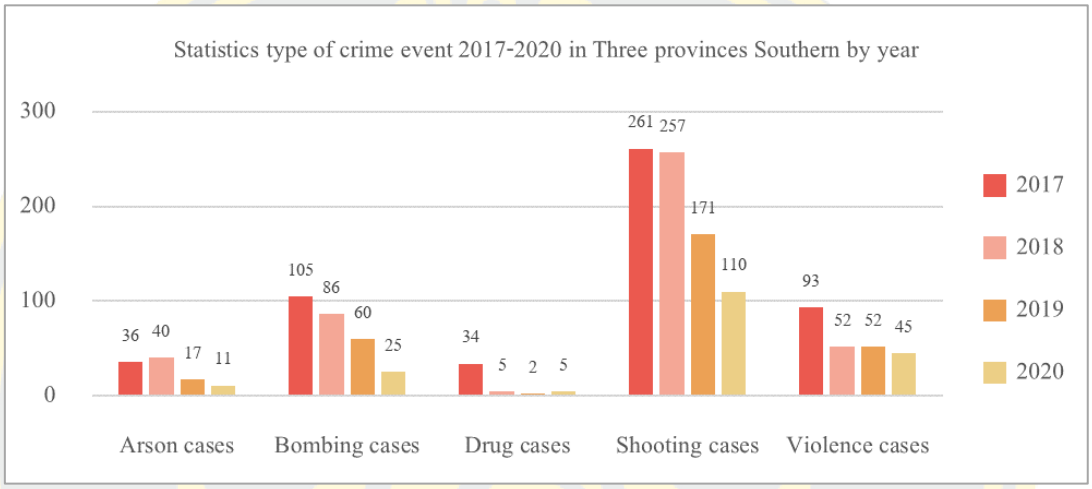

Figure 18 Statistics type of crime event by year

Figure 18 shows comparison of types of crimes in the Three southern border provinces each year. It was found that the crime rate of arson case was highest in 2018 (40 cases accounted for 38.5 percent), crime rate of bombing cases was highest in 2017 (105 cases accounted for 38.0 percent), crime rate of drug cases was highest in 2017 (34 cases accounted for 73.9 percent), crime rate of shooting cases was highest in 2017 (261 cases accounted for 32.7 percent), and crime rate of violence cases was highest in 2017 (93 cases accounted for 38.4 percent).

4.2.6 Comparison of crimes by provinces

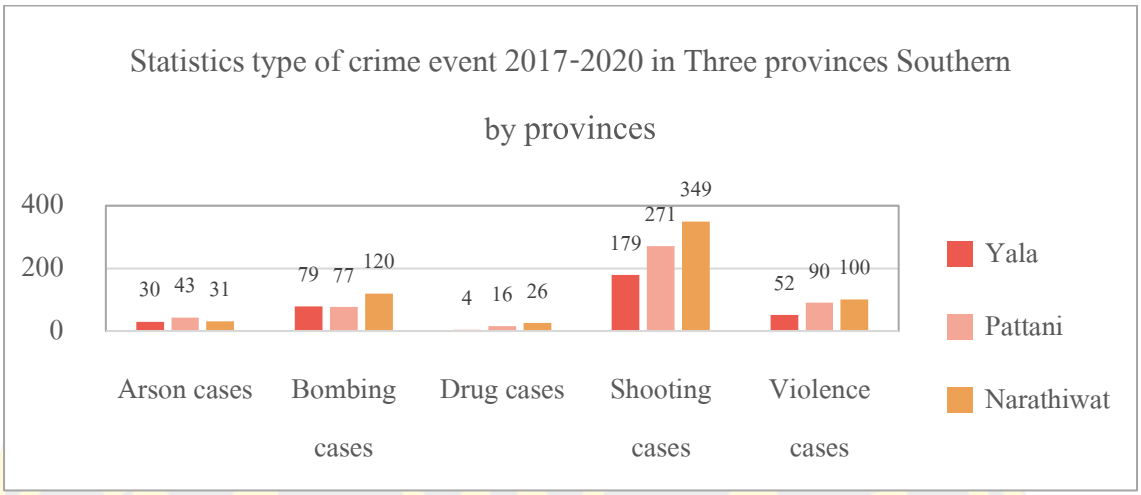

Figure 19 Statistics type of crime event by provinces

Figure 19 shows comparison of types of crimes in the Three southern border provinces by provinces. It was shown that the crime rate of arson case was highest in Pattani Province (43 cases accounted for 41.3 percent), crime rate of bombing cases was highest in Narathiwat Province (120 cases accounted for 43.5 percent), crime rate of drug cases was highest in Narathiwat Province (26 cases accounted for 56.5 percent), crime rate of shooting cases was highest in Narathiwat (349 cases accounted for 43.7 percent), crime rate of violence cases was highest in Narathiwat Province (100 cases accounted for 41.3 percent).

4.2.7 Comparison of types of crimes by times

Type	Time				
	Day		Night		Total
	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**
Total	**359**	**356**	**507**	**245**	**1467**

Figure 20 Statistics type of crime event 2017-2020 by time

Regarding to Figure 20 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).

4.3 Statistical analysis

Multiple Regression Analysis to study the factors affecting the number of crimes in the Three southern border provinces. The statistics chosen for hypothesis testing is Multiple Regression Analysis using SPSS software for Windows.

Before Multiple Regression Analysis, it is necessary to verify preliminary agreement that the independent variables are not in a very high degree of correlation, or namely "Multicollinearity." If the independent variables have a very high correlation, it leads that the relationship between the independent variables and the dependent variables obtained from the multiple regression analysis has an error from reality.

Therefore, the conclusion of this hypothesis testing is inaccuracy. Due to the reasons mentioned above, it is required to test "Multicollinearity" with every independent variable before Multiple Regression Analysis. The two ways for Multicollinearity are the following.

4.3.1 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.

4.3.2 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 11 Results of the correlation analysis between factors affecting the number of crimes in the Three southern border provinces

	Crime	**Area**	**Population**	**Population Density**	**Household**	**Student Drop out**	**Industrial Establish-ment**	**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	0.957***	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***	0.814***	0.825***	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

Note * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Table 12 The first inspection of Variance Inflation Factor (VIF) values and Tolerance values with eight independent factors

Independent factors	Tolerance	VIF
Area	0.371	2.694
Total Population	**0.051**	**19.665**
Population Density	**0.106**	**9.405**
Household	**0.032**	**30.805**
Student Drop out	0.665	1.503
Industrial Establishment	0.318	3.142
Employee	**0.086**	**11.617**
Capital	0.387	2.584

According to Table 12, the correlation analysis between factors affecting the number of crimes in the Three southern border provinces suggests independent variables with a high correlation above 0.8, such as 1) population, 2) population density, 3) the number of households, and 4) the number of employees. These factors are therefore considered to be Multicollinearity. In addition, When the four factors were considered together with Variance Inflation Factor (VIF) values and Tolerance values from Table 2, Variance Inflation Factor (VIF) values and the Tolerance values of these four factors were more than 5.000 and below 0.200, respectively. Based on these results, the summary is 1) population, 2) population-density, 3) the number of households, and 4) the number of employees having a very high correlation and multicollinearity.

As a result, Therefore, some factors have to be excluded from Multiple Regression Analysis before be testing the hypothesis. The excluded variable was the number of employees because it has a high correlation with both the population density and the number of households. It is also a relatively low correlation with the number of crimes.

Table 13 The second inspection of Variance Inflation Factor (VIF) values and Tolerance values with seven independent factors

Independent factors	Tolerance	VIF
Area	0.426	2.345
Total Population	**0.065**	**15.412**
Population Density	0.213	4.691
Household	**0.041**	**24.239**
Student Drop out	0.694	1.441
Industrial Establishment	0.363	2.756
Capital	0.436	2.295

Based on the second inspection of Variance Inflation Factor (VIF) values and Tolerance values when the number of crimes was eliminated from Multiple Regression Analysis, the results show that Variance Inflation Factor (VIF) values were high than 0.500, while Tolerance values of population and the number of households were below 0.200 (Table 3). In accordance to these values, the results indicate that these factors had a high degree of correlation and Multicollinearity; consequently, any factors had to be removed.

When Variance Inflation Factor (VIF) values and Tolerance values of population and the number of households were evaluated, values of the number of households were higher. Moreover, the number of households had a lower correlation with the number of crimes than the population, so the number of households was omitted from the next step of Multiple Regression Analysis.

Table 14 The third inspection of Variance Inflation Factor (VIF) values and Tolerance values with six independent 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

In Table 14, when the number of households and the number of employees were deleted from Multiple Regression Analysis, the maximum Variance Inflation Factor (VIF) was 3.440, which was less than 0.500. On the other hand, the minimum Tolerance value was 0.259, which was higher than 0.200; therefore, it can be concluded that the independent variables were not correlated too high or did have Multicollinearity.

Table 15 Results of Multiple Regression Analysis of factors affecting the number of crimes in the Three southern border provinces

Model	Unstandardized Coefficients		Standardized Coefficients	t	p-value
	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	0.0000	0.000	-0.122	-1.345	0.181

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

According to results of Multiple Regression Analysis using Enter's technique Table 15 for testing hypothesis, five independent factors, such as 1) province area size, 2) population, 3) population density, 4) the number of students who drop out from schools, 5) the number of industrial establishments in the area. can predict the number of crimes in the Three southern border provinces were statistically significant at the 0.05 level. On the other hand, the amount of investment (Capital) was unable to predict the number of crimes in the Three southern border provinces with statistical significance.

When every independent variable was bought into predictable equation, the multiple correlation coefficient (R) was 0.392, and Adjusted R Square was 0.362. On the other words, it can predict 36.2%. In summary, it can forecast the number of crimes in the Three southern border provinces at 36.2 in accordance to five factors, while the rest percentages may originate from other factors.

The highest factor could predict the number of crimes in the Three southernmost provinces was the population, followed by population density, the number of industrial establishments in the area, 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.

The results can be concluded that if other factors remained constant, and 1 increasing unit of the population, and the number of industrial establishments in the area, the increasing numbers of crimes in the area were 0.812, and 0.409 units, respectively. On the other hand, if other factors remained constant, and 1 increasing unit of province area size, population density, and the number of students who quitted from schools, the decreasing numbers of crimes in the area were 0.280, 0.626, 0.183 units, respectively.

4.4 Spatial accessibility analysis

4.4.1 The Demand and supply index

In almost all Floating Catchment Area methods research, Network Analyst is used. Network Analyst is an ESRI ArcGIS extension that computes driving distance. This driving distance creates the catchment area as described in the research papers. Obtaining this Network Analyst extension could be easy, but for this study, obtaining the road network is difficult. In addition, running Network Analyst could be difficult. So, to demonstrate how to perform these steps, we simply use Buffer instead of the Network Analyst polygon. By (Luo & Wang, 2003) applied 2SFCA methodology, obtaining Accessibility Index scores. This index determined how well the police stations could provide enough resources to the crime cases, around the police stations with 10 km buffer.

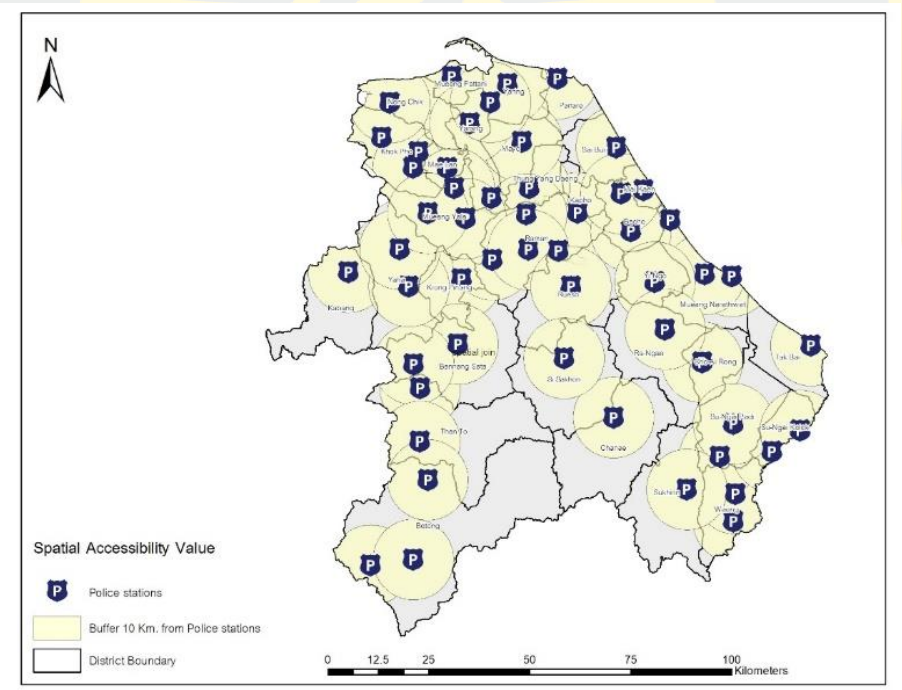

Figure 21 The police stations were buffered 10 km.

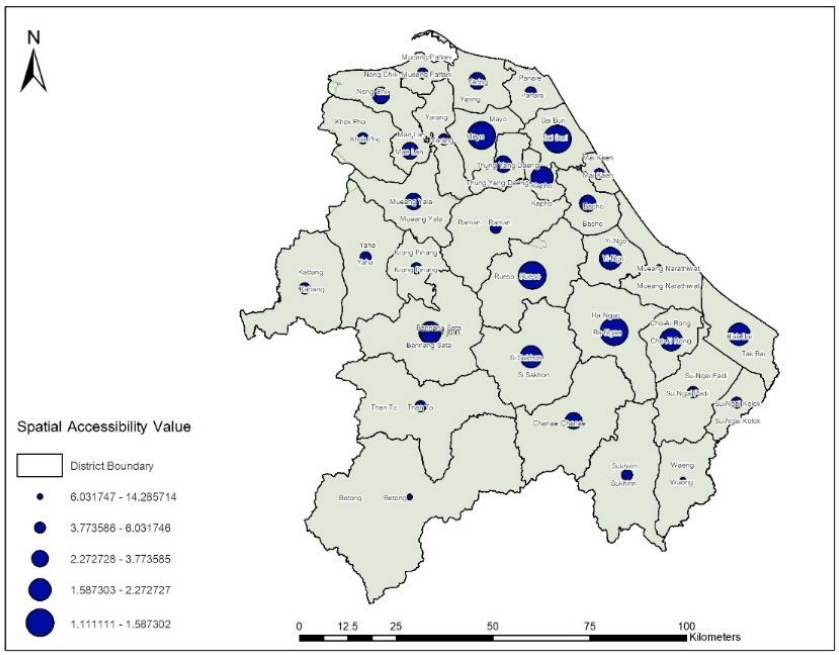

Figure 22 The demand and supply classified with sizes of symbol

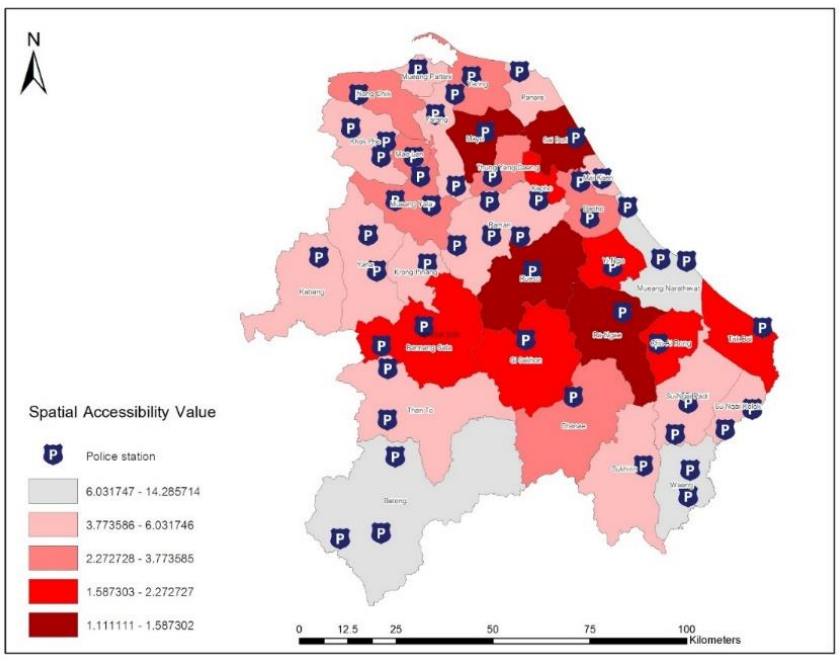

Figure 23 The demand and supply spatial accessibility index

The results of combination between the catchment area of the first step and the second step to calculate the spatial accessibility of police stations in Three province southern Thailand. As show the overall spatial accessibility of police stations in Three Provinces in Southern Thailand is unequaly distributed and concentrated. The inequality in overall accessibility is huge due to the concentrated distribution of police stations. For facilities at higher levels, the average accessibility of index is higher coherently.

The accessibility index of police stations and checkpoints on criminal incidents, the police station which should highly servient to cope with crimes in the area, Table16 was Mueang Pattani Police Station in Pattani Province, followed by Ra-ngae Police Station in Narathiwat, Ma Yor Police Station in Pattani Province, and Reuso Police Station in Narathiwat respectively. This is due to high criminal density in the responsible areas and criminal distribution in the areas beyond the responsible areas at 10-km radius position from the police stations and checkpoints.

Table 16 The Accessibility index scores with 2SFCA in each police station

District	Police stations	Accessibility index
Pattani	Sai Buri Provincial Police Station	1.111111
Narathiwat	Rangae Provincial Police station	1.333333
Pattani	Mayo Provincial Police Station	1.428571
Narathiwat	Ruso Provincial Police station	1.587302
Narathiwat	Tak Bai Provincial Police station	2.083333
Narathiwat	Yi-Ngo Provincial Police station	2.083333
Yala	Bannang Sata Provincial police station	2.12766
Narathiwat	Cho ai rong Provincial police station	2.12766
Pattani	Kapho Provincial Police Station	2.222222
Narathiwat	Srisakon Provincial Police station	2.272727
Pattani	Tuyong Provincial Police Station	2.663139
Pattani	Mae Lan Provincial Police Station	2.749719
Yala	Tase Provincial police station	2.970297

Table 16 (Cont.)

District	Police stations	Accessibility index
Pattani	Yaring Provincial Police Station	2.985075
Pattani	Thung Yang Daeng Provincial Police Station	3.08642
Narathiwat	Chanae Provincial police station	3.448276
Narathiwat	Bacho Provincial police station	3.773585
Yala	Yaha Provincial police station	4.166667
Yala	Kabang Provincial police station	4.166667
Narathiwat	sungaikolok Provincial Police station	4.166667
Narathiwat	Sako Provincial Police station	4.166667
Pattani	Mueang Pattani Provincial Police Station	4.219643
Yala	Krong Pinang Provincial police station	4.305556
Narathiwat	Sukhirin Provincial Police station	4.347826
Pattani	Khok Pho Provincial Police Station	4.369748
Pattani	Bansarong Provincial Police Station	4.446889
Pattani	Mai Kaen Provincial Police Station	4.75229
Yala	Than To Provincial police station	5.157963
Pattani	Panare Provincial Police Station	5.687777
Yala	Jagua Provincial police station	6.031746
Narathiwat	khokkian Provincial police station	7.773585
Narathiwat	Buketa Provincial police station	8.695652
Yala	Betong Provincial police station	14.285714

CHAPTER 5
DICUSSION AND CONCLUSION

5.1 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 these 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 Trarde'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.

5.2 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.

5.3 Recommendation

Although we cannot say that the physical environment factor has direct effects on criminal cases, it is a latent factor which cause suitable situations facilitating crimes. This factor can be studied for planning criminal prevention and suppression in the area. Although the study may have some limitations, especially from the data collection about criminal statistics and study of various environmental factors, the recommendation is given as follows.

The study should be scoped in a small scale for studying more details than in a large scale. The study should include physical aspects of different areas since each area consists of particular internal components in relation to wrong-behavioral aspects and crimes. Accordingly, studying in a small area can cover more different factors than studying in a large area.

It is necessary to give importance on other factors such as societies, communities, lifestyles, cultures, or religions. These factors may support troublemakers' resistance to be stronger in the southern border provinces, and they are cited by (Ninsri, 2014) as a remarkable conflict factor. In fact, 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.

Regarding data collection, the criminal data in this study are obtained from the government agencies so they are screened and examined as the real cases. In fact, there may be some unrecorded cases due to compromise between victims and criminals. This is one limitation of the present study because the data of some cases are missing.

To find the criminal trend in the area, the study period should be longer such as for 10 - 30 years to depict changes and movements in a clearer way.

The study results can be expanded by using them as criminal databases or guidelines for studying other types of criminal incidents by creating criminal maps used as guidelines for criminal surveillance and prevention in risk areas.

5.4 Recommendation for the government

Recommendation for the government officers in prevention or reduction of criminal risks.

Management: Management should be on accessing criminal data since data retrieval from the center takes a lot of time and faces problems of data traffic. It is necessary to plan on data mapping, criminal data, other relating data, and rights to access data according to operation needs of the police officers at each police station and relating agencies.

Development of Various Application Programs: Application programs should be developed specifically for security mission and crime management in Three southern border provinces. These applications should facilitate the agencies on criminal mapping from different criminal data ranging from crime analysis, criminal mapping in various forms, mapping with display of important places or spots in responsible areas, to uses of criminal maps for public relation to inform general people about criminal conditions.

Ready-made information in web portal can be used for linking map data to criminal cases, and setting guidelines for criminal surveillance and prevention in areas with high crimes in order for people, users, or relating officers to access the information timely, thoroughly, and quickly. In addition, the police station can manage police forces for more surveillance and risk assessment at particular areas to reduce criminal rate.

Personnel: Personnel should be prepared to support knowledge and technology of criminal mapping. They should be trained and developed to be skillful in operation as well as to be supported for career path as building motivation and encouragement of the practitioners.

REFERENCES

Becker, F. D., & Mayo, C. (1971). Delineating personal distance and territoriality. *Environment and Behavior*, *3*(4), 375.

Boba, R. (2005). Crime analysis defined. *Crime analysis and crime mapping*, 5-18.

Bourdieu, P. (1984). A social critique of the judgement of taste. *Traducido del francés por R. Nice. Londres, Routledge*.

Brantingham, P. J., Dyreson, D. A., & Brantingham, P. L. (1976). Crime seen through a cone of resolution. *American Behavioral Scientist*, *20*(2), 261-273.

Breslin, P. (1999). *Getting to know ArcView GIS: the geographic information system (GIS) for everyone*. ESRI, Inc.

Brower, S. N. (1965). *Territoriality, the exterior spaces: the signs we learn to read*.

Burgess, E. W., & Bogue, D. J. (1967). *Urban sociology*. University of Chicago Press.

Goffman, E. (1961). *Encounters: Two studies in the sociology of interaction*. Ravenio Books.

Guerry, A.-M. (2002). *A Translation of Andre-Michel Guerry's Essay on the Moral Statistics of France (1883): a sociological report to the French Academy of Science* (Vol. 26). Edwin Mellen Press.

Herbert, D. T. (1982). *The geography of urban crime*. Longman London.

Kaplan, S. J. (1956). Criminal Responsibility. *Ky. LJ*, *45*, 236.

Katzman, M. (1981). The Supply of Criminals: A Geo Economic Examination. *Crime spillover*, 119-134.

Lambert, J. R., & Jenkinson, R. F. (1970). *Crime, police, and race relations: A study in Birmingham*. Oxford University Press London.

Luo, W., & Wang, F. (2003). Measures of spatial accessibility to health care in a GIS environment: synthesis and a case study in the Chicago region. *Environment and planning B: planning and design*, *30*(6), 865-884.

Lyman, S. M., & Scott, M. B. (1967). Territoriality: A neglected sociological dimension. *Social problems*, *15*(2), 236-249.

Mannheim, H. (1965). *Criminology in transition: essays in honour of Hermann Mannheim*. Tavistock Publications.

Maurizio, G., Paul, L., & Phil, A. (2007). Kernel density estimation and percent volume contours in general practice catchment area analysis in urban areas. GISRUK

2007: Proceedings of the Geographical Information Science Research UK 15th Annual Conference,

Mayhew, H., & Binny, J. (2011). *The criminal prisons of London: And scenes of prison life*. Cambridge University Press.

Ninsri, S. (2014). Resurgence of violence in Southern Thailand. *RUSAMILAE JOURNAL, 35*(3), 23-36.

Pyle, G. F. (1976). Spatial and temporal aspects of crime in Cleveland, Ohio. *American Behavioral Scientist, 20*(2), 175-198.

Sahapattana, P. C. P., Kuntee, P. C. P., & Kanjanawong, S. (2010). An Analysis of Burglary Hot Spots in Bangkok. *Thai Journal of Public Administration, 8*(2), 185-185.

Snodgrass, J. (1976). clifford r. shaw and henry D. McKay: chicago criminologists. *The British Journal of Criminology, 16*(1), 1-19.

Soontorn, N., & HONG, S. (2020). *THE KERNEL DENSITY ESTIMATION FOR CRIME ANALYSIS: A CASE STUDY IN THREE PROVINCES SOUTHERN OF THAILAND* Burapha University].

Sundstrom, E., & Altman, I. (1974). Field study of territorial behavior and dominance. *Journal of Personality and Social Psychology, 30*(1), 115.

Walker, D., & Tait, R. (2004). Health and safety management in small enterprises: an effective low cost approach. *Safety science, 42*(1), 69-83.

Wolfgang, M. E. (1957). Victim precipitated criminal homicide. *The Journal of Criminal Law, Criminology, and Police Science, 48*(1), 1-11.

Yiampisan, M., & Srivanit, M. (2010). Using the Kernel Density Estimation surface for criminal pattern: A case study in Phranakhon district, Bangkok. *Journal of Architectural/Planning Research and Studies (JARS), 7*(1), 87-102.

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