Article Journal of Asian Geography, 2022, Volume 1 (Issue 1), 25-33.

Geographic Information System for Crime Mapping: A Case Study of Property Crime in Kuching, Sarawak

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Received: 2 Mac 2022; Revised: 15 Mac 2022; Accepted: 25 Mar 2022; Published 21 Sep 2022

Abstract: Residents in Kuching claim to be worried about the increasingly of property crime. In Sarawak property crime was reported more frequent occur and contribute 88% cases compared with violent crime 11.2%. The aim of the study is to identify the spatial pattern of property crime in Kuching, Sarawak. This study using spatial data such as road data, police station boundary and police sector boundary that obtained from police station heads in the form of pictures and street names. Digitization was conducted based on road data to facilitate accurate dividing of police sector boundaries. Non-spatial data including property crime cases (2015-2017), month, time, types and incident address which is taken directly from the Police Reporting System. The crime data in PRS does not contain any coordinate reference system (x, y) and GIS help to locate the coordinate through the address of the incidents. Global Moran's I tool help to identify the overall pattern and trend of property crime in Kuching, Sarawak. This study has shown that the spatial pattern of property crime in Kuching, Sarawak in 2015-2017 was random because of p value greater than 1.0 and Moran's Index approaching zero. However, the result of stolen cases showed a positive spatial autocorrelation p-value of 0.063805 ($p<0.10$) indicating a case was clustered with 90% of confidence level in 2015. The result of stolen cases showed p-value 0.000371 ($p<0.01$) which indicate cluster at 90% of confindece level. The stolen cases in Kuching showed a strong positive spatial autocorrelation in 2017 because z-score of 2.830712 greater than 2.58 with the p-value of 0.004644 ($p<0.01$). Thus, the stolen cases do not occur at random in 2015-2017. This study can help police and authorities in making decision for preventing property crime.

Keyword: Geographic Information System; Crime Mapping; Property Crime; Kuching; Global Moran's I.

1.0 Introduction

Space is an interconnected element of crime in the city (Ceccato, 2008). Crime can occur in certain locations. Thus the aspect of space is often emphasized in criminal studies (Jubit et al., 2020a; Jubit et al., 2019 Nordin et al., 2020; Zakaria & Abdul Rahman, 2016; Carter et al., 2020; Ibrahim et al., 2016 ; LaRue 2013). Space autocorrelation was introduced by Sir Francis Galton in 1850 who was also a cousin of Charles Darwin (Getis, 2008). The idea of space autocorrelation exists because the need to compare maps and awareness of a phenomenon does not occur randomly in space but rather clustered or centralized. Hubert et.al, (1981) defines space autocorrelation as;"Given a set S containing n geographical units, spatial autocorrelation refers to the relationship between some variable observed in each of the n localities and a measure of geographical proximity defined for all n (n-1) pairs chosen from n".

The occurrence of crime in space context can be seen in the growth of urban population which leads to an increase of crime cases in urban areas. There were 60% to 70% of the total urban population that have become victims of crime, especially in developing countries due to the high growth of population. High population density and complex infrastructure, the existence of slums, illegal immigrants and drug addiction have made urban areas potentially become a hot spot of crime such as extortion and snatch theft cases (UN-HABITAT, 2016). In addition, physical environmental factors also contribute to the existence of property crime. The spatial design of physical features has an impact on the pattern of crime, target, surveillance and location. Criminals are more attracted to areas with high crime rates. The types of housing characterized by road design influence the occurrence of crime (John et.al, 2018). For example, physical surveillance and commercial space design influence the occurrence of property crime in commercial areas (Byun and Ha, 2016). Nordin and Masron, (2016) have identified drug hot spot in the Northeast District in Penang, Malaysia by using Getis Ord Gi*. In 2013, 7 sectors were detected as hot spot while in 2014 there are 3 sectors were classified as hot spots. Jubit et al., (2021) conducted a study motorcycle theft hot spots in Kuching, Sarawak by using Kernel Density Estimation. Hot spot locations change by year and time. The study found that most of the hot spot areas of motorcycle theft were detected within the Sentral boundary. This indicates that the city centre is an area with a high density of motorcycle theft

The same goes for the location of the police station which affects the numbers of crime rate. (There is no information about number of cases from literature review) Areas that are closer to the police station have a declining crime rate. Physical environmental factors such as various services and land use influence criminal behavior (Ahmed and Salihu, 2013). This shows that space as a location plays an important role in understanding the phenomenon of crime. Advances in new technologies for data storage and analysis such as GIS have led to the creation of systems that visualize and analyze crimes that have been processed through encoding in large numbers (Ceccato, 2008). Thus, crime analysis using GIS allows researchers to study crime in spatial context in a more dynamic way. This paper aims to analyze the spatial pattern of property crime in Kuching, Sarawak. Property crime was selected as the focus of this study due to the more frequent cases of property crime in Sarawak which is reported at 88.8% while violent crime 11.2% in the period of 2004-2016 and Kuching is one of the major cities in Sarawak which recorded the highest property crime rate

2.0 Study Area

Kuching district has an area of 1, 862.8 sq km (Sarawak Department of Statistics, 2015). Kuching is located in the southwest of Sarawak with latitude 1.6019N and longitude 110.3244E (Soo et al., 2016). In addition, Kuching is the fastest growing area in Sarawak and attracts more people (Lai, et al., 2008). Kuching also has the highest population percentage in Sarawak with a total population of 617,887 people in 2010. Kuching is the capital of Sarawak and was declared a city in August 1988. The city is the main focus of the population in Sarawak due to rapid development and economic opportunities. Kuching is the 7th Metropolitan city among the 14 states in Malaysia while at the Sarawak level, Kuching is the first-ranked Metropolitan city followed by Miri and Sibu (Sarawak Department of Statistics, 2015). Kuching also experienced strong economic growth, increased per capita income and high industrial productivity which led to the rapid growth of municipalities in Kuching compared to other districts in Sarawak (World Bank Group, 2018). Kuching district has nine police stations with a total of 57 police station sectors administered under the Kuching District Police Headquarters and this area has been the focus of the study namely (1) Padungan, (2) Bintawa, (3) Sekama, (4) Tabuan Jaya, (5) Sungai Maong, (6) Gita, (7) Santubong, (8) Central, and (9) Satok as shown in Figure 1.

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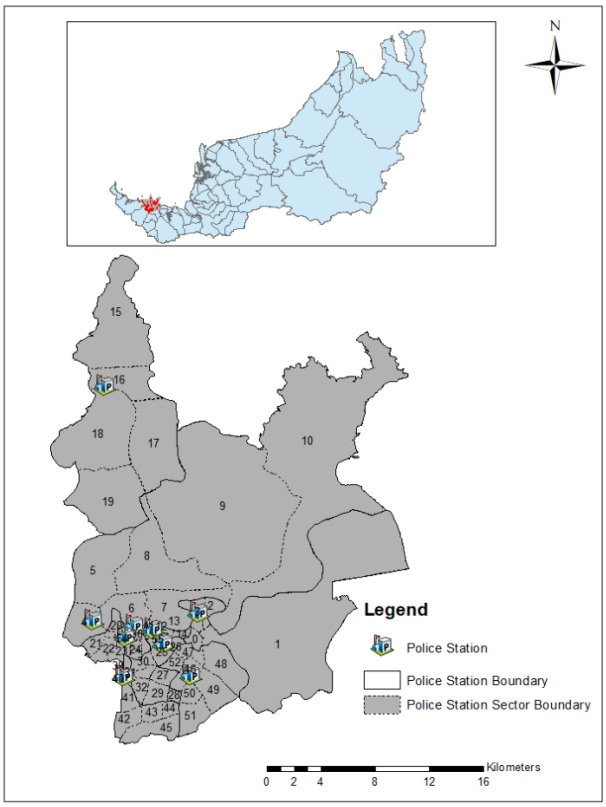

ID	Police Station Sectors	1D	Police Station Sectors	ID	Police Station Sectors	1D	Police Station Sectors
0	Bintawa Sector 1	15	Santubong Sector 1	30	Sekama Sector 7	45	Sg Maong Sector 7
1	Bintawa Sector 2	16	Santubong Sector 2	31	Sekama Sector 8	46	Tabuan Jaya Sector 1
2	Bintawa Sector 3	17	Santubong Sector 3	32	Sekama Sector 9	47	Tabuan Jaya Sector 2
3	Bintawa Sector 4	18	Santubong Sector 4	33	Sentral Sector 1	48	Tabuan Jaya Sector 3
4	Gita Sector 1	19	Santubong Sector 5	34	Sentral Sector 10	49	Tabuan Jaya Sector 4
5	Gita Sector 2	20	Satok Sector 1	35	Sentral Sector 2	50	Tabuan Jaya Sector 5
6	Gita Sektor 3	21	Satok Sector 2	36	Sentral Sector 3	51	Tabuan Jaya Sector 6
7	Gita Sector 4	22	Satok Sector 3	37	Sentral Sector 8	52	Tabuan Jaya Sector 7
8	Gita Sector 5	23	Satok Sector 4	38	Sentral Sector 9	53	Sentral Sector 4
9	Gita Sector 6	24	Sentral Sector 6	39	Sg Maong Sector 1	54	Sentral Sector 7
10	Gita Sector 7	25	Sekama Sector 2	40	Sg Maong Sector 2	55	Sekama Sector 1
11	Padungan Sector 1	26	Sekama Sector 3	41	Sg Maong Sector 3	56	Sentral Sector 5
12	Padungan Sector 2	27	Sekama Sector 4	42	Sg Maong Sector 4	30	Sekama Sector 7
13	Padungan Sector 3	28	Sekama Sector 5	43	Sg Maong Sector 5	31	Sekama Sector 8
14	Padungan Sector 4	29	Sekama Sector 6	44	Sg Maong Sector 6	32	Sekama Sector 9

Figure 1: Study Area

3.0 Data and Methodology

Figure 2 shows the process of collecting data and spatial analysis. The first step in data collection process was to apply the approval from Crime Investigation Department of Bukit Aman to get the data from Kuching District Police Headquarters. After receiving the approval the next step was collecting data. There were two types of data namely spatial data and non spatial data. The spatial data was taken directly from police stations under the administration of Kuching District Police Headquarters. The spatial data consists of police station boundaries (9 police stations), police station sector boundaries (57 sectors) and road data. The next step was the process of building a spatial database using ArcMap 10.3. While non spatial data include property crime (2015-2017) by police stations of Kuching, Sarawak, types of property crime, address of incidents and date of incidents. All this non spatial data were taken directly from Police Reporting System of Kuching District Police Headquarters and were sorted out using Microsoft Excel 1997. The information was later transfer to data sheet before it is uploaded into Geocoded to track the location of an address by using geographical coordinates. Geocoding enables researchers to track the location of property crime cases to be displayed in the forms of point on the map. The projection was set up to ensure the coordinate system of property crime cases with the police station sector boundaries were the same

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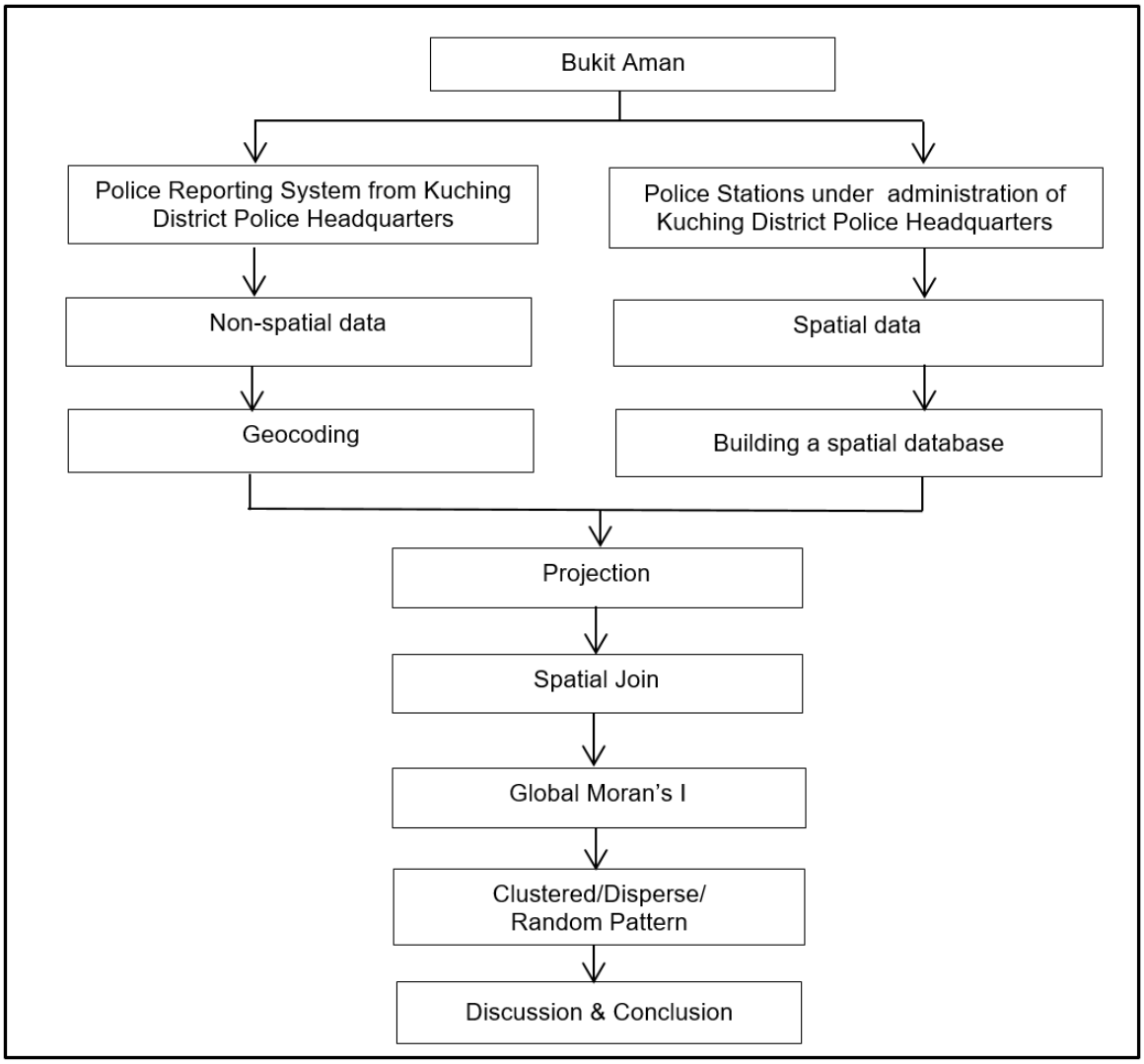

Figure 2: Process of Collecting Data and Spatial Analysis

In this study, spatial data and non spatial data were integrated by converting the coordinate system from WGS 1984 to Timbalai 1948 TBRSO Borneo (Meters). Subsequently, the spatial join was performed to combine property crime cases and police station sector boundaries (Join feature: property crime, Target feature: police station sector boundaries). The spatial join method was used to calculate incidents within the boundaries of each neighborhood (Zhang et al., 2012). Thus, projection and spatial join is enable spatial analysis.

Table 1: p-value and z-score with different confidence level

Z-score	P-value	Confidence Level
<-1.65 or + 1.65	<0.10	90%
<1.96 or > +1.96	<0.05	95%
<2.58 or >+2.58	<0.01	99%

Global Moran's I was used in this study to identify the spatial distribution of different types of property crime in urban areas in Kuching, Sarawak. It measures spatial autocorrelation based on both feature locations and feature values simultaneously. Global Moran's I was selected because it evaluates whether the pattern expressed is clustered, dispersed or random. The tool calculates the Moran's I index value and both a z-score and p-value to evaluate the significance of that index (ESRI, 2018). Table 1 shows the p-value and z-score with different confidence level.

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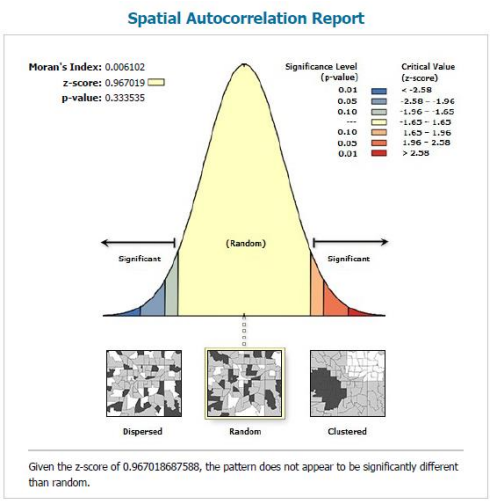
4.0 Results

4.1 Spatial Pattern of Property Crime in Kuching, Sarawak (2015-2017)

Figure 3 shows the spatial patterns of property crime in Kuching, Sarawak from 2015-2017. The results showed that the property crime in Kuching, Sarawak for 2015 in study areas was clustered. The result of the Moran index value was 0.006102 with a Z-score value of 0.967019 while the p value was 0.333535>0.10 which indicated that property crime in 2015 was likely to occur randomly in the study area. Thus, the null hypothesis is accepted because no spatial pattern was generated. [Refer Figure 3(a)]. In 2016 property crime case also showed a cluster pattern based on the model shown in Figure 3(b) which displayed the Moran I index value of 0.014196 approaching zero and the p value of 0.199023 (> 0.10). The result of the Global Moran's I for property crime in 2017 is shown in Figure 3(c). This study found the Moran I index value is 0.003702 with z-score = 0.864292, p-value is 0.387427 (> 0.10). This result found the property crime in Kuching, Sarawak in for 2017 was random pattern.



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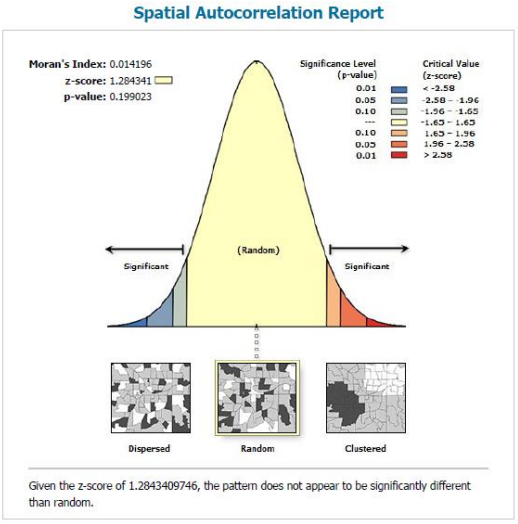

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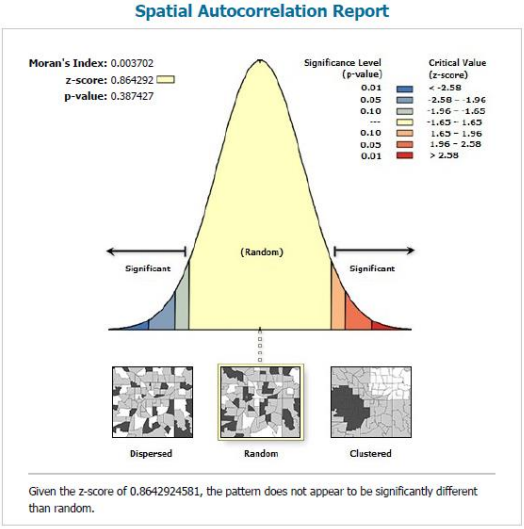

(c)

Figure 3: Result of Global Moran's I Analysis for Property Crime of Kuching, Sarawak in (a)2015, (b) 2016 and (c) 2017

4.2 Spatial Pattern of Stolen Cases in Kuching, Sarawak (2015-2017)

The result of Global Moran's I for stolen cases in Kuching for 2015-2017 is shown in Figure 4. The stolen cases in 2015 showed a positive spatial autocorrelation as shown in figure 4(a). The Moran index was 0.28085 with a z-score of 1.853539, p-value of 0.063805 ($p<0.10$) indicating a case was clustered with 90% of confidence level. In 2016, Moran index = 0.069622, z-score 3.559847 with p-value 0.000371 ($p<0.01$) [Refer Figure 4(b)]. The stolen cases in Kuching showed a strong positive spatial autocorrelation in 2017 as shown in Figure 4(c). Global Moran's I analysis showed that the Moran index was 0.052529 with a z-score of 2.830712 greater than 2.58 with the p-value of 0.004644 ($p<0.01$). The null hypothesis is rejected as the case of stolen cases does not occur at random.

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4.3 Spatial Pattern of daytime Burglary in Kuching,Sarawak (2015-2017)

To enable the analysis of spatial distribution of burglary cases to be carried out in more detail, the spatial pattern of daytime burglary cases for the period 2015-2017 has been discussed in this section [Refer Figure 4 (d), (e) and (f)]. In 2015 the z-score for daytime burglary is 2.388252 with p-value <0.05 which is significance at 95% of confidence level. Thus, the daytime burglary in 2015 was clustered and the null hypothesis is rejected [Refer Figure 4(d)]. The result of Global Moran's I for daytime burglary in 2016 is shown in Figure 4(e). The Moran index is 0.009930, z-score 1.119632, p-value >0.10 which indicates that daytime burglary in 2016 was random pattern. The null hypothesis is accepted. Figure 4(f) show the daytime burglary in 2017. Based on the result, the moran index = 0.022785, the z-score = 1.622652 with p-value 0.104664 whis is > 0.10. This indicates that the daytime burglary in 2017 is high probability of random pattern. The null hypothesis is accepted.

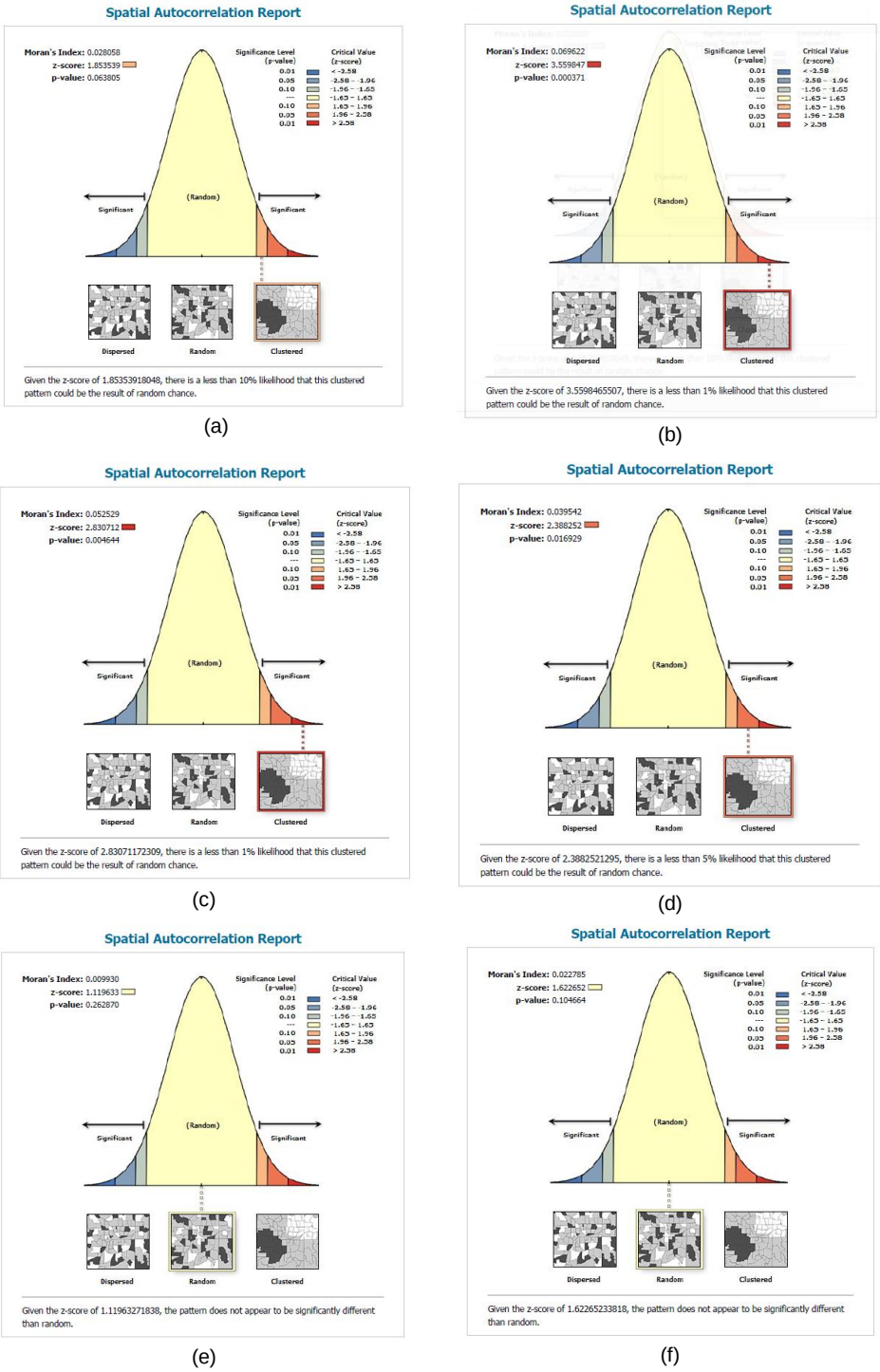

Figure 4: Result of Global Moran's I Analysis for Stolen Cases of Kuching, Sarawak in (a)2015, (b) 2016, (c) 2017 and burglary in the daytime in (d) 2015, (e) 2016 and (f) 2017

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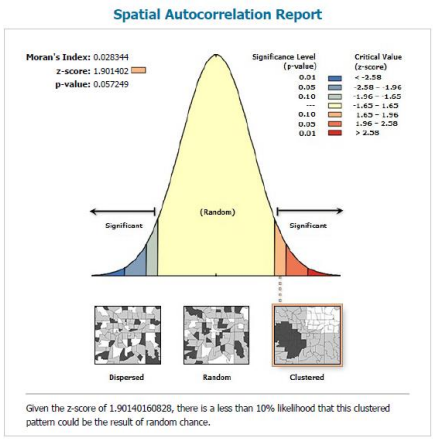
4.4 Spatial Pattern of Nighttime Burglary in Kuching, Sarawak (2015-2017)

Besides discussing daytime burglary cases, this study also conducted an analysis of the spatial distribution of nighttime burglary cases in Kuching, Sarawak. The incidents of nighttime burglary in 2015 showed a random pattern. Based on Figure 5(a) the Moran index value = 0.028344 with a significant level of p<0.10, z-score value is 1.901402. This shows that the nighttime burglary was clustered pattern with level confidence at 90%. The null hypothesis was rejected because the spatial pattern of burglary cases for 2015 was clustered. Although the nighttime burglary case showed a cluster pattern in 2015, the result of the analysis showed a random pattern in 2016 with Moran index = 0.015249 [Refer Figure 5(b)].

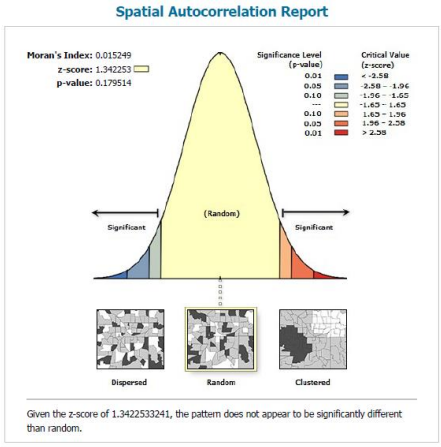
The z-score value is 1.342253, while p-value greater than 0.10 and tends to be random. Thus, this study accepted the null hypothesis because the nighttime burglary in 2016 was reported in a random pattern in Kuching, Sarawak. The result of Global Moran's I for nighttime burglary in 2017 is shown in Figure 5(c). The Moran index value is 0.061225, z-score = 3.191644 which is greater than 2.58 with p-value <0.01. The significant value explains that the chance for nighttime burglary in 2017 to produce random pattern was only 1% while 99% tend to be clustered. Thus, the null hypothesis was rejected.

4.5 Spatial Pattern of Vehicle Thefts in Kuching, Sarawak (2015-2017)

Based on the result of Global Moran's I for vehicle theft in 2015 that shown in Figure 5(d), the Moran index = -0.012219, z-score = 0.225588 while p-value is 0.821522 which is greater than 1.10. This indicates that vehicle theft in 2015 was random pattern and the null hypothesis is accepted. The vehicle theft in 2016-2017 was random pattern [Figure 5(e) and (f)].



(a)



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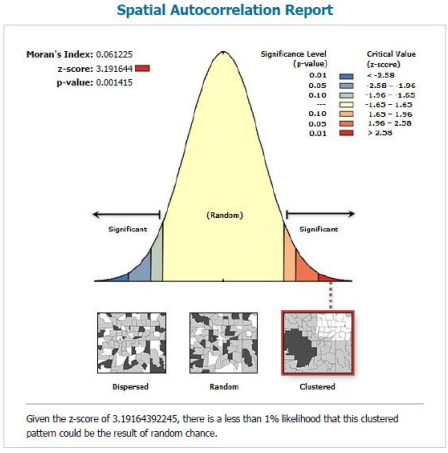

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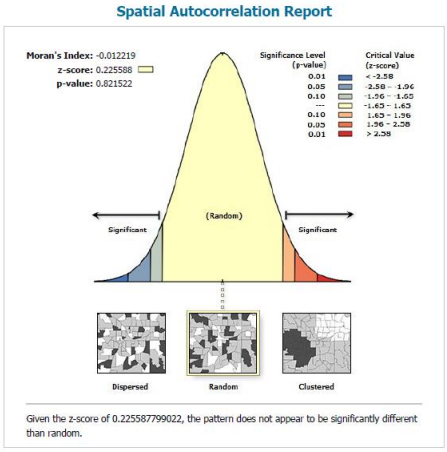

(d)

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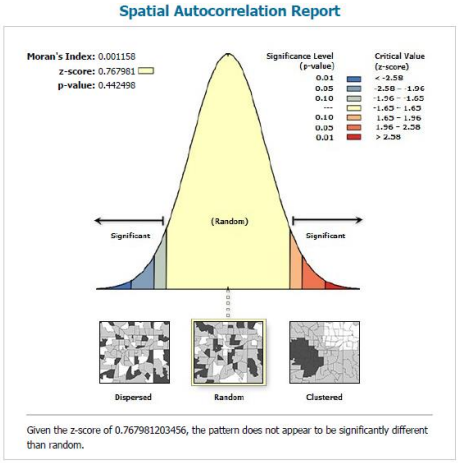
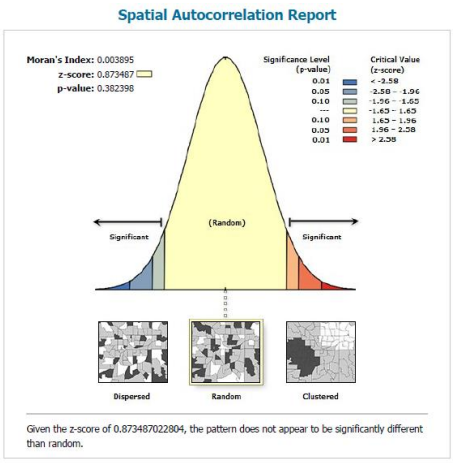


(e)



(f)

Figure 5: Result of Global Moran's I Analysis for Burglary in the nighttime of Kuching, Sarawak in (a) 2015, (b) 2016, (c) 2017 and Vehicle Theft in (d) 2015, (e) 2016 and (f) 2017

5.0 Discussion

This study has shown that the spatial pattern of property crime in Kuching, Sarawak in 2015-2017 was random. Interestingly, the findings of this study are different from previous studies which mostly found that property crime tends to clustered (Zakaria & Abdul Rahman, 2014; Uiitenbogaard, 2014; Wang et.al, 2019). According to Spencer Chainey (2001) if crime happens randomly, this shows that crime has the same chance of happening anywhere and anytime. Although property crime occurs randomly, it is likely that the same victim will be the target or repeat victim will occur by chance. This is because some is properties tend to be more attractive to the offenders (Davies and Bishop, 2013). In fact, most crime victims tend to have the experience of falling victim to crime almost three times if crime occurs randomly in an area (Trickett, 1992).

Overall, the spatial pattern of stolen cases in Kuching Sarawak indicated clustered in three years from (2015-2017). This indicates that there are certain sectors being targeted by offenders in the study area. Moran's I positively indicates that the crime rate in one area is positively related to the crime rate in its neighborhood (Larue, 2005). In 2015 and 2016, stolen cases in Kuching mostly occurred in residential areas of 42.2% and 95.1% respectively. However, in 2017, 50.4% of the highest number of stolen cases were reported in business area (Criminal Investigation Division of Kuching District Police Headquarters, 2018). This finding concurred with previous studies that found that property crime in urban areas is more likely to occur in business areas such as hotels, restaurants, shops, supermarkets and nightclubs, offices and shopping malls as well as in residential areas (Dutkowska and Leitner , 2017; Yusof & Fauzi, 2019).

The findings of Global Moran's I analysis found that daytime burglary cases in 2015 were clustered ($p < 0.05$) with a confidence level of 95%. Based on the Criminal Investigation Division of Kuching District Police Headquarters, (2018) daytime burglary cases were reported to be highest in 2015. Unoccupied houses are a contributing factor to burglary cases because houses are more likely to be uninhabited during the day. Houses that do not have fences, are isolated, located on less busy roads, away from neighbors, surrounded by trees and high fences are at risk of being targeted by criminals. Crime victims are often concentrated in neighborhoods and homes where thieves had broken into will be targeted again (Lindberg, 2010). However, daytime burglary cases in 2016 and 2017 in Kuching were random due to value ($p > 0.10$).

The distribution of nighttime burglary cases in Kuching, Sarawak in 2015 was clustered ($p < 0.10$) with a confidence level of 90%. Some areas are more prone to burglary cases than others. Based on social organization theory and routine activity theory, there are various environmental factors that affect housebreaking cases, including road configuration, residential instability, demographics, income, unemployment rate, mixed land use, housing characteristics, surveillance, accessibility and physical environment (Chen et.al, 2017). In 2016, spatial pattern of nighttime burglary have p-value greater than 0.10 which indicates random pattern. In 2017, nighttime burglary cases strong positive spatial autocorrelation with a z-score value (> 2.58), a p-value ($p < 0.01$) with a significant level of 99%. At night most occupants sleep, and the streets become deserted. This situation opens up opportunities for criminals to break into a property which in turn creates property crime cases cluster in certain sectors (Aksoy, 2017). The results of Global Morans' I analysis of vehicle theft cases in 2015-2017 found that vehicle theft cases were random. The attribute values in different neighborhoods indicate that spatial autocorrelation is negative and tends to produce random patterns (Zulkifli et.al, 2015).

Thus, global statistics like the Global Moran's I tool help to identify the overall pattern and trend of property crime in Kuching, Sarawak. Global Moran's I value indicating the strongest spatial autocorrelation of property crime density. The z-score and p-value are measures of statistical significance which revealed whether to reject the null hypothesis. The advantage of Global Moran's I is it can be measuring the concentration of property crime that have similar value either high or low. However, Global Moran's I cannot distinguish the dissimilar value in spatial context.

6.0 Conclusion

Spatial technique of Global Moran's I help to detect the spatial distribution of property crime in Kuching, Sarawak by index Moran, z score and p value. The result is not statistically significant if p-value greater than 0.10 and the result indicate random which is no spatial autocorrelation exist. When the result of p-value is less than 0.10, it shows the spatial autocorrelation does exist and the crime tend to clustered. A z-score and p-value indicating whether this difference is statistically significant or not.This study found that the spatial patterns of property crime were different by types and year. The occurrence of property crime in Kuching, Sarawak depends on the opportunities that exist in a space. The cluster pattern of property crime shows that there is a target space and create opportunities for criminals to commit the crime. GIS

E-ISSN: 2948-5231

is one of the approaches that helps to understand the phenomenon of crime in the spatial context that can help the authorities and PDRM in combating crime and creating a safe city.

Acknowledgement: This paper is under the funding of the FRGS / 1/2020 / SSO / UNIMAS / 01/1 Grant. The author also thanked the Royal Malaysian Police Bukit Aman, Kuching District Police Headquarter especially the Criminal Investigation Department and Kuching Police Station Chiefs for their cooperation and support.

Conflicts of Interest: There is no conflict of interest in this study

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