SPATIAL ANALYSIS OF VEHICLE THEFT IN KUCHING, SARAWAK

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ABSTRACT
Vehicle thefts are raising concern among society because it contributes to the highest rate of property crime in Malaysia. GIS is an important base system that allows locating crime hot spots. The aim of the study is to determine the hot spot of vehicle theft with statically significant from 2015-2017 in Kuching, Sarawak. The spatial data for this study obtained from Kuching District Police Headquarters which include Kuching district boundary, police station boundary, and police station sector boundary. Attribute data were obtained from the police reporting system such as addresses of incidents and types of vehicle theft includes motorcycle theft, car theft and heavy machinery, truck and lorry theft. This study using Local Indicators Spatial Autocorrelation (LISA) technique. The outcome of the study revealed the location hot spots and a cold spots of vehicle theft across police station sector boundaries. Vehicle theft in Kuching, Sarawak is spatially concentrated. Hot spot of car theft mostly detected in Sungai Maong, Tabuan Jaya and Sekama police station boundaries where there are more shopping malls, hospitals, retails and restaurants whereas motorcycle theft mostly clustered in Gita police station sector boundaries, while van/lorry/bus and heavy machine theft tend to cluster in the industrial zone, which is included sector boundaries of Bintawa, Padungan and Tabuan Jaya police station. The findings of the study have a significant impact on the policing to combat vehicle theft by sector boundaries. Local Indicator Spatial Autocorrelation can help identify the risk area of vehicle theft and it is hoped that the outcome from this study can be contributed to the crime and other fields.

Keywords: Spatial Analysis, Vehicle theft hot spots, GIS, Kuching.

INTRODUCTION

There are almost all countries in the world face with a problem of vehicle theft and this issue becomes more serious because it is contributing to the increase of crime index (Yong, 2006; Fujita, 2010; Malina et.al, 2015; Rozaimi and Narimah, 2017). Vehicle theft is one of the property crimes that often been reported as the highest crime rate by 80% to 90% throughout the world. There are some countries that were recorded having the highest motor vehicle theft rate such as Israel, South Africa, Malaysia and Sweden (UNODC, 2010). Vehicle theft was reported almost daily in urban areas around the world (Guebuza, 2012; Yocum, 2016). The Director School of Criminology at the University of Science Malaysia recognizes that the vehicles theft such as cars and motorcycles that regularly occur has led to insecurity among society because almost every resident in Malaysia having their own vehicle (Utusan Malaysia, 2012).

Statistics of property crime by types in Malaysia from 2013-2016 indicate that vehicle theft contributed 53.8% or 218,263 cases of the entire property crime in Malaysia (PDRM 2017). According to the latest report issued by Insurance Services Malaysia Berhad (2007), the average loss of motorcycles in Malaysia occurs at 1 case every 10 seconds within the first 9 months of 2007 (Insurance Services Malaysia BHD, 2007). In 2010 the value of lost vehicles is estimated at RM1 billion (National Transformation Programmed, 2011). Agencies such as PDRM and Customs often caught offender that involve in activity of stolen vehicle (Che, 2008).

Based on Table 1 the number of vehicles theft occurring in Malaysia from 2013 to 2016 amounting to 233,765 cases. The vehicle theft was recorded highest in 2013 with 70, 857 cases. However, the number of cases decreased by 22,436 cases or 31.6% in 2014-2016. The total number of vehicle theft still recorded a high rate because it reaching tens of thousands despite the number of cases showing decreases in three years (Royal Malaysia Police, 2018).

Table 1 shows that Selangor record the highest cases of vehicle theft in Malaysia with 659, 984 cases, second highest in Johor with 32, 197 cases followed by Kuala Lumpur 30, 157 cases and Kedah 16, 125 cases as well as Sarawak ranked fifth with 15, 242 cases from 2013 to 2016 (Royal Malaysia Police, 2018).

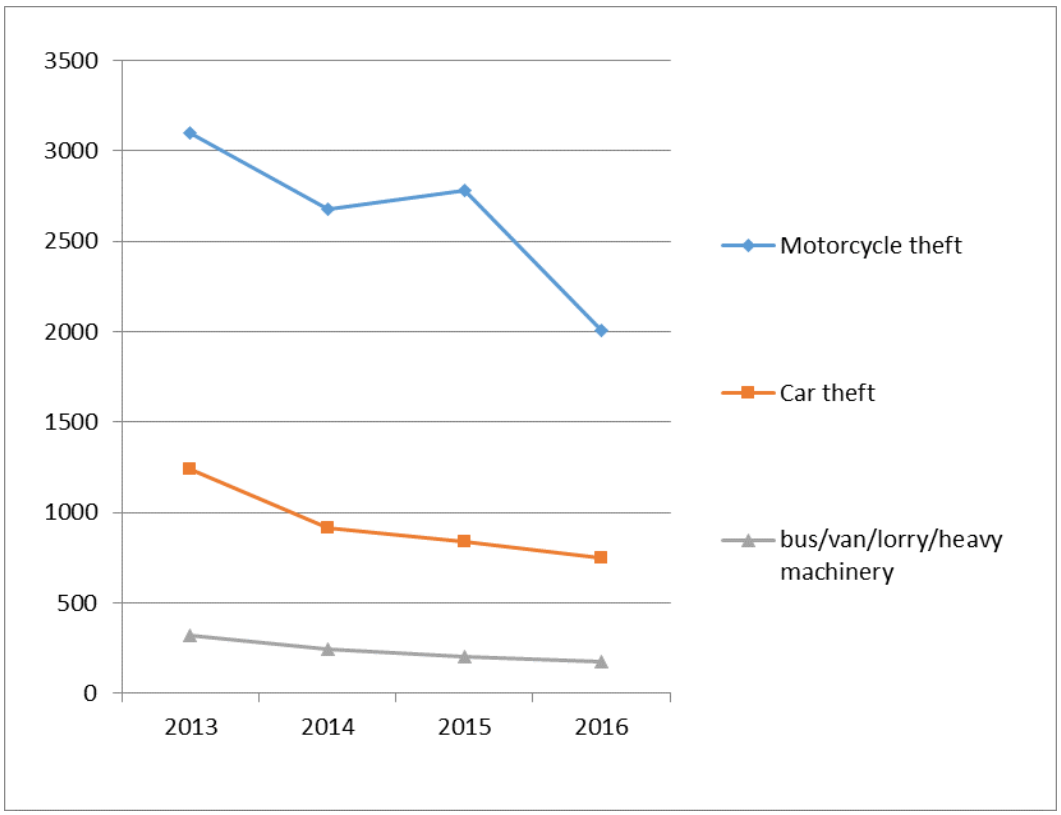
Figure 1 shows trend of vehicle theft by types in Malaysia from 2013-2016. The number of motorcycle theft has been failing 35.3% from 2013 to 2016 as shown in Figure 1. According to the statistics, the number of car theft decrease from 1239 cases in 2013 to 916 cases in 2014. In 2015 the car theft increase to 840 cases but decrease again to 748 cases in 2016. The statistics reveal that the bus/van/lorry/heavy machinery theft has been decline 45.1% from 2013 to 2016. According to the report of vehicle theft in Sarawak, motorcycle theft was the highest rate with 10, 564 cases or 39% compare to car theft (13.8%), while bus/van/lorry/heavy machinery theft (3.45%) in four years.

Kuching was reported the highest vehicle theft compared to other districts in Sarawak. Kuching district police ACP Abang Ahmad Abang Julai stated that the average of motorcycle theft occur two to four cases per day compared to one car theft per day. He also stated that motorcycle theft cases occur every day and contributed to the index crime in Kuching, Sarawak (Patricia, 2016).

Table 1: Trend of Vehicle Theft in Malaysia (2013-2016)

State	Year								Total
	2013		2014		2015		2016		
	Total	%	Total	%	Total	%	Total	%	
Selangor	20534	29.0	17059	28.1	15052	27.8	13339	27.5	65984
Johor	9718	13.7	8290	13.7	7660	14.1	6529	13.4	32197
Kuala Lumpur	9428	13.3	7498	12.3	6768	12.5	6463	13.3	30157
Kedah	4319	6.1	4272	7.1	3801	7.0	3733	7.7	16125
Sarawak	4656	6.6	3840	6.3	3818	7.1	2928	6.0	15242
Pulau Pinang	4292	6.1	3775	6.2	3136	5.8	2960	6.1	14163
Kelantan	3551	5.0	3080	5.1	2937	5.4	2649	5.4	12217
Perak	3506	4.9	3003	4.9	2767	5.1	2616	5.4	11891
Pahang	2737	3.8	2513	4.1	2016	3.7	1756	3.6	9022
Terengganu	2359	3.8	1825	3.0	1512	2.7	1180	2.4	6876
Melaka	2022	3.3	1752	2.8	1497	2.7	1441	2.9	6712
Negeri Sembilan	1729	2.4	1525	2.5	1484	2.7	1346	2.7	6084
Sabah	1658	2.3	1707	2.8	1172	2.1	1219	2.5	5756
Perlis	339	0.4	359	0.5	389	0.7	252	0.5	1339
Total	**70847**		**60498**		**54009**		**48411**		**233765**

(Cited From Royal Malaysia Police, 2018)



(Cited From Royal Malaysia Police, 2018)

Figure 1: Trend of Vehicle Theft in Malaysia (2013-2016)

However, the study of vehicle theft based on statistics and trends does not help to detect the hot spots of vehicle theft in the space context. In Sarawak, the study of vehicle theft using the GIS approach is rarely highlighted especially in Kuching. The objective of this study was to identify the hot spots of vehicle theft with statistically significant in Kuching Sarawak. Most of the previous studies have used mukim, district, town, police station boundaries and state boundaries as a unit of analysis. This study has its own uniqueness as it uses the sectors boundaries of the police station as a unit of analysis. This study also using Local Indicator Spatial Autocorrelation (LISA) to detect a hot spots of vehicle thefts in Kuching, Sarawak.

LITERATURE REVIEW

Vehicle theft tends to cluster in areas of high road accessibility. In addition, vehicle theft is also common in potential areas such as parking lots and business areas. Consequently, high accessibility networks with high traffic density contribute to crime and target opportunities (Dan et.al, 2015). Mohd Norarshad

et.al, (2020), using Getis Ord Gi* to identify the hot spot of home burglary and the result showed that hot spots of home burglary are more concentrated in residential areas with good road network accessibility.

Tarmiji Masron et.al, (2018) using Nearest Neighbor (ANN) to analyze fatal accident spatial pattern, while Kernel Density Estimation (KDE) is utilized for fatal accident black spots. The result shows the fatal accident pattern for 2011, 2012 and 2013 is clustered and the black spots areas happened at main road areas. Norita Jubit et.al (2020), study the spatial patterns of residential burglary in Kuching, Sarawak by using Global Moran's I. The result revealed that the residential burglary patterns for 2015 and 2017 are clustered, while there is no global spatial pattern found in 2016.

Yongmei & Xuwei, (2007) conducted a study of vehicle theft patterns that occurred along the road in San Antonio, Texas using K-function techniques to determine whether the vehicle theft had a positive or negative relationship with the road network in urban areas. K-function measures the density of road segments and road lengths. The results show a positive relationship with low crime density. Therefore, short lanes with low segment density cause low access to such roads.

Yongmei (2006) conducted a study on the analysis of vehicle theft in Buffalo. The Linear Nearest Neighbor Indexes (LNNI) method reveals that locations close to the main road and that are directly connected to the main road are at high risk of vehicle theft. In addition, various types of urban socioeconomic activities have also been found to contribute to vehicle theft in Buffalo, New York.

Natalia et.al, (2011) studied the relationship between the simulation of offender movement along a road network and the actual location of crime in geographic space. This study used criminal home location data with crime scene locations using Dijkstra's shortest path algorithm. High crime rates are found to be very close to the road and criminal incidents are often carried out on the regular route and have experience of getting out. The euclidean analysis found that 30% of crimes were committed within 32m of their route. This study found that offenders do not take long-distance exits.

Ifeanyi (2012) using network analysis to measure the accessibility of healthcare facilities in Enugu Urban, Nigeria. The result shows there are two settlements that were identified as derived areas with no access to healthcare such as Emene and Amechi-Akwunanuw settlements. The one settlement travel several kilometers to access the facilities and different from other settlements that have to assess within a distance less than 500 meters. The result concluded that network analysis in GIS is effective in determining the accessibility of health institutions in Enugu urban area.

However, this study could not be conducted using network analysis because existing road data does not contain complete information. The complete and accurate geospatial data on the road network are very important and valuable not just for planning but also for understanding certain phenomena (Millard-Ball, 2019). Therefore, this study only uses LISA to enable the identification hot spots of vehicle theft in Kuching, Sarawak.

Dain Kim and Hohyun Lee, (2016) conducted a crime study in Seoul from 2011 to 2013 using the Local Indicator Spatial Autocorrelation (LISA) technique. Seoul's hot spots and cold spots are declining. The results of this analysis have highlighted the types of crime such as theft, murder and robbery based on the area. The technique found that hot spots were detected in Songpa-gu while cold spots were detected in Nowon-gu within three years. Although the Seochogu area shows a decline in crime trends, the area is classified as a hot spot and low-quality. The results of this study can be used to prevent crime and to identify hot spots and crime related to space.

Yuanyuan et.al, (2018) identify hot spots and cold spots of vehicle theft (2006-2007) using real estate data such as housing, commercial and public facilities such as shops, hospitals, libraries, and others. LISA's autocorrelation analysis showed that non-motor vehicle case hotpots were located along the Huangpu River in Gaoqiao and Chaunsha cities while motor vehicle theft hot spots were found in Gaoqiao, Chuansha, Gulu and several Beicai urban areas which are central to the suburbs. Hot spots were also found on Jinyangxincun Road and Shangnan Road which is a city center near the highway and easy for criminals to escape. The results show that there is significant value in the grouping of high-risk vehicle thefts in residential areas.

The physical environment in the slum area is known to affect the health of the population. However, the effects of slum environments on health are rarely highlighted and analysis of squatter mental health spaces is rarely performed. The objective of this study was to study mental health data in slum area of Dhaka, Bangladesh taking into account social and physical neighborhoods using space statistics. The result shows a significant spatial pattern in different population groups. The spatial patterns would relate to spatially-correlated health-determining factors (HDF). The study was conducted using Global Moran's I and Local Moran's I. The study found that poor mental health with a WHO-5 <13 score among adults over 15 years of age in slum. Studies have found that WHO-5 scores have autocorrelation (poor and good mental health grouping among different populations). These results indicate that there is a spatial relationship between mental health and quality of housing, sanitation, income, environment, education, age, gender, flood and natural environment (Oliver, et.al., 2011).

LISA is used as a pointer to a location or area that has a cluster of case with the same value and a cluster of case with different values. The analysis of the crime scene in Turkey was conducted using Moran's I. The purpose of this study was to use the room's autocorrelation to detect possible patterns of crime patterns, measure the strength of the pattern and show how crime rates correlated in the Turkish state. First, the grouping of cases with high-value, the second grouping of cases with high-low value and the third grouping of cases with low-high value, the fourth grouping of cases with low-value. The LISA results show that the 1997-2011 criminal cases were identified at a 0.05 level in several areas namely Usak, Aydin, Denizli, Mugla, Sinop and Manisa. In addition, a grouping of cases with significance of 0.05 was also detected in Duzce, Bartin and Igdir during 2002-2006. The use of LISA techniques can help identify crime patterns and present a clear pattern of crime statistics. The results show that

crime does not happen randomly in space and time. Highly grouped crimes are believed to have occurred in the Eastern and Eastern parts of Turkey. This finding was confirmed by global and local autocorrelation of Moran's I (Saffet Erdogan et.al, 2011).

Lucy and Mohamed Bakillah, (2016) conducted a case study of a home in the Metropolitan City of Greater London, United Kingdom. This study was conducted using house case data from 2011-2015, unemployment data, income, population density, distance to the city, homeownership, building density, house price, etc. Local Indicator Spatial Autocorrelation (LISA) helps to identify burglary risk such as crime concentration patterns, spatial clusters whereas Ordinary Least Square help to identify the correlations between variables.

Courage et.al, (2019) conducted the mapping spatial variations in crime in rural Zimbabwe using Geographic Information System. The data that using in this study were included Chivi district boundary, type of crime, time of crime occurrence from july 2018 to September 2018. To determine crime hot spot and crime clusters, there are two techniques were applied in this study, which is included Local Indicator Spatial Autocorrelation and Getis Ord Gi*. The results revealed the location with significant high-high crime clusters and crime hot spots at 99% confidence level around the certain area in Chivi district. The result of the study show that crime hot spots and clusters were detected around the Chivi growth point and help to establishing beat patrols to prevent crime.

Syerrina and Nuzlinda, (2012) study the violent crime patterns in Peninsular Malaysia and identify the hot spot of the violent crime by each district. These studies were used 3 years data of violent crime for the year 2001, 2005 and 2009 whereas spatial data consist of district boundaries. The hypothesis of spatial randomness was rejected because the results show clustered in the study area. From this study, local indicator spatial autocorrelation is the suitable technique to measure the local spatial cluster because it can help to identify the existence of spatial autocorrelation in each location.

Ruth Kerry, (2010) was study about car related theft in the Baltic States using local indicator spatial autocorrelation. The objective of this study is to identify clusters of car theft for year 2000. The spatial data in the study include district boundary of Estonia, Latvia and Lithuania. LISA revealed the location of hot spot and cold spot for the car related theft. LISA shows that hot spot tend to occur at the local scale whereas cold spots are a more occur in regional. In this study cold spot was detected in eastern Latvia with lower GDP in this area.

The results of previous study have mostly used district and city boundaries as a unit of analysis. In addition, the previous study of vehicle theft in spatial context did not use the police station sector boundary as a unit of analysis. Overall, previous studies revealed that this LISA analysis is a technique that can help detect the located of crime hot spot and cold spot, measure the strength of pattern, reveal the type of crime pattern, and detect areas with high cluster. Researcher found that spatial analysis of vehicle theft that using GIS application in Malaysia is still limited.

METHODOLOGY

Study Area

Kuching is the capital city of Sarawak which is located at the southwest of the Sarawak state with latitude and 1.6019N and longitude 110.3244E (Soo See et.al, 2016). Kuching city is the fastest growing area in Sarawak (Lai Sai Hin et.al, 2008) and attract more population that contribute highest crime rate especially property crime that frequently reported (Royal Malaysian Police of Kuching Sarawak). Thus, this study was focused on Kuching, Sarawak which is under administration of 9 police station with 57 sector boundary as shown in Figure 2.

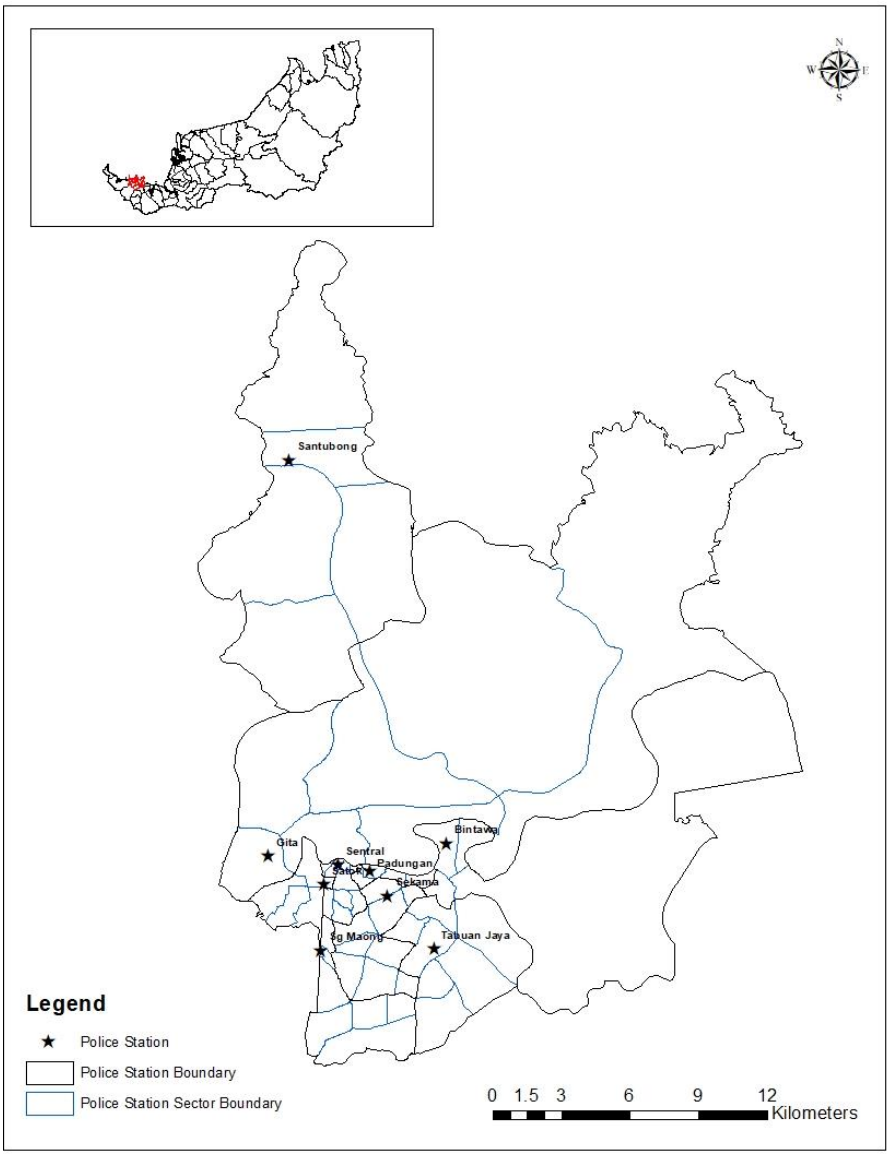


Figure 2: Study Area

This study using Local Indicator Spatial Autocorrelation (LISA) to explore the spatial autocorrelation of vehicle theft and identify hot spots and cold spots and spatial outliers. This technique also applied to explore cluster of vehicle theft such as car theft, motorcycle theft and lorry. LISA help to identify the location with high or low values cluster spatially and detect features with different value from those surrounding features (Lu Wang et.al, 2019).

LISA technique is used in this study because it can identify the pattern of vehicle theft at the local scale. LISA technique enables the evaluation of the strength pattern and reveal the valid of cluster pattern through statiscally significance level. Thus, LISA is the best technique for reveal hot spots and cold spots areas compared to Global Moran's I techniques which only can reveal the pattern of crime by global scale without showing areas that classified as hot spots and coldspots of crime. The index of Moran's I and significant levels can be identified based on normal distribution estimates.

LISA is very useful for showing places or verifies where significant spatial autocorrelation exists (E Santoso, 2019). LISA provide greater possibilities than the hot spot analysis because LISA can detects the different value from that of its neighbours, while Getis Ord Gi* only can detects the areas with similar value around its neighbour. Thus, LISA is the most appropriate technique for identifying clusters of vehicle theft with similar values and different values locally (Jose et al, 2019).

The weighting value for LISA autocorrelation consists of four categories namely high-high, low-low, high-low, low-high. Areas with high-high values indicate that the area has a high index and it surrounded by high values around it or the area of its fall. High-high areas are known as hot spots while low-low value areas are known as cold spot crime. Areas with high-low and low-high values represent different index values in their surrounding area or neighborhood. Here's the formula;

$$I_i = \frac{z_i - \bar{z}}{\sigma^2} \sum_{j=1, j\neq i}^{n} \left[W_{ij}(z_j - \bar{z}) \right],$$

The value of z is the mean value of z score, while n is the total number of samples. The value of zi is the variable value in this location. The value of z is the value in another location (where j≠ i); σ 2 is a z variant. Wij is the weighting distance between zi and zj.The weight Wij can also be determined using a distance band. Samples within a distance band are given the same weight, while those outside the distance band are given the weight of 0 (et.al, 2014).

Data

There are two types of data were used in this study such as attribute data and spatial data. Attribute data consists of vehicle theft from January 2015 to December 2017 were obtained directly from Police Reporting System in Kuching District Police Headquarters. In this study, vehicle theft includes motorcycle theft, car theft and heavy machinery, truck and lorry by year, by police station, address of incidents and coordinate (x, y). The addresses of all vehicle theft were

geocoded using the online by google drive. Spatial data consist of 9 police station boundary with 57 police sectors boundaries, road data and map of Kuching, Sarawak.

FINDINGS

Figure 3 show statistic of vehicle theft in Kuching, Sarawak from 2015-2017. In 2015 the total number of vehicle theft was recorded 1000 cases. In 2016 the vehicle theft decreased to 748 cases with reduction of 252 cases or 33.6 percent. The vehicle theft crime rate has generally been increasing with 85 (10.2%) cases and the overall number of cases in 2017 was 833 cases.

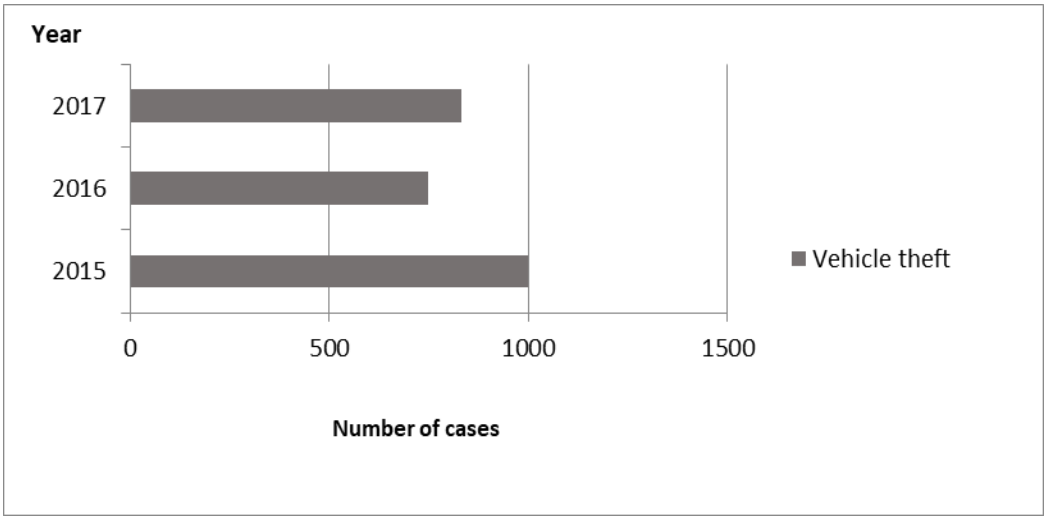


Figure 3: Trend of Vehicle Theft 2015-2017

The different types of vehicle theft examined here are motorcycle theft, car theft and van/lorry/bus and heavy machinery theft from 2015-2017 as shown in Figure 4. According to police report, the number of motorcycle theft decrease 252 cases or 32.6 percent in between year of 2015 and 2016 while in 2017 the cases increase with 122 cases or 19.03 percent. The number of car thefts reported in Kuching has rised over two years. It has increased from 207 cases in 2015 to 211 cases in 2016. In 2017 there were 181 cases of car theft reported and it show the cases drop by 14.2%. Statistic of vehicle theft shows the trend of van/lorry/bus/heavy machinery theft decrease 50% from 2015-2017. On the whole, motorcycle were the most stolen vehicle and its contribute 68% to property crime cases in Kuching, Sarawak while car theft were reported 30% and van/lorry/bus/heavy machinery theft was 7% since year 2015-2017.

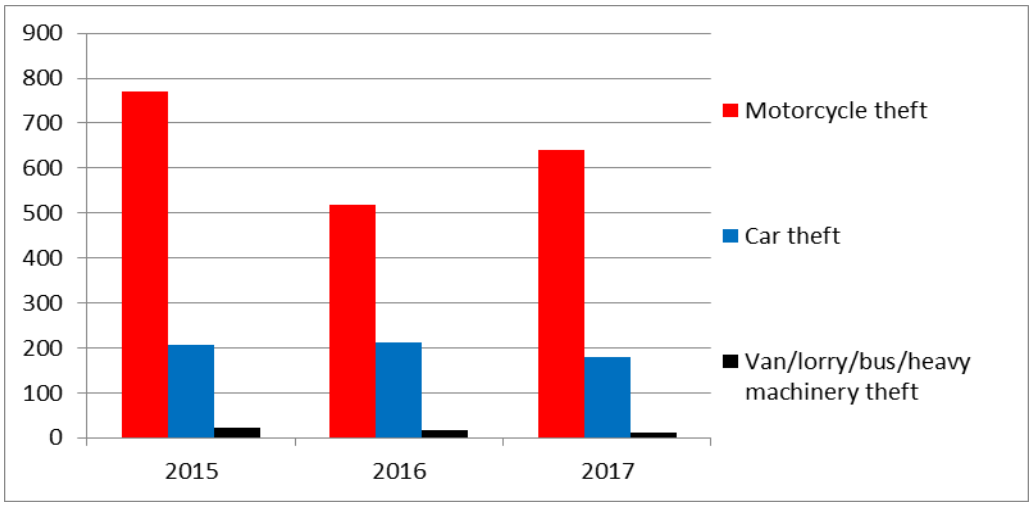


Figure 4: Trend of Vehicle Theft by types 2015-2017

Hot Spots of Vehicle Theft in 2015-2017

Based on the analysis of Moran's I the study found that there was spatial autocorrelation of vehicle theft case in 2015. The Figure 5 show there was a low cluster of vehicle thefts in sector 2 in Santubong police station boundary with an index value of 0.000886 while a z score of 2.399832, a value of $p < 0.05$. This indicates that the area is a cold spot of vehicle theft with a 95% confidence level. The null hypothesis is rejected because the vehicle theft is significant cluster.

However, the study found that the highest value of vehicle theft was detected in sector 2 which is located in Gita police station boundary with Moran's I value of 0.001492, z score of 2.275231, p-value <0.05 as shown in Figure 5. Thus, that there is a positive autocorrelation at a near location and it's classified as a hot spot. Thus, in 2015, there were 2 sectors under the administration of Gita police station were classified as significant cluster of car theft with 95% of level confidence. In 2016 vehicle theft shows no cluster as shown in Figure 5. The null hypothesis was accepted because the pattern is random.

LISA shows that there were two sectors of police station found to have a high-high cluster of vehicle theft in 2017. Sector 3 under the administration of Padungan police station had a high-high cluster of Moran's I 0.003663, a z-score value of 2.071951 and a value of $p < 0.05$. Meanwhile, sector 4 under the administration of Sekama police station has Moran's I value of 0.003351 with a z score of 2.464516 and a value of $p < 0.05$. This result suggested that hot spot of vehicle theft existed in 2017.

Figure 5 suggest in 2017 there are two sectors boundary of police station tended to concentrate with low-low value of vehicle theft in sector 2 under supervision of Santubong police station, Moran's I was 0.000989, z-score was 2.699093 with a p value of 0.01. For sector 4 in Santubong, Moran's I was 0.000726, z-score was 1.983262 with a value of $p < 0.05$. Both results indicate a positive autocorrelation which meant that cold spot existed in 2017. The null hypothesis is rejected due to vehicle theft were found to be clustered.

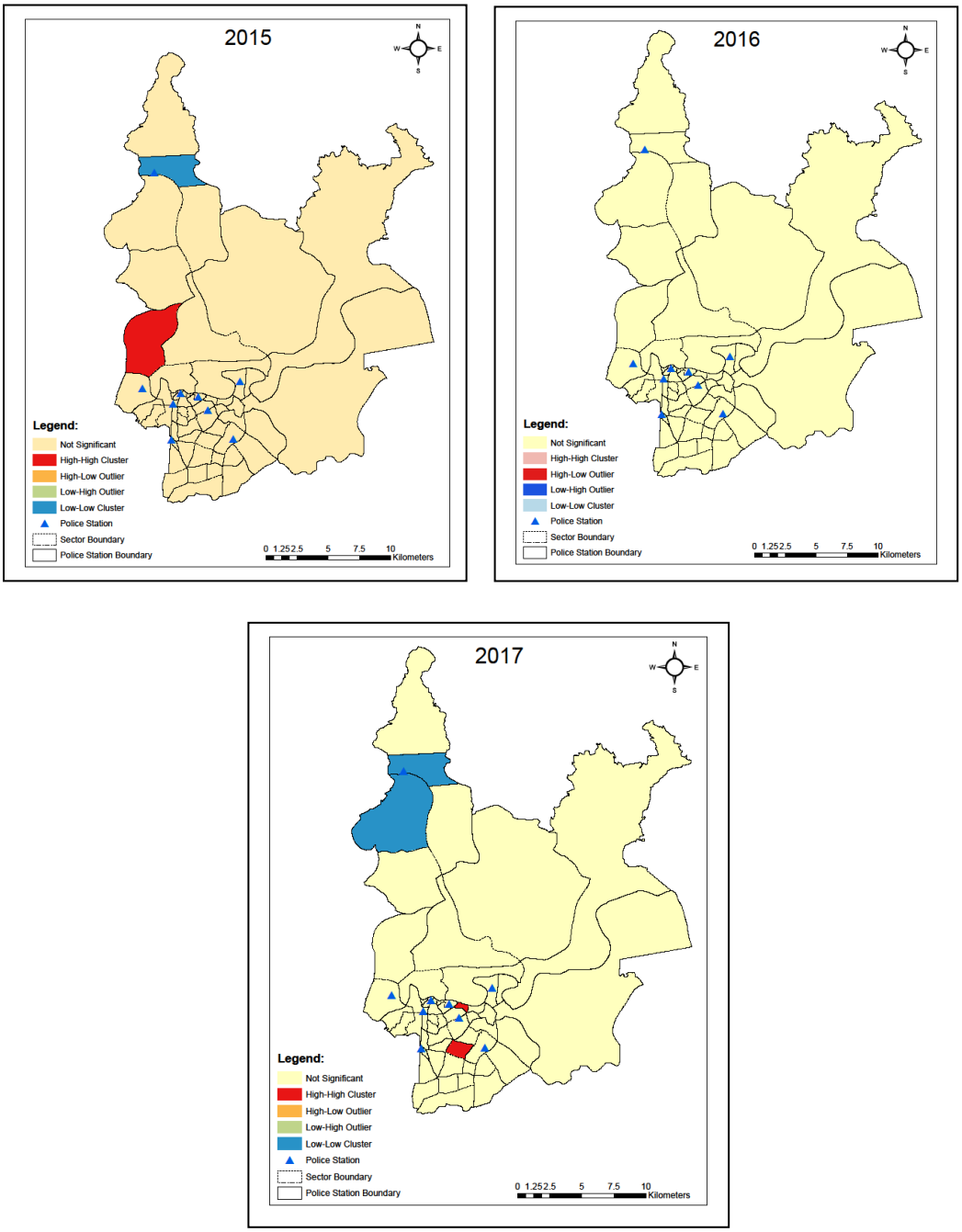


Figure 5: Hot Spot and Cold Spot of Vehicle Theft in Kuching Sarawak for 2015-2017

Hot spots of Car Theft in 2015-2017

Figure 6 displays the LISA analysis of car theft from 2015 to 2017 in Kuching, Sarawak. In year 2015 vehicle theft had six clusters. A local spatial autocorrelation analysis indicated that the hot spot of car theft was located at sectors 2, 4 and 6 in Sekama police station boundary, as well as sectors 2, 3, and 5 under the administration of Sungai Maong police station. Besides that sector 1 that located in Tabuan Jaya police station boundary also detected as hot spots of vehicle theft. All these areas suggested a high-high value cluster of car theft with 99% of level confidence, $p<0.01$.

The result shows low-high clusters at 95% of level confidence, $p<0.05$ indicate that negative autocorrelation of car theft existed in three sectors such as sector 6 in Sungai Maong police station boundary and sector 6 and 7 in Tabuan Jaya police station boundary. These areas have low value and it is surrounded by high value around it. Thus, in 2015 there are 10 sectors found clustered. The null hypothesis was rejected because car theft tends to cluster in 2015.

The number of sectors that classified a cluster of car theft decreases to 5 sectors in 2016. The hot spots was found in three sectors of Sekama police station boundary which are include sector 4,6,9 and sector 3 in Sungai Maong police station boundary. All of these sectors had high-value clusters with a 99% confidence level, $p<0.01$ as shown in Figure 6. The hot spots was also found in sector 6 that located in Sungai Maong Police station boundary with a 95% confidence level, $p<0.05$.

The result shows the high value of cluster with a 99% confidence level was found located in sector 2,4,6 and 8 of Sekama police station boundary as well as sectors 2 and 5 in Sungai Maong police station boundary and sector 1 under the administration of Tabuan Jaya police station. These results suggested that hot spots existed. However, sector 6 in Sungai Maong police station boundary show low-high value, which meant this area has low value and it is surrounded by high value around it.

Hot Spots of Motorcycle Theft in 2015-2017

Results found that the cold spot of motorcycle theft located in sector 2 of Santubong police station boundary with a 95% confidence level, $p<0.05$ (Refer Figure 7). High clusters were detected in sectors 1 and 2 under the administration of the Gita police station with a 99% confidence level while sector 3 recorded a 95% confidence level. Overall the result indicates three hot spots and one cold spot area of motorcycle theft in 2015**.**

For 2016, a high cluster of motorcycle theft found located in sectors 1,3 and 5 under the administration of Gita police station with a 99% confidence level, $p<0.01$ that indicates a positive autocorrelation which meant hot spot existed. In 2017, a high cluster of motorcycle theft found in sector 3 of Gita police station at a 99% of significant level. The areas in sector 2 of Santubong police station were identified low cluster at a 99% of significant level. This result indicates one hot spot and one coldpsot of motorcycle theft in 2017. Thus, the null hypothesis can be rejected, because the pattern expressed is clustered (Figure 7).

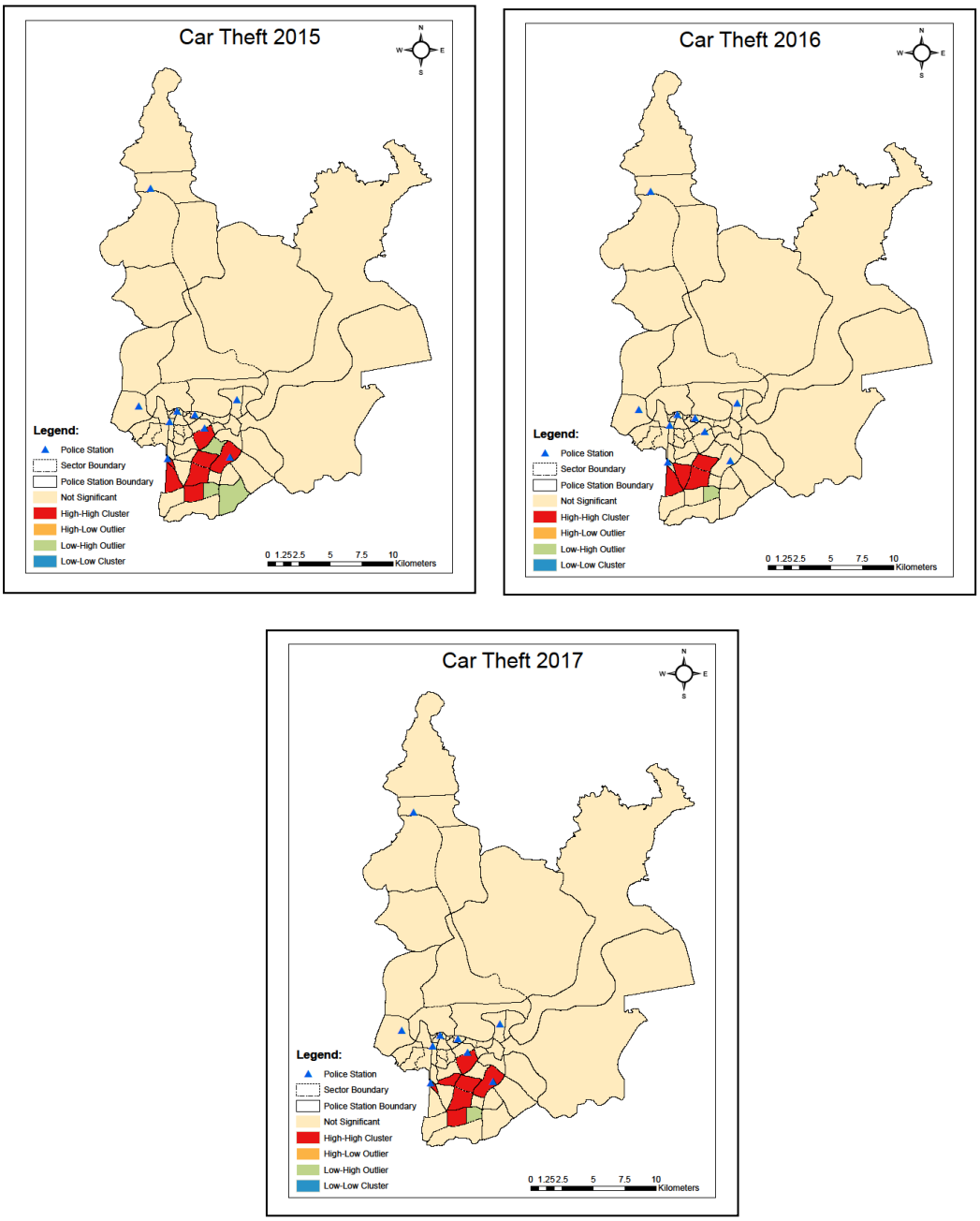


Figure 6: Hot spots of Car Theft in Kuching, Sarawak for 2015-2017

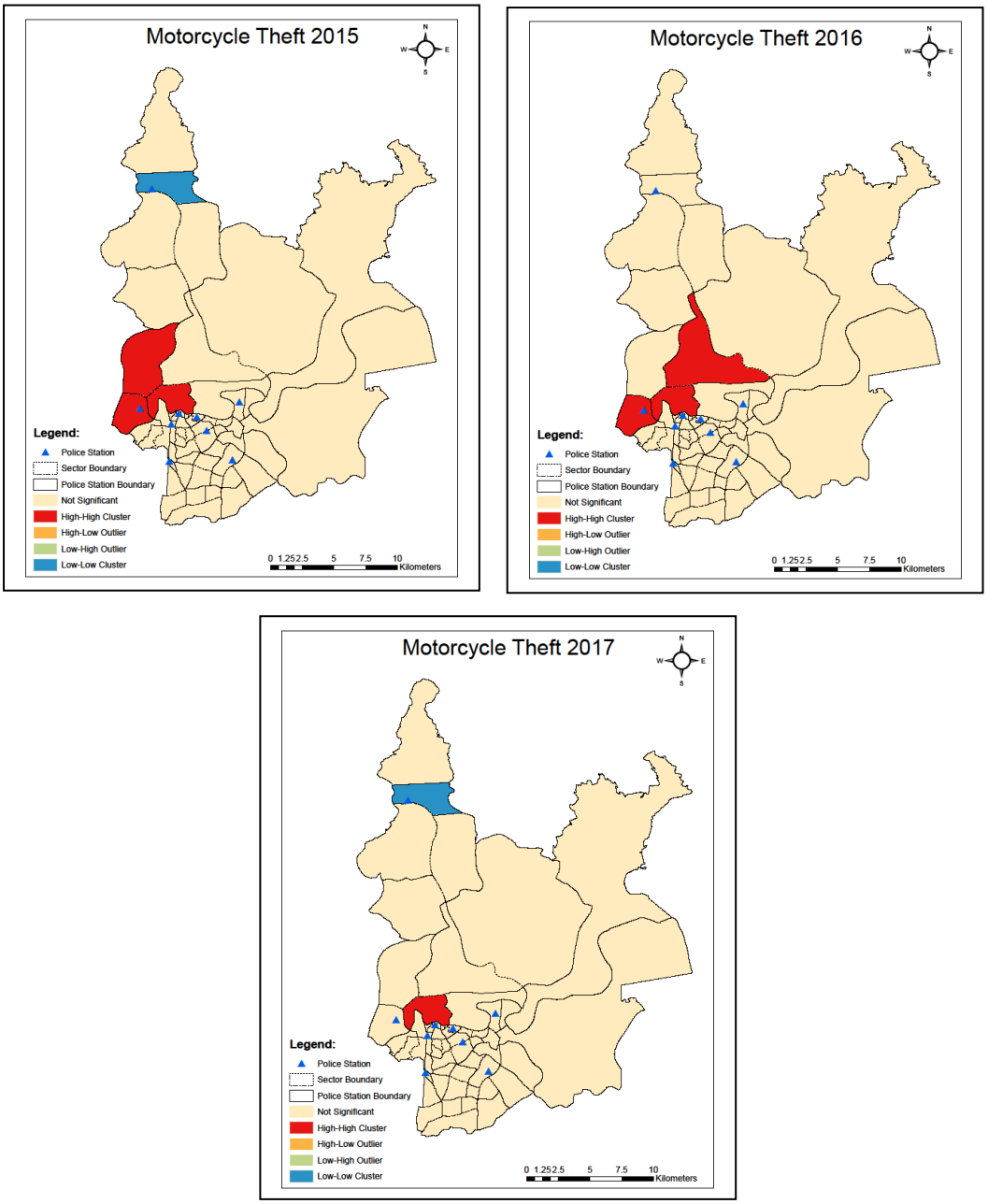


Figure 7: Hot Spots of Motorcycle Theft in 2015-2017

Hot spots of bus/van/lorry/heavy machinery theft in 2015-2017

The result shows that there is no significant of bus/van/lorry/heavy machinery theft was identified which meant bus/van/lorry/heavy machinery theft shows a random pattern in 2015 as shown in Figure 8. During 2016 there are three areas

hot spots of bus/van/lorry/heavy machinery theft were found located in sector 1 under administration of Bintawa police station boundary, sector 4 which is located in Padungan police station boundary and sector 2 in Tabuan Jaya police station boundary at a 99% confidence level, $p<0.01$. Another area located in sector 4 of Bintawa police station identified hot spot at 95% of confidence level, $p<0.05$. In 2017, a high-low outlier found located in sector 6 of Gita police station and sector 3 in Padungan police station boundary. Both results suggested a negative autocorrelation at a 95% confidence level, $p<0.05$, which meant this area has high value and it is surrounded by low value around it.

DISCUSSION

Overall, using the LISA technique, this study was able to identify the location of vehicle theft hot spots based on 9 police station boundary with 57 of sector boundary. The study found that vehicle theft hot spots were more likely to occur in areas near the city center while the cold spots occurred in areas far from the city center. From this study the pattern illustrates that the density of vehicle theft was the highest near CBD. Crime pattern theory suggests that CBD areas attract more people and existence of concentration potential targets and motivated offenders. Motivated offenders are presented with great opportunities (Bryan, 2000). There is a concentration of vehicle theft in certain police station sectors.

Besides that, LISA revealed that the spatial pattern of vehicle theft in Kuching, Sarawak are different by types and location. There is a low risk of car theft in Santubong police station boundary because this area located far from urban. The hot spot of car theft for 2015-2017 was mostly detected in certain sectors of police station boundaries which include Sungai Maong, Tabuan Jaya and Sekama (Refer Figure 6). These indicate that the hot spot of car theft in Kuching was located where there are more shopping malls, hospitals, retails and restaurants. All of these places attract a lot of people including offenders and generate opportunities for car theft due to the concentration of vehicles and the high potential of victims. The previous study shows that the existence of business areas and facilities in a neighborhood is usually associated with more vehicles and more opportunities for vehicle thieves (Yong Mei, 2006; Dan Jerome et.al, 2015).

Motorcycle theft hot spots are mostly located in Gita police station boundary. The Gita area has a higher population density than other areas and most of the low-income people, work in services and sales. Soetomo, (2018) state that the level of motorcycle use is influenced by low-income communities to fulfill their mobility needs. As a result, the high number of residents with low-income has increased the number of motorcycles in Gita, while increasing the target of criminals and there is a high chance of motorcycle theft in the Gita area. In addition Gita is near to the CBD areas.

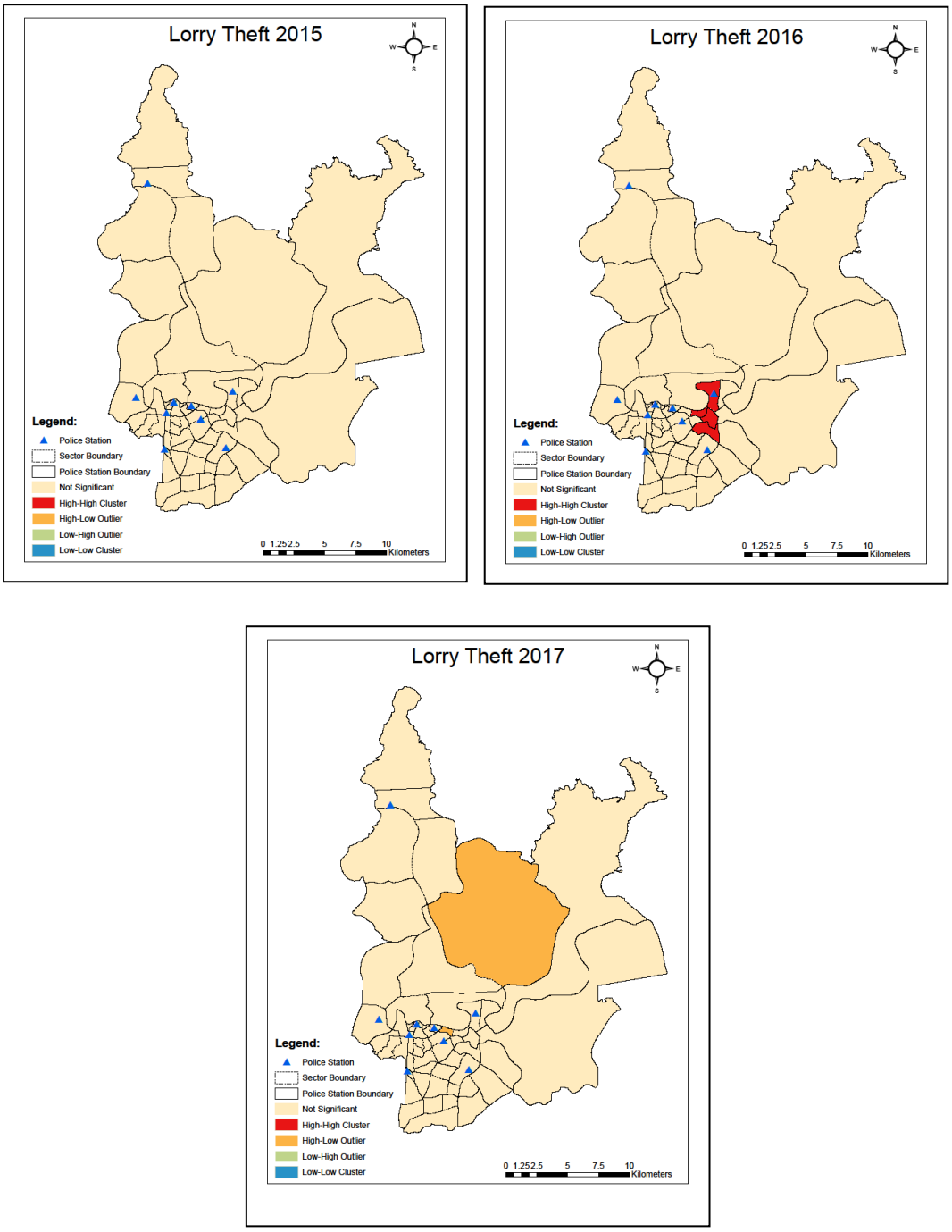


Figure 8: Hot spots of bus/van/lorry/heavy machinery theft in 2015-2017

The result of this study shows that high cluster or a hot spot of bus/van/lorry/heavy machinery theft mostly located at Pending Industrial Estate such as sector 1 and 4 in Bintawa police station boundary, sector 4 in Padungan police station boundary and sector 2 in Tabuan Jaya police station boundary. According to a zoning by the South Kuching City Council, (2020) all these sectors are located at zone 6 which mean industrial zone. Thus, the hot spot of bus/van/lorry/heavy machinery theft tends to occur in this area because that area located in an industrial zone.

Increasing use of vehicles contributes to the territory of predatory criminals. Millions of vehicles left unguarded on the city provide widespread opportunities for theft. The opportunities for crime are clustered around certain places because the road network is easy to access and provides a better chance for thief to drive a stolen vehicle away quickly (Lu, 2006). Vehicle theft is spatially concentrated. As crime pattern theory suggests, thefts occur when there is high availability of targets (Bryan, 2000) such as car theft tend to cluster in Sungai Maong, Tabuan Jaya and Sekama police station sector boundaries whereas motorcycle theft mostly cluster in Gita police station sector boundaries, while van/lorry/bus and heavy machine theft tend to cluster in industrial areas.

CONCLUSION

The pattern of vehicle theft shows that the available vehicles and socioeconomic activity have an influence on vehicle theft locations. The findings of the study also have implications for policing to combat vehicle theft. Local Indicator Spatial Autocorrelation can help identify the risk area in the sectors of police station boundary. Local Moran's I is the appropriate technique used to determine the clustering of vehicle theft in the local scale. Besides, that identifies significance cluster of crime and spatial outliers of high and low crime rates. Vehicle theft tends to cluster in urban.

ACKNOWLEDGEMENT

The authors would like to acknowledge the Bukit Aman and Criminal Investigation Department of Kuching District Police Headquarters for help in access to Police Reporting System. Financial support from Top Down Grant (SPTDG) F06 / SpTDG / 1731/2018, Spatial Distribution and Pattern of Drugs Addict and Crime: Case Study in Kuching and Penang, University Malaysia Sarawak is gratefully acknowledged.

REFERENCES

Bryan, L. M. (2000). Visualising The Spatio-Temporal Patternsof Motor Vehicle Theftin Adelaide, South Australia. Adelaide: GISCA National Key Centre for Social Applications of GIS Lecturer, GISCA National Key Centre for Social Applications of GIS.

Che E. R., (2008). Pembaharuan Pada Sistem Kunci Kereta (Proton Wira). Melaka: Universiti Teknologi Malaysia Melaka.

Courage M., Emmerson C., Taona M., Godwin K. Z. & Molline R. N. (2019). Mapping the spatial variations in crime in rural Zimbabwe using geographic information systems. *Cogent Social Sciences. 5*, 1-10.

Dain K. & Hohyun L. (2016). Crime Trend Analysis by Changes of Spatial Autocorrelation and Hot Spot. Proceedings of the 2016 International Conference on Industrial Engineering and Operations Management Kuala Lumpur, Malaysia (pp. 1854-1865). Kuala Lumpur: IEOM Society International.

Dan J. B., Rachelle M. O., Galo A., Roy G., Jason O., Kenneth A., & Jason M. (2015). Motor vehicle theft in Negros Oriental Philippines: Patterns across space, time and targets. *Prism. 20*(2), 2-16.

Fujita, S. (2010). Risk Factor For Auto Theft. RTM Insight, 1-2.

Guebuza G. M. M. (2012). Car Theft Prevention in Maputo Mozambique. The Netherlands: International Institute of Social Studies.

Huabao Z., Jiang P., Keli Z. & Guomo Z. (2014). Using Moran's I and GIS to study the spatial pattern of forest litter carbon density in a subtropical region of southeastern China. *Biogeosciences (11)*, 2402-2409.

Insurance Services Malaysia Bhd. (2007). Insurance Industry Statistics on Stolen Vehicles. Malaysia: http://www.piam.org.my/news/piamnews/p014.htm.Accessed 22 June 2011.

Lai S. H., Darrien M. Y. S., Frederik J. P. & Salim S. (2008). Ecological Sanitation, Sustainable Strategy As An Alternative Urban Water Source. International Conference on Environment ICENV (pp. 1-10). Penang, Malaysia: School of Chemical Engineering, Universiti Sains Malaysia.

Lu W., Gabby L. & Ian W. (2019). The spatial and social patterning of property and violent crime in toronto neighbourhoods: A spatial-quantitative approach. *International Journal of Geo-Information, 8*(51), 1-18.

Lu, Y. (2006). Spatial choice of auto thefts in an urban environment. *Security Journal*, *19*, 143-166.

Lucy W. M. & Mohamed B. (2016). Modeling spatial interactions between areas to assess the burglary risk. *International Journal of Geo-Information,* 5(47), 2-16.

Mohd Norarshad Nordin, Tarmiji Masron, Nur Emyliana Yunos & Norita Jubit. (2020). Spatial hots spots patterns of a home burglary in Penang. *Malaysian Journal of Society and Space, 16*(2), 29-40

Millard-Ball, C. B. L. (2019). The world's user-generated road map is more than 80% complete. *Plus One, 14*(10), 1-20.

Natalia I., Richard F., Vahid D., Andrew R. & Patricia B. (2011). Analyzing an Offender's Journey to Crime: A Criminal Movement Model (CriMM). European Intelligence and Security Informatics Conference (pp. 70-77). Athens, Greece: IEEE.

National Transformation Programmed. (2015). Laporan Tahunan 2011. Kuala Lumpur: Unit pengurusan Prestasi dan Pelaksanaan (PEMANDU) Jabatan Perdana Menteri.

Norita Jubit, Tarmiji Masron & Azizan Marzuki. (2020). Spatial pattern of residential burglary. The case study: Kuching, Sarawak. *Journal of the Malaysian Institute of Planners*, *18*(3), 190-201.

Oliver G., MdMobarak H K., Sven L., Daniel M., Alexander K., Tobia L. & Patrick H. (2011). A spatial epidemiological analysis of self-rated mental health in the slums of Dhaka. *International Journal of Health Geographics*, *10*(36), 2-15.

Patricia G. (2016, march). Borneo Post. Police Focused on the Increases of Crime. Retrieved from https://www.utusanborneo.com.my/2016/03/14/polis-tumpu-peningkatan-beberapa-kes-jenayah.

Royal Malaysia Police. (2017). Crime Statistics Index For whole Malaysia by crime types, state and Year. Putrajaya: MAMPU.

Royal Malaysia Police. (2018). Crime Statistics Index For whole Malaysia by crime types, state and Year. Putrajaya: MAMPU.

Rozaimi M. & Narimah S. (2017). Pemetaan hot spot GIS dalam kejadian jenayah kecurian motosikal di Bandaraya Alor Setar, Kedah Darul Aman. Buletin GIS dan Geomatik. *Bil 1*, 9-19.

Ruth K., G. P. (2010). Applying geostatistical analysis to crime data: car-related thefts in the Baltic States. *Geographical Analysis, 42(1)*, 53-77.

Saffet Erdogan, Mari A. D., Musataf Y. (2011). Spatial Analysis of Five Crime Statistics in Turkey. Marrakech, Morocco: SIM and Planning.

Soetomo, S. I. (2018). Model of motorcylce ownership and its impact to urbanization in rural area: A case of Kudus Regency, Indonesia. *Journal of Geomatics and Planning, 5*(1), 147-156.

Soo S. C., Wei K. W. & Kok L. G., (2016). Backpropagation vs radial basis function neural model: Rainfall intensity classification for flood prediction using meteorology data. *Journal of Computer Sciences. 12(4)*, 192-200.

Syerrina Z. & Nuzlinda A. R. (2014). Analyzing the property crime pattern in Peninsular Malaysia: ESDA Approach. *Journal of Business and Social Development*, *2*(1), 104-113.

Tarmiji Masron, Wan Muhammad Taufik Wan Hussin, Mohd Norarshad Nordin, Nur Faziera Yaakub & Mohd Azizul Hafiz Jamian. Applying GIS in analysing black spot areas in Penang, Malaysia. *Indonesian Journal of Geography*, *50*(2), 133-144.

UNODC. (2010). International Statistics on Crime and Justice. European Institute For Crime Prevention and Control Affiliated With the United Nations. Findland: United Nation

Utusan Malaysia. (2012, Februari). Unit Khas Atasi Kecurian Kenderaan. Retrieved from index.php/ms/papercutting: unit-khas-atasi-curi-kenderaan.html

Yocum, A. A. (2016). Spatial Pattern of Motor Vehicle Theft in Beltrami Country, Minnesota. Bemidji State: University Criminal Justice.

Yongmei. L. (2006). Spatial choice of auto thefts in an urban environment. *Security Journal*. *19*, 143-166.

Yongmei L., Xuwei, C. (2007). On the false alarm of planar k-function when analyzing urban crime distributed along streets. *Social Science Research*, *36*, 611-632.

Yuanyuan M., Shenzhi D., Jiajun D., Wei Z., Can W. & Xinyue Y. (2018). Space-time analysis of vehicle theft patterns in Shanghai, China. *International Journal of Geo-Information*, *7*(357), 2-14.