Crime Prediction Using Geospatial Intelligence System for Crime Preventing

Hasranizam Hashim*

Centre of Studies for Surveying Science and Geomatics, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
**E-mail: nizam99pol@gmail.com*

Abstract

Crime prediction relies on significant amounts of various data sources and is analysed through mathematical models, predictive analytics techniques, and machine learning algorithms to identify patterns of crime. To date, there has been little research conducted to examine and extend which repeat and near-repeat victimisation within crime hotspots can be collocated for crime prediction (Chainey et al., 2018). Therefore, this paper aims to identify crime patterns using crime prediction with repeat and near-repeat analysis. This study employed the GIS tool, namely, repeat and near-repeat analysis as the primary methods. Historical crime: all types of data used in the years 2015 and 2016 are analysed. The area of study is Petaling Jaya, Selangor. By using repeat and near-repeat analysis, the results reveal that there is a significant (p=0.01) and a meaningful near-repeat victimisation pattern were found in the study area. The most over-represented space-time range that is significant is the zone from 1 to 100 metres and from 0 to 7 days from the initial incident. The likelihood of another crime incident is approximately 22% higher than if there is no discernible pattern. The most over-represented repeat victimisation range that is significant is the zone from 0 to 7 days after an initial incident. The likelihood of another incident is approximately 78 percent higher than if there were no repeat victimisation patterns. This result also shows there are five local hotspots as prediction zones in the study area. The importance of the study is that it provides useful information for assisting law enforcement in improving crime prevention strategies using geospatial technologies.

Keywords: Crime mapping; GIS; Spatial statistic; Crime prediction

1. Introduction

Crime prediction relies on significant amounts of various data sources and is analysed through mathematical models, predictive analytics techniques, and machine learning algorithms to identify patterns of crime. Crime prediction is one type of tactical crime analysis. Tactical crime analysis is the study of recent criminal incidents and potential criminal activity that has occurred to assist in crime pattern development. Some researchers found that offenders would repeat another crime at the same location, which is called the repeat victimisation (RV) phenomenon (Pease, 1998). First coined by Morgan (2000), the near-repeat (NR) phenomenon is when those that live near an elevated risk of repeat victimisation are victimised later. The "boost" explanation and the "flag" explanation are two primary reasons to interpret the mechanism of repeat and near-repeat victimisation (Weisel, 2005). According to Wang and Lui (2017), boost theory suggests that the risk of future victimisation is boosted by past victimisation and the success of previous crime commissions. While flag theory argues that specific target properties are flagged by high vulnerability associated with the attentions of the first offender in the commission of a previous offence against that target (victim), Recent research has been used to test both the

boost explanation and the flag explanation in the phenomena of repeat victimisation (RV) and near-repeat victimisation (NR) (Sagovsky and Johnson, 2007). Some researchers suggest these patterns offer a powerful means by which predictions of crime can be made (Bowers et al., 2004), with prediction accuracy improvements can be made in hotspot analysis methods (Johnson et al., 2009). Unfortunately, to date, there has been little research conducted to examine and extend the repeat and near-repeat victimisation within crime hotspots collocated for crime prediction (Groff and Taniguchi, 2019).

Ratcliffe and Rengert (2008) are among the pioneer conducting research in testing the near-repeat phenomena about crime type outside of burglary. Understanding this phenomenon will allow police to focus more precisely on crime prevention programmes. Recent researchers, such as Haberman and Ratcliffe (2012), find that near-repeat robbery chains an average of only 4.2 days in Philadelphia. Wells et al. (2012) argue that business locations and gang-linked shootings are statistically significant and generate near-repeat shootings in Houston.

By addressing the research gap, this study aims to identify spatial repeat and near-repeat patterns of crime for use in a geospatial policing strategy to improve community safety. In the simplest terms, repeat victimisation is a type of crime pattern (Weisel, 2005). The geospatial policing strategy was first coined by the National Institute of Justice in the United States. According to a National Institute of Justice survey from 2001, 62 percent of police departments with more than 100 officers use Geographic Information Systems (GIS) for mapping crime, identifying crime hotspots, assigning officers, and profiling offenders (Weisburd and Lum, 2006), but little research has been done on the technology's effectiveness in reducing crime.

The first crime prevention programme to prevent domestic burglary that took advantage of repeat victimisation patterns was The Kirkholt Burglary Prevention Project in Rochdale, England. The result shows there is a reduction in burglary of 80 percent in burglary repeat victimisation and 53 percent across the Kirkholt estate (Forrester et al., 1988).

Another program, such as The Trafford Experiment in Manchester, United Kingdom, to prevent near-repeats, involves police officers visiting the crime incident location twenty-four hours after the incident and conducting door-to-door visits near burgled houses on the day after the incident, resulting in a 42 percent reduction in burglaries (Fielding and Jones, 2012). Repeat and near-repeat victimisation using spatial analysis is to understand this phenomenon and make this purpose a relatively simple task. Analysis of repeat and near-repeat victimisation using GIS can help to predict how many crimes will occur within the hotspot location in the area. The importance of this study produces competence in answering the everyday questions concerning crime incident locations, patterns, and policing policy implications.

2. Methodology

The study adopts the crime pattern theory, which has been proposed by Brantingham and Brantingham (2008). The crime pattern theory is now the pillar of environmental criminology together with rational choice and routine activities theory, by introducing new concepts as purpose by Morgan (2000).

Study Area, Datasets, and Background Study

The study area is Petaling Jaya in Selangor, Malaysia. Petaling Jaya is located between 03° 05′ 50″ north latitude and 101° 38′ 40″ east longitude, and the city's population is about 613,977 residents living around 51.4 square kilometres (19.8 square miles). Justification for the study area is due to one of the highest crime cities in Selangor. Seven police stations in Petaling Jaya, which are covered by the boundary administration area, as shown in Figure 1, are analyzed. The crime data index is based on a set of raw data with x and y coordinates from the police department and the web portal i-selamat.my in 2015 and 2016.

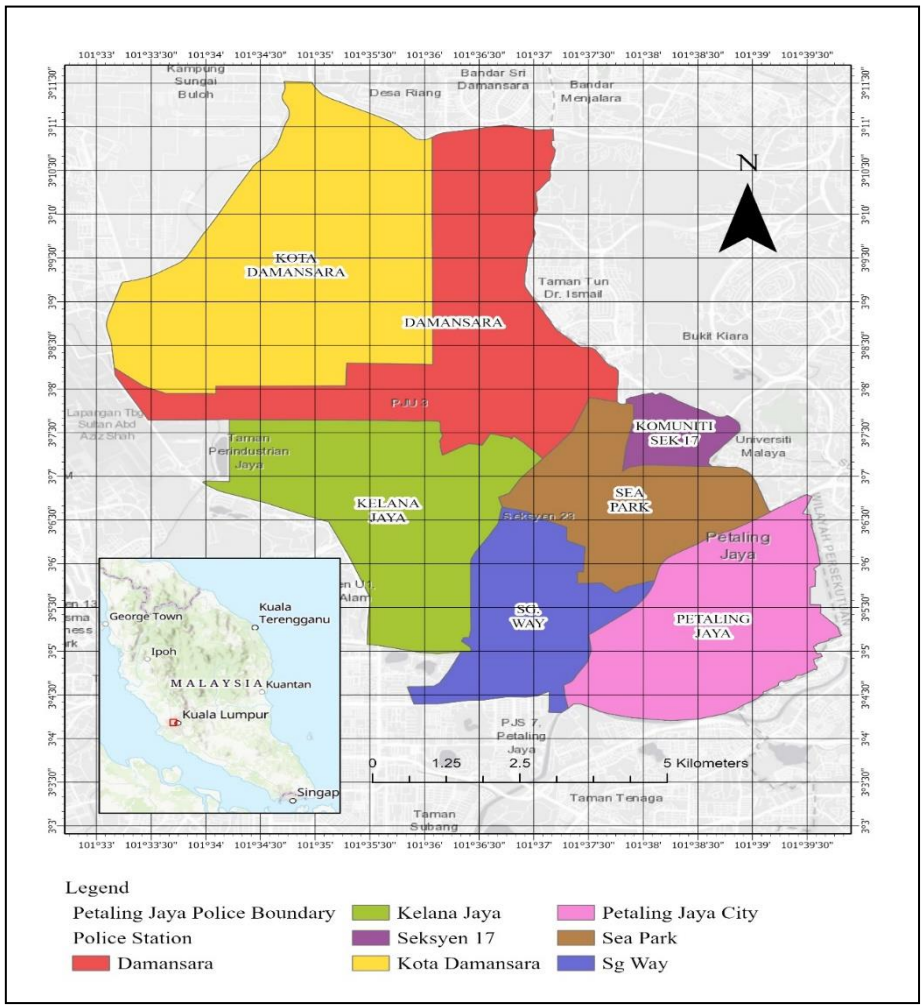
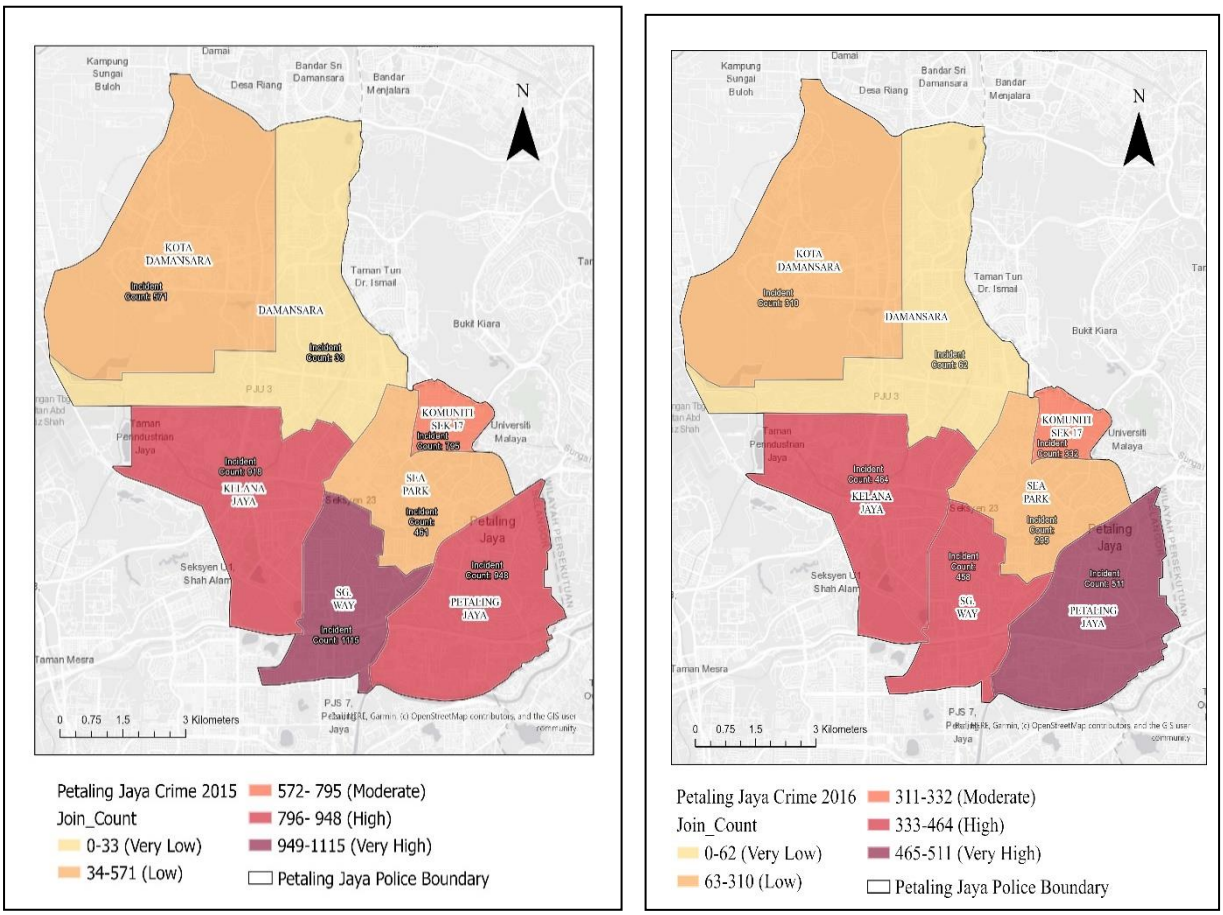


Figure 1: Study area

Crime Distribution in Petaling Jaya

The methodology employed is recorded crime data on all types of crime index from Petaling Jaya Police for the period January 2015 to December 2016. There are 4,846 crimes recorded in 2015 and 2,434 crimes recorded in 2016, as shown in Figure 2. The type of crime data for analysis is from ten types of crime index, which is theft, snatch theft, motorcycle theft, car theft, van/lorry/heavy machine theft, house break-in night, house break-in day, and from

violent crime is gang robbery without a firearm, robbery without a firearm, and assault without a firearm.



(a) (b)

Figure 2: Crime distribution in 2015 (a) and 2016 (b)

Figure 2 shows that crime density is very high in Sungai Way in 2015, followed by Kelana Jaya and Petaling Jaya City Centre. In 2016, the density was changed to Petaling Jaya City Centre, with very high density, followed by Kelana Jaya and Sungai Way using Natural Breaks (Jenks) classification.

Workflow of Analysis

The software used is ArcGIS Pro 2.5 and the primary tool is Repeat and Near-repeat Analysis. The near-repeat calculator software was also used to determine if the pattern of crime repeats was statistically significant using Monte Carlo simulation. The study adopted a method proposed by using a two-stage approach. The first stage repeats the record address database for the same dwelling using the same geographic coordinates. The second stage is based on the same text string recorded in the address field. These two stages are for measuring repeat victimization. The analysis of crime repeats was conducted for the whole 2-year dataset and for each year over the two years.

For measuring near-repeat victimization, the spatial bandwidth in the near repeat calculator is set to 100 m with four bands. The temporal bandwidth set to 7 days with four

bands was applied to determine the number of offences committed. An analysis was conducted within 100 metres and 7 days, within 200 metres and 7 days, within 300 metres and 7 days, and more than 400 metres of the originator of the offense. As a result, the result shows the location of the original offenders as well as repeat and near-repeat maps. The Prediction Zones tool is used to identify areas at risk of repeat and near-repeat incidents by the range of influence of past crime incidents. The workflow analysis is shown in Figure 3.

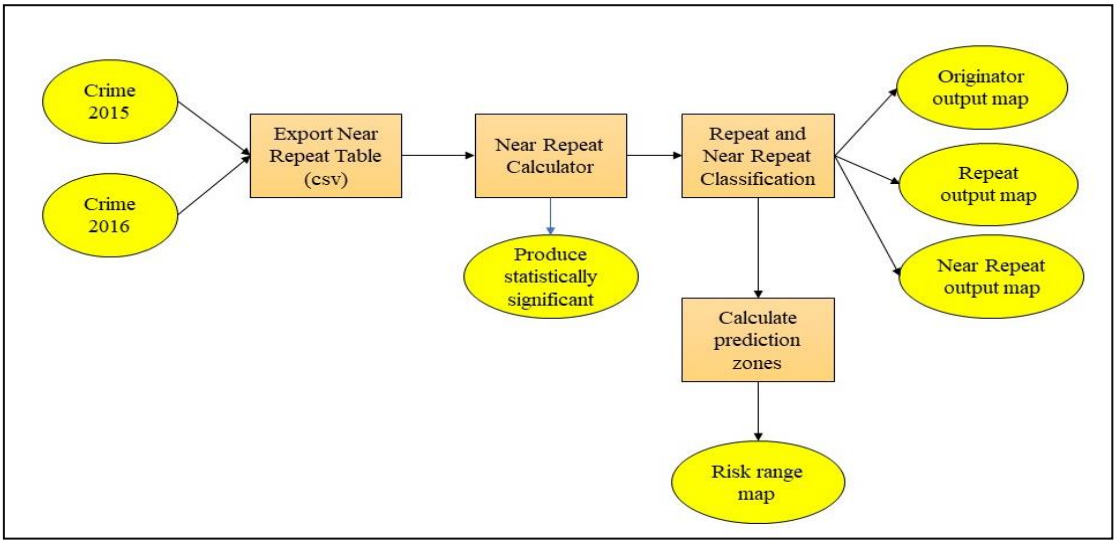


Figure 3: Workflow of analysis

3. Results and Discussion

Analysis of Repeat Victimisation and Near-Repeat Victimisation in 2015

As shown in Table 1, during the 2015 period, the number of repeats and near-repeats of crime incidents in the same location accounted for 34 in 0 to 7 days, equivalent to 0.7 percent of all recorded crime index in Petaling Jaya. In 0-7 days, the repeat and near-repeat crime index is very high, accounting for 3,453 total, or 71.3% of all recorded crime incidents in Petaling Jaya.

Table 1: Number of repeat and near-repeat incidents per spatial and temporal band

	0 to 7 days	8 to 14 days	15 to 21 days	22 to 28 days
Same location	34 (0.7%)	47 (1.0%)	57 (1.2%)	62 (1.3%)
1 to 100 m	1456 (30.0%)	1870 (38.6%)	2130 (44.0%)	2338 (48.2%)
101 to 200 m	2299 (47.4%)	2848 (58.8%)	3164 (65.3%)	3394 (70.0%)
201 to 300 m	2925 (60.4%)	3506 (72.3%)	3777 (77.9%)	3989 (82.3%)
301 to 400 m	3453 (71.3%)	3964 (81.1%)	4196 (86.6%)	4345 (89.7%)

As a result, as shown in Table 2, after an incident, there is evidence of an over-representation of events in the local area. There may be a crime prevention value in addressing this pattern. Within 1 to 100 metres of an initial incident, near-repeats are overrepresented for up to 7 days. The most over-represented space-time range that is significant is the zone from 1 to 100 metres and from 0 to 7 days from the initial incident. The likelihood of another incident is approximately 30% higher than if no discernible patterns existed. A significant and

meaningful repeat victimisation pattern was found. There is evidence of an over-representation event at the same place up to 7 days after an initial incident. The most over-represented repeat victimisation range that is significant (p = 0.01) is the zone from 0 to 7 days of originator crime incidents. The likelihood of another incident is approximately 71% higher than if there were no repeat victimisation patterns. The pattern of repeat victimisation was not statistically significant (p = 0.05) for the 2015 year between 15–21 and 22–28 days of the originator incidents. These results indicate that in Petaling Jaya, a repeat crime incident is more likely to occur swiftly after (and within 7 days) of a previous crime incident than at any other time, as shown in Figure 4.

Table 2: Statistical significance table

	0 to 7 days	8 to 14 days	15 to 21 days	22 to 28 days	More than 28 days
Same location	**0.01**	0.62	0.25	0.06	0.98
1 to 100 meters	**0.01**	**0.01**	0.84	1.00	1.00
101 to 200 meters	**0.01**	**0.01**	0.19	1.00	1.00
201 to 300 meters	**0.01**	**0.01**	0.60	1.00	1.00
301 to 400 meters	**0.01**	**0.01**	0.08	0.82	1.00

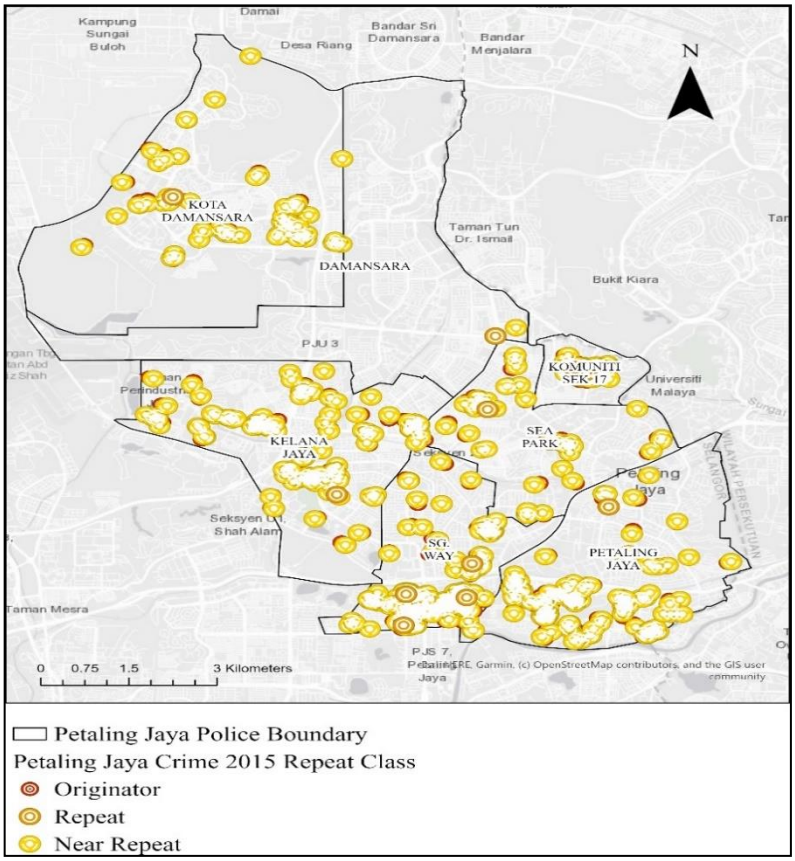


Figure 4: Repeat class map by originator, repeat, and near-repeat in 2015

Analysis of Repeat Victimisation and Near-Repeat Victimisation in 2016

As shown in Table 3, during the 2016 period, the number of repeats and near-repeats of crime incidents in the same location accounted for 12 in 0 to 7 days, equivalent to 0.5 percent of all recorded crime indexes in Petaling Jaya. Repeat and almost-repeat crime index is very high in the first seven days, with 1,559 crimes, or 64.1% of all crimes reported in Petaling Jaya.

Table 3: Number of repeat and near-repeat incidents per spatial and temporal band

	0 to 7 days	8 to 14 days	15 to 21 days	22 to 28 days
Same location	12 (0.5%)	15 (0.6%)	16 (0.7%)	18 (0.7%)
1 to 100 m	595 (24.4%)	721 (29.6%)	835 (34.3%)	927 (38.1%)
101 to 200 m	996 (40.9%)	1171 (48.1%)	1328 (54.6%)	1432 (58.8%)
201 to 300 m	1324 (54.4%)	1541 (63.3%)	1703 (70.0%)	1792 (73.6%)
301 to 400 m	1559 (64.1%)	1815 (74.6%)	1944 (79.9%)	2008 (82.5%)

As a result, as shown in Table 4, after an incident, there is evidence of an over-representation of events in the local area. There may be a crime prevention value in addressing this pattern. Within 1 to 400 metres of an initial incident, near-repeats are overrepresented for up to 7 days. The most over-represented space-time range that is significant is the zone from 201 to 300 metres and from 0 to 7 days from the initial incident. The likelihood of another incident is approximately 54% higher than if no discernible patterns existed. A significant and meaningful repeat victimisation pattern was found. After an incident, there is evidence of an over-representation of events in the same place up to 7 days after the initial incident. The most over-represented repeat victimisation range that is significant ($p = 0.01$) is the zone from 0 to 7 days of originator crime incidents. The likelihood of another incident is approximately 159 percent higher than if there were no repeat victimisation patterns. The pattern of repeat victimisation was not statistically significant ($p = 0.05$) for the 2016 year between 8 to 14, 15 to 21, and 22 to 28 days of an originator incident. These results indicate that in Petaling Jaya, a repeat crime incident is more likely to occur swiftly after (and within 7 days) of a previous crime incident than at any other time, as shown in Figure 5.

Table 4: Statistical significance table

	0 to 7 days	8 to 14 days	15 to 21 days	22 to 28 days	More than 28 days
Same location	**0.01**	0.95	0.82	0.31	0.95
1 to 100 meters	**0.01**	1.00	0.95	0.01	1.00
101 to 200 meters	**0.01**	0.99	0.52	0.16	1.00
201 to 300 meters	**0.01**	0.69	0.82	0.08	1.00
301 to 400 meters	**0.01**	0.28	0.91	0.45	1.00

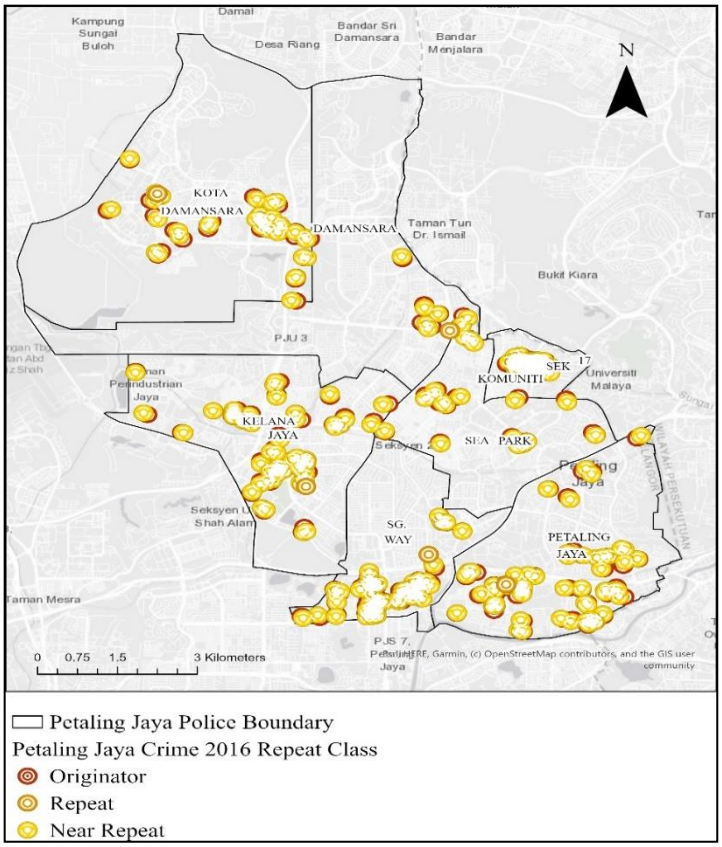


Figure 5: Repeat class map by originator, repeat, and near-repeat in 2015

By using the calculate prediction zones tool, whose spatial range of influence is 400 meters, the result (Figure 5) shows the most affected areas are Kota Damansara (Dataran Sunway Damansara) and Kelana Jaya (Taman Megah Mas) in Petaling Jaya. The value area in the map refers to the risk of future incidents taking place. The result shows the area around an incident that is practical for additional police patrols and deployment.

4. Conclusion

The study has identified a significant and meaningful repeat victimisation pattern in Petaling Jaya City Council. By using the near repeat calculator and the near repeat analysis tools, the study found a pattern of repeat victimisation that was statistically significant ($p = 0.01$) in areas of Seksyen 17 and Sungai Way in 2015, as well as Kota Damansara and Kelana Jaya in 2016. The main recommendation is to provide more resources for additional police patrols in targeting and deployment in this high-risk area to reduce crime patterns in future crime incidents. Safe city programs that have been implemented in Petaling Jaya City Council must be the focus of these high-risk places.

References

Bowers, K. J., Johnson, S., & Pease, K. (2004). Prospective hot spotting: the future of crime mapping. *British Journal of Criminology, 44*(5), 641-658.

Brantingham, P.L., & Brantingham, P.J. (2008). Crime pattern theory. In Wortley, R., and Mazerolle, L. (Eds.), Environmental criminology and crime analysis. UK: Willan Publishing.

Fielding, M., & Jones, V. (2012). Disrupting the optimal forager: Predictive risk mapping and domestic burglary reduction in Trafford, Greater Manchester. *International Journal of Police Science and Management*, *14*(1), 30-41.

Forrester, D., Chatterton, M., Pease, K., & Brown, R. (1988). The Kirkholt burglary prevention project, Rochdale (Crime Prevention Unit Paper 13). London: Home Office.

Groff, E., & Taniguchi, T. (2019). Using citizen notification to interrupt near-repeat residential burglary patterns: the micro-level near-repeat experiment. *Journal of Experimental Criminology*, *15*, 10.

Haberman, C., & Ratcliffe, J. (2012). The predictive policing challenges of near-repeat armed street robberies. *Policing. A Journal of Policy and Practice*, *6*, 151-166.

Johnson, S, D., Summers, L., & Pease, K. (2009). Offender as forager? A direct test of the boost account of victimization. *Journal of Quantitative Criminology*, *25*, 181- 200.

Morgan, F. (2000). Repeat burglary in a Perth suburb: indicator of short-term or long-term risk? *Crime Prevention Studies*, *12*, 83-118.

Pease, K. (1998). Repeat victimisation: taking stock. Crime detection and prevention series paper 90. London: Home Office Police Research Group.

Ratcliffe, J., & Rengert, G. (2008). Near-repeat patterns in Philadelphia shootings. *Security Journal*, *21*, 58-76.

Sagovsky, A., & Johnson, S. D. (2007). When does repeat burglary victimisation occur? *Australian & New Zealand Journal of Criminology, 40*(1), 1-26.

Wang, Z., & Lui, X. (2017). Analysis of burglary hot spots and near-repeat victimization in a large chinese city. *ISPRS International Journal of Geo Information, 6*, 148.

Weisel, D. (2005) Analyzing repeat victimization, problem solving tools series No. 4. Problem-oriented guides for police. Washington, DC: Office of Community Oriented Policing Services, U.S. Department of Justice.

Weisburd, D., & Lum, C. (2006). The diffusion of computerized crime mapping in policing: linking research and practice. *Police Practice and Research*, *6*(5), 420-432.

Wells, W., Wu, L., & Ye, X. (2012). Patterns of near-repeat gun assaults in Houston. *Journal of Research in Crime and Delinquency*, *49*, 186-212.