IDENTIFICATION OF ROAD ACCIDENT RECURRENCE IN SRI RACHA DISTRICT, CHON BURI PROVINCE

Narong Pleerux, Attawut Nardkulpat

Burupha University, Saensuk, Mueang, Chon Buri, 20131, Thailand
Email: narong_p@buu.ac.th, attawut@buu.ac.th

KEY WORDS: Road accident hot spot, Spatial distribution, Spatial statistic, Getis-Ord Gi*, GIS

ABSTRACT: Road accidents are one of the important problems in Thailand and they cause economic losses to victims, their families, and the nation. Understanding the road accident hot spots is essential to reduce high density areas of accidents. Sri Racha district, Chon Buri province was selected as the study area. Road accident data during 2012 – 2017 from the Road Accident Data Center (ThaiRSC) were used to complete the aims of study. Spatial statistical method, Getis-Ord Gi* in Geographic Information System (GIS), was applied to identify hot spot and distribution of road accidents in Sri Racha. The finding showed 458 grid cells with six consecutive years of road accident occurrence. The maximum number of road accidents, 17, were observed at the intersection along highway No. 3)Sukhumvit Road(. The results can be used by several agencies for planning and managing strategies for road accident reduction. Further, GIS and spatial statistical methods are effective tools which are quite widely used for accident analysis.

1. INTRODUCTION

Road transportation is very important, but it causes the highest accidents compared to other modes of transportation (Dereli and Erdogan, 2017). The impact of road accidents is injuries and fatalities (Anderson, 2009). Fatality from road accidents tends to increase, especially in low-to-middle income countries (Ouni and Belloumi, 2018). The main cause of road accidents results from human mistakes which can be solved by using traffic control devices, using better road designs and increasing the efficiency of traffic police to reduce the number of accidents (Shafabakhsh et al. 2017).

In Thailand, the fatality rates of road accidents were estimated at 24,237 people or 36.2 per 100,000 (WHO, 2013). Chon Buri province is considered one province with the high number of accidents. According to the statistics of road accidents in 2018, 522 fatalities and 51,841 injuries were found in Chonburi with the second largest economy in Thailand, following Bangkok (the Road Accident Data Center (ThaiRSC), 2018). Therefore, understanding the spatiotemporal of road accidents is important (Harirforoush and Bellalite, 2017). The concept of point event is used extensively in analyzing the distribution of points (Ervin, 2015) such as accidents. Over the past years, there have been studies about the effects of accidents such as relationship between real-time traffic and road safety (Zheng et al. 2010; Xu et al., 2013; Yu and Abdel-Aty, 2014), analysis of spatial and temporal road accident patterns (Yu et al., 2014; Ouni and Belloumi, 2018) and hot spot assessment (Li et al., 2007; Harirforoush and Bellalite, 2017). These are the keys to traffic safety strategies (Xie and Yan, 2013; Yu et al., 2014).

Geographic Information System (GIS) is a very effective tool for analyzing spatiotemporal data. GIS is used to analyze and display road accidents (Deepthi and Ganeshkumar, 2010). Spatial pattern and hot spot classification of road accidents (Benedek et al., 2016) and estimation of density and distribution of accidents (Zheng et al. 2010; Mohaymany et al., 2013; Satria and Castrob, 2016) are also used. At present, GIS and spatial statistical techniques have been developed such as density analysis using Kernel density estimation (KDE) (Pulugurtha et al., 2007; Plug et al., 2011; Bíl et al., 2013; Hashimoto et al., 2016), distribution analysis using Ripley's K-function (Keskina et al., 2011; Thacher et al., 2017) and Getis-Ord Gi∗ which is another popular method for accident hot spot analysis. The principle of these tools is to determine the spot with the highest value surrounded by features with high values as the statistically significant hot spot. The analytical results include z-score and p-value which indicate whether the clustering point has a high or low value (Ord and Getis, 1995; Prasannakumar et al., 2011; Satria and Castro, 2016; Aghajania et al., 2017; Soltani and Askari, 2017).

In this research, a road accident hot spot was analyzed by using Getis-Ord Gi* in Si Racha district, Chon Buri province. The data to be analyzed are the accident data from 2012 – 2017. Then, the recurrence of accidents was analyzed by overlaying the annual hot spot data. The research results can be used to plan, prevent and mitigate accidents in Si Racha.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is Sri Racha district, Chon Buri province, which includes an area of approximately 616.40 km^2 and a population of approximately 51,197. Sri Racha is the industrial and transportation center, and the district was supported by the port of Laem Chabang, the 20th largest port in the world. Therefore, Sri Racha has high economic growth, and there are many people traveling to and from there to live and work. As a result, an increase in the number of vehicles may lead to an increase in the number of road accidents, as shown in Figure 1.

2.2 Data

The road accident data used in this research are from ThaiRSC. Figure 1 shows that 20,003 accidents occurred between 2012 and 2017 in Sri Racha. Details of road accidents include the date, time and location of the accident which are stored in the form of GIS shapefile.

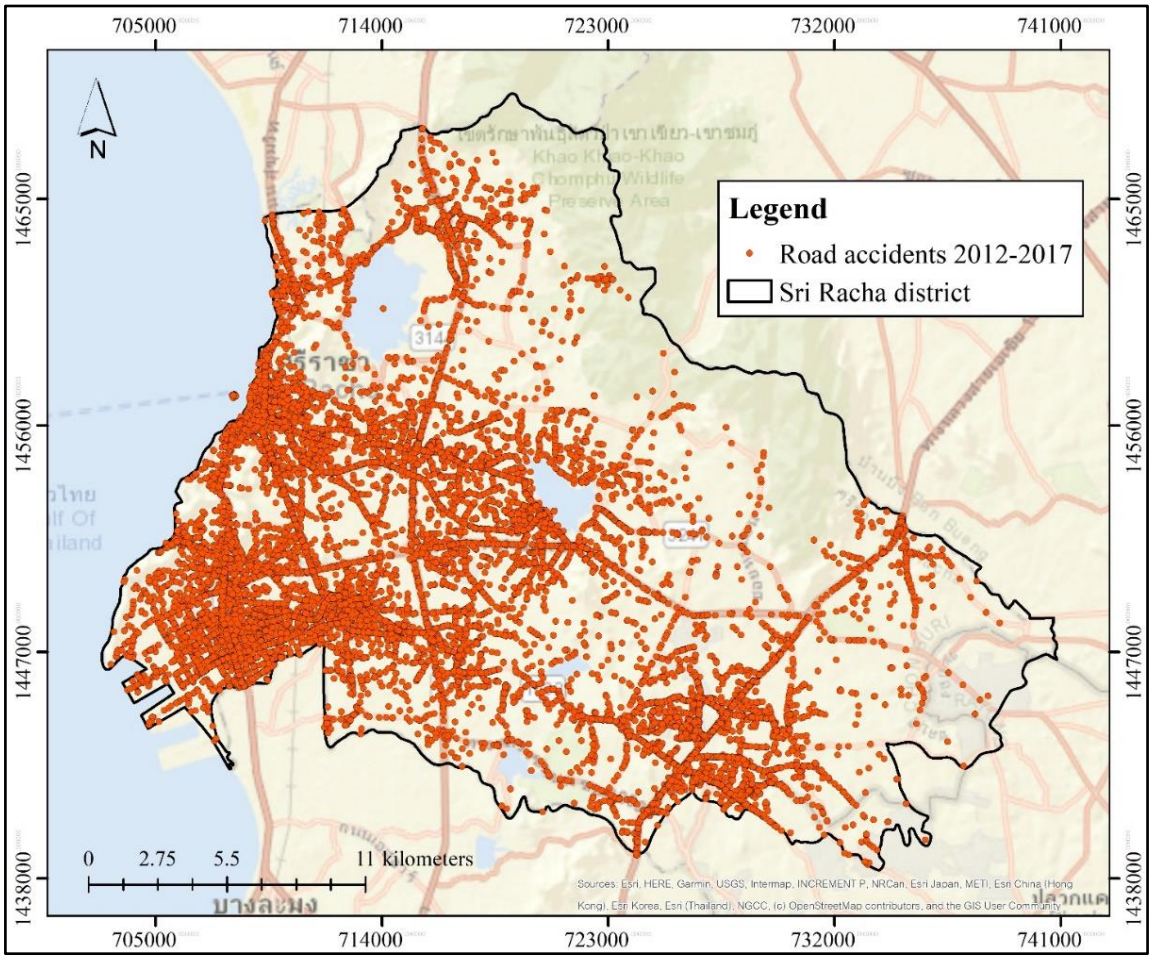


Figure 1 Study area and road accident distribution in 2012 – 2017

2.3 Hot spot analysis using Getis-Ord Gi*

Getis-Ord Gi* is one of tools for analyzing road accident hot spot. The resultant z-scores and p-values indicate where features with either high or low values cluster spatially. This tool works by looking at each feature within the context of neighboring features. A feature with a high value is interesting but may not be a statistically significant hot spot. To be a statistically significant hot spot, a feature will have a high value and be surrounded by other features with high values as well. The local sum for a feature and its neighbors are compared proportionally to the sum of all features; when the local sum is very different from the expected local sum, and when that difference is too large to be the result of random chance, a statistically significant z-score results. When the false discovery rate (FDR) correction is applied, statistical significance is adjusted to account for multiple testing and spatial dependency (ArcGIS Desktop Help, 2018). The hot spot analysis function is as follows:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{[n\sum_{j=1}^{n} w_{i,j}^2 - (\sum_{j=i}^{n} w_{i,j})]}{n-1}}} \quad (1)$$

where $w_{i,j}$ is the spatial weight between feature i and j, x_j is the attribute value of feature j, n is the total number of features, and:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \quad (2)$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2} \quad (3)$$

The analysis of hot spot values of annual accidents from 2012 – 2017 in Si Racha started from determining the grid size used in the analysis which was equal to 50 m. Then, the number of annual accidents occurring in each grid was counted, and the hot spot values were analyzed afterwards.

2.4 Analysis of Recurrence of Accidents

After the analysis of annual accident hot spot was done, the hot spots with high values or p-values of less than 0.01 were selected. Then, the selected hot spot values were overlaid, and the recurrence of accidents in each grid from 2012 – 2017 or 6 consecutive years was obtained. The last step is to identify the characteristics of roads where accidents occurred during the 6 consecutive years which included a direct path, a curved path and an intersection.

3. RESULTS AND DISCUSSION

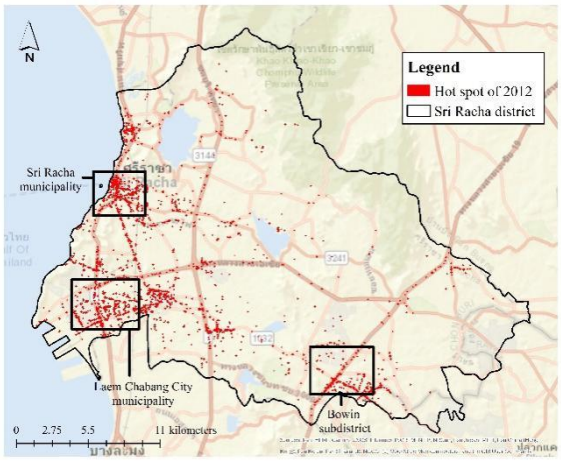
3.1 Road accident hot spots

According to the spatiotemporal analysis of annual accidents from 2012 – 2017, there were a total of 20,003 accident points with the most accidents in 2016 being 3,555 points, followed by 2013 and 2015 being 3,436 and 3,406 points, respectively. The year with the least number of accidents was 2012 with 3,031 points. According to the hot spot analysis of annual accident with the Getis-Ord Gi* method, the GiZscore statistics obtained from the analysis can be used to classify the areas: hot spot and cold spot. If the GiZscore is high, it is a hot spot. On the other hand, if the GiZscore is negative, it is considered a cold spot. In this analysis, the p-value is less than 0.01. The results revealed that in 2012, the GiZscore was 3.83 – 106.57, 4.29 – 57.72 in 2013, 4.48 – 73.97 in 2014, 4.19 – 82.30 in 2015, 3.76 – 136.40 in 2016, and 2.82 – 130.37 in 2017.

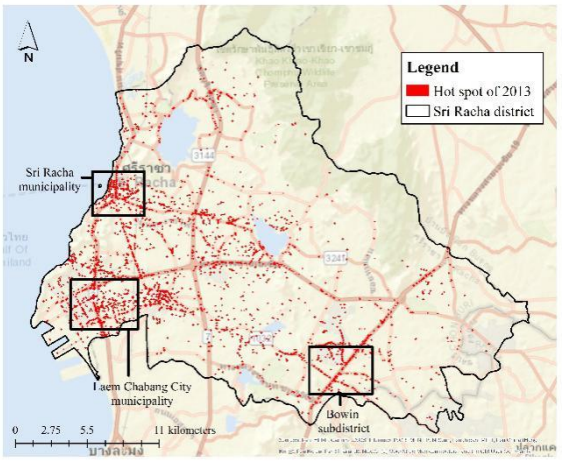
The hot spot of road accidents occurring during the year 2012 – 2017 was mostly found in the three main areas, namely Sri Racha municipality, Laem Chabang City municipality and Bowin subdistrict. All the three areas are considered the economic, industrial and transportation hubs of Sri Racha. The Sri Racha municipality is the center of the district and an important commercial area consisting of shops, department stores, hotels, hospitals, and government agencies. It is also the location of the piers where people can go to Ko Sichang island, which is considered a major tourist attraction in Sri Racha. As a result, there is heavy traffic in this area in the morning and the evening. There are a number of accidents occurring at the clock tower intersection along highway No. 3 (Sukhumvit Road), as shown in Figure 2.

Laem Chabang municipality, which is located at the south of the Sri Racha municipality, is the location of Laem Chabang Port, the main seaport used by the international sea freight and transportation industry. In addition, there is a large population resulting in heavy traffic during the day due to people commuting to work and shipping trucks. The hot spot is the highest on Highway No. 3 (Sukhumvit Road) in front of Laem Chabang Port, compared to every time and every area of Sri Racha as shown in Figure 2.

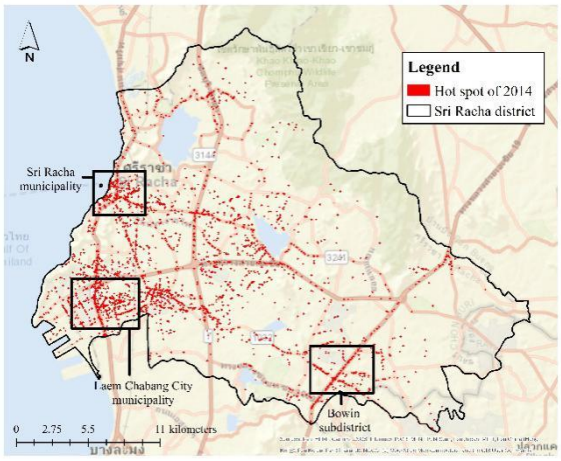
Another area where many accidents occur is Bowin subdistrict, which is a large community. It is located close to five large industrial estates, namely WHH Chon Buri Industrial Estate 1, Eastern Seaboard Industrial Estate, Rojana Industrial Estate, Bowin Industrial Estate, Hemaraj Eastern Seaboard Industrial Estate 2, and Amata City Industrial Estate Rayong. The area is congested owing to the transportation of goods, raw materials, and workers throughout the day. As a result, there are frequent accidents in this area on Asian Highway No. 19 and Highway No. 1032 as shown in Figure 2.



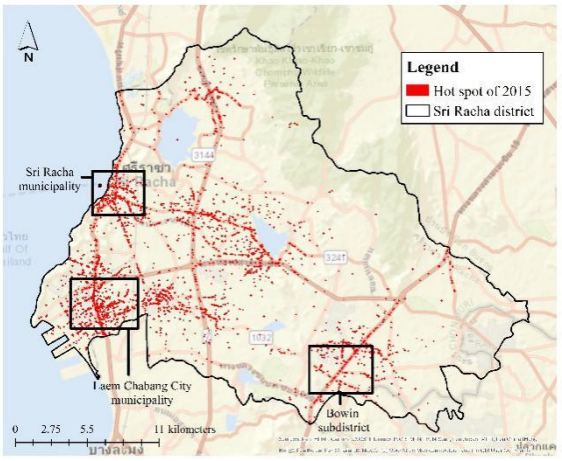
a. Road accident hot spot of 2012



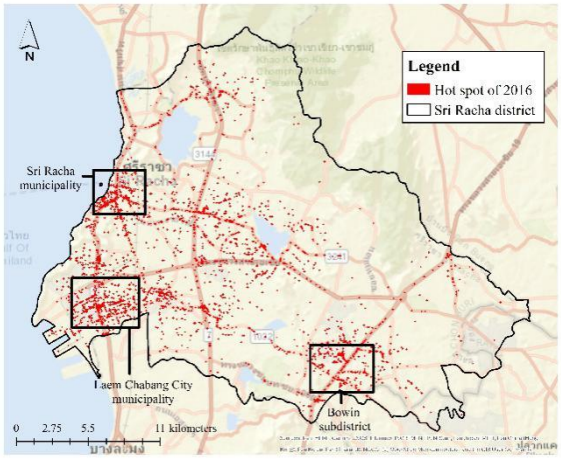
b. Road accident hot spot of 2013



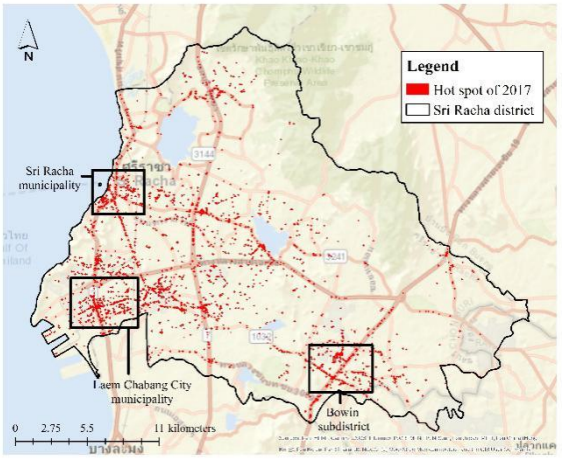
c. Road accident hot spot of 2014



d. Road accident hot spot of 2015



e. Road accident hot spot of 2016



f. Road accident hot spot of 2017

Figure 2 Hot spot of road accidents in Sri Racha district (2012 – 2017)

3.2 Recurrence of Road Accidents in Sri Racha district

The recurrent analysis of road accidents from 2012 – 2017 was done by overlaying hot spot of each year. The results revealed that there were 458 grid cells with recurring accidents in the six consecutive years. Most of them were in the Sri Racha municipality, Laem Chabang City municipality and Bowin subdistrict, respectively. In Sri Racha municipality, accidents occurred along Highway No. 3 (Sukhumvit Road) to Laem Chabang City municipality. In Bowin subdistrict, road accident recurrences were found on Asian Highway No. 19 as shown in Figure 3.

In addition, the 17 times of road accidents occurrence in the six consecutive years were found at Sukhaphiban 8 intersection next to Nong Kham subdistrict police station in Laem Chabang City municipality, followed by 16 times at Muang Mai 3 road intersection in Laem Chabang City municipality. Considering the six consecutive years of recurrent road accidents, they were found that Laem Chabang City municipality has the highest number of 272 grid cells or 59.39 percent of all recurrent road accidents (458 grid cells). The areas where accidents reoccurred the most were the intersection, followed by the direct path. Therefore, accidents should be monitored and prevented in the areas of Si Racha, especially in the three areas with heavy traffic, namely Laem Chabang City municipality, Sri Racha municipality and Bowin subdistrict, respectively, because there is a continuous recurrence of road accidents throughout 2012 – 2017. Therefore, the directly responsible agencies should implement measures or plans to prevent accidents in the mentioned areas.

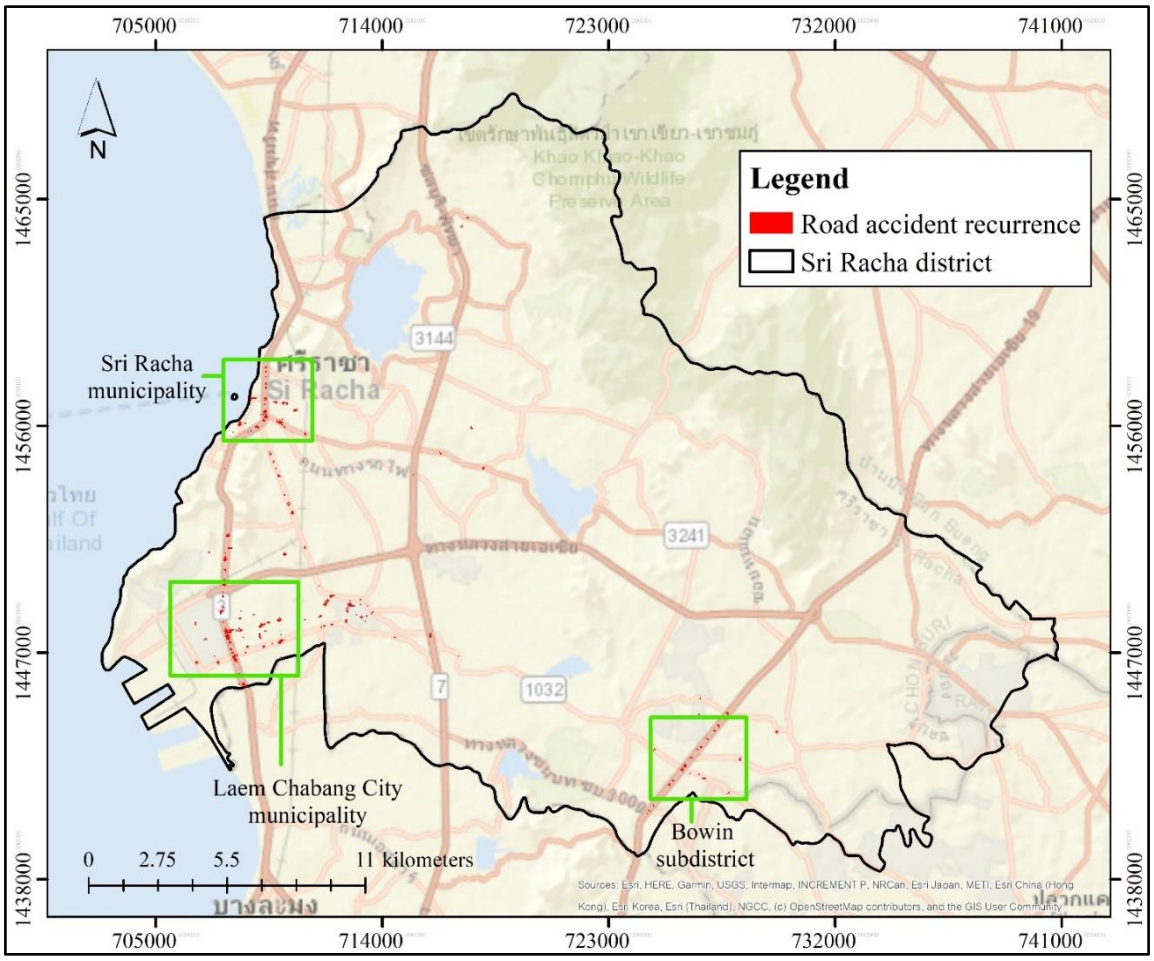


Figure 3 Road accident recurrence of Sri Racha in 2012 – 2017

4. CONCLUSIONS

Thailand is one of the countries facing the greatest impact and loss from road accidents. The study and understanding of the characteristics of road accident areas provide important information for solving and reducing road accident problems. GIS is an effective tool and can be used to study road accidents. Sri Racha district, Chon Buri was chosen as the study area in this research because it is the center of transportation, industry and tourism and is also the area where road accidents occur at an alarming rate.

In this analysis, road accidents data during 2012 – 2017 were analyzed by using the Getis-Ord Gi* technique in GIS to determine accident hot spots each year. The results show that throughout the six years, the areas with the most hot spots are the same areas, namely Laem Chabang City municipality, Sri Racha municipality and Bowin subdistrict, especially in Laem Chabang City municipality which is the location of Laem Chabang Port. There are many shipping and logistics companies located in that area, and there is transportation of goods throughout the day. Sri Racha municipality is the center of the district and an important commercial area where hospitals and government agencies are located. In addition, Bowin subdistrict is an area with a very dense population because it is close to many large industrial estates.

Moreover, according to the study of road accident recurrence in 2012 – 2017, there were a total of 458 spots, and most of them are in Sri Racha municipality, Laem Chabang City municipality and Bowin subdistrict, respectively. The areas with road accidents recurrence were mostly the intersection, followed by the direct path. The results of the study provide very important information and can be used in planning and setting measures to reduce accidents, especially in the areas with recurrent and continuous road accidents.

However, there are limitations in this study on the following issues. First, the accident data used in this study are not all accident data, some of which are from the Road Accident Victims Protection Company Limited (RVP Co., Ltd.). Second, published accident data still lack important information such as gender and age of the accident victims, as well as causes of accidents, which is important information that can be used in the analysis to increase the integrity of the study. However, despite the limitations mentioned above, the results of the study can still be used to solve the problems and reduce accidents well.

5. REFERENCES

Aghajania, M.A., Dezfoulian, R.S., Arjroodyb, A.R. and Rezaeid, M., 2017. Applying GIS to identify the spatial and temporal patterns of road accidents using spatial statistics)case study: Ilam province, Iran(. Transportation Research Procedia, 25, pp. 2126-2138.

Anderson, T.K., 2009. Kernel density estimation and K-means clustering to profile road accident hotspots. Accident Analysis and Prevention, 41, pp. 359-364.

ArcGIS Desktop Help, 2018. Hot Spot Analysis (Getis-Ord Gi*)**.** Retrieved August 16, 2019, from http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-statistics-toolbox/hot-spot-analysis.htm

Benedek, J., Ciobanub, S.M. and Man, T.C., 2016. Hotspots and social background of urban traffic crashes: a case study in Cluj-Napoca)Romania). Accident Analysis and Prevention, 87, pp. 117-126.

Bíl, M., Andrásik, R. and Janoska, Z., 2013. Identification of hazardous road locations of traffic accidents by means of kernel density estimation and cluster significance evaluation. Accident Analysis and Prevention, 55, pp. 265-273.

Deepthi, J.K. and Ganeshkumar, B., 2010. Identification of accident hot spots: a GIS based implementation for Kannur district, Kerala. International Journal of Geomatics and Geoscience, 1)1(, pp. 51-59.

Dereli, M.A. and Erdogan S., 2017. A new model for determining the traffic accident black spots using GIS-aided spatial statistical models. Transport Research Part A, 103, pp. 106-107.

Ervin, D. 2015. Advance spatial analysis. Retrieved August 16, 2019, from http://gispopsci.org/point-pattern-analysis/

Harirforoush, H. and Bellalite, L., 2016. A new integrated GIS-based analysis to detect hotspots: a case study of the city of Sherbrooke. Accident Analysis and Prevention. In Press, Available online 24 August 2016.

Hashimoto, S., Yoshiki, S., Saeki, R., Mimura, Y., Ando, R. and Nanba, S., 2016. Development and application of traffic accident density estimation models using dernel density estimation. Journal of Traffic and Transportation Engineering, 3)3(, pp. 262-270.

Keskina, F., Yenilmezb, F., Çolakc, M., Yavuzerc, I. and Düzgün, H.S., 2011. Analysis of traffic incidents in METU campus. Procedia Social and Behavioral Sciences, 19, pp. 61-70.

Li, L., Zhu, L. and Sui, D.Z., 2007. A GIS-based bayesian approach for analyzing spatial-temporal patterns of intra-city motor vehicle crashes. Journal of Transport Geography, 15, pp. 274-285.

Mohaymany, A.S., Shahri, M. and Mirbagheri, B., 2013. GIS-based method for detecting high-crash-risk road segments using network kernel density estimation. Journal Geo-Spatial Information Science, 16)2(, pp. 113-119.

Ord, J.K. and Getis, A., 1995. Local spatial autocorrelation statistics: Distributional Issues and an Application. Geographical Analysis, 27)4(, pp. 286-306.

Ouni, F. and Belloumi, M., 2018. Spatio-temporal pattern of vulnerable road user's collisions hot spots and related risk factors for injury severity in Tunisia. Transportation Research Part F, 56, pp. 477-495.

Plug, C., Xia, J.C. and Caulfield, C., 2011. Spatial and temporal visualisation techniques for crash analysis. Accident Analysis and Prevention, 43, pp. 1937-1946.

Prasannakumar, V., Vijitha, H., Charuthaa, R. and Geetha N., 2011. Spatio-temporal clustering of road accidents: GIS based analysis and assessment. Procedia Social and Behavioral Sciences, 21, pp. 317-325.

Pulugurtha, S.S., Krishnakumar, V.K. and Nambisan, S.S., 2007. New methods to identify and rank high pedestrian crash zones: an illustration. Accident Analysis and Prevention, 39, pp. 800-811.

Satria, R. and Castro, M., 2016. GIS tools for analyzing accidents and road design: a review. Transportation Research Procedia, 18, pp. 242-247.

Shafabakhsh, G., Famili, A. and Bahadori, M.S., 2017. GIS-based spatial analysis of urban traffic accidents: case study in Mashhad, Iran. Journal of Traffic and Transport Engineering, 4)3(, pp. 290-299.

Soltani, A. and Askari, S., 2017. Exploring spatial autocorrelation of traffic crashes based on severity. Injury, 48, pp. 637-647.

Thacher, D., Milne, S.B. and Park, R., 2017. Applying GIS and statistical analysis to assess the correlation of human behaviour and ephemeral architectural features among Palaeo-Eskimo sites on southern Baffin island, Nunavut. Journal of Archaeological Science: Reports, 14, pp. 21-30.
Road Accident Data Center)ThaiRSC(, 2018. Statistic of Injuries and Deaths All Provinces 2017. Retrieved August 16, 2019, from http://www.thairsc.com/
World Health Organization (WHO), 2018. Road Traffic Deaths: Data by Country 2013. Retrieved August 16, 2019, from http://www.who.int/gho/road_safety/mortality/traffic_deaths_number/ en/
Xie, Z. and Yan J., 2013. Detecting traffic accident clusters with network kernel density estimation and local spatial statistics: an integrated approach. Journal of Transport Geography, 31, pp. 64-71.
Xu, C., Tarko, A.P., Wang, W. and Lui, P., 2013. Predicting crash likelihood and severity on freeways with real-time loop detector data. Accident Analysis and Prevention, 57, pp. 30-39.
Yu, H., Liu, P., Chen, J. and Wang, H., 2014. Comparative Analysis of the spatial analysis methods for hotspot identification. Accident Analysis and Prevention, 66, pp. 80-88.
Yu, R. and Abdel-Aty, M., 2014. Using hierarchical bayesian binary probit models to analyze crash injury severity on high speed facilities with real-time traffic data. Accident Analysis and Prevention, 62, pp. 161-167.
Zheng, Z., Ahn, S. and Monsere, C.M., 2010. Impact of traffic oscillations on freeway crash occurrences. Accident Analysis and Prevention, 42, pp. 626-636.