Transactions on Science and Technology Vol. 8, No. 3-3, 408 - 418, 2021

Mapping the Potential Pattern of COVID-19 Disease Risk Using Spatial Analysis in Kota Kinabalu, Sabah

Oliver Valentine Eboy#, Haryati Abd Karim, Lizalin Kalang

Faculty of Social Sciences and Humanities, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, MALAYSIA.

Corresponding author. E-Mail: oliver@ums.edu.my; Tel: +6088-320000; Fax: +6088-320242.

ABSTRACT Movement Control Order (MCO) has been declared in Malaysia on 17th Mac 2020 to break the chain of the COVID-19 pandemic. Since at that time, no vaccine was made to cure the disease, therefore, the MCO was the best method implemented by many countries to minimize or eradicate the disease. COVID-19 is a contagious disease that can be easily contracted to others based on touch, mouth, nose, and eye. Thus, physical distance from each other must be applied and crowded places must be avoided. However, people tend to violate the MCO ruling and the physical distance. This was evident based on the record from phase 1 to phase 5 of MCO in Malaysia. The number of COVID-19 positive cases were decreased during the early phase of MCO but gain traction in phase 4 and 5. At the same time, the total of manpower in the authority is limited and it was difficult for them to monitor in all places. The geographical factors and the distance were also some of the challenges that they must face to make sure the people follow the MCO ruling. The aim of this study is to analyze the spatial distribution of the location factors that the people frequently visited with the help of spatial analysis through Geographic Information System (GIS). By using the Getis-Ord Gi* (hotspot), Kernel density and Overlay technique from the spatial analysis method, this study could then produce a density map of potential COVID-19 risk. Subsequently, this study manages to identify the area of potential risk of COVID-19 that can be contracted and validate it with the current location of the positive cases in Kota Kinabalu district of Sabah. Lastly, the findings of this study are suitable for the authorities to act and mainly focused the spreading of COVID-19 in the high-risk area.

KEYWORDS: Movement Control Order (MCO), COVID-19, density pattern, spatial analysis, Geographic Information System (GIS), kernel density, overlay

Received 15 March 2021 **Revised** 25 March 2021 **Accepted** 1 August 2021 **Online** 2 December 2021

Original Article

INTRODUCTION

Coronavirus (COVID-19), which started in December 2019 in Wuhan, China from the SARS-CoV-2 virus, is a global pandemic due to the rapid and rapid spread of the disease (WHO, 2020a). According to the WHO (2020b), there were more than 761, 779 deaths on 16 August 2020 with almost 21,294,845 cases of incidents globally confirmed. These numbers are still increasing every day. The disease can be described as a social, human, and economic crisis (United Nations, 2020). The impact of this disease on the socio-economy is greater for developing countries but can also have significant implications for developed countries (United Nations, 2020).

As a result, the spread of COVID-19 successfully reached Malaysia. Therefore, the movement control order (MCO) issued by the Malaysian government on 18 March 2020 aims to reduce the spread of COVID-19 disease (Sarif & Yahya, 2020). MCO was started through the Prevention and Control of Infectious Diseases Act 1988 and the Police Act 1967. The purpose of MCO is to prevent coronavirus outbreaks. This prevention of coronavirus pandemic resources include prohibition of any travelling and assembly throughout the country, including all social, sports, and cultural activities; postponement of all religious activities; ban on travel out from the country temporarily with prohibition of foreigners from entering into Malaysia; close down of all premises except supermarket services and infrastructure, wet markets, grocery stores and multifunctional stores selling daily necessities; close down of all nurseries, government and private schools,; including public and private universities and vocational facilities (Sarif & Yahya, 2020).

However, many residents do not comply with the MCO despite restrictions imposed nationwide. After the fourth (4) phase of the MCO, there were more than 22,432 individuals arrested for MCO violations (The Star, 2020). This MCO violation is due to the inevitable behavior of the population. The behavior of the residents who have become accustomed to going to an area for the purpose of certain activities, will be the cause of the spread of COVID-19 disease occurs either before or after MCO. To address this problem, a mapping of population behavior must be made. Action maps are observational products and tools for place analysis and design at the same time (Marusic & Marusic, 2012). In performance mapping, these areas are the focus of the public (Klein *et al*., 2018) and this also involves socio-economic and environmental (Mollalo *et al*., 2020).

One of the tools that can help identify the conduct and location of this COVID-19 distribution is the Geographic Information System (GIS). GIS is an important tool for identifying the spatial spreading of contagious diseases (Mollalo *et al*., 2019). It can help in the process of fighting pandemics and improve the quality of treatment (Lovett *et al*., 2014). Subsequently, it becomes an important technique in analyzing and visualizing the spread of COVID-19. In the study of Wu *et al*. (2020), the researcher stated that geographical visualization is an efficient method to look at the spatial pattern of the spread of COVID-19 disease. Users can plot to visualize disease information on a world map. With previous data, researchers can combine temporal and spatial information to produce animations to show how SARS-Cov-2 is spread. The method of spatial analysis in GIS also received attention by several researchers in the COVID-19 study. Franch-Pardo *et al*. (2020) have reviewed 63 articles related to geospatial and spatial analysis. He stated that the method of spatial analysis is very useful to the study of COVID-19 and can explain the extent and impact of this pandemic in decision making by the authorities. Therefore, this study was conducted to determine the potential density pattern of COVID-19 risk using spatial analysis.

BACKGROUND THEORY

Application of Spatial Analysis

Spatial analysis refers to methods for studying the location, organization, and inter-connection of spatial events (Bäing, 2014). This study uses two spatial analysis techniques, namely Getis-Ord Gi, Kernel Density and Overlay.

Getis-Ord Gi or hotspot is a GIS analysis developed to exhibit type of spatial patterns in an area (Getis & Ord, 1992; Ord & Getis, 1995). They represent a global spatial autocorrelation index. The Gi* statistic, on the other hand, is a local Spatial Autocorrelation index. It usually used to show the structures of high or low cluster pattern. Below indicates a simple formula (Equation (1)) of the Gi* statistic (Songchitruksa, 2010).

$$G_i^* = \frac{\sum_{j=1}^{n} w_{ij} x_j}{\sum_{j=1}^{n} x_j} \quad (1)$$

Gi*: the spatial autocorrelation statistic of an event i over n events; x_j: the magnitude of the variable x at events j over all n.

Kernel Density is a GIS analysis technique that considers the position of interconnected characteristics (King *et al*., 2016). This is one of the most well-known analyzes for hotspot and spatial data dissemination. This analysis is used to look at density patterns in GIS. Kernel Density can be used to calculate the density of both point and line characteristics as well as used to determine the focus area (Silverman, 1986). In addition, Kernel Density is widely accepted as the most accurate analytical technique used to view patterns because they produce maps and are not limited by shapes or boundaries (Chainey *et al.*, 2008). Density kernels will produce high, medium, and low-density patterns (Dick *et al.*, 2014). In this study, the output of kernel density will be suppressed. Overlapping can only be done after the reclassify method and the raster to polygon method are made. Generally, the formula for Kernel estimator is as follow (Equation 2).

$$\hat{f}(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right) \quad (2)$$

h: the parameter for smoothing or bandwidth, K: kernel and f^: estimator of the probability density function f.

Overlay analysis uses two or more layers of data and is processed using one operation to run the duplication of data. The result of this overlap will result in a new pattern for each position in the output data layer (Mitchell & Minami, 2020). In this study, Union suppression techniques were used. Union techniques are used to unite polygons. In Figure 1, Union operations are shown in which the two unified polygons still retain their spatial and attribute.

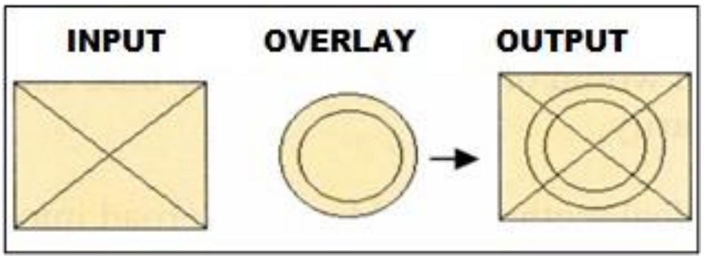

Figure 1. Overlay analysis using UNION technique.

Both methods have been used in previous studies (Kalang & Eboy, 2019; Sieng & Eboy, 2021) to identify the distribution and density of their study data. Kalang & Eboy (2019) use kernel density and suppression methods to determine high risk areas of crime in the city of Kota Kinabalu, Sabah. The same method is also used by Sieng & Eboy (2021) in determining areas with high, medium, or low ethnographic characteristics in Tambunan district.

Based on the above sources, the spatial analysis techniques which are kernel density and overlay are suitable for use in this study. This will help authorities identify all areas of focus or potential for the spread of COVID-19 disease.

METHODOLOGY

Area of study

This study chose Kota Kinabalu district as the study area because it is one of the red zone areas in Sabah for COVID-19 disease in Malaysia. Figure 2 below shows the location of Kinabalu district in Sabah.

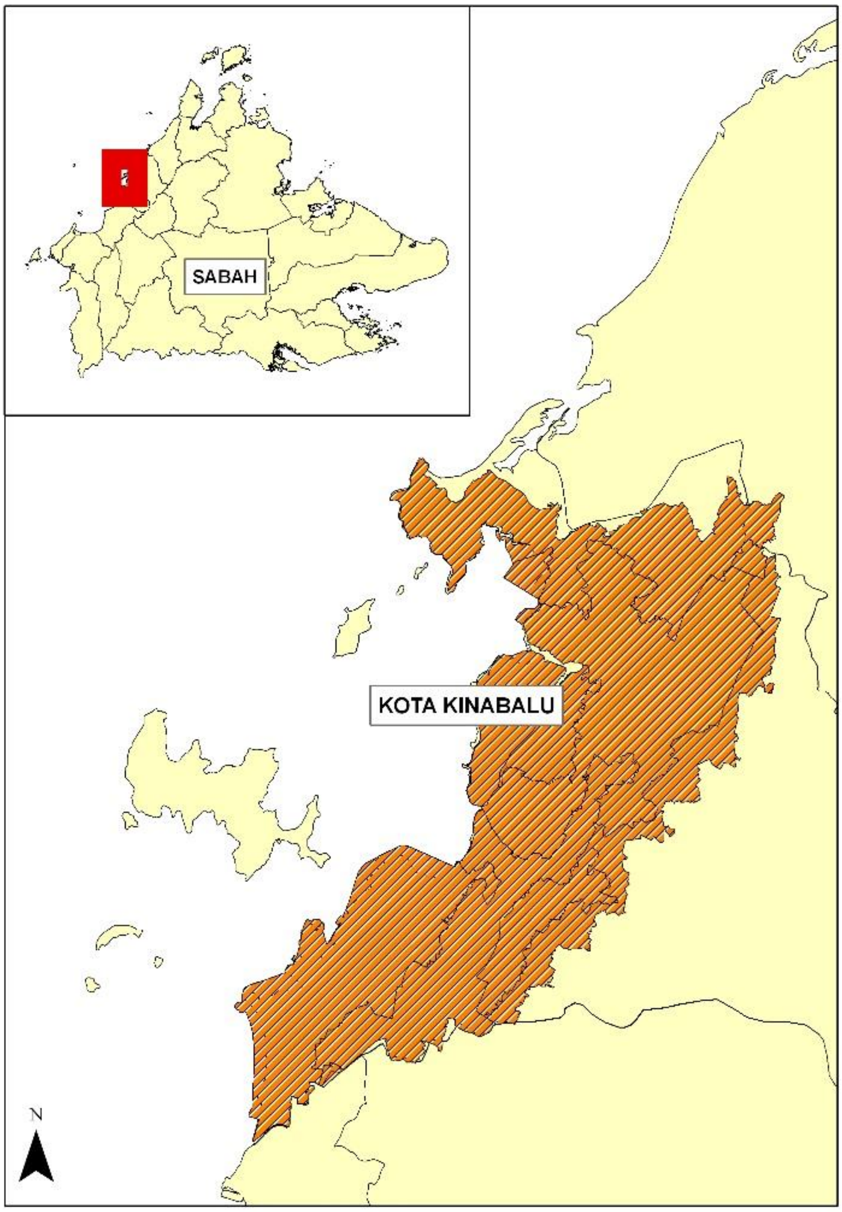

Figure 2. Kota Kinabalu District Map

Data and Method of Study

The data used in this study is based on the survey distributed to the people in Kota Kinabalu district. About 200 respondents were collected from all the zones in Kota Kinabalu district from the survey. All these data were then compiled in GIS database for the purpose of spatial analysis.

Figure 3 briefly shows the process of this study. It begins with data collection of the study and follow up with the editing of the data in GIS database. Spatial data consists of the district boundaries, zone boundaries and respondent locations which was obtained using Global Positioning System (GPS) device, were also included in the database. Spatial analysis was then conducted to identify the behaviour factor of the people to which location they frequently go in their daily activities.

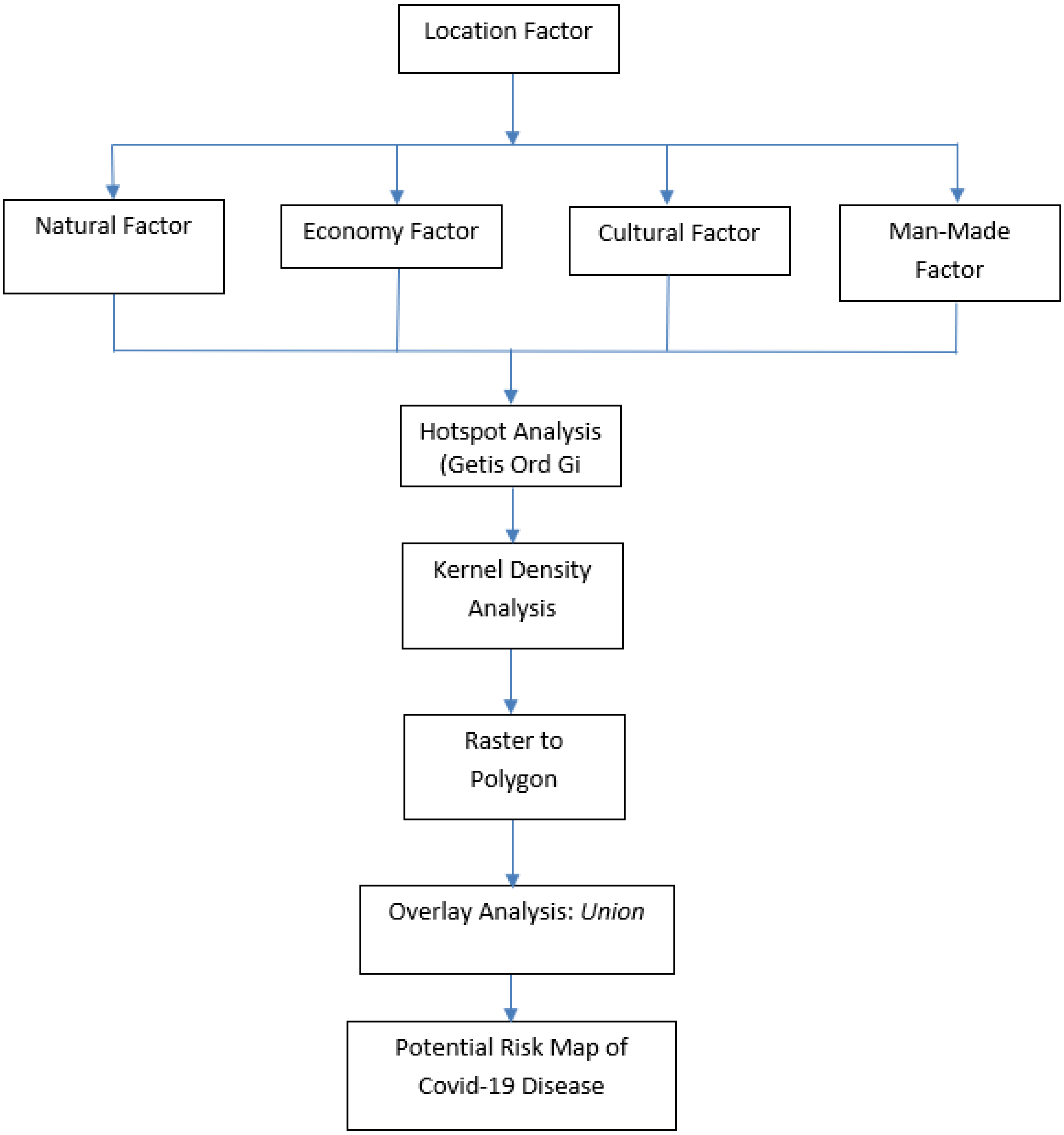

Figure 3. Flow Chart of the Study

The location factors that the people frequently visited were obtained from the survey consists of natural, economic, man-made and cultural factors. Natural factors consist of recreational or tourist areas in the natural environment such as hiking in hilly places, picnic spots on the beach or activities on the river. Meanwhile, economic factors consist of markets, commercial centers, restaurants, shopping complexes and workshops. Next, man-made factors consist of schools, hospitals, sports complexes, public halls, and recreational places. Finally, cultural factors consist of religious places, museums, cultural halls, tourist centers and community halls. All the location factors were mapped and included in the GIS database as shown in Figure 4.

Each response was then analyzed using Getis-Ord Gi technique to estimate the distribution pattern towards each location factor in the area. Subsequently, the process of reclassification and conversion of raster to polygon was performed before overlay analysis was conducted to produce a map of potential risk for COVID-19 disease. The map of potential COVID-19 risk areas consists of three types of patterns, namely high-risk areas, medium risk areas and low risk areas.

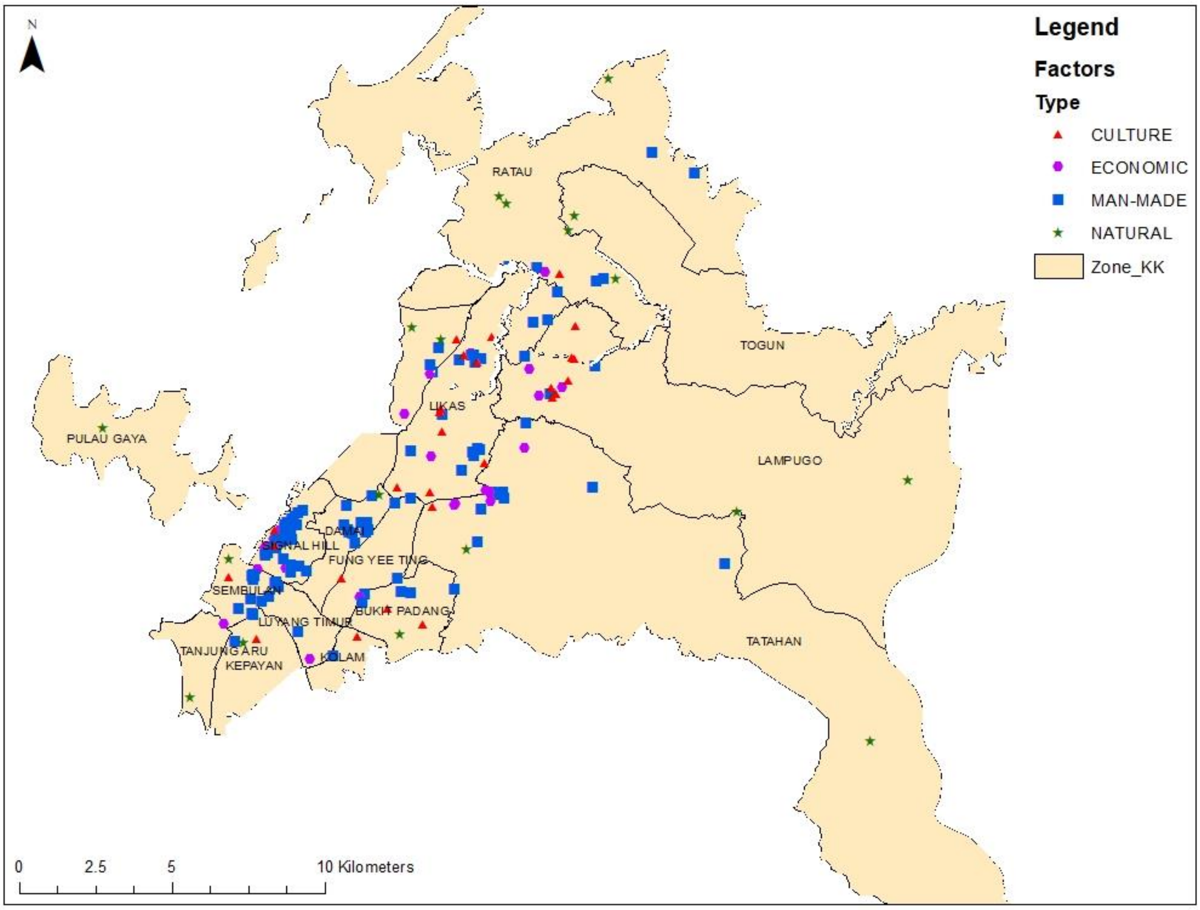

Figure 4. Location factors in Kota Kinabalu

RESULT AND DISCUSSION

In the early stages of analysis, this study uses the spatial analysis method of kernel density technique for location factor. The density kernel will use the location factor point and propagate it to form a density pattern in the area. The output display is shown from Figure 5 to Figure 8. Areas with darker colors indicate the influence of high location factor while lighter color areas show less influence. The higher the number of classes, the higher the density.

The location factor for culture is shown in Figure 5 where high-density areas for culture are mostly concentrated in the Tanjung Aru and Sembulan area and partly in Tatahan area. Next, the economic location factor influences as shown in Figure 6 shows that the tendency for the people to go there is more concentrated in Likas area and some parts of the Tanjung Aru area. The same influence is also for the man-made location factor in Figure 7 as it is also concentrated in urban areas near signal hill.

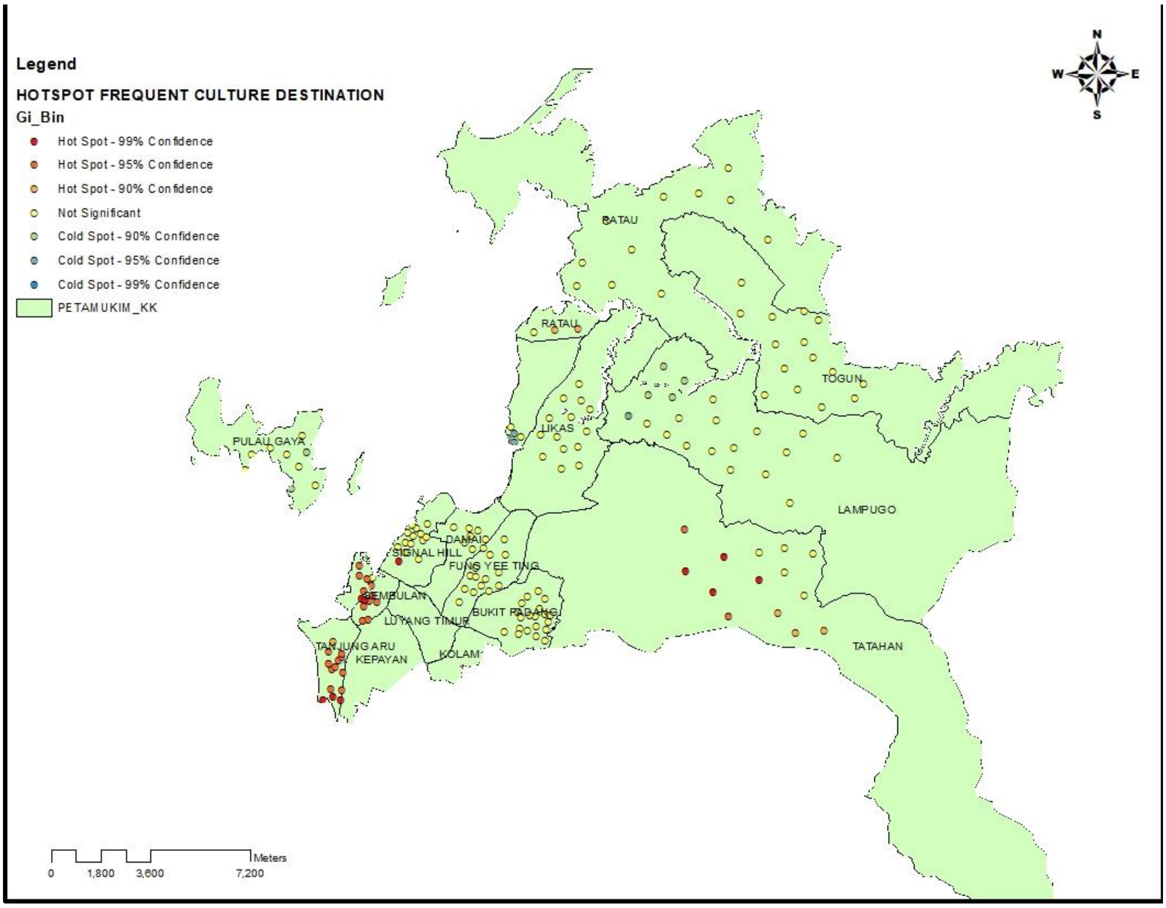

Figure 5. Cultural location factor in Kota Kinabalu

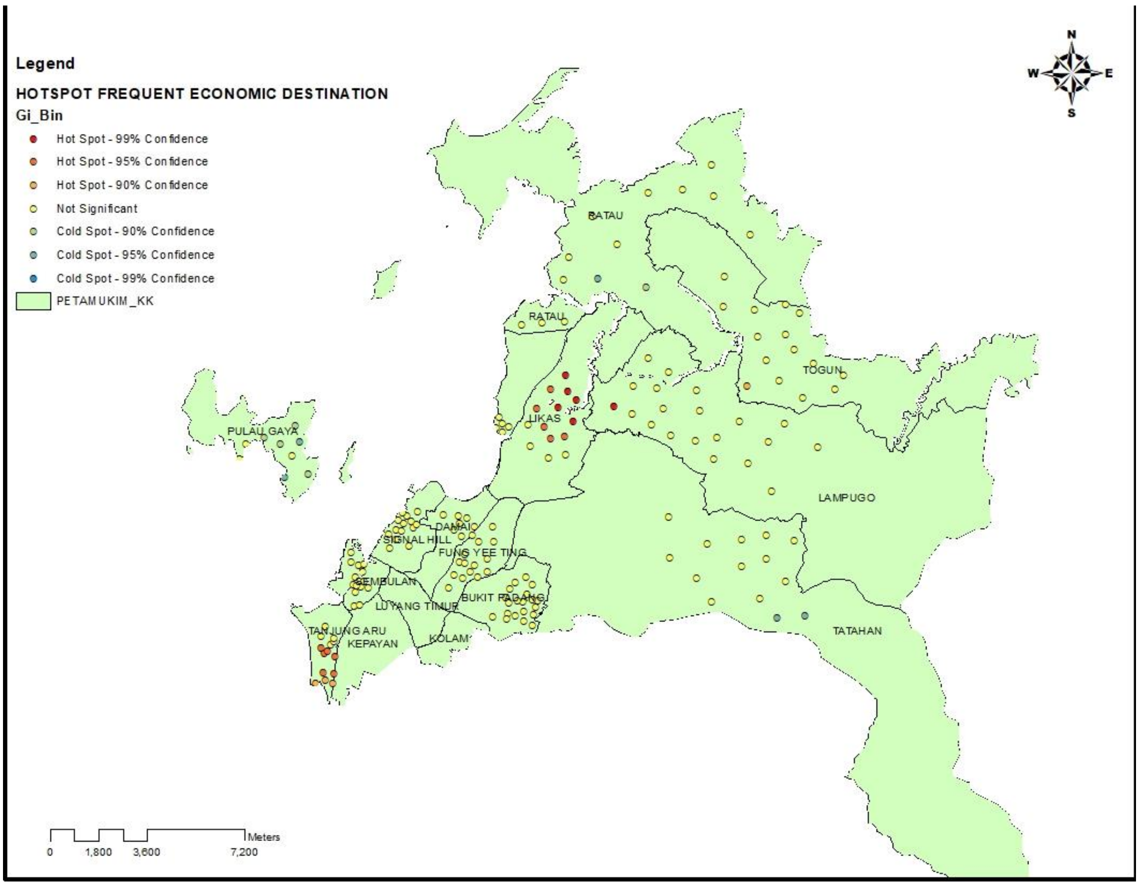

Figure 6. Economy location factor in Kota Kinabalu

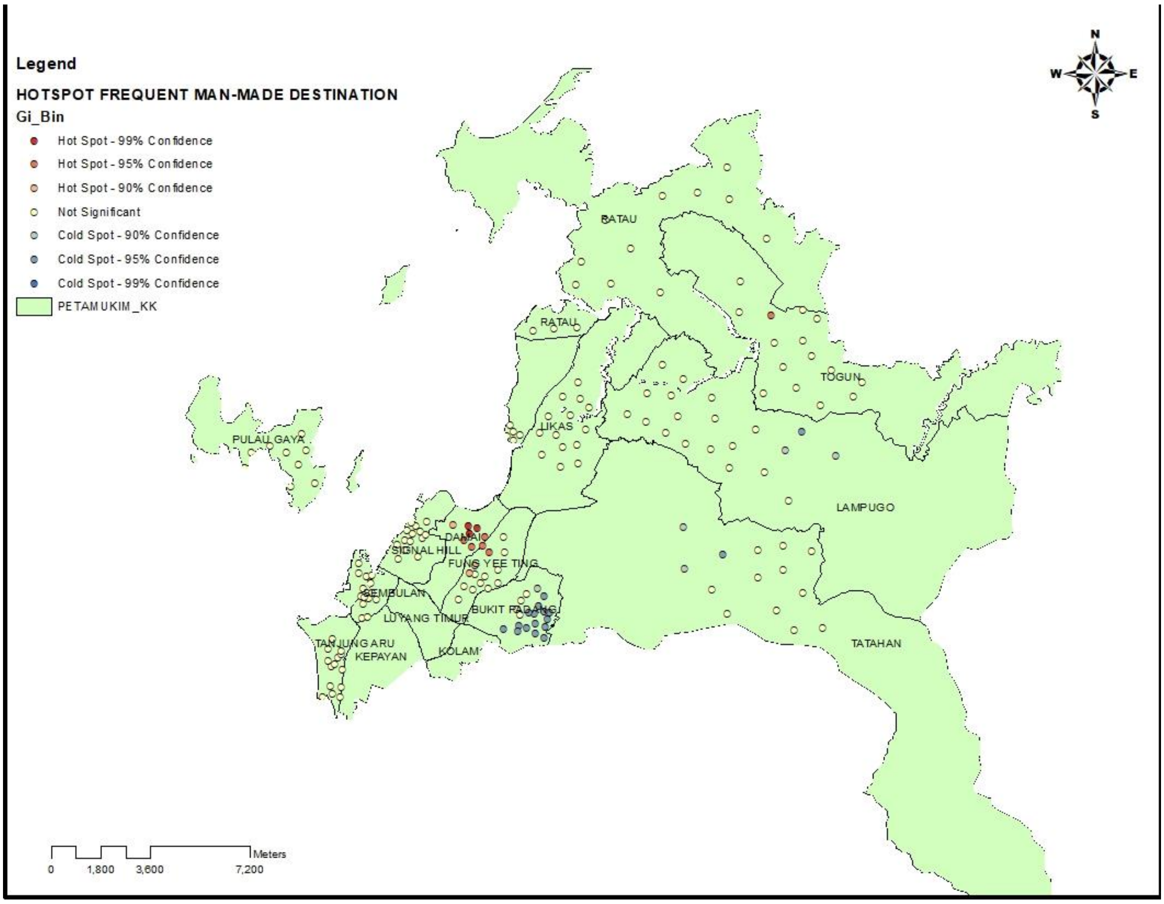

Figure 7. Man-made location factor in Kota Kinabalu

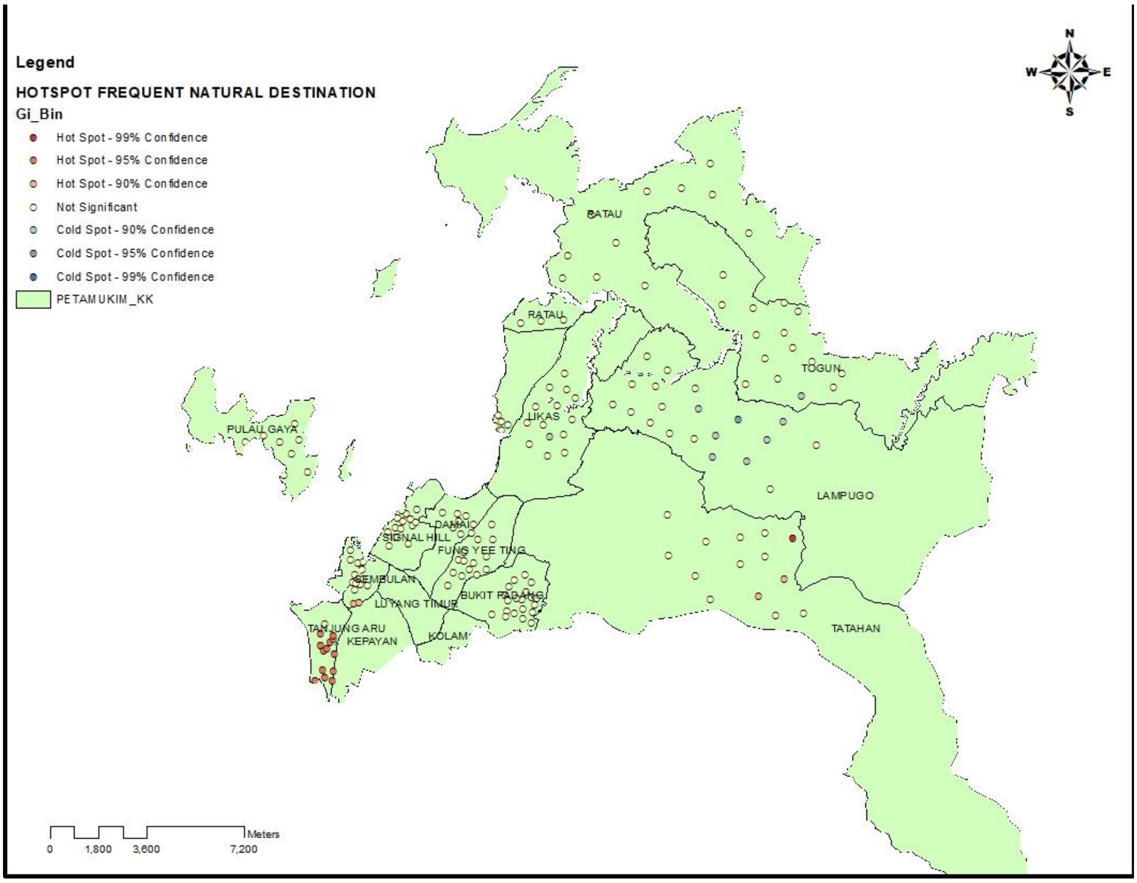

Figure 8. Natural location factor in Kota Kinabalu

Similar with the cultural and economy, the natural location factor influences also focused in Tanjung Aru area (Figure 8).

All the output from the Getis-Ord Gi analysis were then analysed using kernel density to map the distribution pattern of each of the location factor in the study area. After that, overlay analysis was then performed using UNION techniques. This technique was applied from the output of the kernel map to obtain the COVID-19 risk pattern in the area. The map classified into 3 classes as low-risk, medium-risk, and high-risk areas.

The result of this study is a map of the potential risk areas of COVID-19 disease as shown in Figure 9. The map shows three types of patterns consisting of low-risk, medium-risk, and high-risk patterns. High-risk pattern areas indicate that the focal point of most people is potentially infected with COVID-19 disease.

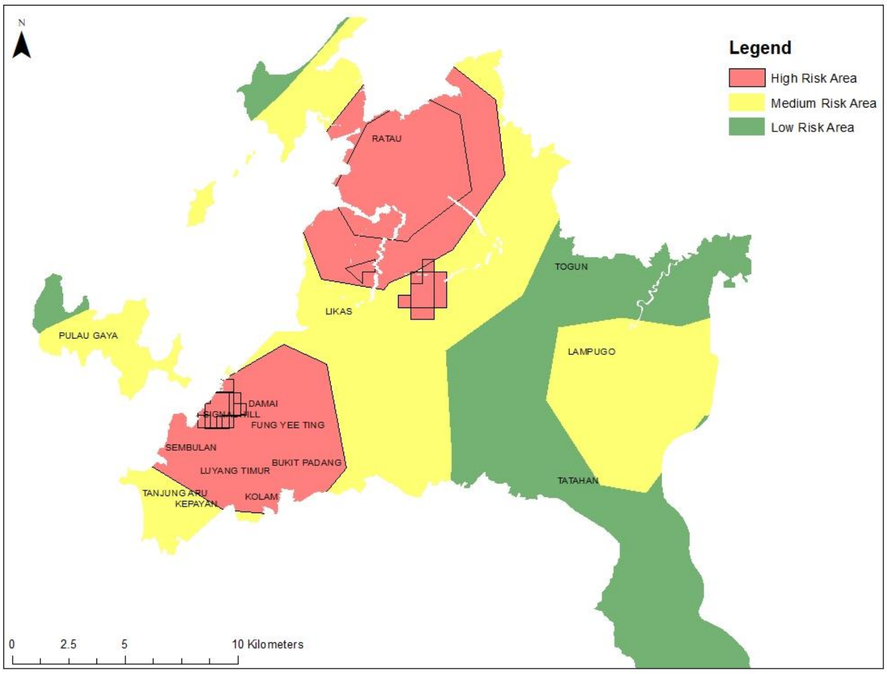

Figure 9. Potential Risk Map of COVID-19 Disease

Based on the risk map in Figure 9, the high-risk areas are concentrated into two grouped areas namely in Ratau and around Damai, Signal Hill, Sembulan, Fung Yee Ting, Luyang, Kolam and Bukit Padang areas. These locations are in the western and northern parts of Kota Kinabalu district.

Generally, the potential risk map of COVID-19 generated in this study achieves the desired overall result even though it does not reach the accurate level entirely. Thus, other factors such as human movement, demographics or topography may also be needed to strengthen the results of this study.

CONCLUSION

This study attempts to unravel the most visited public areas in the Kota Kinabalu district. Location factors that influence people to visit specific places were used as the main data for the purpose of this study. Assist by using spatial analysis in GIS, this study was able to identify density patterns for public concentrated locations. However, this study does not consider other factors such as migration, socio-economic, health level, climatic conditions, demographics, and topography in the areas involved. Therefore, the results of this study may not be accurate if the other factors are considered. However, this can be conducted further in future studies. This study was able to prove the capability of spatial analysis in solving problems that usually conducted by the authorities with limited data but easy to refer as it can be displayed visually with accurate geographical reference. Finally, this potential risk map of COVID-19 is indeed suitable to be used as reference to the authorities to address the spread of COVID-19 disease. The risk map is also easy to be produced by using spatial analysis despite limited data and with low cost, less time and minimal manpower.

ACKNOWLEDGEMENTS

The authors would like to express their appreciation to the referees of this paper in producing a quality publication in this journal. The authors would also like to give thanks to Universiti Malaysia Sabah for awarding us an internal grant with the vot number SDK0171-2020 to conduct this study.

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