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22–26 April, Hanoi, Vietnam

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"Geospatial Information for a Smarter Life and Environmental Resilience"

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ROAD TRAFFIC ACCIDENT BLACK SPOT DETERMINATION BY USING KERNEL DENSITY ESTIMATION ALGORITHM AND CLUSTER STATISTICAL SIGNIFICANT EVALUATION

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1. INTRODUCTION

1.35 million deaths and 50 million people injured every year in the world.

The leading cause of death for people aged between **5 and 29 years**.

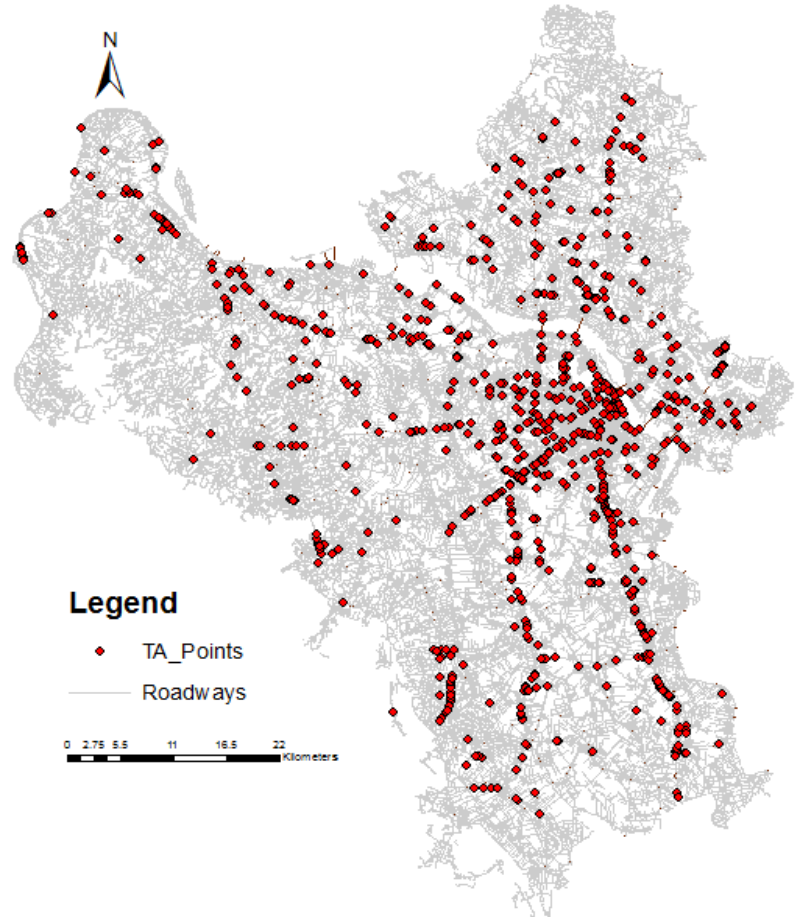
(WHO, 2018)

In Vietnam, in 2017, there were 20,000 traffic crashes; 8,200 deaths and 17,000 wounded owing to TA.

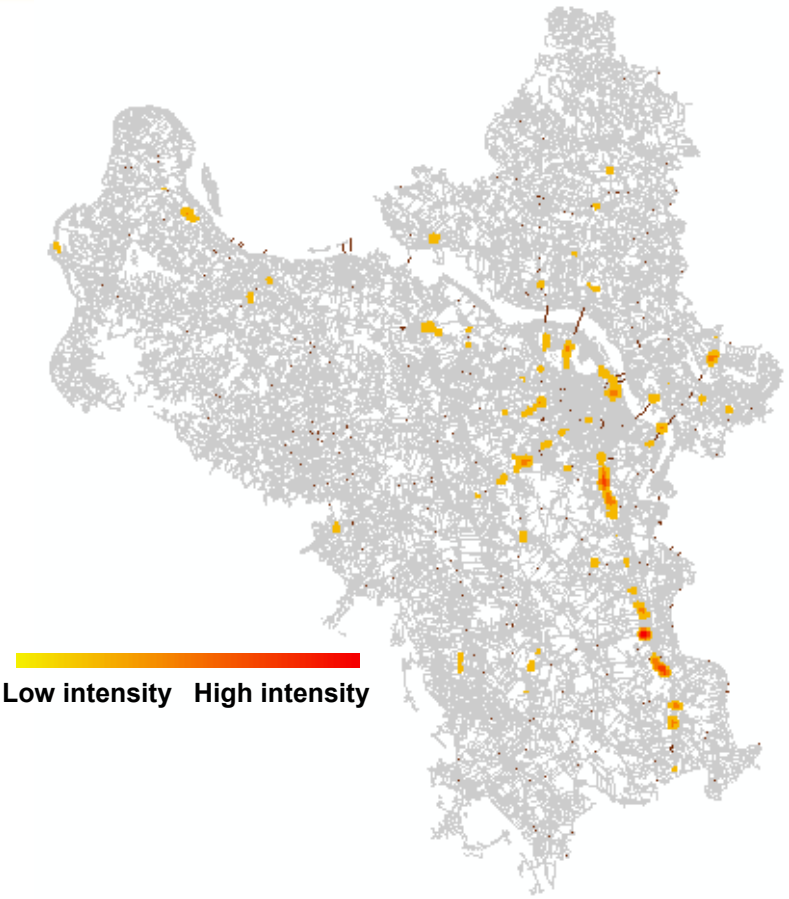
1. INTRODUCTION

- To reduce the number of TAs, need to know where and when TAs occur frequently (**black spots**).

- GIS is a powerful tool for analyzing TA.



The distribution of TA in Hanoi (2015-2017)



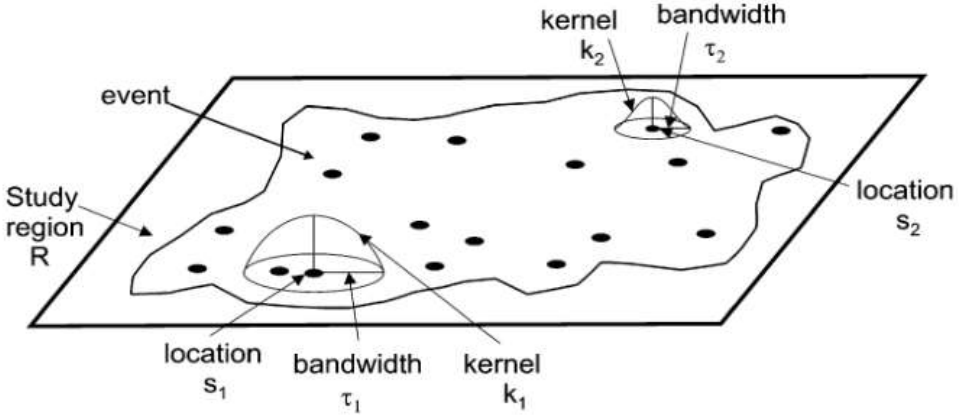
Map of black spot locations in Hanoi (2015-2017)

1. INTRODUCTION

- GIS-based KDE algorithm applied widely to detect black spots.

$$f(s) = \frac{1}{nh^2} \sum_{i=1}^{n} K\left(\frac{d_i}{h}\right) \quad (1)$$

where f(s) is the intensity estimate at the position s, n is the amount of point events, h is kernel size, K is the kernel function, and d_i is the distance between the position s and the position of the i^{th} point event.



- However, KDE method lacks an investigation of the statistical significance of the high-density locations. Thus, how to identify which clusters is statistical significance is really necessary.

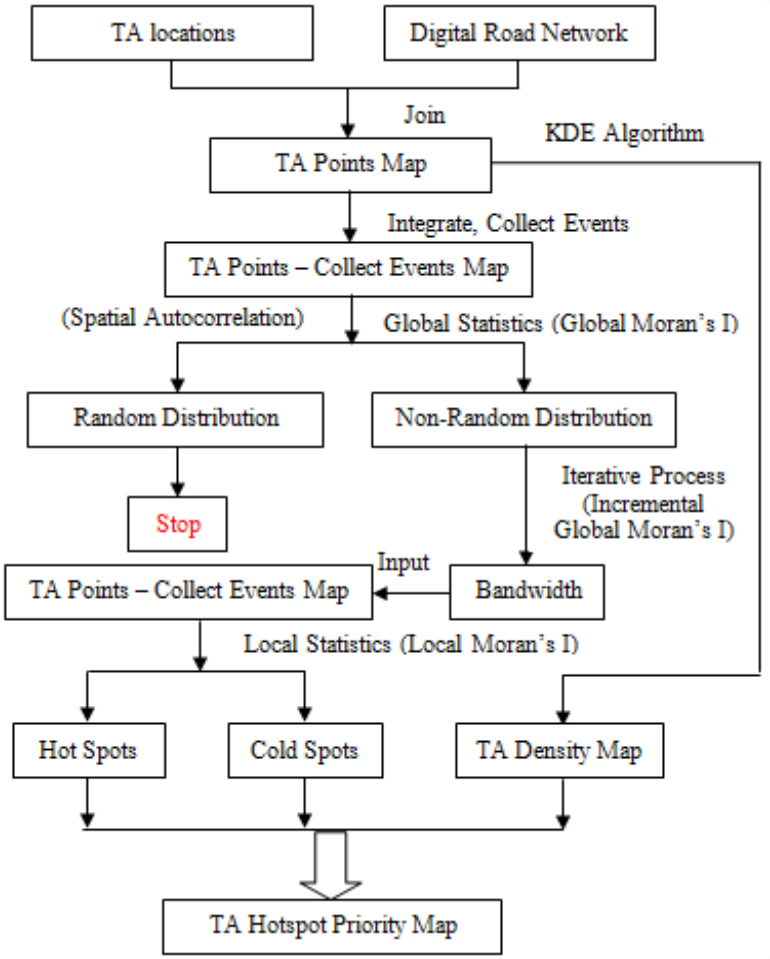
2. METHODOLOGY

2.1. Kernel Density Estimation (KDE)

2. 2. Local Moran's I

Is one of the most widely used Local Indicators of Spatial Association (LISA) statistics. It measures the statistical correlation between attributes at each location in a study area and the values in the neighboring locations. It also tests the significance of this similarity.

$$I_i = \frac{(x_i - \bar{X})}{S_i^2} \sum_{j=1, j \neq i}^{n} w_{i,j}(x_j - \bar{X}) \quad (2)$$



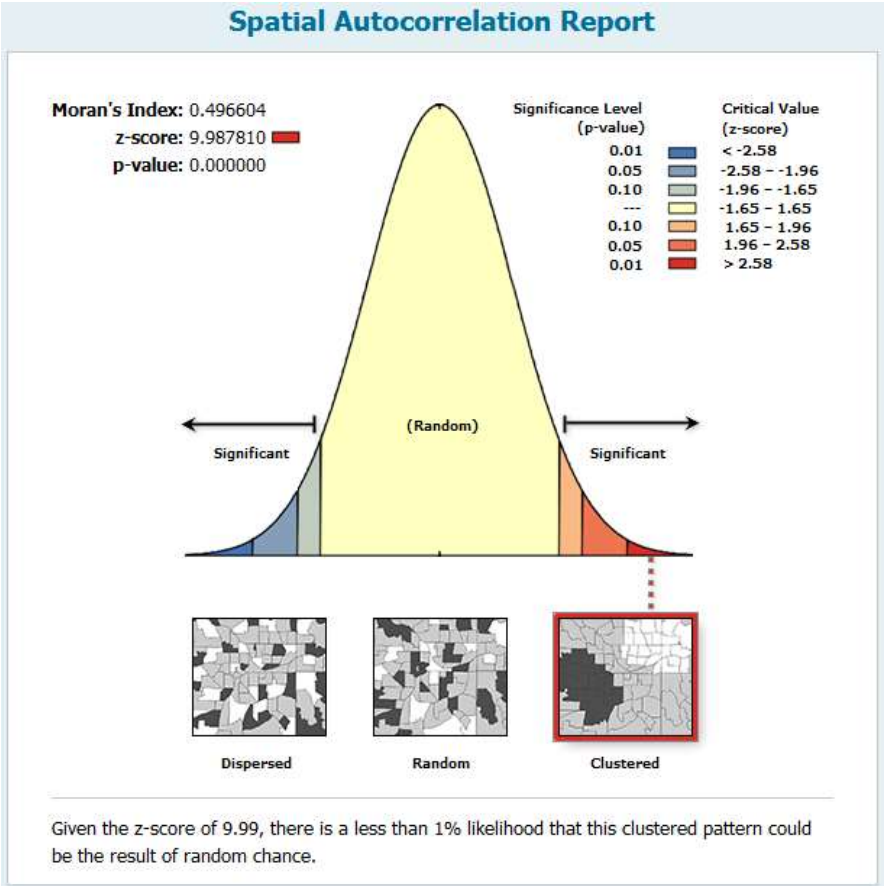
3. RESULTS

3.2. Statistical Significance Evaluation Process

- The null hypothesis: "TA in a section are distributed randomly".

- Statistical testing of the null hypothesis is based on a Spatial Autocorrelation in ArcGIS that is Global Statistics – Global Moran's I.

- Therefore, the next step is to identify bandwidth in which clustering phenomena is maximized.



3. RESULTS

3.2. Statistical Significance Evaluation Process

- We use incremental spatial autocorrelation to calculate and the result is showed as Fig. 6 and Table 1.

Distance	Moran's Index	Expected Index	Variance	z-score	p-value
500.00*	0.026614	-0.001616	0.000867	0.958860	0.337629
750.00*	0.018387	-0.001372	0.000892	0.661623	0.508213
1000.00*	0.039438	-0.001307	0.000758	1.480188	0.138823
1250.00*	0.041200	-0.001233	0.000676	1.631558	0.102773
1500.00*	0.049820	-0.001202	0.000564	2.147713	0.031737
1750.00*	0.038418	-0.001182	0.000476	1.814229	0.069643
2000.00*	0.044918	-0.001168	0.000411	2.272086	0.023081
2250.00*	0.060999	-0.001156	0.000347	3.337184	0.000846
2500.00*	0.054846	-0.001152	0.000286	3.313633	0.000921
2750.00*	0.048476	-0.001147	0.000254	3.114572	0.001842

First Peak (Distance, Value): 1500.00, 2.147713

Max Peak (Distance, Value): 2250.00, 3.337184

Distance measured in Meters

* At least one distance increment resulted in features with no neighbors which may invalidate the significance of the corresponding results.

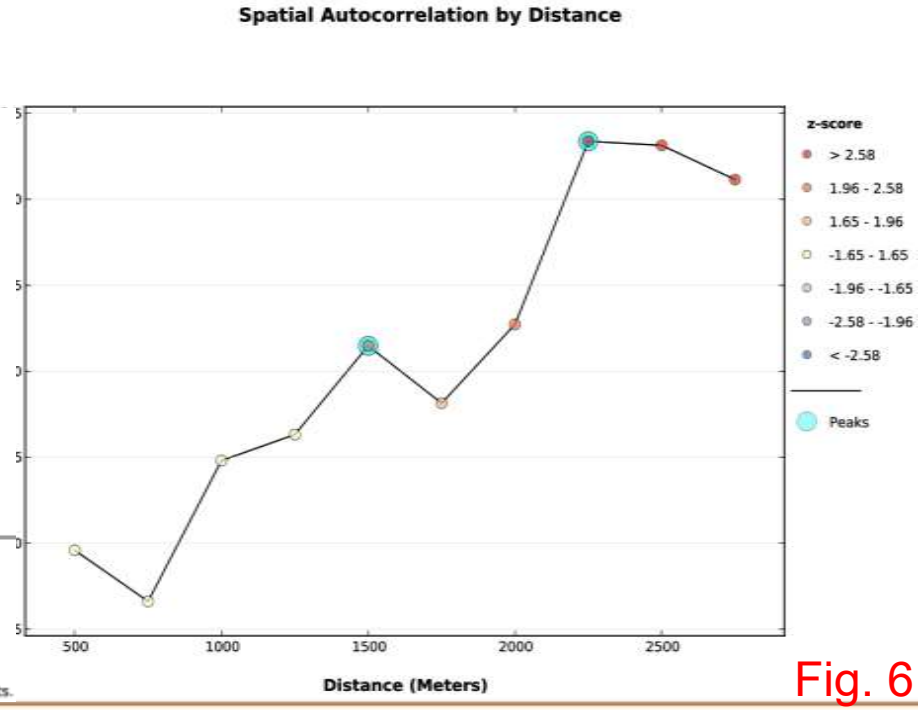


Fig. 6

3. RESULTS

3.2. Statistical Significance Evaluation Process

- A couple of Peaks where z-score gets very high which is an indication that it is at those distances where the clustering is maximized.

- Fig. 6 shows that the maximum peak is at 2250 m at which we can find maximum clustering and that is the number that we need in order to process forward.

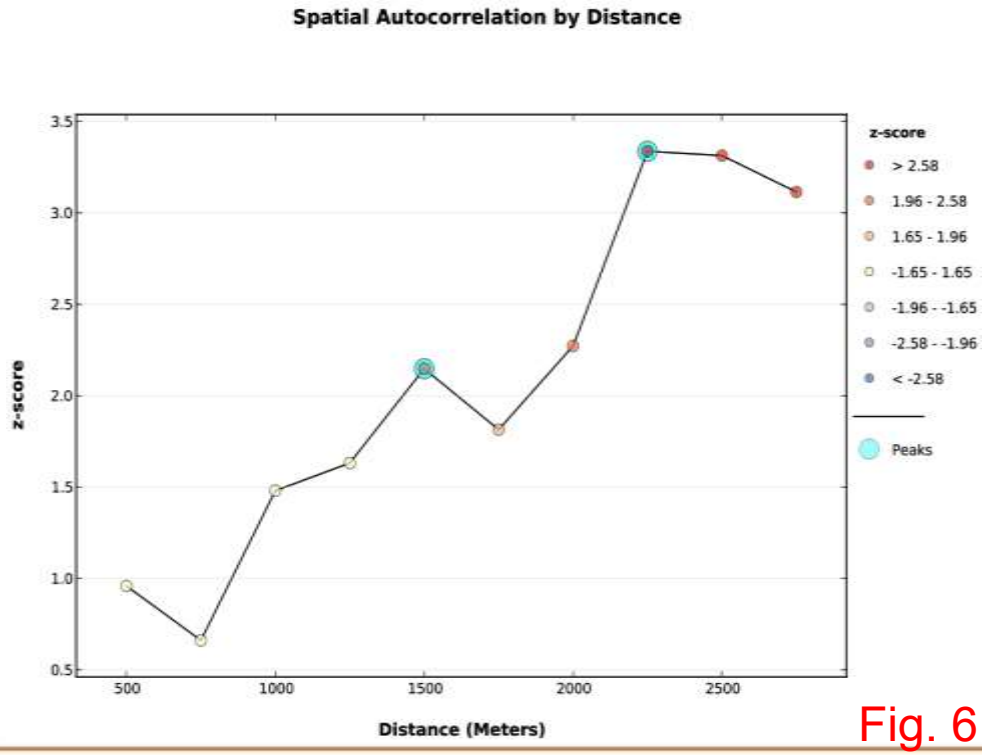


Fig. 6

3. RESULTS

3.2. Statistical Significance Evaluation Process

- We applied the cluster and outlier analysis (Local Moran's I) to generate a map of hotspots (Fig. 7).

- Fig. 7 shows that all the gray points that did not show any significant clustering with z-scores are low, so there is nothing really happening.

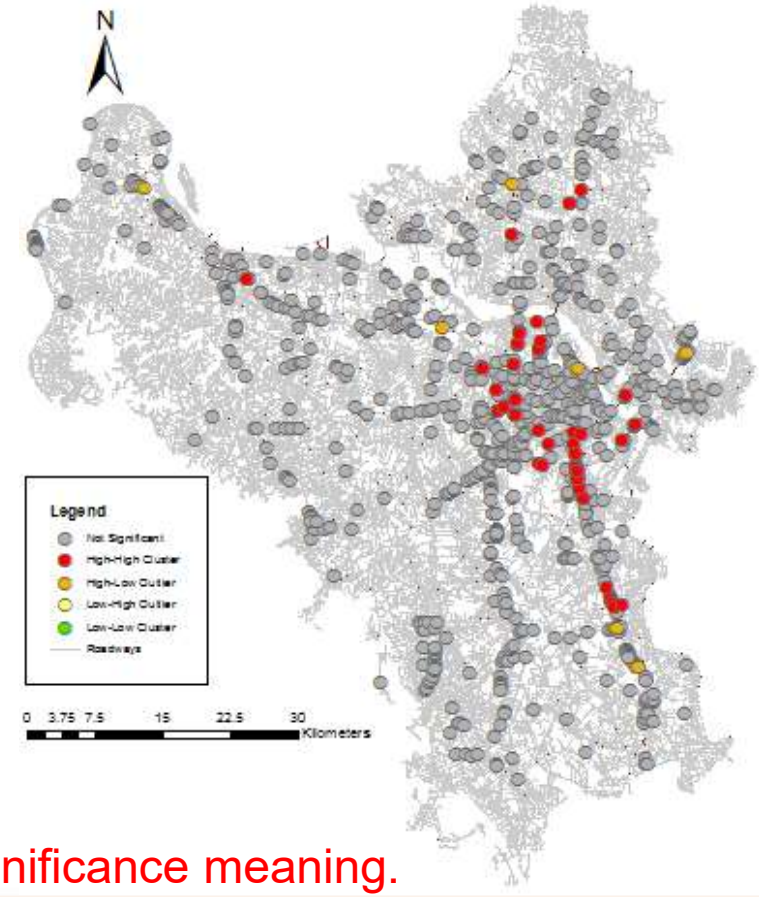


Fig. 7. Map of Hot spots, Cold spots with statistical significance meaning.

3. RESULTS

3.2. Statistical Significance Evaluation Process

- The red points show areas of clusters where high values near each other so in this case we have TA point's high priority near each other and those clusters are statistically significant meaning.

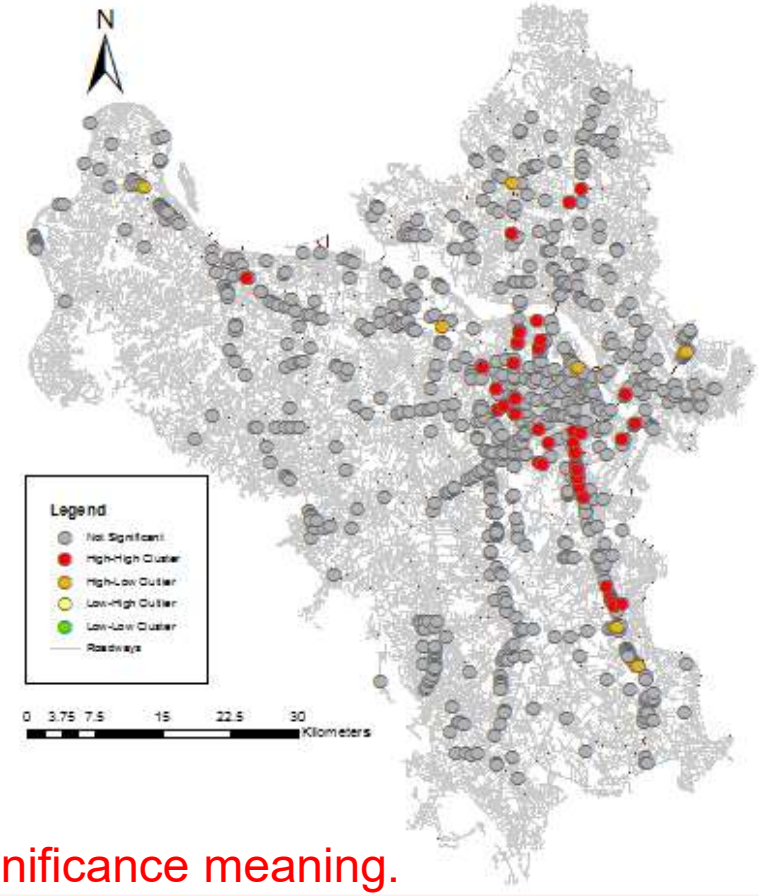


Fig. 7. Map of Hot spots, Cold spots with statistical significance meaning.

4. VALIDATION PROCESS

- The results of the proposed methodology are appropriate to the observations from the reality and the reference data. This proposed methodology enables traffic authorities understand the situations more clear and comprehensively.

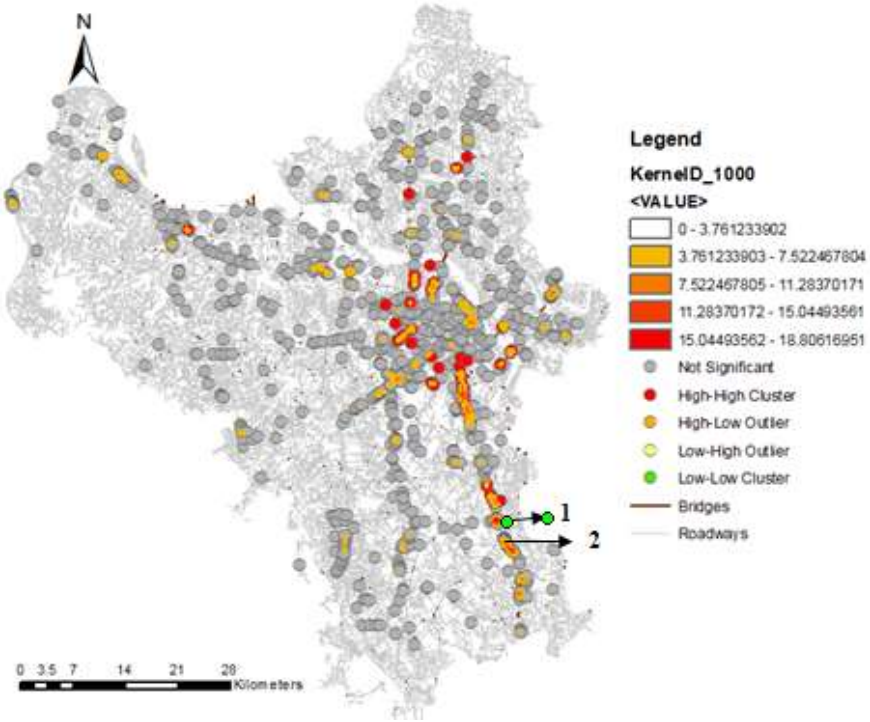


Fig. 8. Hotspot priority Map

4. VALIDATION PROCESS

For instance, location 1 was identified as a high density point of TA through applying KDE method. However, after investigating the statistical significance of the high-density locations, this location was identified as a (H-L) outlier point.

The results showed that this approach is appropriate for overcoming drawbacks of KDE method.

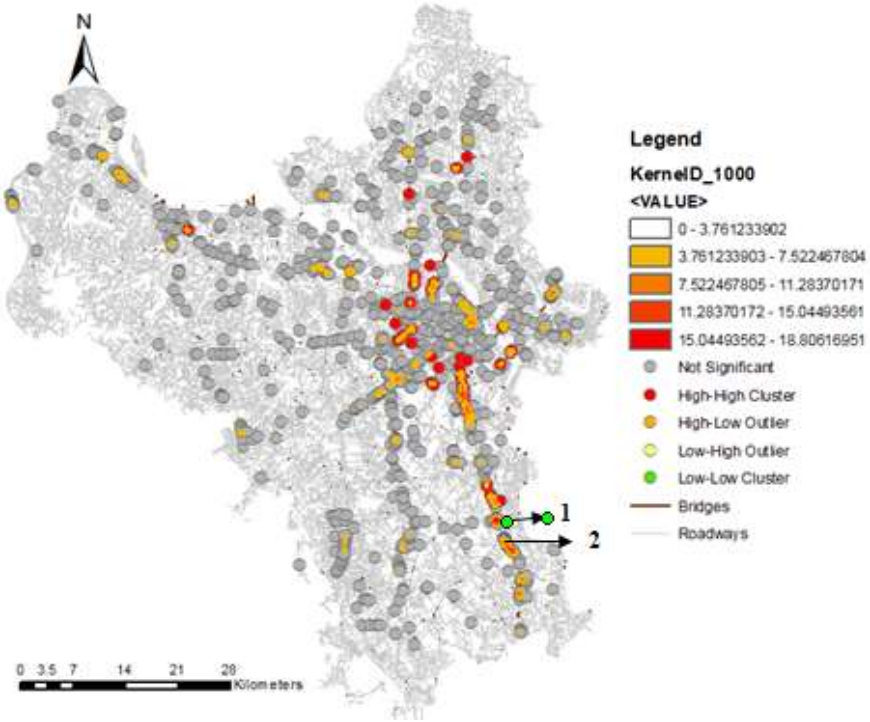


Fig. 8. Hotspot priority Map

5. CONCLUSION

- Spatial analysis for TA is necessary, especially in identifying TA BS.

- An approach that determines BS by using GIS-based KDE, evaluated statistical significance of clusters.

- The integration of KDE and statistical significance evaluation of the clusters help to overcome the drawbacks of KDE.

5. CONCLUSION

- The approach was effective and exact in identifying BS in Hanoi. These outcomes will not only enable transport authorities to know the reasons for each collision, but also to help them manage and deal with hazardous areas according to the prior order.

- However, traffic volume needs to be concerned in identifying BS. In addition, it should be deployed online, which not only helps the transport authorities, police patrol to update emergence information easily but also provide the citizen a black spot map in an updated, accurate, and visual way.

THANK YOU FOR YOUR ATTENTION!