Did the Toronto crime rate in 2021 increase compared to 2020? If yes, which area is at high risk of crime?

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Background / Problem

The crime rate is increasing around urban areas. Hence, Toronto is at risk of an increase in crime rate. For instance, There was a homicide on April 23, 2018 in North York, Toronto, where a van deliberately hit the pedestrians who were walking on the street (Boyko, 2021). The van attack killed 10 people and 16 were injured (Boyko, 2021). Recently, auto theft crime has gone up as well from Downtown Toronto. According to the *Toronto Star* Torstar Open Data team, a thirty-eight-year-old man stole several vehicles in the Old Toronto district from November 3 to November 9 (Torstar Open Data Team, 2022). Moreover, 33.1 percent increase in auto theft crime compared to the same period of time in last year 2021 (Torstar Open Data Team, 2022). According to multiple reports, increases in crime are detected in many years. Hence, this research has questioned, did the crime rate in Toronto actually increase from 2020 to 2021? If it did, which areas are at high risk of crime? What are the causes? What crime type shows increase or decrease? To address these questions, the research will evaluate increases in crime rate using multiple spatial analysis methods and data. It will also discuss the limitations of the data sets and critically think about how to overcome them.

Research Questions / Objective

Because of all the crime incidents and research questions mentioned above, this research will compare the crime rates in Toronto between 2020 and 2021 to see the temporal changes. To determine the severity

of criminal occurrences, the research will analyze the clustering of the crime data in 2021.

Data

For the purpose of spatial analysis, the two Toronto Police Open Source data sets, *Homicide ASR RC TBL-002* and *Neighbourhood_Crime_Rates*, were used (See Appendix 5 for the details).

Methods

To measure the crime severity, the research did the two different approaches. One involved analyzing the temporal crime rate differences between 2020 and 2021 based on the types of crime : break and enter, auto-theft, robbery, assault and homicide. I have shown robbery data to show the step of the difference (See Appendix 0). Secondly, by evaluating the clustering of crimes in each neighborhood, the severity of crime in each neighborhood is numerically evaluated. The objective was to determine the risk of crime by finding the clustering of a crime occurrence. For determining the clusterings, the research has used hotspot analysis, local Moran's I with global Moran's I, and aggregation clustering from the Feature layer.

For the setting of the hotspot analysis, the researcher used *Neighbourhood_Crime_Rates* as an input table and chose homicide, break and enter, robbery, auto-theft and assault individually as the input field for each map. Other settings are left as default. For the global Moran's I, the *Neighbourhood_Crime_Rates* was an input table and generated the report by enabling the report button (see Appendix 1).

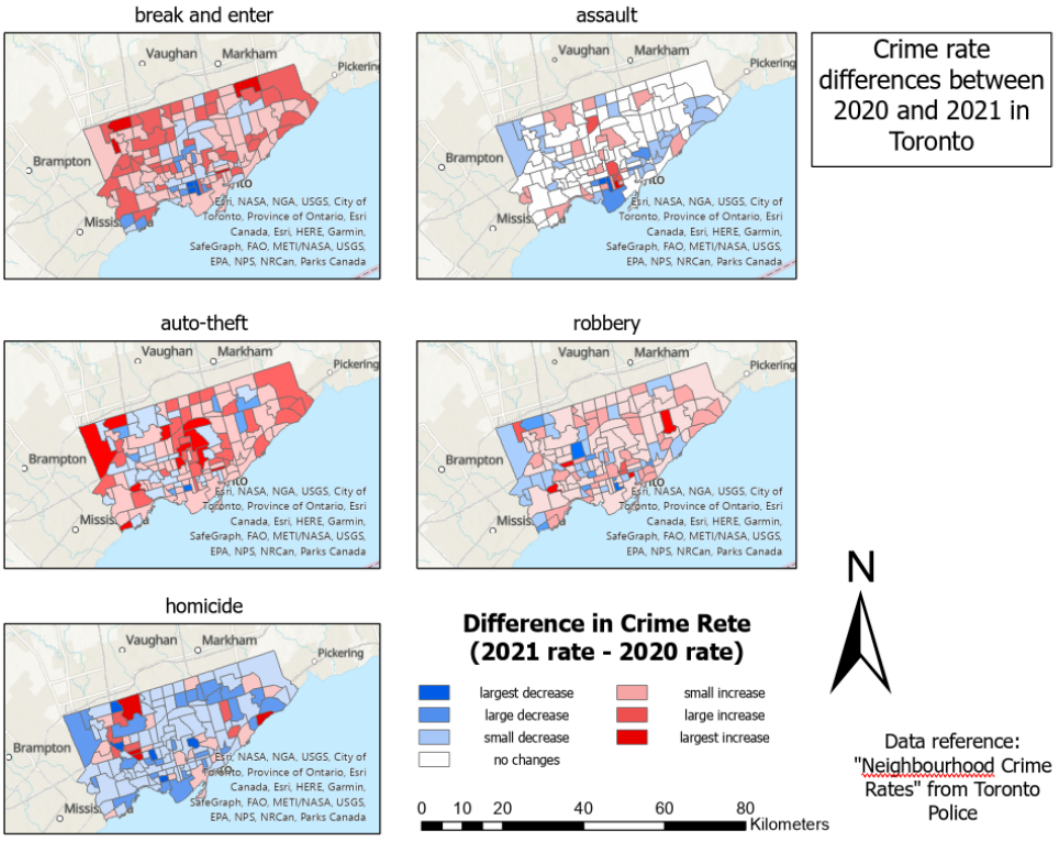
For local Moran's I, the researcher used *Neighbourhood_Crime_Rates* as an input Feature Class and chose homicide, break and enter, robbery, auto-theft and assault individually as an input field for each map. Other settings were left as default (see Appendix 2). The Local Moran's I was used

to see the danger regions for each type of crime while a Global Moran's I was used to see the statistical distribution of the crime clusters with enabling the “Generate Report” button (see Appendix 3). There are z-score, p-value and Moran’s index value to show the clustering statistically.

For aggregation clustering, the *Homicide ASR RC TBL-002* was used. In the Feature Layer, the aggregation icon was clicked and clustering was selected as a method (see Appendix 4d). (aggregation clustering image)

Results

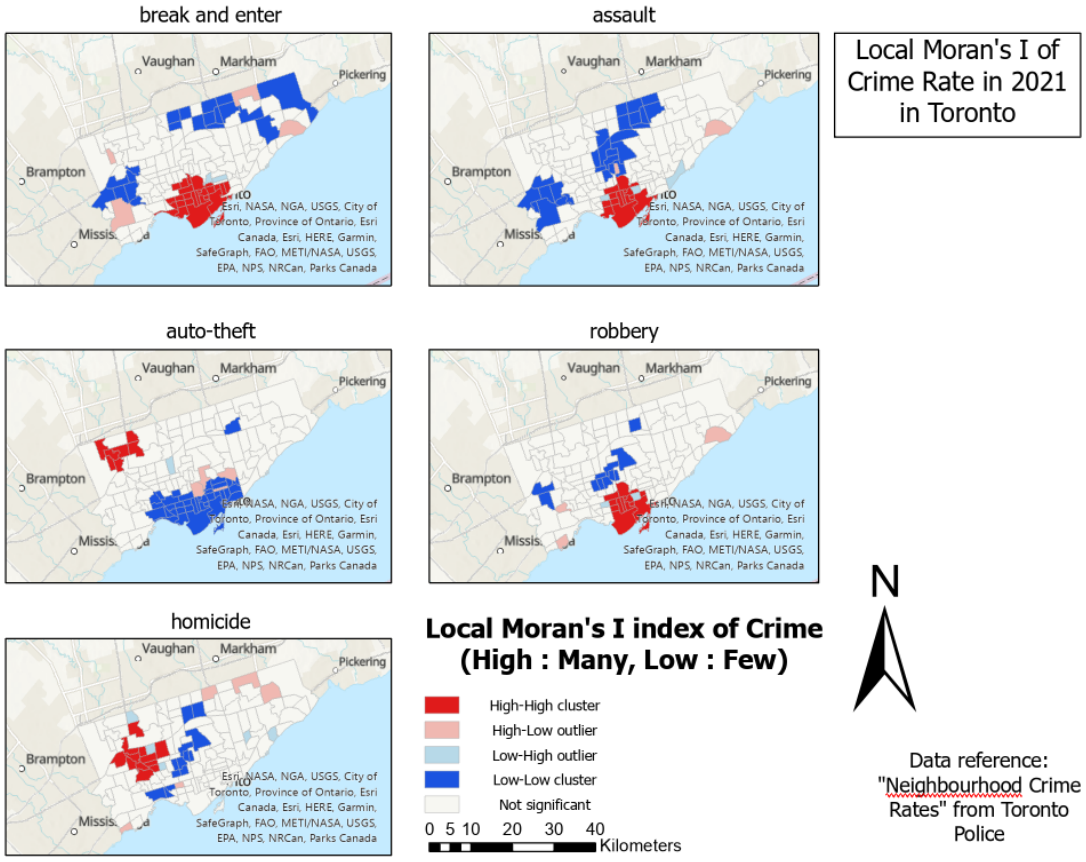
The spatial analysis results were displayed in choropleth maps.



(**Figure 1.** Map of Temporal crime rate differences from 2020 to 2021)

According to the differences in crime rate between 2020 and 2021 (see Figure 1), there was an increase in crime rates for all types of crime except homicide. The regions where the crime increased in 2021 compared to 2020 are colored in red and the regions that showed a decrease in crime in 2021 compared to 2020 are colored in blue.

For the second approach, the result of clusterings can determine the frequency of the crime occurrence in certain neighborhoods in Toronto. To produce this result, Hot Spot analysis and Local Moran's I were used. The method involving Local Moran's I and Global Moran's I shows high and low clusterings of each neighborhood in Toronto (see Figure 2a).



(**Figure 2a.** Map of local moran's I analysis on crime for each type of crime in Toronto, 2021)

The map displays the regions in four different categories: high-high, high-low, low-high, and low-low. The *high-high* means that not only the indicated neighborhood has a high crime rate but also the surrounding neighborhoods do as well. *High-low* means a high crime rate in the current neighborhood but a low one in its surroundings; *low-high* means a low crime in the current neighborhood but a high one in its surroundings; *low-low* means a low crime rate in the current spot as well as in its surroundings. The high-clustered, red neighborhood represents the high exposure to crimes, whereas the low-clustered, blue region represents the low exposure to crime. This can be presented in a scatterplot. The 1st quadrant is *high-high*, 2nd quadrant is *low-high*, 3rd quadrant is *low-low* and 4th quadrant is *high-low* (see Figure 2d). Moreover, the Global Moran's I method shows the spatial autocorrelation of the crime, meaning it shows the extent to which the data points are clustered and determines the significance of the data based on the z-score, a standard deviation, and the p-value, which indicates the chance of randomness. If p-value is smaller than 0.01 and z-score is negative, then it is dispersed meaning the high risk and low risk regions are in a pattern of chess-board. Whereas, if the z-score is positive and p-value less than 0.01, then there is a high clustered pattern. If z-score is close to 0 but p-value is greater than 0.10, then it is considered as Completely Spatially Random (CSR). Moreover, if a Moran's index is positive, then it is clustered, whereas, if negative, then dispersed. Apparently, the neighborhood crime data are significant, which implies that the p-value is near to zero and therefore less random, which is in this case equivalent to 95% or more confidence (see Figure 2b).

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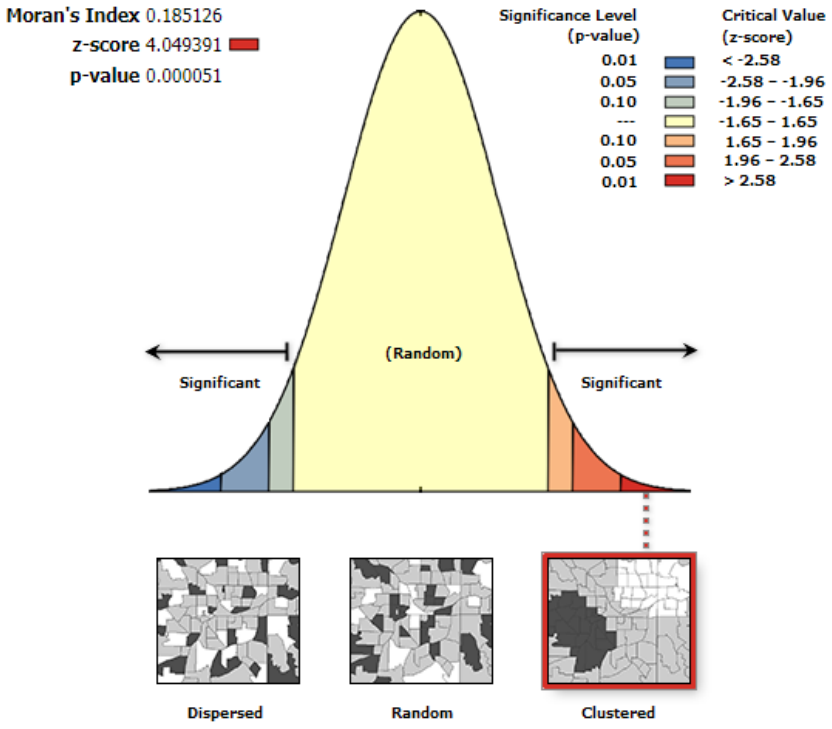
Spatial Autocorrelation Report

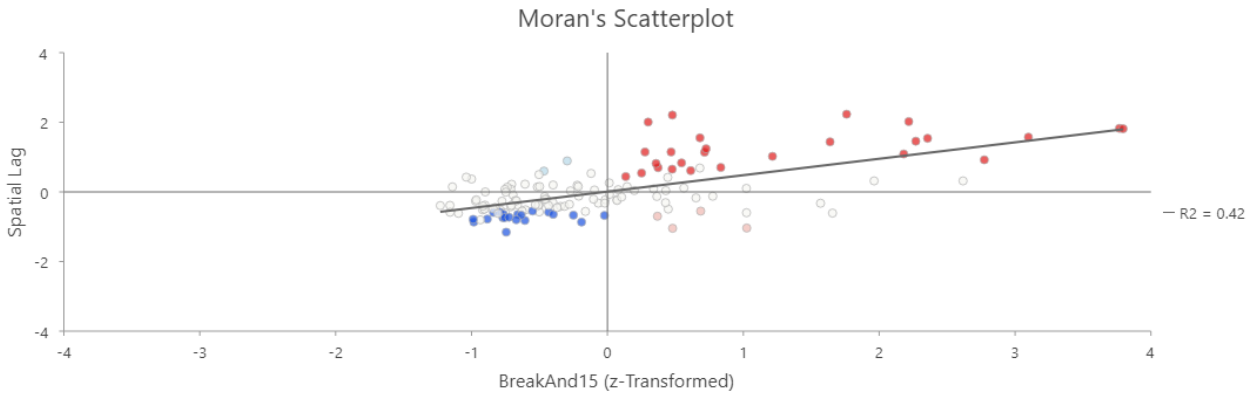


Given the z-score of 4.049391, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary

Moran's Index	0.185126
Expected Index	-0.007194
Variance	0.002256
z-score	4.049391
p-value	0.000051

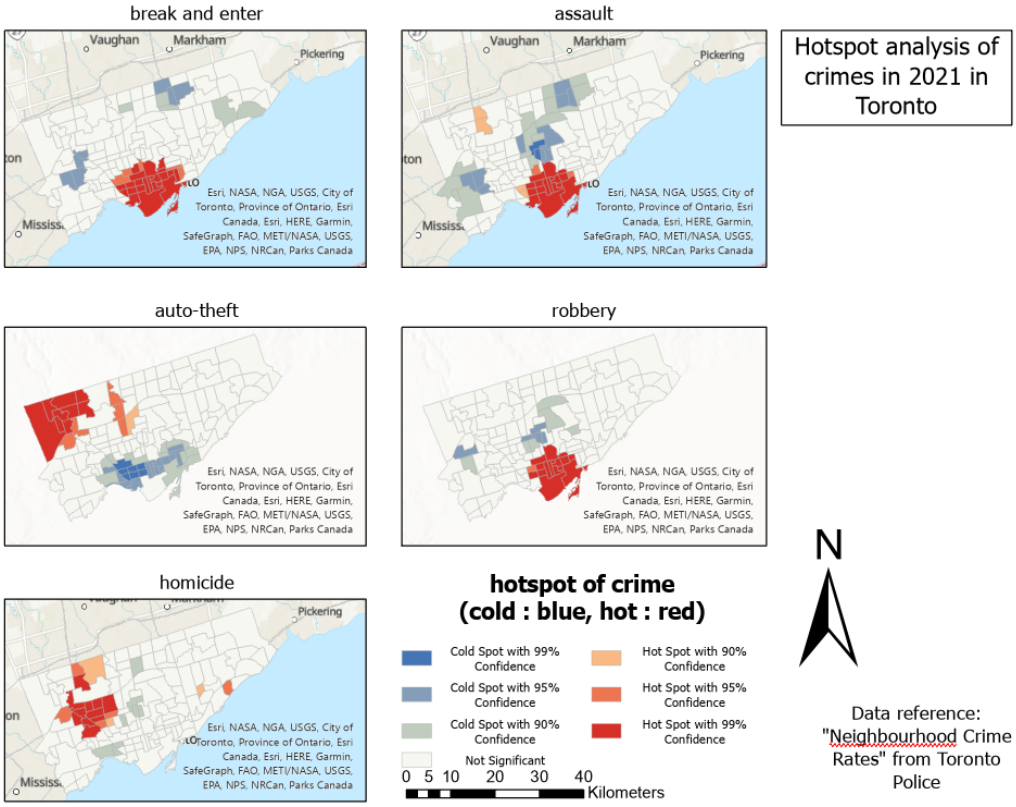
(**Figure 2b.** Global Moran's I result / Spatial Autocorrelation of Neighbourhood Crime Rate data-set)



(**Figure 2d.** The scatterplot is showing the 2021 Break and Enter crime data. See the rest in Appendix 6)

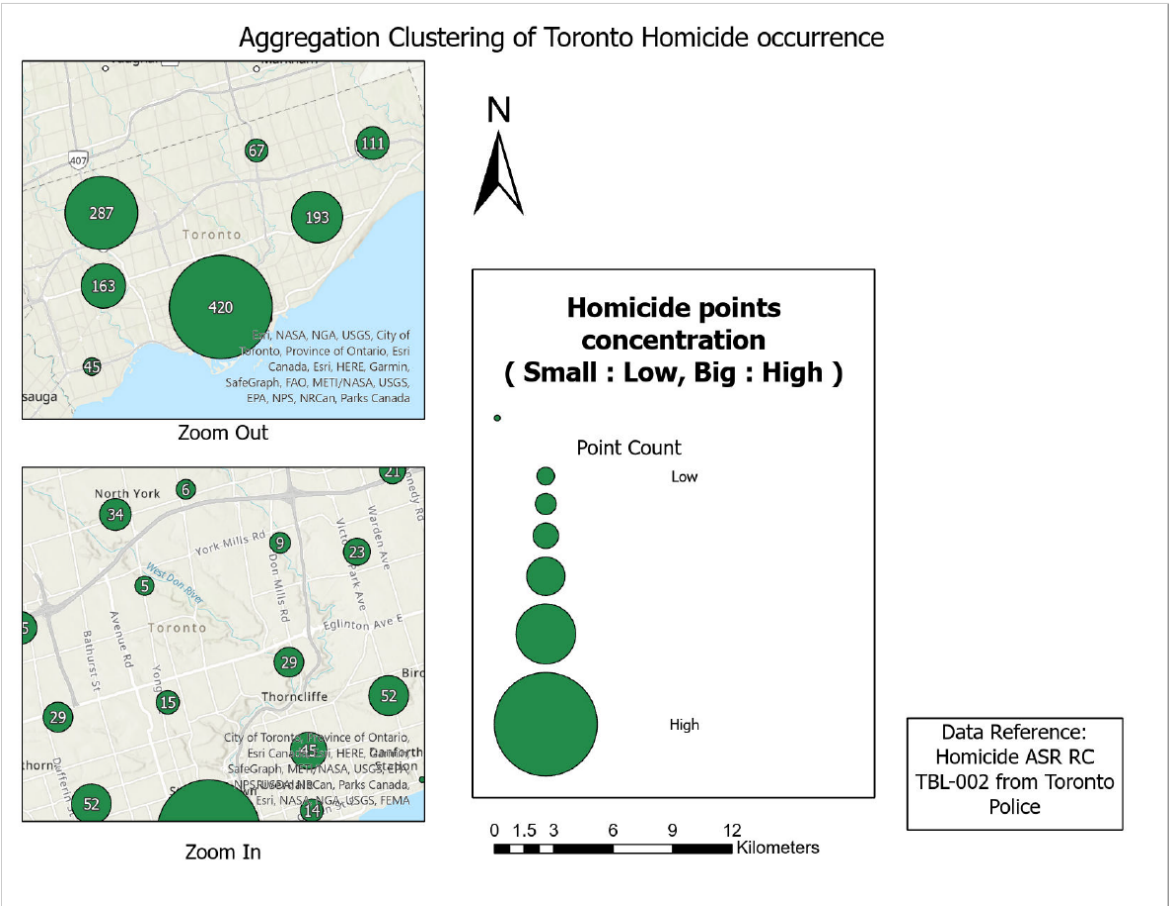
At the global scale, it is slightly clustered according to p-value of 0.000051, which means it is significant because it is less than 0.01. However, Moran's I index is 0.185126 which is relatively close to being considered as Complete Spatial Random (CSR) however, since Moran's index and z-score are positive, it is considered as a clustered result. In addition, the local Moran's I shows the map of concentration of crime in each neighborhood (see Figure 2b).

The hotspot analysis was another method to show the frequency of crime in 2021 Toronto which showed the cold spot, blue region, to be a low crime rate and hot spots, red region, to be a high crime rate with 99% or 95% accuracy (see Figure 2c).



(**Figure 2c.** Map of the hotspot analysis of Crime rate based on type of crime in Toronto, 2021)

For the deeper spatial interpolation, I look specifically at the homicide crime dataset that only consists of homicide data points with its locations. By using the clustering method in aggregating feature layers, the research was looking for the concentration of homicide occurrences in Toronto (see Figure 3).



(**Figure 3.** Tools order: Feature layer > Aggregation > method: Clustering using homicide data)

Discussion

According to *The Spatial and Social Patterning of Property and Violent Crime in Toronto Neighbourhoods: A Spatial-Quantitative Approach*, between 2014 and 2016, the crime rate went up in Toronto (Wang et al., 2019). The study found multiple factors that have a correlation with high crime rate which are the regions with high proportion of young people, higher level of economic disadvantage and greater residential instability (Wang et al., 2019).

Vilkhov Law lawsuit has detected there is an 11 percent increase in assault, 47.8 percent increase in auto-theft, 5.2 percent in break and enters in Toronto this

year (Vilkhov, 2022). However, there was a 16.7 percent decrease in homicide (Vilkhov, 2022). Hence, this research shows that the crime rate increased in 2021 compared to 2020 except the homicide crime rate which reflects my research.

The report from police in the City of Toronto has shown that people under 15 or between age 20 to 29 are the cause of increasing the crime rate whereas the older people, age 65 or higher, tends to decrease the major crime rate (Charron, 2009). The report also shows that urbanized areas tend to have higher major crimes rates except robberies (Charron, 2009). However, the commercial areas are the place where there are high assault and robbery rates but, contracting, low crime rates in the area where there are a lot of office workers (Charron, 2009). The author, Mathieu Charron, also said there was a decrease in robbery in certain areas in Toronto because of the increase in elder population, people who are older than 65 years old (Charron, 2009).

limitation

The Homicide data contained mis-leading location information. The location information of each crime point, latitude and longitude, is not clearly stated; instead the points were located at the crossroad on a street. Because of it, any spatial interpolation analysis done based on this homicide data will create a misleading result. However, there is a reason why the location of crime scenes is inaccurate. According to one of the police officers from Edmonton Police, it is necessary to protect the privacy of the victims (Rusnell & Fralick, 2010). Therefore, concealing the exact crime location is required. Also, the Honolulu police department pointed out that the action of concealing the exact crime location can be a tool to build a safer community (Blair, 2021).

From the above police statements, even though the data contains misleading information, the data itself has a meaning and values to it. Therefore, we should not ignore data only because it is not showing the exact information. Then how should we overcome this issue about inaccurate information and continue with our research? *Neighbourhood_Crime_Rates* data has homicide data categorized based on each Neighborhood which is suitable for this research because it is protecting the privacy of victims by not revealing the exact accident locations, meanwhile showing the occurrence of crimes based on neighborhoods. Hence, the research can evaluate clusterings of crime and estimate the riskiness of crime.

Conclusion

Therefore, most of the crime rate in 2021 has gone up compared to 2020 especially in Downtown Toronto except homicide. The factors probably causing the increase in crime rates are the high population of young people, the commercial use, people with economic disadvantage or greater residential instability of certain regions in Toronto.

While we are predicting the crime occurrence, the data provided by Toronto Police are not revealing the exact location of individual crime because there is a need for protecting the privacy of victims and to create a safe neighborhood environment. To overcome this issue, I applied hotspot analysis and local Moran's I on “Neighbourhood_Crime_Rates” data from Toronto Police to determine the area where there is a high exposure of crime. Hence, it is suitable for this research because it is showing the clusterings but also protects the victims privacy by concealing the location information of each crime.

References

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Vilkhov, I. (2022, September 23). *Toronto crime rates in 2022*. Vilkhov Law. Retrieved November 14, 2022, from https://vilkhovlaw.ca/toronto-crime-rates/

Wang, L., Lee, G., & Williams, I. (2019). The spatial and social patterning of property and violent crime in Toronto neighbourhoods: A spatial-quantitative approach. *ISPRS International Journal of Geo-Information*, *8*(1), 51. https://doi.org/10.3390/ijgi8010051

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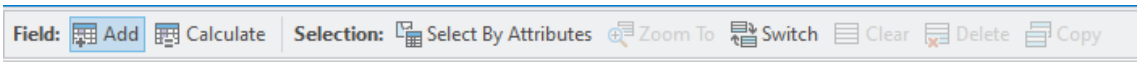
Appendix

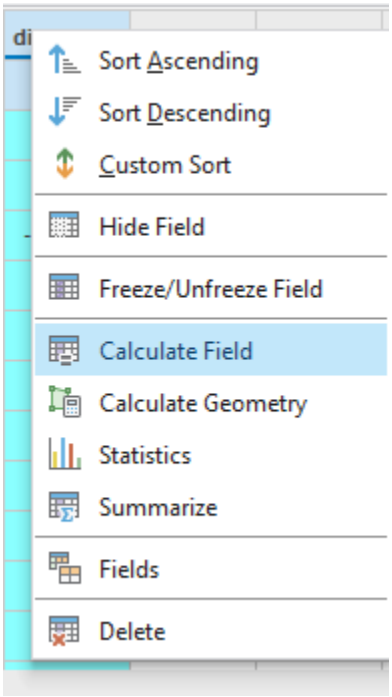
Appendix 0



Step 1: open the table and click the “add” button to add a new column

Visible	Read Only	Field Name	Alias	Data Type	Allow NULL	Highlight	Number Format	Default	Precision	Scale	Length
☑	☐	diff_2021h	diff_2021h	Float	☐	☐	Numeric		0	0	
☑	☐	dif_1421as	dif_1421as	Float	☐	☐	Numeric		0	0	
☑	☐	dif_1420as	dif_1420as	Float	☐	☐	Numeric		0	0	
☑	☐	dif_2021as	dif_2021as	Float	☐	☐	Numeric		0	0	
☑	☐	dif_1421be	dif_1421be	Float	☐	☐	Numeric		0	0	
☑	☐	dif_1420be	dif_1420be	Float	☐	☐	Numeric		0	0	
☑	☐	dif_2021be	dif_2021be	Float	☐	☐	Numeric		0	0	
☑	☐	df_1421bec	df_1421bec	Long	☐	☐	Numeric		5	0	
☑	☐	diff_1420	diff_1420	Float	☐	☐	Numeric		0	0	
☑	☐	dif_2021at	dif_2021at	Float	☐	☐	Numeric		0	0	
☑	☐	dif_1421at	dif_1421at	Float	☐	☐	Numeric		0	0	
☑	☐	dif_1420at	dif_1420at	Float	☐	☐	Numeric		0	0	

Step 2 : create a new column, create a suitable field name, make data type “float” and save the result



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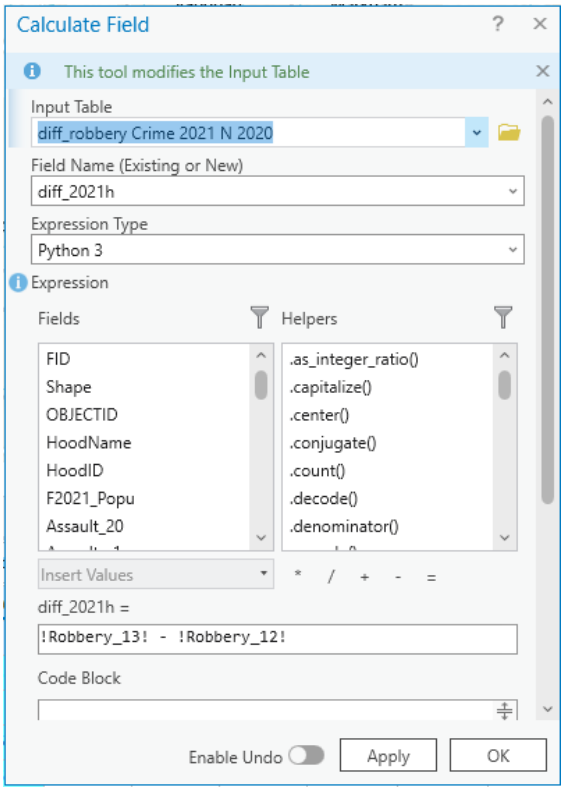
Step 3: go back to the table, and click on the newly made column. Right click and select the Calculate Field.



Step 4: at the bottom where we have to make a calculating expression, choose the year 2021 robbery (robbery_13) and subtract the year 2020 robbery.

Do apply the same steps for the rest of other crime types: Assault, break and enter, homicide, auto theft. The result will look something like at the bottom. The bottom is only showing partial results.

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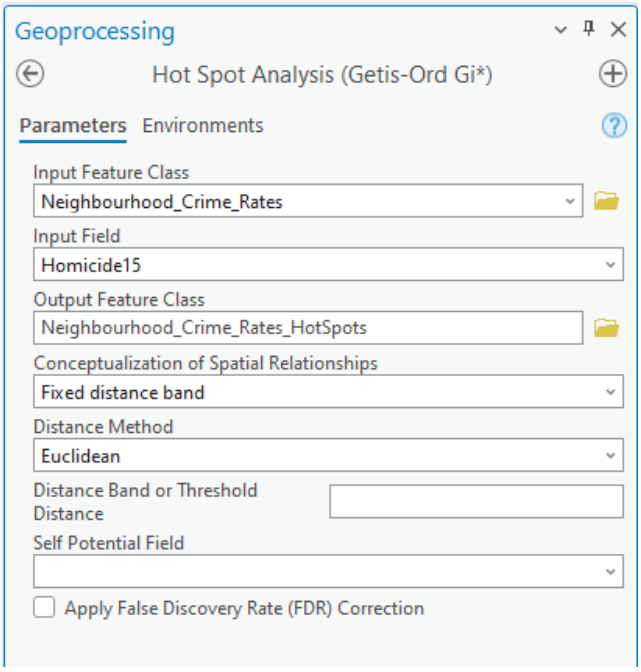
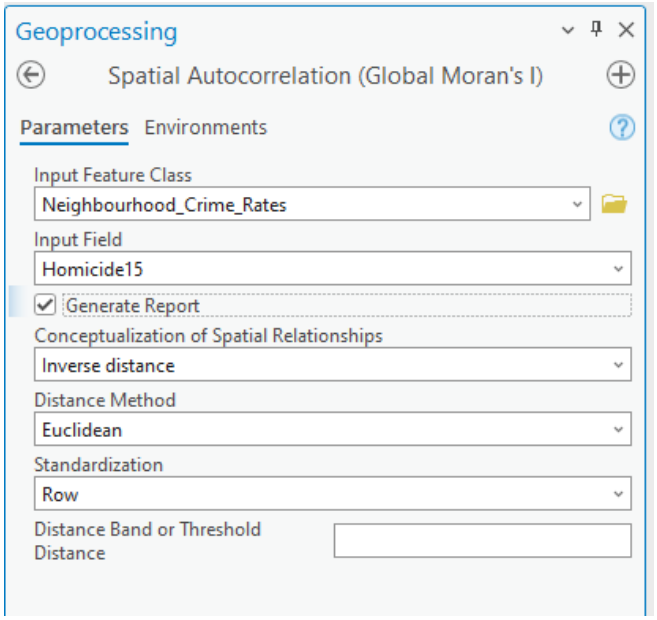
diff_2120	diff_1421	diff_1421h	diff_2021h	dif_1421as	dif_1420as	dif_2021as	dif_1421be	dif_2021be	dif_1420be	df_1421bec	diff_1420	dif_2021at	dif_1421at	dif_1420at
-0.68971	3.0605	0	0	255.941	36.3031	219.637	-84.8361	17.1641	-102	-7	3.75021	33.5726	0	48.03
-28.073	-71.4867	16.0876	16.2666	155.118	198.83	-43.712	-0.9631	28.2836	-29.2467	7	-43.4137	-56.6391	0	238.104
9.35958	-4.62003	0	0	261.055	289.989	-28.9345	-125.236	-128.795	3.5595	-18	-13.9796	69.4806	0	141.601
-133.868	-57.423	-1.05538	-0.169899	219.621	196.571	23.0496	29.0483	-96.6347	125.683	15	76.4447	7.1484	0	60.2624
-8.30625	-1.65318	3.59221	3.59221	-78.3693	28.1023	-106.472	-173.089	-19.9242	-153.164	-42	6.65307	72.744	0	26.8896
-17.2617	-52.8276	0	-3.33667	26.9741	72.3083	-45.3342	-124.161	-130.797	6.6367	-34	-35.5659	60.9053	0	41.9976
37.7471	-18.2458	0	0	-10.2694	-22.6444	12.375	-39.2717	-109.014	69.7422	-6	-55.9929	32.6418	0	62.1428
-27.5719	-124.915	0	0	-49.3462	-93.2917	43.9455	-135.054	-27.6285	-107.425	-14	-97.3434	7.8898	0	298.266
37.5336	-17.3966	-14.2857	-8.50412	81.8251	2.9262	78.8989	-14.9201	-27.3498	12.4297	1	-54.9302	-17.8482	0	27.8984
-21.9104	15.5213	0	-5.42682	-64.7572	-78.5999	13.8427	-52.9674	-55.2026	2.2352	-8	37.4317	-6.03626	0	52.6001
-19.1863	-35.4828	0	0	68.4417	28.5069	39.9348	-84.858	-190.896	106.038	-11	-16.2965	41.3408	0	83.2439
-26.4737	-49.0566	-2.75764	1.88693	-142.079	-103.279	-38.8001	-35.1156	30.3543	-65.4699	7	-22.583	29.3538	0	81.984

Appendix 1



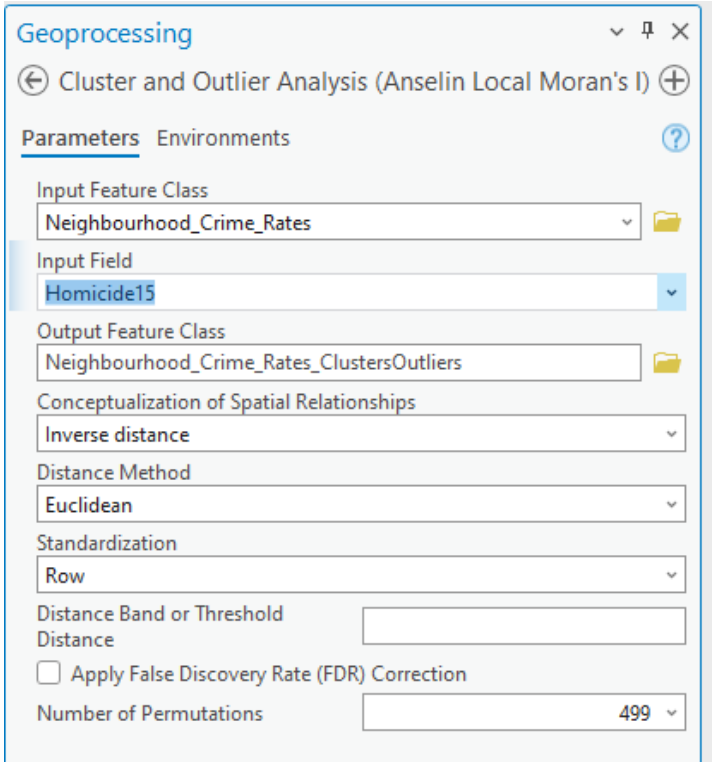
(HotSpot Analysis example using homicide 2021 data)

Appendix 2



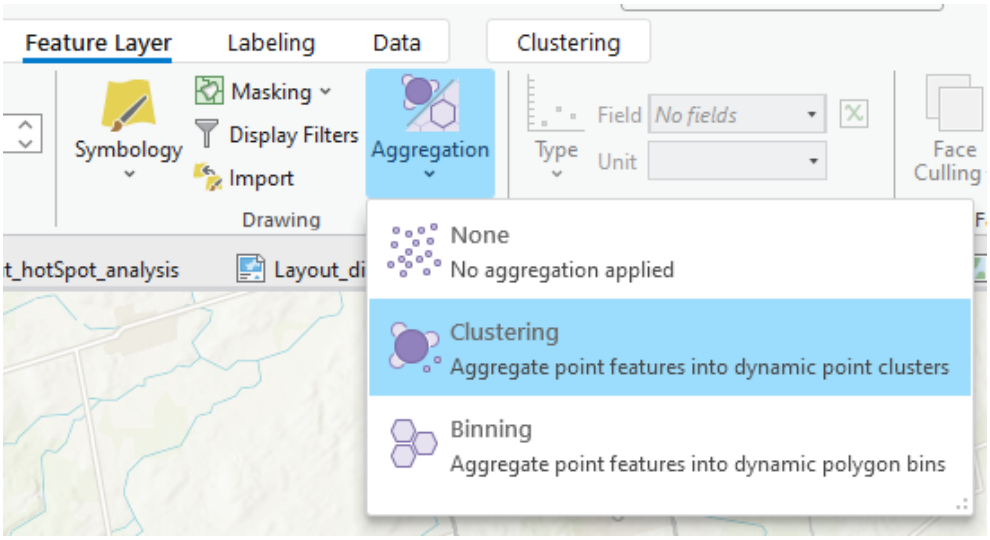
(Global Moran's I example using homicide 2021 data)

Appendix 3



(Local Moran's I example using homicide 2021 data)

Appendix 4



(click order : Feature layer > Aggregation > method: Clustering using homicide data)

Appendix 5

Name of the dataset	The availability and the latest update of the data	Description of the reason of choice and what data I have used.
Neighbourhood_Crime_Rates	The data is available from Toronto Police Open Data and the data are available starting from 2014 to 2021. The link to the dataset: https://data.torontopolice.on.ca/datasets/TorontoPS::neighbourhood-crime-rates-2/about	There are multiple different types of crimes categorized in each neighborhood in Toronto organized in different years. The data were collected as a crime rate for each year for each crime type based on neighborhood and another column showing the number of crimes occurring for each type of crime for each year based on neighborhood. For instance, there is a column I have used the crime rate of crime types: - Homicide - Assault - Robbery - Break and enter - Auto theft

Homicide ASR RC TBL-002	The data is available from Toronto Police Open Data and the data are available starting from 2004 to 2022. The link to the dataset: https://data.torontopolice.on.ca/pages/homicide	Each row in the table has the description of one crime incident. It contains occurrence date, occurrence year, homicide type, police division near to the crime scene, latitude and longitude of the crime location, neighborhood name, X and Y value and others columns. However, other than using location information of the crime, all other information did not take any important role in my research. I have used all the data to see the clustering of crime occurrences in Toronto in a proportional symbol map. The clustering of the crime is represented in terms of the size of the circle. If I zoom in, then the circle is divided into smaller circles and show the distribution of the crime clusterings in specific regions.

Table 1. This is showing the table of the datasets I used and contains the description of what these datasets are, how and what data in the datasets are used, where can we find the data and where these datasets can be found.

Appendix 6

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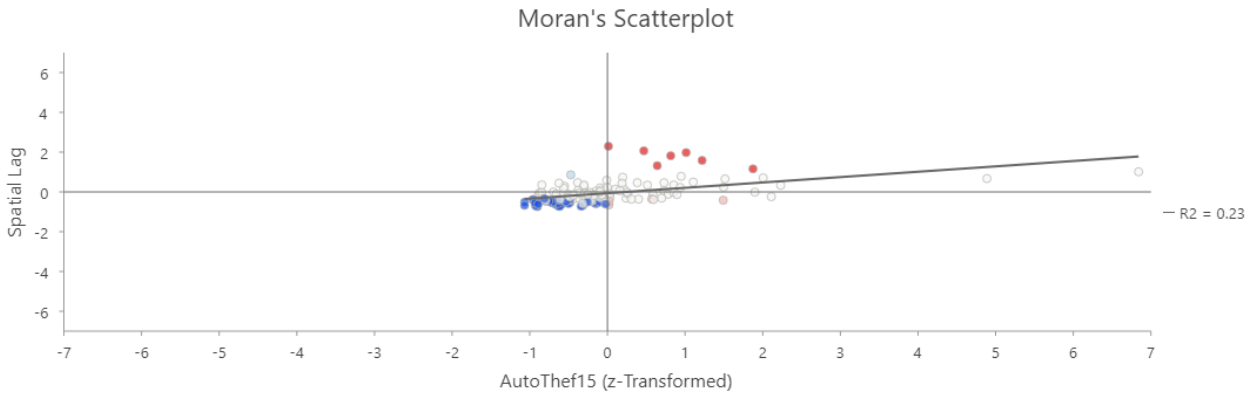
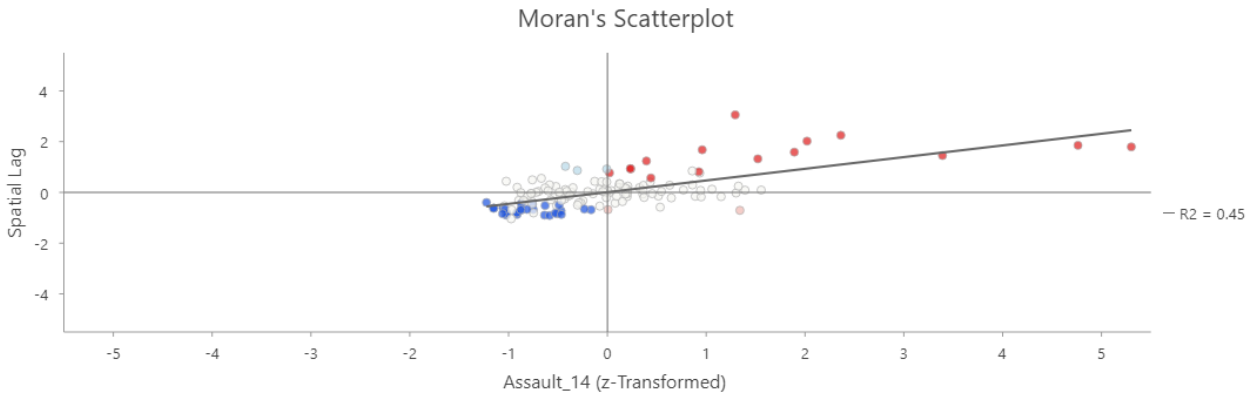
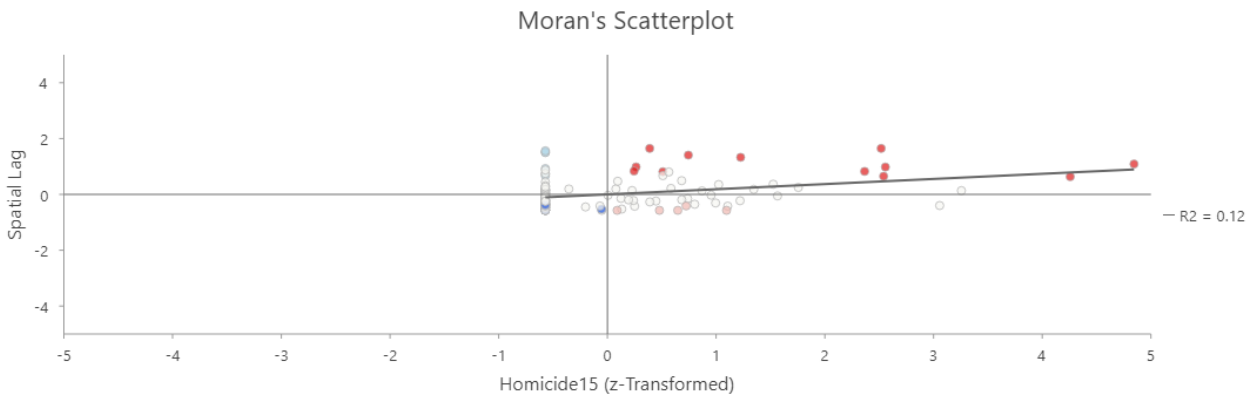


(Local Moran's I of 2021 AutoTheft Scatter Plot)



(Local Moran's I of 2021 Assault Scatter Plot)



(Local Moran's I of 2021 Homicide Scatter Plot)

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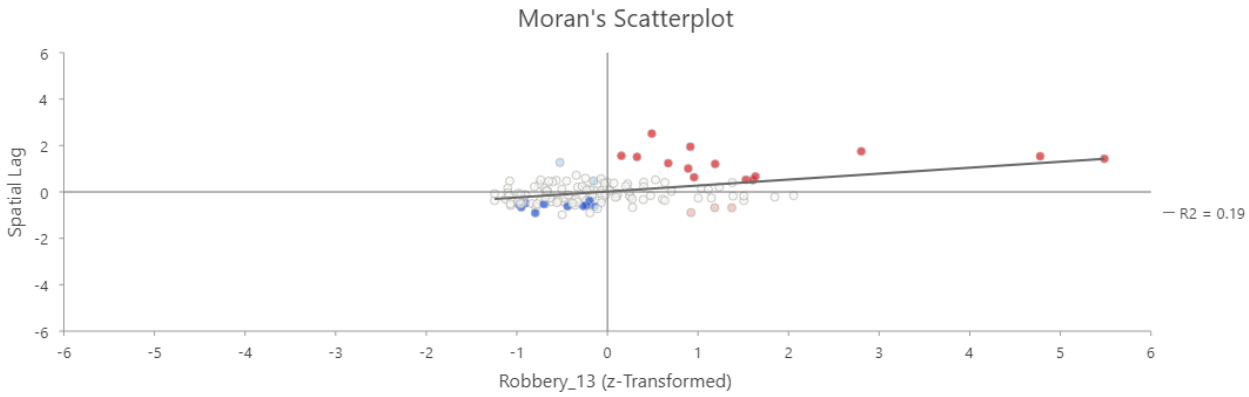

(Local Moran's I of 2021 Robbery Scatter Plot)