The Relationship between Urban Green Space and Socioeconomic Factors in the City of Vancouver: A Case of Environmental Injustice *

Daina De Angelis *400240413*
Tim Truong *400264793*
Maeve Nowitsky *400264259*
Jillian Mezenberg *400243427*

R Markdown

Introduction

Urban green spaces are crucial for creating sustainable and livable cities, and Vancouver is often recognized as a leader in this area as it strives to become a zero-carbon emission city. Green spaces have numerous benefits, including mitigating climate change impacts, supporting urban ecology, improving property values, and fostering social interactions (Nesbitt et al. 2019). However, the distribution of urban green space in Vancouver, as in many cities, may be unequal, with certain populations having less access to these spaces (Nesbitt et al. 2019). Equitable access to green space is particularly important for disadvantaged and lower socioeconomic groups, as it can positively impact their well-being. This report focuses on Vancouver due to the availability of high-resolution data on urban green space and socioeconomic factors, aiming to explore the relationship between green space accessibility and socioeconomic factors across different areas in the city.

Background

Cities must ensure that all residents can benefit from green spaces by prioritizing accessibility. Research conducted in Atlanta, Georgia by Dajun Dai found that poorer access to green spaces is associated with neighborhoods with higher percentages of Black populations, households with overcrowded living conditions, female-headed households, populations below the poverty line, and households without access to a car (Dai 2011). Similarly, a survey conducted in Pittsburgh, Pennsylvania found that only 8.5% of residents in predominantly African American, low-income neighborhoods were aware of their closest park (Vaughan et al. 2018). This disparity in access to green spaces is also evident in Canadian cities such as Toronto, Montreal, and Vancouver, where areas with higher poverty rates have lower walkability, less streetscape greenness, and worse traffic-related air pollution, leading to negative health and social outcomes such as premature mortality and poorer mental health (Wawin 2022). This inequity in green space access highlights the contrast between easily accessible public parks in white, upper-class communities and the barriers faced by racialized communities with lower socioeconomic status (Zuniga-Teran and Gerlak 2019).

In one study in 2021, they found out that elementary schools in high income neighborhoods are surrounded by an average of 14% more greenspace and 16% less greenspace than in schools in low income. The presence of green spaces around schools can potentially provide various health benefits for children, as they spend significant amounts of time in or near their school premises. However, the study only focuses on income as a factor and should consider including additional factors in their analysis to provide a more comprehensive understanding of the relationship between green space and children's health. This report will incorporate additional demographic characteristics, such as ethnicity, in order to broaden the analysis (Ng, Gergel, and Eskelson 2021).

Vancouver, being one of the top ten census metropolitan areas in Canada, with a population of 662,248 in 2022, of which are highly diverse, it will be interesting to analyze if more affluent groups get to experience the benefits of greenery ("The 2022 Canadian City Parks Report: Nurturing Relationships & Reciprocity," n.d.).

*Paper submitted to complete the requirements of ENVSOCTY 4GA3 Applied Spatial Statistics.

Study Area

This study took place at the Census Subdivision level to target the municipality of Vancouver, BC. There are 127 census tracts in Vancouver that were studied.

Data

The data used for analysis includes census data for variables of population, population density, visible minority status, non-visible minority status, and income for each census tract in the census subdivision of Vancouver. This data was obtained from Statistics Canada through use of the cancensus package in R. All census data used is from the 2021 census. Point data for each the location of each park, homeless shelter, and street tree in the census subdivision was downloaded in a .csv file format from the City of Vancouver's open data portal. To use the r5r package so that accessibility to parks by both walking and public transit could be determined, a road network dataset of Vancouver, and as well as a public transport feed of the city was needed. The road network dataset was obtained from BBBike, and was stored as a .pbf file ("OSM Extracts for Vancouver," n.d.). The public transport feed was obtained from Transitland and stored in a GTFS.zip file ("GTFS Feed: West Coast Express, British Columbia Rapid Transit Company,TransLink," n.d.).

Methods

To determine the relationship between greenspace and other socioeconomic factors in Vancouver, Rstudio was used to analyze and visualize the variables being examined. Choropleth maps for variables of population, population density, visible minority status, non-visible minority status, and income, and accessibility to parks were made to provide a visual representation of the difference between census tracts. Regression analysis was used to determine the relationship between the independent variable studied (number of parks accessible within a 30 minute travel time) and dependent variables (population, population density, visible minority status, non-visible minority status, and income). Scatterplots were used to show a visual representation between independent and dependent variables studied to better understand the results of regression analysis.

Results

To begin our analysis, the centroids for each census tract in the Vancouver CSD were obtained and put into a dataframe with latitude, longitude, and census ID. This allowed us to have point data describing the middle of each CT.

The point data for park in the Vancouver CSD was obtained from a csv file from Vancouver's open data portal and transformed into a data frame with columns describing the X and Y coordinates of each park.

The point data for parks was prepared for use of the r5r package by renaming columns for latitude, longitude, and park ID data and to the names required by r5r. Data for latitude and longitude was converted into a numeric format. Lastly, a column to indicate that each park point was one singular park was added to meet the requirement of the opportunities parameter in r5r.

Next, the r5r package was used in order to build a transport network for Vancouver, so that the distances and routing between the centroids of census tracts and park locations can be calculated.

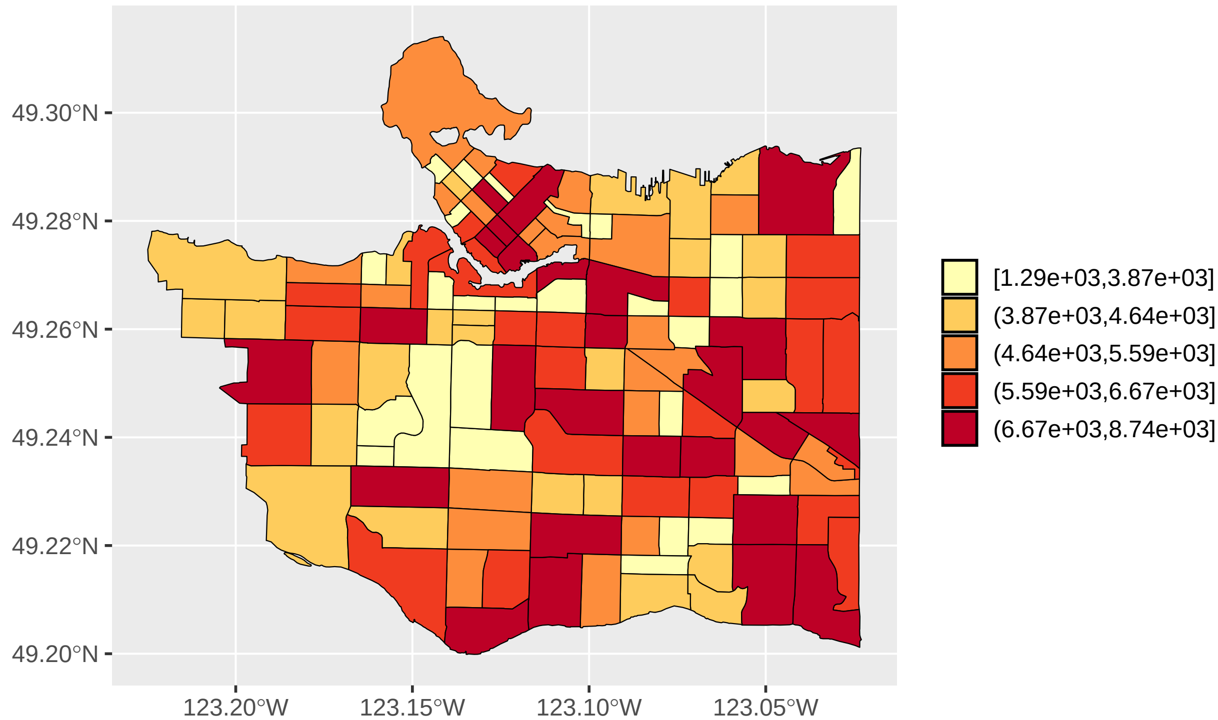
The transport network was built with using a road network dataset of Vancouver, and as well as a public transport feed of the city. The road network dataset was obtained from BBBike, and was stored as a .pbf file. The public transport feed was obtained from Transitland and stored in a GTFS.zip file.

The accessibility function in r5r was used to compute how many parks were accessible within 30 minutes of each census tracts centroid by walking or public transit.

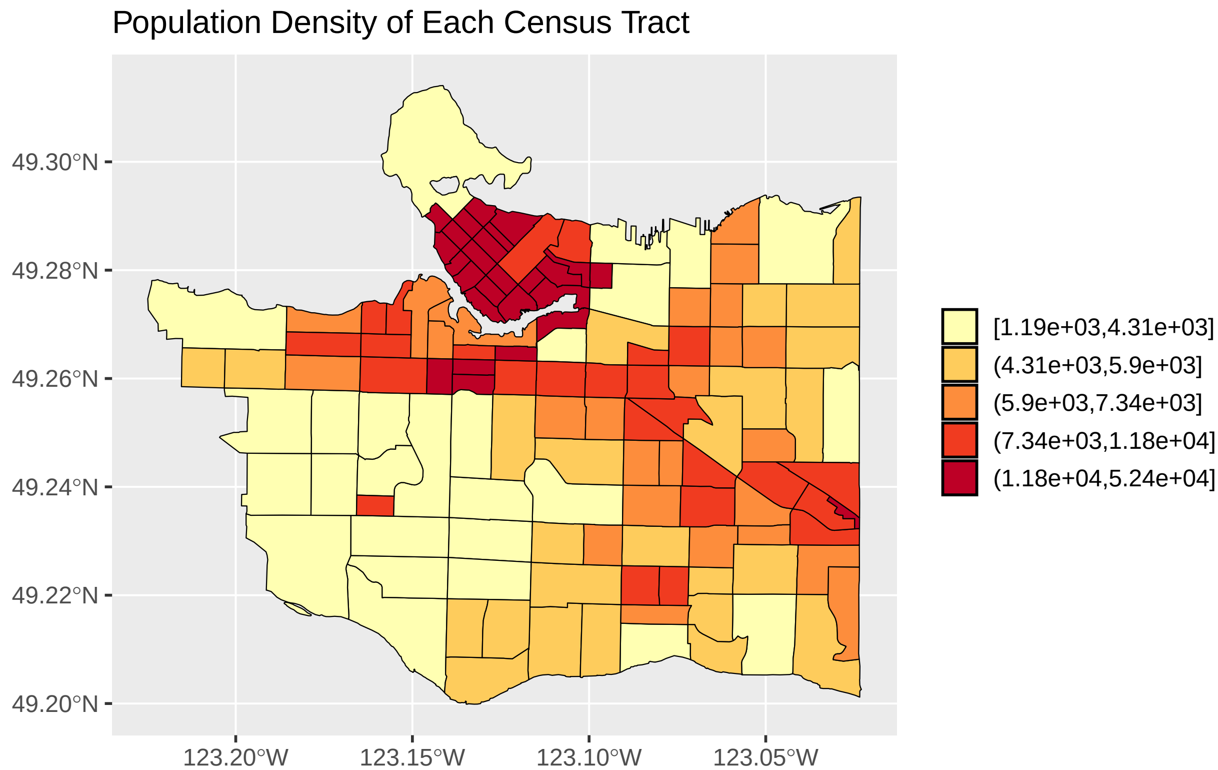
Once the number of accessible parks was calculated, this was added to the data frame displaying census data.

After all variables were in one data frame and prepared for analysis, data was first visualized by creating choropleth maps for each variable of interest. Maps were created for each variable as follows, beginning with creating a choropleth map for the 2021 population:

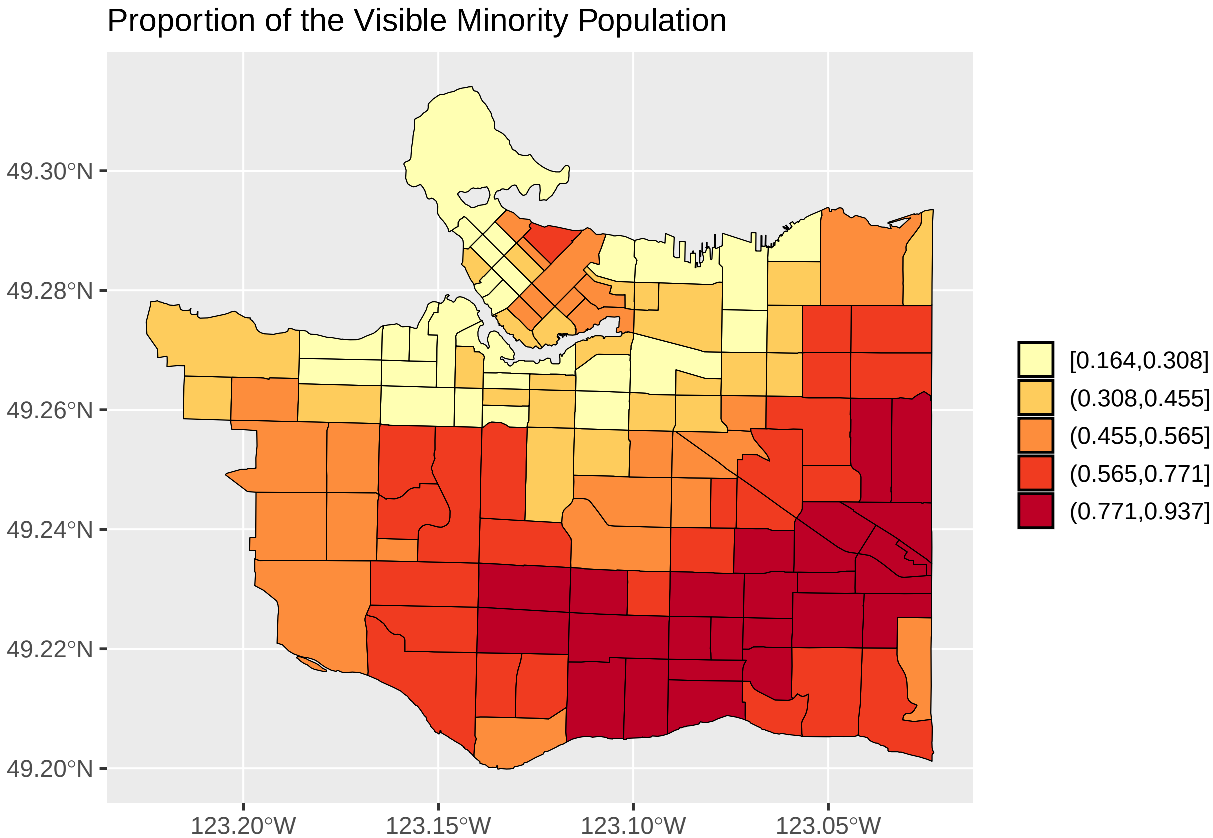
Population of Each Census Tract



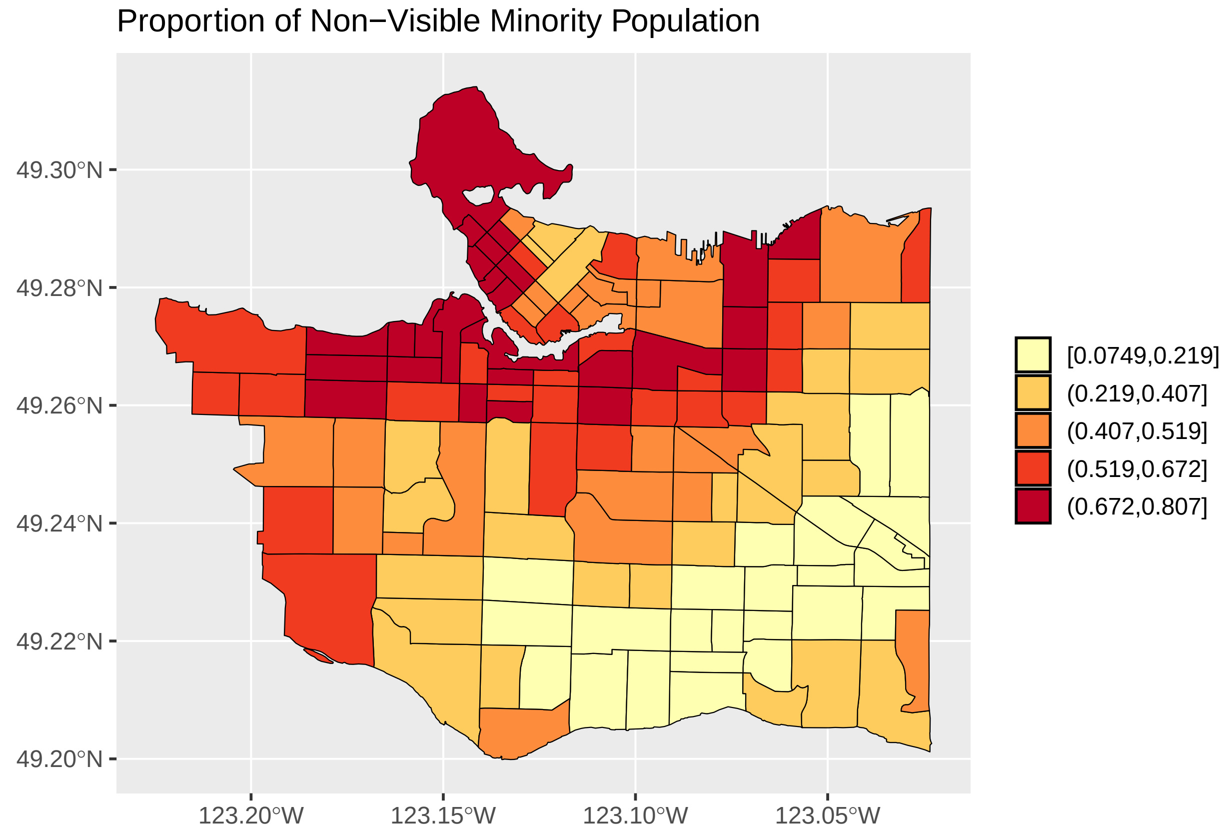
Next, creating a choropleth map for the population density of each census tract.



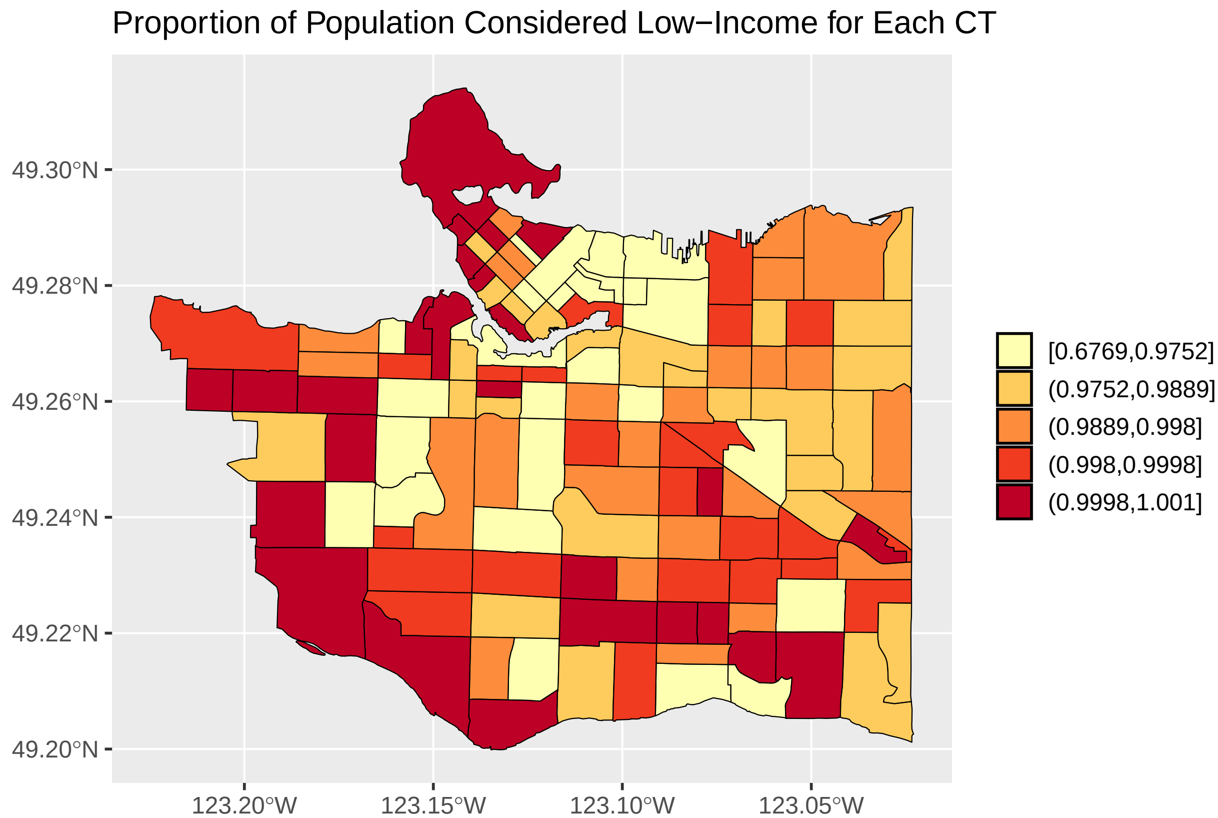
Now creating a choropleth map for the proportion of the visible minority population.



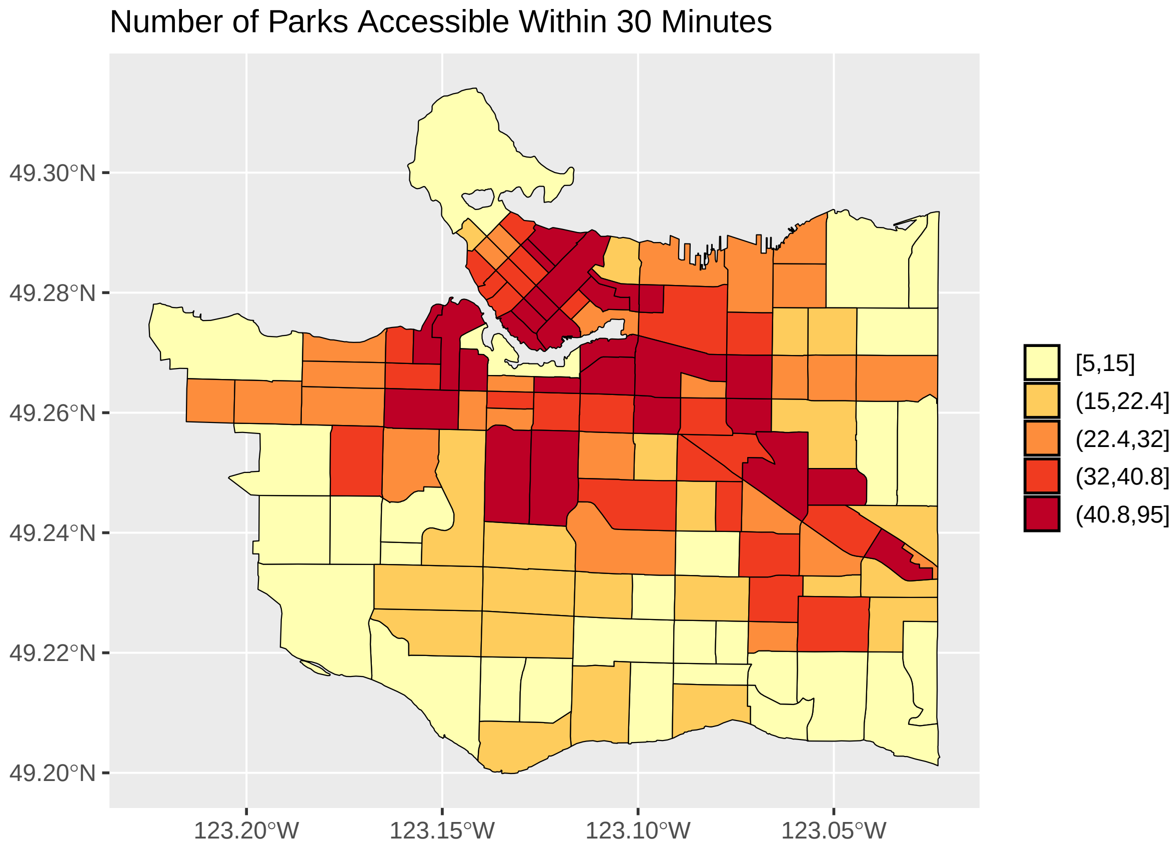
Creating a choropleth map for the proportion of the non-visible minority population.



Creating a choropleth map displaying the proportion of low-income areas.



Finally, a choropleth map was created to display the independent variable, parks accessible within 30 minutes of a centroid.

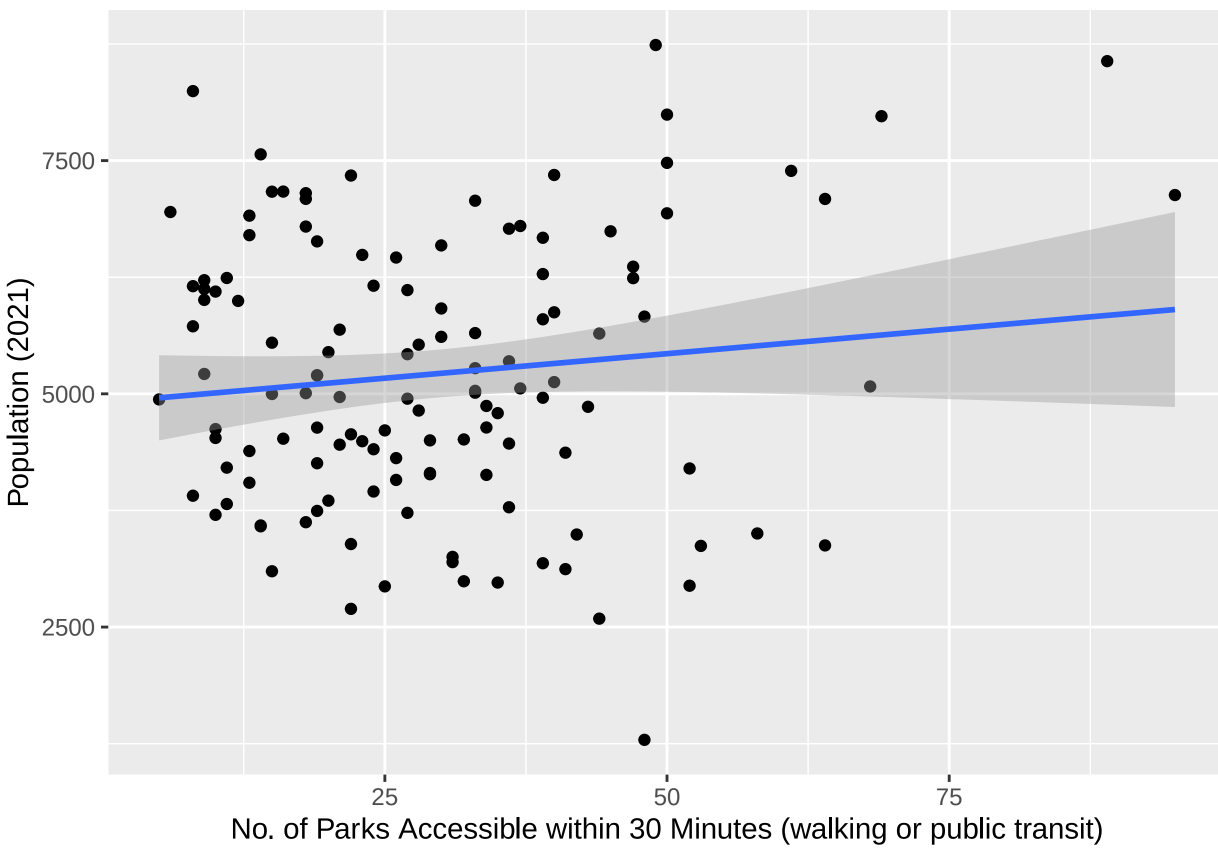


Next, to determine the relationship between the number of accessible parks and each independent variable, the independent variables were regressed to number of accessible parks for each CT.

Table 1: Population of Census Tracts regressed on Number of Parks Accessible

	Dependent variable:
	Population_2021
accessibility	10.518
	(7.816)
Constant	4,904.639***
	(264.208)
Observations	127
R^2	0.014
Adjusted R^2	0.006
Residual Std. Error	1,459.451 (df = 125)
F Statistic	1.811 (df = 1; 125)
Note:	*p<0.1; **p<0.05; ***p<0.01

For each regression, a scatter plot was created to provide a visual representation of the data.

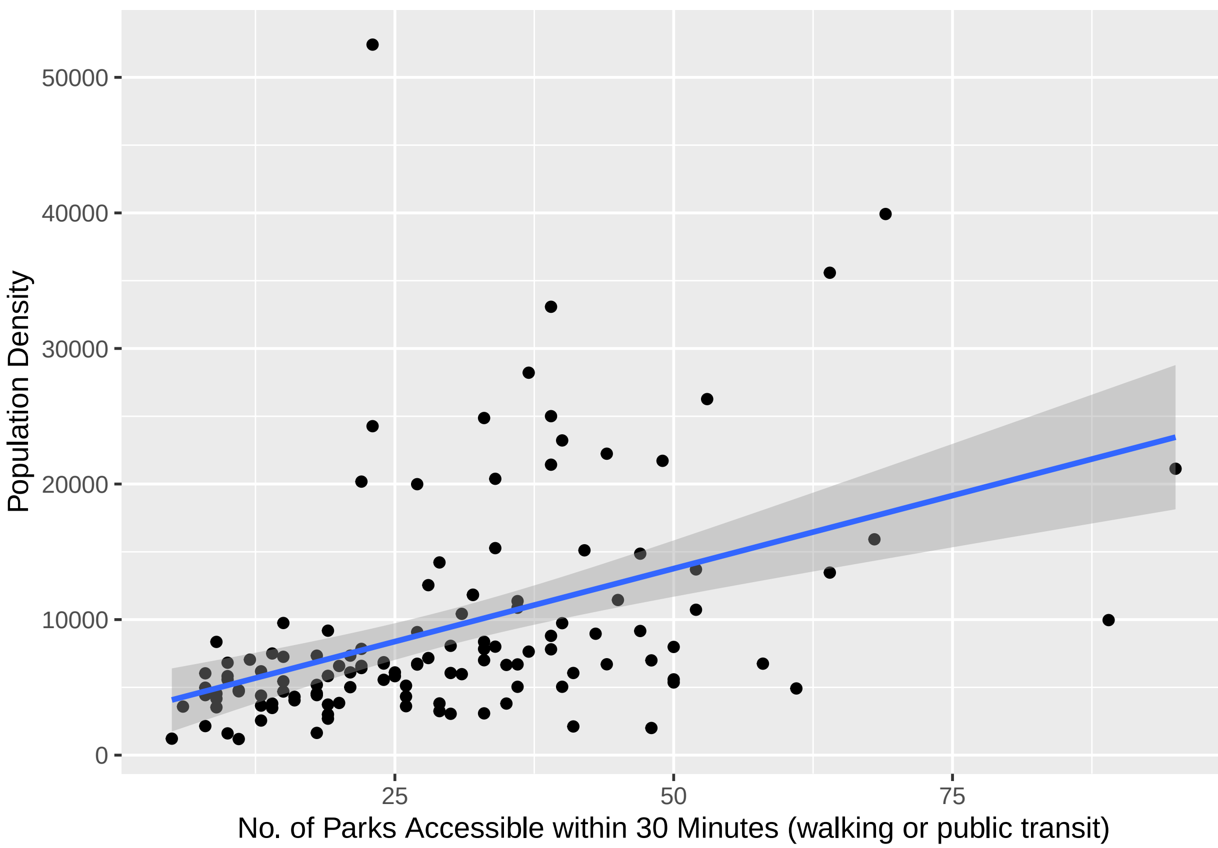


Model regressing population density on number of accessible parks.

Table 2: Population Density of Census Tracts regressed on Number of Parks Accessible

	Dependent variable:
	Population_density
accessibility	215.382***
	(39.775)
Constant	2,995.220**
	(1,344.555)
Observations	127
R^2	0.190
Adjusted R^2	0.184
Residual Std. Error	7,427.142 (df = 125)
F Statistic	29.322*** (df = 1; 125)
Note:	*p<0.1; **p<0.05; ***p<0.01

Scatterplot of population density vs number of accessible parks.

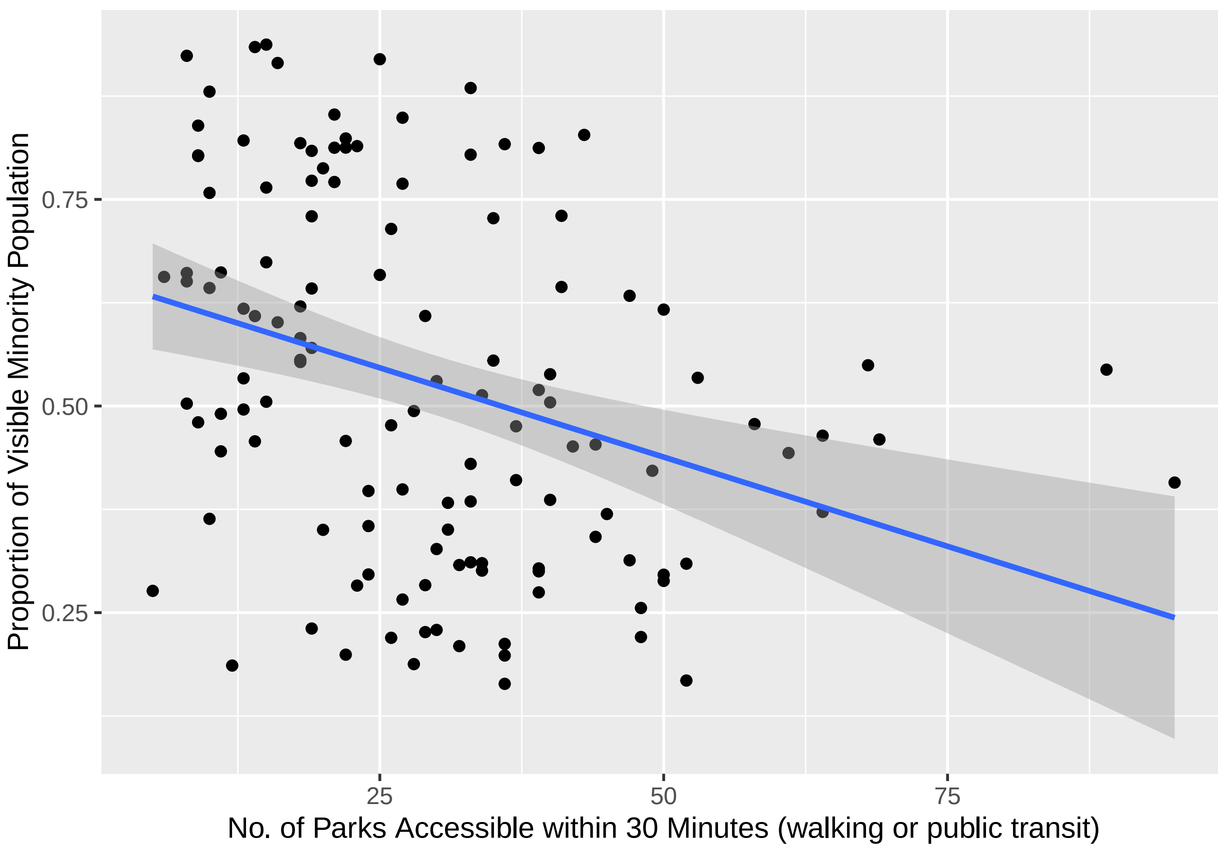


Model regressing proportion of visible minorities on number of accessible parks.

Table 3: Proportion of Visible Minority Population in Census Tracts regressed on Number of Parks Accessible

	Dependent variable:
	Proportion_visible_minority
accessibility	-0.004^{***}
	(0.001)
Constant	0.654^{***}
	(0.037)
Observations	127
R^2	0.110
Adjusted R^2	0.103
Residual Std. Error	0.205 (df = 125)
F Statistic	15.511^{***} (df = 1; 125)
Note:	*p<0.1; **p<0.05; ***p<0.01

Scatterplot of proportion of visible minorities vs number of accessible parks.

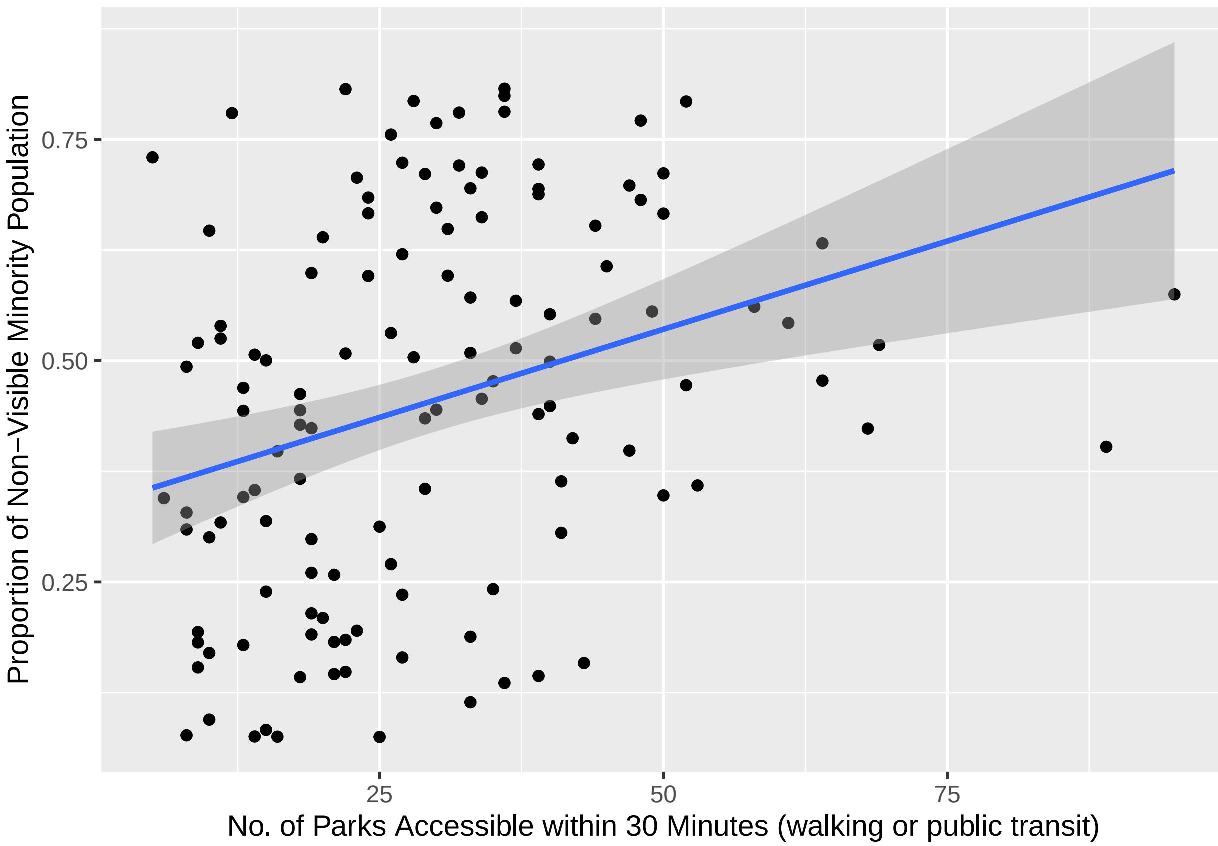


Model regressing proportion of non-visible minorities on number of accessible parks.

Table 4: Proportion of Non-Visible Minority Population in Census Tracts regressed on number of Parks Accessible

	Dependent variable:
	Proportion_nonvisible_minority
accessibility	0.004***
	(0.001)
Constant	0.336***
	(0.037)
Observations	127
R^2	0.097
Adjusted R^2	0.090
Residual Std. Error	0.203 (df = 125)
F Statistic	13.473*** (df = 1; 125)
Note:	*p<0.1; **p<0.05; ***p<0.01

Scatterplot of proportion of non-visible minorities vs number of accessible parks.

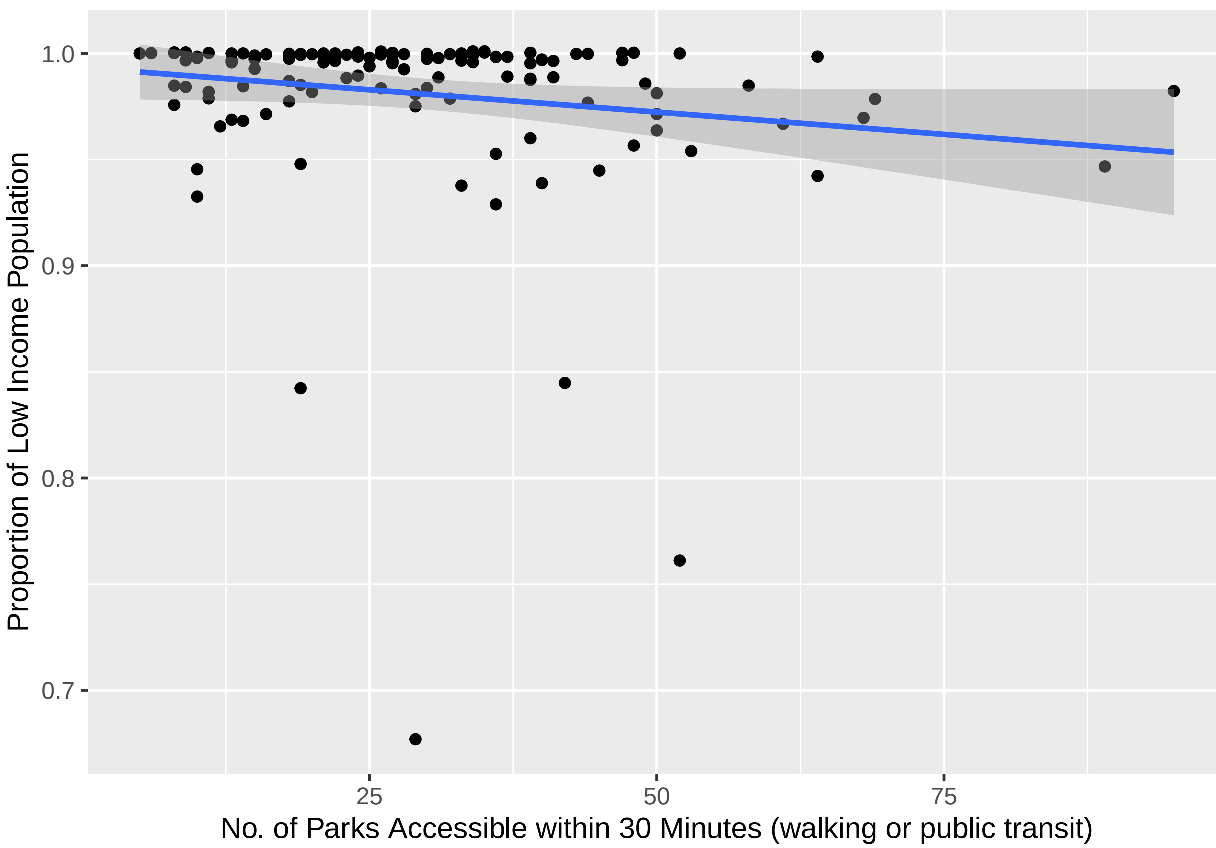


Model regressing proportion of low income population on number of accessible parks.

Table 5: Proportion of Low Income Population in Census Tracts regressed on Number of Parks Accessible

	Dependent variable:
	Proportion_low_income
accessibility	-0.0004^{*}
	(0.0002)
Constant	0.993^{***}
	(0.008)
Observations	127
R^2	0.028
Adjusted R^2	0.020
Residual Std. Error	0.041 (df = 125)
F Statistic	3.571^{*} (df = 1; 125)
Note:	*p<0.1; **p<0.05; ***p<0.01

Scatterplot of proportion of low income population vs number of accessible parks.



Analysis

When analyzing the results, we are looking to answer our research question: "Do socioeconomic factors play a role in one's accessibility to parks and greenspace, specifically in Vancouver, Canada?"

In Figure 1, we notice that the population has the highest density per census tract in the Northern part of Vancouver. However, in Figure 2, it is evident that the highest density of a visible minority population is visible in the Southeastern part of the city. As expected, based upon those results, Figure 3 confirms that the highest non-visible minority population density can be found in the North and Northwestern part of the city.

When mapping the proportion of the population considered low-income for each Census Tract, the results had more variation. As shown in Figure 4, there was census tracts in both the North, West, and South parts of the city that had high proportions of Hamilton's low-income population.

This means that the census tracts with the highest total population density are typically opposite of the census tracts with the highest visible-minority population density. We see a similar contrasting affect when we study Figure 4 and Figure 5.

Figure 4 represents low-income population, and Figure 5 represents the number of parks accessible within 30 minutes. Through visual analysis, it is clear that the lowest-income population is directly opposite from the highest number of parks. This means that the higher-income areas have a higher number of parks available within 30 minutes of the middle of their census tract, measured by either walking or public transit distance. This could be due to several factors; population density (and therefore demand for infrastructure), investment into infrastructure due to perceived "higher value" in these census tracts, and more.

When performing a regression for each of these factors, we noticed that not all of the factors studied (population density, visible-minority, non-visible minority, and low income) were equally significant. In Figure 6 we see the relationship between population and accessible parks, and in Figure 7 we see the relationship between population density and accessible parks. We notice that the relationship between population density (Figure 7) is more significant than the relationship with raw population numbers.

In Figures 8 and 9, the relationship between parks and the demographic of the population (the number of visible minorities) is studied. In both cases, as demonstrated by the scatter plots and an identical value of 0.001 for each, the relationship between accessibility to parks and visible-minority status is low.

The most significant variable was visualized in Figure 10. This was the relationship between the proportion of low-income population and accessibility of parks. While there were a few outliers, for the most part this model represented a very strong correlation.

This tells us that there is a trend that areas with low-income individuals do not have the same level of access to parks infrastructure as other census tracts that contain a higher proportion of high-income individuals.

Conclusion & Recommendations

Through data processing that included visualization through choropleth mapping and scatter plots, as well as a regression, the relationship between accessibility to parks and socioeconomic factors was revealed. While the minority status within a census tract was not found to be significant, the income-level of the residents was strongly correlated to reduced access to parks. Many census tracts that have a high proportion of low-income residents happen to be located along the western border of the city. This area likely lacks parks infrastructure.

We recommend focusing on the area that was identified as a potential problem (the census tracts on the western border) and conduct further studies to assess the need in this area. This is important to ensure accuracy and potentially narrow down the census tract areas to smaller neighborhoods that may require more aid. If further studies confirm a lack of park infrastructure, our recommendation would be the allocate further resources to this area, so that the residents can benefit from the several health benefits that parks and green space provide in a community.

References

10 Dai, Dajun. 2011. "Racial/Ethnic and Socioeconomic Disparities in Urban Green Space Accessibility: Where to Intervene?" *Landscape and Urban Planning* 102 (4): 234–44.

"GTFS Feed: West Coast Express, British Columbia Rapid Transit Company,TransLink." n.d. https://www.transit.land/feeds/f-c28-nstranslinkca.

Nesbitt, Lorien, Michael J Meitner, Cynthia Girling, Stephen RJ Sheppard, and Yuhao Lu. 2019. "Who Has Access to Urban Vegetation? A Spatial Analysis of Distributional Green Equity in 10 US Cities." *Landscape and Urban Planning* 181: 51–79.

Ng, Aeryn, Sarah E Gergel, and Bianca NI Eskelson. 2021. "Inequality and Allergenic Cover of Urban Greenspaces Surrounding Public Elementary Schools in Vancouver, British Columbia, Canada." *Ecosystems and People* 17 (1): 178–90.

"OSM Extracts for Vancouver." n.d. https://download.bbbike.org/osm/bbbike/Vancouver/.

"The 2022 Canadian City Parks Report: Nurturing Relationships & Reciprocity." n.d. https://ccpr.parkpeople.ca/2022/.

Vaughan, Christine A, Natalie Colabianchi, Gerald P Hunter, Robin Beckman, and Tamara Dubowitz. 2018. "Park Use in Low-Income Urban Neighborhoods: Who Uses the Parks and Why?" *Journal of Urban Health* 95: 222–31.

Wawin, O. 2022. "Environmental Racism and the Struggle for Change in Canadian Law."

Zuniga-Teran, Adriana A, and Andrea K Gerlak. 2019. "A Multidisciplinary Approach to Analyzing Questions of Justice Issues in Urban Greenspace." *Sustainability* 11 (11): 3055.