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Developing Youth-informed and Quality-aware Spatial Accessibility Measures to Urban Parks Using a Survey-based 2SFCA Method in London, Ontario and Halifax, Nova Scotia

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Abstract

Park-related research has gained much attention in recent years, yet not enough studies have focused on the inequity of park accessibility and quality. These are crucial elements that influence youth's park use, which in turn influence their physical, mental, and social development. Existing literature uses park size as the supply level to examine park accessibility but fails to consider any other park characteristics (e.g., amenities, general condition). This research developed youth-informed and quality-aware measures to consider the influence on park attraction by its quality and size rather than size only. This was implemented by consulting a youth advisory council to determine the relative importance of park features and the travel threshold used in the analysis to better understand park attractiveness for youth. Then, an accessibility score for each population unit is computed to represent the level of park accessibility, using the two-step floating catchment area (2SFCA) method. The proposed method can better differentiate higher accessibility from lower accessibility, providing more detailed accessibility results. The social equity analysis results indicated that median household income was not strongly correlated with the level of park accessibility. The research outcomes bring critical insights for park planners to improve park and recreational facilities in the city and promote healthy living among youth.

Keywords

Urban parks; Spatial Accessibility; Spatial Analysis; GIS; Recreation; Youth; Park Quality

Summary for Lay Audience

Youth are spending less time playing outdoors and connecting with nature. According to the World Health Organization (WHO), 3 in 4 adolescents worldwide do not meet the global recommendations on physical activity for health (Bull et al., 2020). It is widely acknowledged that parks and recreation facilities provide space for outdoor activities, build connections with nature, and promote physical activities for youth. Given the context, there's a clear need in developing more park research to better understand park accessibility in relation to youth. However, research has confirmed that residents in modern cities have unequal access to parks and recreation facilities. This makes youth a particularly vulnerable age group that requires adequate access to quality parks as their physical, social, and cognitive developments are closely related to their exposure to green space.

The overarching goal of this thesis is to gain a better understanding of the provision, quality and spatial accessibility to urban parks using geospatial data in London, Ontario and Halifax, Nova Scotia, and further investigate whether and how spatial accessibility to parks are associated with socioeconomic factors. Focusing on the population under 19 years old, this thesis is part of a national park research project ParkSeek, which provided the park quality data. A scoring system is used to reflect park quality based on feature availability, and a weighting scheme is developed to incorporate youth perspectives on park quality. Combining those two procedures, a youth-weighted park quality score is developed to represent the overall quality of parks for youth. In previous park accessibility research, size is the most common variable used to reflect park attraction. However, size is not the only element that influences park visitation. The features, conditions and overall quality can all impact the attractiveness of a particular park. This thesis modifies the traditional methods of measuring park accessibility to consider not only park size but also park quality.

Methodology developed in this study highlights the importance of quality in park accessibility research, as well as the significance of youth engagement. Findings of this research may provide insights into supporting positive youth development, building stronger communities, promoting social justice, and fostering more sustainable and inclusive urban environments.

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Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1. Introduction

1.1 Introduction

Urban parks in modern cities provide important ecosystem services for the environment (Wolch et al., 2014). Nature and open green space in parks offer opportunities for recreation, relaxation, and communication which are crucial elements for people's health and social well-being (Chiesura, 2004; Smith et al., 2013; Van Kamp et al., 2003). Studies have suggested that living in close proximity to parks is associated with more frequent park visitation and is linked to fewer chronic diseases, and better self-reported health outcomes (Bedimo-Rung et al., 2005; Mullenbach et al., 2018). Youth relies on neighbourhood parks to connect with nature, and in turn, their forms of activities are shaped by their neighbourhood settings (Loebach & Gilliland, 2016).

Research has demonstrated that effective access, frequent park visitation, and nature connection have positive effects on the population and can bring extensive health benefits to youth (Bento & Dias, 2017; Chawla, 2015; Gilliland et al., 2006; Tillmann, Clark, et al., 2018). Better access to parks is positively associated with increased physical activity (Tucker et al., 2009). Although not directly linked, parks provide the essential environment for the potential decrease of child obesity (Alexander et al., 2013). Additionally, more time spent in contact with nature is beneficial for not only physical health but also the mental and cognitive development of teenagers (Barton & Pretty, 2010; Nutsford et al., 2013; Sugiyama et al., 2008).

Given these health benefits, a growing body of recent studies has investigated people's spatial accessibility to urban parks (Dai, 2011; Liu et al., 2021; Xing et al., 2018) As public parks differ in size, location, features, and vegetation/water coverage, they vary greatly in both condition and quality (Wolch et al., 2014). These variations can significantly impact how frequently and in what ways parks are utilized. However, most green space accessibility research used park proximity and/or size to represent park attractiveness, with few studies considering park quality or condition. For example, studies have investigated the walkability of urban parks or play facilities in neighbourhoods based on the distance between neighbourhood centres and park facility centres (Cradock et al., 2005; Talen & Anselin, 1998). The aforementioned studies consider the distance to the closest park without taking the park's size into account. Park size is one of the characteristics that influence the capacity of parks for having more spaces, features, and amenities for more activities. It is the most applied factor representing the attractiveness of parks in previous park accessibility.

Several popular methods have been developed to measure the spatial accessibility based on park size, and among which the two-step floating catchment area method (2SFCA) gained most popularity because of its matured development and wide application in healthcare accessibility research (Wang & Luo, 2005). This method is a gravity-based model that considers the spatial interaction between supply points (e.g., parks) and demand points (e.g., population centres or individuals) (Xing et al., 2020). It takes into account the distribution of both the service facilities and population, providing a more realistic assessment of accessibility compared to distance-based methods to help identify underserved communities. This method defines catchment areas based on travel times or distances from service locations and population centres. This reflects the idea that people are more likely to utilize services that are closer to their location. By incorporating catchment areas, the 2SFCA method considers the potential demand from surrounding areas and provides a more realistic representation of park services utilization. Moreover, the 2SFCA method allows for the consideration of multiple supply points and potential demand within each catchment area. This is particularly valuable when analyzing accessibility to parks with high demand or limited capacity, as it captures the spatial distribution of service providers more accurately.

Although updates and modifications for the 2SFCA have been introduced by multiple studies, few existing park accessibility studies considers other park characteristics such as the quality, condition or amenity when measuring spatial accessibility (Dony et al., 2015; Xing et al., 2020). Park quality can significantly shape how parks are being used and by whom (McCormack et al., 2010). The attractiveness of a park is directly dependent on its quality, amenities, general condition and more. For youth specifically, their contact with nature and outdoor activities is directly associated with their access to recreational facilities (Tillmann et al., 2018). In summary, studies should evaluate the quality of parks and be more considerate in defining the supply level in measuring park accessibility.

Recent articles have started finding ways to consider park quality when measuring accessibility, where the attractiveness of park is defined as the combination of both park size and park quality (Dony et al., 2015; Xing et al., 2020). Because both park size and quality can heavily influence people's choice of parks, it is highly necessary to incorporate them into the accessibility measures to better consider influence of park size and quality on park accessibility results. Following a similar research approach, this thesis will further address the research gap that quality is not well integrated in park accessibility measures and aims to modify the existing methods to incorporate youth-focused and quality-aware approaches to measure spatial accessibility to urban parks. More specifically, this research adopts youth-informed and quality-aware accessibility measures to examine the provision and spatial distribution of urban parks in two Canadian cities, London, Ontario, and Halifax, Nova Scotia.

This study is unique from previous research because it emphasizes the youth engagement, making the youth-informed survey one of the major contributions of this thesis. The primary author consulted with high school students to gain their perspectives on what makes a quality park. Their input is used in quantifying park quality via a set of accessibility measures. This approach makes the study population the expert in the study subject, enabling them to make real contributions towards research that directly relates to their life. This study approach can be used in a different study area on various population groups. The proposed method is not intended to replace existing methods, rather an alternative for future park research focusing on youth.

1.2 Need for the Study

The WHO guidelines on physical activity report that more than three-quarters of youth worldwide do not meet the recommended levels of physical activity (Bull et al., 2020). In a Canadian context, Statistics Canada reports that the percentage of youth meeting the Canadian physical activity recommendation for children and youth dropped from 50.8% in the fall of 2018 to 37.2% in the fall of 2020, moreover, statistics indicate that physical activity decreased more among youth living in urban areas compared with rural areas (Jenny Watt & Rachel C. Colley, 2022). This alarming trend underscores the urgent need for more research into the quality, provision, and spatial accessibility to parks and recreational facilities for youth to promote their physical activity levels. Public health agencies have proposed large-scale health promotion strategies that focus on modifying infrastructures to encourage more frequent outdoor physical activities (US Department of Health and Human Services, 2001; Tam, 2017). Following this guidance, many more planning professionals and researchers have started investigating parks and recreational facilities in cities. Public parks are one of the most common community resources where residents can connect with nature, spend leisure time, and exercise at no cost. Ideally, all neighbourhoods should have relatively equal access to parks and recreational facilities, and making sure parks are equipped with safe and quality features is highly valuable. Studies in this field bring critical insights for promoting higher levels of physical activity in youth and improving health city planning.

In summary, this thesis utilizes qualitative and quantitative research methods to investigate the distribution, quality, and spatial accessibility to urban parks for the youth population in two Canadian cities, which not only addresses the lack of consideration of park quality but also explores modified methods for park accessibility research. By incorporating geospatial data, qualitative field data, and youth-informed survey data, the study will aim to develop youth-informed and quality-aware accessibility metrices to measure spatial accessibility for youth. Furthermore, this study can be a model for future park research and promote youth-focused park research in Canada.

1.3 Research Questions and Objectives

This thesis aims to develop youth-informed, quality-aware park accessibility metrics to understand the quality and spatial accessibility to urban parks in London, Ontario and Halifax, Nova Scotia. To achieve this overarching goal, this thesis intends to answer the following research questions:

Q1*: How accessible are parks and recreation facilities in London and Halifax for youth of different socioeconomic status?*

Q2*: How does the accessibility of parks and recreation facilities for youth vary when park quality is considered?*

To answer these two research questions, I propose to address the following six specific research objectives,

1) Identify the spatial distribution of parks and recreation facilities and youth population in London and Halifax.
2) Evaluate the accessibility of parks and recreation facilities for youth in London and Halifax.
3) Evaluate how park accessibility for youth varies according to neighbourhood socioeconomic status.
4) Evaluate the quality of parks and recreation facilities in London and Halifax.
5) Evaluate how the accessibility of parks and recreation facilities for youth in London and Halifax varies when the quality of facilities is considered.
6) Evaluate how park accessibility for youth varies according to neighbourhood socioeconomic status when quality of facilities is considered.

1.4 Outline of Thesis

This thesis takes the form of a monograph format that includes five chapters. Chapter one is an introduction chapter that provides the conceptual background of the study, research significance as well as the research questions and primary study objectives. Chapter two provides an in-depth literature review of the study topic looking at park-related health benefits focusing on youth, theories and approaches of understanding park quality, as well as frequently used geospatial technologies in park accessibility studies. Chapter three introduces the detailed methodology used in this thesis, including an introduction of the study areas and study population, steps taken to measure youth-informed park quality score as well as the spatial accessibility to parks. Lastly, chapter three also describes the how social equity issue is addressed in this thesis in the last section. In chapter four, the study results are reported in the form of tables and maps in four sections including data characteristics, park quality, park accessibility and social equity covering all research objectives. Chapter five focuses on summarizing the key study findings, discussing significance, comparisons, limitations, and the future implications for the research.

Chapter 2. Literature Review

2.1 Introduction

In addition to its numerous environmental and ecological contributions, urban nature offers significant social, psychological, and physical advantages to human communities, enhancing human existence with significance and emotions (Chiesura, 2004). Chiesura as well as many other scholars have long ago recognized the wide range of benefits associated with park visitation. Their natural and built features provide opportunities for outdoor exercise and relaxation. Children and teenagers use parks to connect with nature and socialize with other people. More frequent park visitation can potentially bring significant benefits for their mental, physical, and cognitive development (Richardson et al., 2013; Tillmann, Tobin, et al., 2018; Tucker et al., 2009). Section 2.2 of this literature review introduces park-related health benefits specifically for youth. It is widely known that residents in cities often have unequal access to public facilities such as healthcare facilities and recreational facilities. Studies have found that spatial access to urban parks has not been equitable in many cities around the world (Boone et al., 2009; Dony et al., 2015; Liu et al., 2021; Rigolon, 2016; Xing et al., 2020). The third section of this chapter examines how previous studies have investigated the spatial accessibility to urban parks in different parts of the world, addressing the disparity in park accessibility, and focusing on the methodology used. Most of the previous literature measures spatial accessibility based on the distance from population centers to park centers while neglecting the quality of the parks. However, it is commonly known that quality parks can attract more visitors from further away, and being close to quality parks can potentially lead to more frequent park visitation and higher physical activity levels. Section 2.4 of this literature review discusses the importance of park quality, reviews methods developed in the past for evaluating park quality and showcase recent studies incorporating park quality in GIS-based techniques.

2.2 Park-related Health Benefits for Youth

Over the last few decades, Canadian youth have been spending an increasing amount of time indoors and using electronics, which led to a drastic decrease in their physical activity level (ParticipACTION, 2020). Among all age groups, youth is particularly vulnerable because repeated contact with nature is essential for their physical, mental, cognitive, and social-emotional development (Bento & Dias, 2017; Chawla, 2015; Gilliland et al., 2006; Tillmann, Clark, et al., 2018; Tucker et al., 2009), and these studies and reports emphasize the urgent need to promote outdoor activity among youth as well as to improve the built environment in order to provide opportunities to connect with nature. Parks in cities are the primary source of open green space and play structures for youth, making park visitation positively associated with the physical health, mental health, and social well-being of adolescence.

Parks can encourage physical activity, which is important for maintaining a healthy weight and reducing the risk of chronic diseases. Frequent use of local parks has long ago been associated with better self-reported health conditions (Godbey et al., 1992). Chawla (2015) reviews the literature on the benefits of nature for youth from the 1970s to the present. A compelling body of evidence was found highlighting that natural features and open green space are critical elements for well-being, and urban greenways, parks and recreational facilities are essential to building healthy communities for youth. Tucker et al. (2009) conducted a study in the city of London investigating the relationship between the physical activity level of youth with the presence of neighbourhood recreational opportunities by surveying 811 local students in grade 7 and 8. The survey consists of questions asking about the presence of public recreational facilities, the quality of available facilities, and self-report physical activity level. Results show that greater access to recreational facilities in the neighbourhood is positively associated with physical activity levels among youth, making it essential to facilitate youths' healthy levels of physical activity (Tucker et al., 2009).

Bedimo-Rung et al. (2005) developed a framework shown in the following figure that illustrates the relationship between park use, park features, and physical activity level. Physical activities are positively associated with park visitation, and park visitation is dependent on park environmental characteristics. Therefore, this paper suggests that future research consider aspects of park features, conditions, access, aesthetics, safety, and policies. Tucker et al. (2007) found evidence showing that parents and children are willing to travel more to parks with desired amenities such as splash pads, swings, water attractions and cleanliness. These park visitation patterns can potentially increase physical activity levels among children and youth.

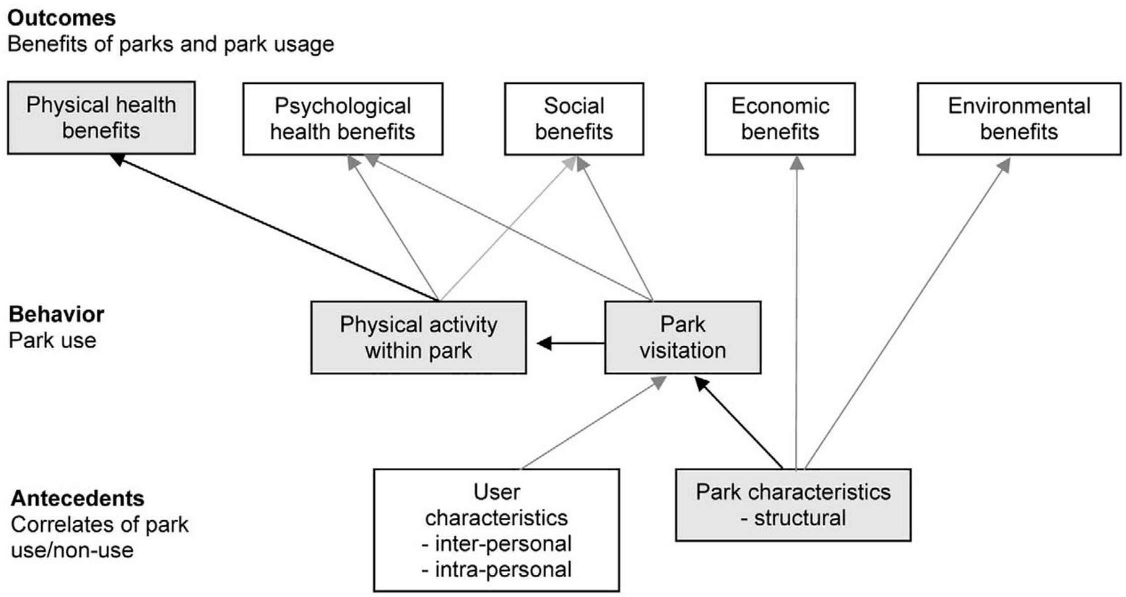

Figure 2.1 - The relationship between parks and physical activity (Bedimo-Rung et al., 2005)

Another study emphasizes that the characteristics of urban parks, such as size, design, proximity, and maintenance, can influence park use and physical activity levels. This article review papers that employ qualitative and quantitative data to unfold the associations between urban park visitations and physical activity patterns (McCormack et al., 2010). A total of 21 papers were included in this literature review. Results show that distance and park qualities are the most influential factors in encouraging park use. While quantitative studies tend to favour park proximity and accessibility, qualitative studies support the importance of proximity and size, meanwhile emphasizing the significant impact of environmental characteristics on physical activity patterns.

When youth mentioned their favourite places, ball fields, parks, trees, rivers, and all sorts of natural features were frequently mentioned. Those features are often associated with positive experiences and optimistic memories. Interactions with nature not only have physical benefits but also encourage positive mental health development. Although some studies suggested that no direct relationship can be found between access to green space and mental health outcomes (Annerstedt et al., 2012), many other studies found interactions with nature, active participation in green space, more exposure to green space, and close proximity to urban parks were positively associated with mental health outcomes (Barton & Pretty, 2010; Nutsford et al., 2013; Sugiyama et al., 2008). Tillmann, Tobin, et al. (2018) conducted a systematic review of the mental health benefits of interactions with nature in children and teenagers, where 35 papers from 1999 to 2017 were reviewed. Results show that besides statistically non-significant findings, almost all research outcomes revealed statistically significant positive relationships between nature and mental health outcomes. A study in New Zealand measured public green space in square meters at the neighbourhood level. By investigating the 2006 New Zealand national health status data, the study found that the greenest neighbourhoods have the lowest risks of poor mental health (Richardson et al., 2013). Another study in Auckland City, New Zealand found associations between decreased distance to green space with decreased anxiety/mood disorder treatment counts, meaning that close proximity to green space is associated with better mental conditions in urban neighbourhoods (Nutsford et al., 2013).

In summary, the literature suggests that parks can provide a wide range of physical, mental, and social benefits to youth. The characteristics of urban parks, such as size, design, and maintenance, can influence park use and physical activity levels, and access to nature is associated with better mental health outcomes. Moreover, free play in nature enhances youth’s social skills and creativity. Urban parks foster social connections and community cohesion which are essential for creating a healthy and safe environment for youth. Further research is needed to fully understand the potential health benefits of parks and to inform policy and practice related to urban planning and green space provision.

2.3 Spatial Accessibility to Parks

Ideally, all neighbourhoods in cities should have equal access to parks and recreation facilities (Bedimo-Rung et al., 2005). However, the spatial access to and quality of urban parks have been proven to be uneven in modern cities around the world. A growing body of case studies investigates environmental justice issues on spatial access to urban recreational facilities using GIS methodologies.

(Comber et al., 2008) conducted a study examining urban green space provision in Leicester, UK. They found that certain ethnic minority groups are disadvantaged in accessing green space than other population groups, and they also found evidence that the city lacks parks that are relatively smaller but more accessible in urban areas. Similar results were reported in studies from Atlanta and Maryland, US. The distribution of and spatial accessibility to urban parks in Baltimore, Maryland and Atlanta, Georgia, are proved to be uneven by (Dai, 2011) and (Boone et al., 2009). More importantly, African and Asian Americans were found to have significantly poorer access to green spaces than other ethnic groups in both study areas. A recent study in the City of Chicago, Illinois, found striking spatial patterns that white-dominant census divisions have better access to urban green space than racial and ethnic minority-dominant census divisions (Liu et al., 2021). When comparing urban green space accessibility within ethnic groups based on income, Liu et al. (2021) found the lowest disparities among white dominant census divisions, indicating that inequality is evident across not only different races but also social-economic status. Xu et al. (2017) observed spatial disparities in park quality as well as accessibility in Shenzhen, China. In addition, socioeconomically deprived communities have significantly lower access to parks that have higher quality due to mobility restrictions, whereas high-income populations are located where more green spaces are available.

Rigolon (2016) conducted a systematic review of the inequalities in park access and environmental justice issue. were reviewed in the article. The review synthesizes 49 empirical papers from the 2000s, providing a systematic summary of the existing knowledge in park accessibility research and valuable insights for future research. Not only did most of the papers find evidence of uneven access to parks in many cities, but many found that low socioeconomic and ethnic minority people have access to fewer acres of parks and to parks with lower quality than more privileged people. Moreover, what's worth noticing is that most studies are conducted in the United States, some are in European countries, Asia, and very few in Canada. Therefore, park accessibility research in a Canadian context is highly valuable.

Given the context of the extensive health benefits associated with park visitation for youth as discussed in the previous section, more and more children's geographers have focused on how to best understand the quality, provision, and distribution of parks recreational facilities in cities specifically targeting the youth population. One of the study cities of this thesis, the city of

London, was proved to have uneven park distributions for youth specifically. Gilliland et al. (2006) examined the distribution of all urban parks and play facilities in the City of London using a mapping approach. The study reveals the existence of ‘recreational deserts’ which refers to areas that lack recreational facilities for youth within walking distance in the city of London. Using a different GIS-based methodology, Reyes et al. (2014) investigated connections between the children and their walking accessibility to urban parks to reveal potential spatial disparities in park distribution in Montreal, Canada. Significant disparities in park accessibility for youth were also found to be evident in Wuhan, China recently. Xing et al. (2020) reported that high park accessibility neighbourhoods were found around the Yangtze River that runs through the city where the city's urban center is located, whereas low park accessibility neighbourhoods are distributed in periphery areas.

In summary, parks, as the essential facility in urban cities, have not been accessible to all populations. The existing literature suggests that youth often have limited access to green space and recreational facilities. Not enough studies focus on behavioural patterns of park visitation for youth in a Canadian context, and few studies use GIS-based methodology to examine the linkage between park accessibility and the youth population.

The definition of accessibility was first introduced by Hansen (1959) as the potential of opportunities for interaction. More specifically, accessibility is a measurement of the spatial distribution of facilities by census division, considering the travel ability and the desire of people to overcome spatial separation. The facility is often associated with goods, services, and various activities that provide the population with space and opportunities for a wide range of interactions. Later Dalvi & Martin (1976) included travel impedance and locational attraction in their definition of accessibility, considering the mobility of the population and facility types. Similarly, Burns (1980) wrote that accessibility refers to the freedom or ability for individuals to travel to facilities for participation in various activities. Later on, Kwan (1998) conceptualized accessibility measures based on Burns (1980) and Lenntorp (1976)’s work into the following measures: the number of accessible opportunities; a weighted sum of accessible opportunities; and the length of the accessible network (Neutens et al., 2010).

In more recent studies, accessibility is also seen as the indicator for land use and transportation development (Geurs & van Wee, 2004). This involves using more advanced measures such as Geographic Information Science (GIS) to evaluate and quantify accessibility, which then can be utilized and interpreted by researchers and policy makers. Originally, GIS-based accessibility measures were primarily implemented in healthcare accessibility research to identify disadvantaged neighbourhoods and population groups in accessing primary healthcare facilities (Luo & Qi, 2009; Luo & Wang, 2003; McGrail, 2012; Wang & Luo, 2005).

One of the most used methods in accessibility literature is the two-step floating catchment area (2SFCA) method first introduced by Luo & Wang (2003). This technique is based on the traditional floating catchment area (FCA) method developed by Radke & Mu (2000). The FCA method computes the ratio of supply to demand within a service area and then sums up the ratios in the study area where service areas overlap. Supply usually refers to the facility or service provider being investigated, and demand can be the population in need.

A major limitation of the traditional FCA method is that a straight-line approach is used in measuring the distance from facility to demand, which may not be a full representation of the relationship between demand and supply as populations travel in different modes. The ability to travel and the mode of travel can significantly influence accessibility results. To overcome this limitation, Luo & Wang (2003) developed the 2SFCA method to consider mobility by using travel time to represent distance.

Recently, this method has been frequently used in park accessibility research (Li et al., 2021; Liu et al., 2021; Shi et al., 2020; Wu et al., 2018). For example, Li et al. (2021) developed a behaviour-based Gaussian 2SFCA method to examine the spatial equity of parks in Nanjing, China. Its modification of the method based on the traditional 2SFCA tests the sensitivity of different travel behaviours such as walking, public transit, subway and driving. Similarly, Wu et al. (2018) adopted the 2SFCA method to compute spatial accessibility to urban green space in Beijing, China, and investigated how income influences residents’ access to urban green space. Focusing on different travel mode, Shi et al. (2020) utilized the 2SFCA method to calculate walking accessibility to urban green space in Urumqi, China. Liu et al. (2021) measured the spatial accessibility using the enhanced version of the 2SFCA (E2SFCA) developed by Luo & Qi

(2009). Since the 2SFCA assumes a uniform access within each catchment area, the E2SFCA method employs a distance decay function which divides the catchment area into multiple travel time zones and assigns weights to each zone based on the decay function.

Studies discussed above use park size as the supply level when calculating park accessibility, which assumes that bigger parks are better. Researchers argue that this method does not take into account other characteristics of the study facility, assuming that distance from population to facility and park size are the sole factors that influence the relationship between park facilities and population (Dony et al., 2015). Since the 2SFCA method has been increasingly popular in park studies, ignoring the significance of other park characters can be a major lamination in park accessibility research.

Another limitation of the 2SFCA method is that it uses fixed catchment size which gives all facility the same service area. To avoid the impact this method has on certain facilities, variable-width catchment area method has been developed by Luo & Whippo (2012) and was used in health care accessibility research. Later this method was adopted by Dony et al. (2015) for a park accessibility study, where the catchment area size around each park is dependent on its number of facilities and size. For example, a larger park with more amenities available would have relatively larger catchment size compared to other parks. The author then compared accessibility results using different travel methods, including automobile, public transit, biking, and walking. The result shows that walking is not particularly highly sensitive to the variable-width floating catchment area method compared to other transportation modes.

2.4 Park quality

Park features and quality can significantly shape how parks are being used and by who (McCormack et al., 2010). The attractiveness of a park is dependent on its quality, features available, general condition and so on. Therefore, studies should evaluate the quality of parks and pay close attention to conceptualizing park supply in measuring park accessibility. As suggested by Bedimo-Rung et al. (2005), park elements such as park features, conditions, aesthetics, safety, and policies are the direct links between park-use patterns and the associated health benefits. More importantly, youth are particularly drawn to the greenness, general condition and favoured amenities of parks. Although many studies have focused on investigating park quality for the general public, recognizing the variations in the quality of different parks, few studies examine how park quality influences youth's participation in parks. Tucker et al. (2007) interviewed a sample of parents/guardians (N=82) watching their children play at community parks in London, Ontario. The study reported that parents would travel a longer distance for parks that have favoured amenities such as water features, swings, and shades. Besides those amenities, cleanliness, lighting, and safety structures are also highly brought up by parents during the interviews.

Given the context, many researchers have developed park audit tools to evaluate the general quality of parks, focusing mainly on the amenities, maintenance, conditions, safety, or other characteristics of parks with the assistance of GIS technology (Bedimo-Rung et al., 2005; Bird et al., 2015; Byrne et al., 2005; Kaczynski et al., 2012; Lee et al., 2005). These park auditing tools provide guidelines and structures in assessing the general quality of urban parks. They are created with the intentions of providing a reliable and user-friendly tool for researcher, policy maker and the general public to better understand their surrounding environment and recreational facilities. Most of the tools developed previously focusing on the general population at all age groups, only a few focus on youth. Bird et al. (2015) developed the parks, activity, and recreation among kids (PARK) tool, and pilot tested the tool in Montreal, Canada. A total of 576 parks were evaluated. The reliability of the tool is tested using Cohen's kappa coefficients and percent agreement, and results indicated the tool is generally reliable. Rigolon & Németh (2018) developed a quality index of parks for youth (QUINPY) tool based on previous literatures that specifically engaged youth in the research activities. Differ from previous studies, authors consulted a group of diverse scholars and practitioners (N=33) who are frequently involved in park planning for youth to validate the QUINPY tool. Based on the literature review and expert consultation, Rigolon & Németh (2018) classify park features that are favoured or beneficial to young people into five main themes: Structured play diversity, nature, park size, park maintenance, and park safety. The finalized quality score is completed using a sum approach adding up scores of all the available features. The paper argues that the QUINPY scores do not represent the absolute quality score of parks, however, it provides the fundamental understandings of the park environment which can be useful for improving park planning strategies (Rigolon & Németh, 2018).

Innovations around GIS-based methodologies have emerged recently incorporating the research needs on park accessibility research, however, very few focus on the ways in which park quality is conceptualized and incorporated. Several recent studies have made modifications to the existing GIS-based method to consider park quality in the accessibility measures. A park Attraction Coefficient (PAC) was introduced by Dony et al. (2015) and was used as the supply level input in the 2SFCA method. The PAC represents the attractiveness of a park, and it is a function of its number of amenities and size using a sum approach. In addition, sensitivity of the method is tested by giving size and park amenities different weights. Results revealed the variation in accessibility scores and spatial patterns of disadvantaged neighbourhoods. This study proposed efficient measures to combine park size and park quality, however, without considering the input from the study population. Following Dony et al. (2015), Xing et al. (2020) made improvements on the traditional 2SFCA method and used PAC as the supply level for study parks. Instead of using the same sum approach as Dony's study, Xing et al. (2020) conducted a weighted approach that the PAC is weighted by a quality index. The quality index for each park is generated following the QUINPY tool. Although the study did interview a random sample of teenagers for their opinions on the subject matter, however the limitation is that only two categories, structured play diversity and nature, from the original QUINPY method is included (Xing et al., 2020), which might not be a full representation of the park environments in the study city.

In summary, park quality is a factor that may significantly influence, and shape park use patterns for all population. Urban parks varying in size and on-site amenities certainly have different general quality. It is critical to recognize the role and influence that park quality has on park use patterns as well as the potential health benefits on the general public and certain vulnerable population groups. Many park auditing tools have been developed in the recent years, yet not enough focusing on the youth. More importantly, very little research has considered incorporating youth's perspective on research conducted for youth. Every generation has distinctive thoughts on what makes a quality park, and what is in parks that really matters to youth remains unknown.

2.5 Conclusion

Parks are essential facilities in the city that provide natural resources for youth's health and well-being. The existing literature helped to identify the health benefits associated with park use and the vulnerability of youth. The extensive health benefits indicate a clear need in developing more park research to better understand the provision and distribution of parks and recreational facilities in cities. Previous literature on the spatial accessibility to parks has demonstrated the disparities in the access to recreational facilities in many cities around the world. Not only has the spatial accessibility been proven to be uneven, but the quality of parks also varies across different neighbourhoods. While investigating the spatial inequality in accessing parks, researchers and scholars have developed park auditing tools to evaluate the quality of parks. The literature review identified the research gap that is, although there has been a growing body of park accessibility research, not enough focuses on investigating how other environmental characteristics of parks influence the behavioural patterns of park visitation for youth in a Canadian context, and yet very few have considered engaging the youth population in the research process.

Chapter 3. Methodology

3.1 Introduction

GIS techniques are commonly used to conduct accessibility research. Distance-based GIS methods determine the travel matrices between demand and supply centres, which are the primary indicators to determine the spatial accessibility between demand and supply. The majority of previous studies have used the traditional two-step floating catchment area (2SFCA) method to measure spatial accessibility in health care research (Luo & Wang, 2003; Wang & Luo, 2005; Xie et al., 2018). As park research started receiving attention, GIS techniques such as the 2SFCA method have been widely applied to park accessibility research as well (Liu et al., 2021). At the supply level, most previous studies used park size as the supply capacity, and park quality is rarely considered. However, other factors such as park amenities can also influence the attractiveness of a park significantly. Rather than only utilizing size, this thesis takes park quality into account in measuring the spatial accessibility to urban parks using both qualitative and quantitative methods. A Park Attraction Coefficient (PAC) is used to represent the supply capacity in this thesis. PAC refers to the attractiveness of parks and is a function of park size and park quality.

This chapter addresses the details of the methods used in this thesis, including the development of park quality score, measuring spatial accessibility to parks, and median household income. Research techniques used in this study include qualitative and quantitative methods. Qualitative methods were used primarily in the data collection, including park field audits, and the design and distribution of the youth-informed survey. Section 3.3 covers a detailed description of the qualitative research process, which includes the development of the park inventory score, youth engagement, and the youth-weighted park quality score. Section 3.4 describes the quantitative research methods including PAC, 2SFCA, proposed quality-aware 2SFCA method, and scenario studies. Section 3.5 introduces the significance of median household income and running statistical tests to find correlations between study variables and socioeconomic status.

3.2 Study Area & Data

This study focuses on two mid-sized Canadian cities, one located in southwest Ontario, and the other one located on the east coast of Canada. The two cities represent distinctive geographic characteristics of Canada. This thesis does not intend to compare accessibility results between the two study cities.

3.2.1 London, Ontario

London is a city located in the province of Ontario, Canada. It is situated in the southwestern region of the province and is located approximately halfway between Toronto and Windsor. London is known for its vibrant arts and culture scene, as well as its many parks and natural areas, including the scenic Thames River running through the heart of the city, offering a range of recreational opportunities for both residents and visitors. Geographically London is a city that has rural and urban combined areas. As shown in Figure 3.1, it is divided into 570 dissemination areas (DA) with a diverse population. According to Statistics Canada, the population of the London Census metropolitan area was 494,069 in 2016, with 16.4% being children under 14 years old, 22.4% being young adults under 18, and 17.1% being 65 years old or older. Between 2011 and 2016, there was an increase in both the population under 18 (from 22.4% to 23.5%) and the population 65 years old or older (from 15% to 17.1%) (Statistics Canada, 2017). This growing youth and senior population highlight the importance of research aimed at improving the built environment in cities.

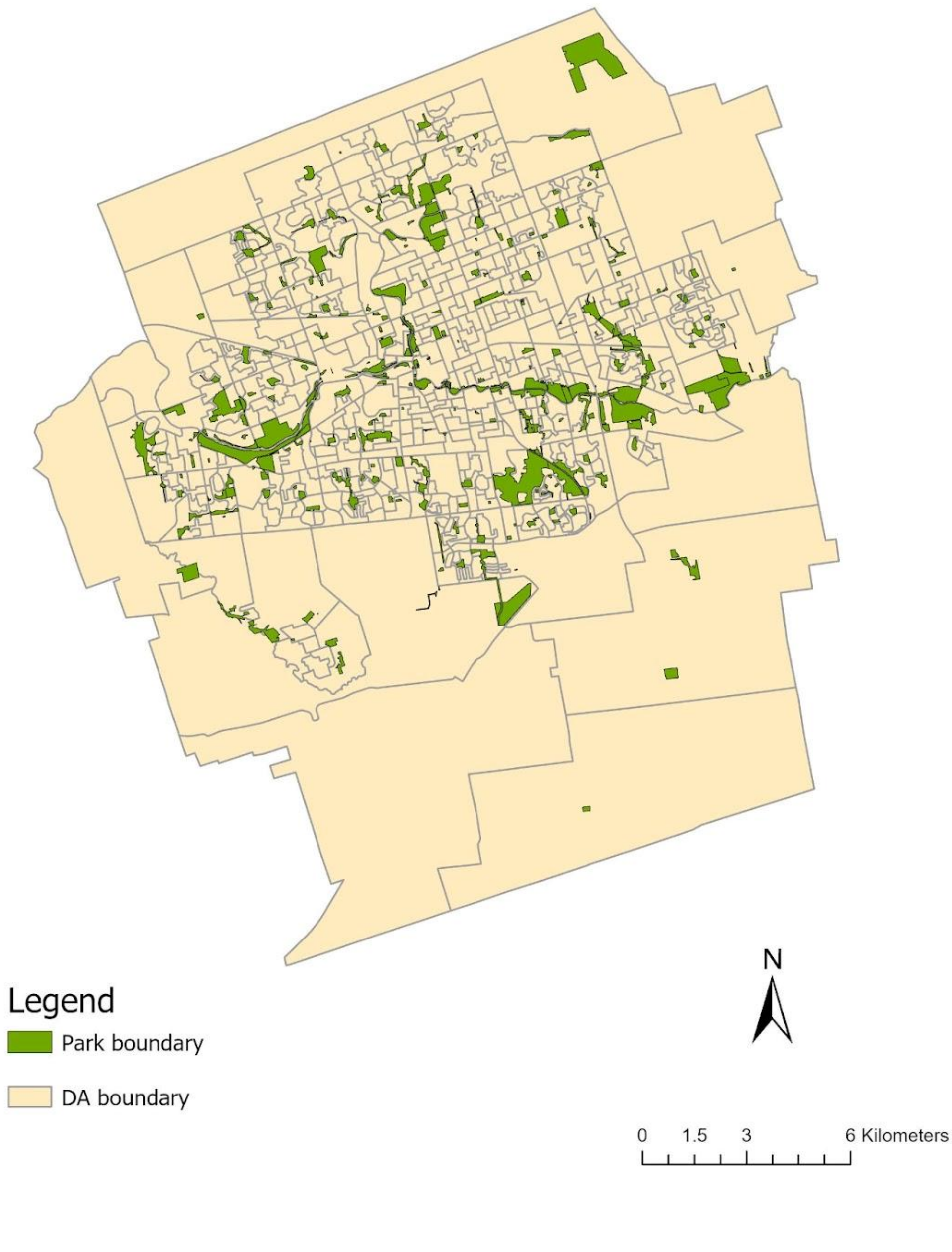

Figure 3.1 - City of London study area & park boundary map (City of London, 2019)

3.2.2 Halifax, Nova Scotia

The second study area is Halifax, Nova Scotia (shown in Figure 3.2). The city is located on the east coast of Canada with rugged coastlines, scenic landscapes, and maritime heritage sites, which make the city a tourism hot spot attracting visitors from around the world with its natural geography and vibrant culture. It is a major economic and cultural center of the region, with a population of over 403,390 people according to Statistics Canada (Statistics Canada, 2017). Moreover, the statistical result reveals that 15% of the population is children under 14 years old, and 5.5% is youth between 15-19 years old. The official name of the city is Halifax Reginal Municipality (HRM) consisting of 200 communities with rural and urban areas combined (HRM Open Data, 2014). This study primarily focuses on the core Halifax community of the HRM where most of the field data were collected. There are 209 DAs included in the study area.

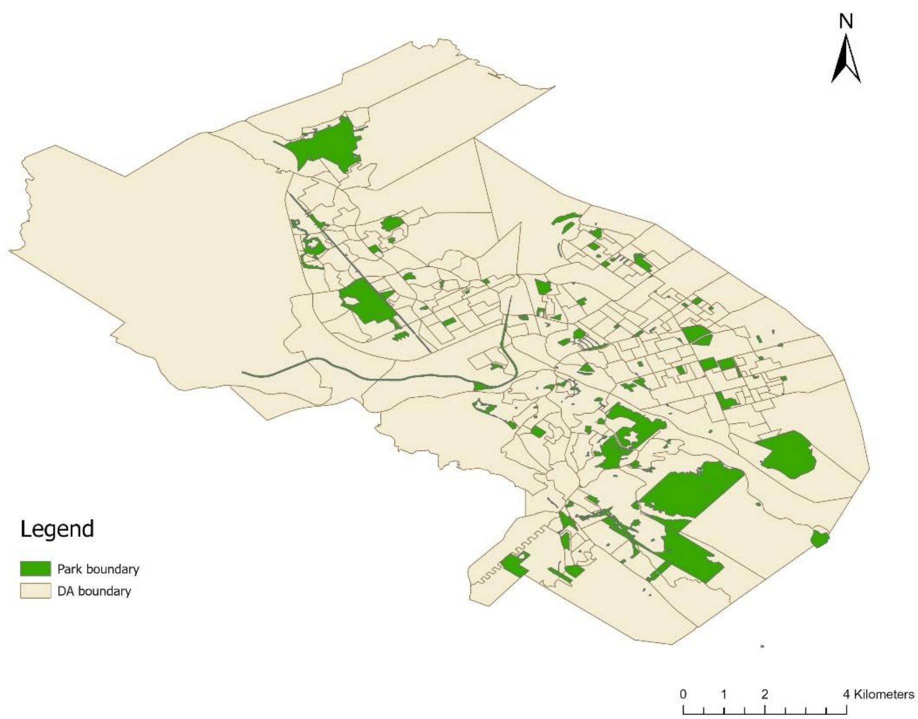

Figure 3. 2 Halifax study area & park boundary map (HRM Open Data, 2014)

3.2.3 Park Data

Parks and recreation facilities in the study cities are maintained and monitored by the City of London and the HRM. Therefore, any urban park that is recognized by the city is included in the analysis. Park-related geospatial data are retrieved from the cities' open data portal (City of London, 2019; HRM Open Data, 2014). This thesis is affiliated with a pan-Canadian park research called ParkSeek at the Human Environments Analysis Laboratory (HEAL), Western University. This project aims to gain a comprehensive understanding of the quality, geospatial accessibility, and policy aspects of Canadian parks. The quality aspect of ParkSeek refers to the fieldwork, in which the quality of parks in the study area is assessed using a comprehensive park audit tool developed by researchers on the team. The full audit tool consists of 72 detailed questions covering 5 main categories, general condition, accessibility, park quality, safety, and target areas (play facility). This tool serves as a guideline for field workers and researchers to conduct park quality assessments in many cities in Canada. Park quality data used in this thesis is a selection of the ParkSeek audit data for London and Halifax. As a member of the research team, the primary author participated in the data collection in London, conducted over park audits for over 100 local parks in London. Additionally, the City of London has a comprehensive park amenity spatial layer published on its open data portal. This data are maintained and monitored by the city and has some interesting features such as the picnic and barbeque areas that are not included in the audit tool. It is also used as the reference data. Park audit data are processed, cleaned, and reconstructed into shapefile using programming language Python in Jupyter Notebook.

Remote sensing imagery from Planet (Planet, 2021) is utilized to determine the water and vegetation coverage in each park in the London. Images were selected based on minimum cloud coverage as well as the same time range as the park audit recorded time to preserve the best image quality and to make sure the water body and vegetation are aligned. Selected satellite images are processed using the band arithmetic function in ArcGIS Pro 3.1.0. Following existing literature, water and vegetation features are classified using the Raster Calculator function in ArcGIS pro based on the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) (Abdullah et al., 2022; Rouse et al., 1974). Lastly, the water and vegetation coverage are determined using Tabulate Area, calculating the number of pixels representing water and vegetation.

3.2.4 Demographic Data

This research is interested in the population under 19 years old. The demographic information is retrieved from the 2016 Census profile, Statistics Canada. Dissemination area (DA) is used as the population division. By definition from Statistics Canada, a DA is the smallest standard geographic area for which all census data are disseminated (Statistics Canada, 2018). It is used as the primary population division in this thesis because it is relatively consistent and stable across the country. In addition, the census population data as well as socioeconomic data at DA level of the same census year are obtained.

3.2.5 Transportation Data

Street network for two study cities is extracted from the City of London open data portal, as well as the HRM open data portal (City of London, 2019; Halifax Regional Municipality, 2013). A network dataset is built using ArcMap 10.8.1 for following network analysis. This study focuses on the walking distance from park center to population center because walking is the most often used travel mode commuting to a park by youth. For measuring travel time, walking speed is set to 4.5 km/hr based on existing literature (Reyes et al., 2014; Stępniak & Goliszek, 2017). The travel time, in minutes, is calculated by having the length of each road segment stored in the street network data from two cities divided by walking speed 4.5 km/hr.

3.3 The Development of Youth-weighted Park Quality Score

Following the park feature categorization developed by the Quality Index of Parks for Youth (QUINPY) tool, this thesis focusses on five main categories of park features: 1) play facility, 2) nature, 3) support facility, 4) maintenance, and 5) safety. Based on previous literature, these park characteristics are the most relevant and beneficial for youth (Rigolon & Németh, 2018). Additionally, these categories are mentioned in the conceptual model on park research developed by Bedimo-Rung et al.., (2005). The model highlighted the importance of categorizing park features and the importance of operationalize the measures for data collection and analysis.

3.3.1 Park inventory score

A park inventory score is designed to reflect the availability of the five categories of park features. Following previous literature discussed in earlier sections, a total of 20 park-related features are included for London, and 19 features are included for Halifax (see Table 1). The City of London dataset has one more feature (picnic/barbeque area) than Halifax because this particular feature is available from the City of London amenity dataset and is not available for Halifax.

Each amenity is assigned with the same maximum inventory score of 2 and no weight. Park inventory score is cumulative, meaning that the more amenities available the higher the score will be. The maximum possible inventory score for a park is 40 (38 for Halifax). For example, if a park has one playground, the playground inventory score is 1; if it has 2 or more playgrounds, the playground inventory score is 2. If a feature is not available in a park, this park will get a 0 for this specific feature. The final inventory score for a specific park is calculated using a sum approach. The sum score of all variables will be the final inventory score of that specific park. See the full score breakdown in Table 1.

Table 3.1 - Park categories, features, and the park inventory score break down

Category	Feature	Score break down
Play facility	Playground	0: no playground 1: 1 playground 2: 2 or more playgrounds
	Pool (indoor & outdoor)	0: no pool 2: pool available
	Sports court	0: no sports court 1: 1 sports court 2: 2 or more sports courts

	Sports field	0: no sports field 1: 1 sports field 2: 2 or more sports fields
	Walking/biking trail	0: no trail 2: trail available
Nature	Vegetation (%)	1: less than 50% 2: more than or equal to 50%
	Water body (%)	0: no water present 1: less than 50% 2: more than or equal to 50%
Support facility	Picnic/barbeque area (London only)	0: no picnic/barbeque area 2: picnic/barbeque area available
	Restroom	0: no restroom 2: restroom available
	Seating	0: no seating 2: seating available
	Water tap	0: no water tap 2: water tap available
Maintenance	General litter	0: widely spread 1: some, spread/clustered 2: no litter
	Graffiti	0: graffiti present 2: no graffiti
	Trashcan	0: no trashcan 2: trashcan available
	Vandalism	0: vandalism present 2: no vandalism
Safety	Adequate lighting	0: no lighting source 2: lighting source available
	Emergency devices	0: no emergency device

		2: emergency device available
	Monitored by staff	0: no 2: yes
	Visibility of surrounding houses	0: clear 1: partial 2: none
	Visibility of surrounding roads	0: clear 1: partial 2: none

3.3.2 Youth engagement

Parks contain a wide variety of features such as playground, sports field, or supporting facility, and each type of feature is associated with different types of activities, favoured by different groups of population. Rather than presuming what's preferred by the study population, or treats all features the same, this study incorporates youth's perspective. The value of doing research with youth and for youth, as opposed to merely on youth, has been widely acknowledged by many children's geographers (Arunkumar et al., 2018; Bowman et al., 2019; Ergler, 2015). Given the study population of this research is youth, incorporating the perspectives of youth allows for the research outcomes to be better aligned with the study population themselves (Jacquez et al., 2013). The Human Environment Analysis Laboratory Youth Advisory Council (HEALYAC) was consulted to meet this objective and determine the weights for each park feature. The council is a group of 13-19 years old high school students with diverse age, gender, and ethnicity who attend different high schools in London. They are frequently exposed to and actively involved in a wide range of projects within the HEAL. A total of 11 youth was involved in the process of setting up the criteria for weighting park features.

The primary author worked with the council through several meetings, during which the study design, study objectives and goal of youth engagement were presented to and discussed with the council members. During those meetings, the park features were reviewed and discussed among the students as well as the primary author and other HEAL graduate students to uncover a wide range of perspectives on park quality. They are provided with the initial park features categorization (Table 1) to review and discuss what features are important for them when visiting parks. Discussions then centered around gathering missing information, and correcting terms that were not understandable. Following by those productive discussions, a youth-informed survey created based on park features approved by council members is introduced to determine weights for each park feature for following accessibility analysis.

3.3.3 Youth-weighted Park Quality Score

The park inventory score gives all park features the same weight, which assumes all park features are equally important to the study population. However, teenagers are more likely to go to a park that has their preferred amenities or scenery. Therefore, we recognize the importance of considering the popularity of certain park features. Features that are preferred by the study population should have higher weight over less preferred features. A youth-informed survey is created to gain a youth perspective on the relative importance of the study park features. The survey answers were then used to compute weights for each park feature to represent their attraction level.

The survey is designed based on the selected park features after consulting with the YAC. It contains a series of questions asking participants to rate each park feature based on how important they are to them on a scale from 0 to 4, with 0 being not at all important and 4 being extremely important. There are a total of 20 questions in the survey corresponding to the features included. Besides rating park features, a travel behaviour question (*What is the maximum amount of time (in minutes) you would be willing to walk to a park?*) is also included to determine the maximum travel threshold for the following analysis. Each YAC member answered the survey based on their own experience, and the median of all survey responses was used as the weight for each park feature. The final youth-weighted quality score for park feature k (S_j^k) is calculated using a weighted sum approach, see following equation (1):

$$S_j^k = q_j^k \times \gamma_k \tag{1}$$

Where q_j^k is the park inventory score for park feature k at park j, and γ_k is the youth-informed weight for park feature k. The final youth-informed weights and maximum weighted score is shown in Table 2.

Table 3.2 - Youth-informed weights and maximum youth weighted score

Category	Feature	Max score	Youth-informed weight	Max weighted score
Play facility	Playground	2	3	6
	Sports court	2	3	6
	Sports field	2	4	8
	Pool (indoor & outdoor)	2	1	2
	Walking/biking trail	2	3	6
Nature	Water body	2	3	6
	Vegetation	2	3	6
Support facility	Seating	2	3	6
	Water tap	2	3	6
	Picnic/barbeque area (London only)	2	2	4
	Restroom	2	2	4
Maintenance	Trashcan available	2	4	8
	General litter	2	4	8
	Vandalism	2	3	6
	Graffiti	2	3	6
Safety	Adequate lighting	2	3	6
	Monitored by staff	2	1	2
	Emergency devices	2	3	6
	Visibility of surrounding houses	2	3	6
	Visibility of surrounding roads	2	3	6
Sum		40		114

3.4 Measuring Spatial Accessibility to Parks

This thesis adopts the well-established 2SFCA method to measure spatial accessibility to urban parks. This method evaluates the access to a service regarding the provision, service characteristics, and the distance between service to demand (Xing et al., 2020). It has been widely applied in healthcare accessibility research as well as park accessibility research to identify underserved areas and disadvantaged population. Following the 2SFCA method, accessibility is defined as the sum of park to population ratio within a certain travel budget (Luo & Wang, 2003). The service under consideration is parks, and the demand is the youth population in study area at dissemination area (DA) level. Service location is represented by park centroid, and demand location corresponds to the centroid of each DA.

3.4.1 Park Attraction Coefficient

Park Attraction Coefficient (PAC) is used to represent the supply capacity in the 2SFCA method. In this study, PAC is defined as a function of both park size and park quality and is computed using a weighted sum approach. The following notion is used in the description of the methodology:

J = the set of the study parks
K = the set of park features
I = the set of the DA centroid
j = index of the study parks
k = index of the park features
i = index of the DA centroid
A = park size

S_j is the attraction coefficient for park *j*. γ_A is the importance of park size and γ_K is the importance of park quality ($\gamma_A + \gamma_K = 1$). The equation (2) illustrates how PAC is measured:

$$S_j = \left[\gamma_A \frac{S_j^A}{max_{j \in J} S_j^A}\right] + \left[\gamma_K \frac{S_j^K}{max_{j \in J} S_j^K}\right] \quad \forall j \in J \tag{2}$$

where S_j^A is the park size for park *j*, and S_j^K refers to the park quality score for park *j*. The park quality score is determined by the on-site amenity (Park Inventory Score) as explained in section 3.3.1, and how important each type of park feature is to teenagers based on the equation (3) below:

$$S_j^K = \sum_{k \in K} [\, q_j^k \times \gamma_k \,] \tag{3}$$

where S_j^K is the park quality score of park *j*, q_j^k is the park inventory score for park feature *k* of park *j*, and γ_k is the youth-informed weight for park feature *k*.

The calculated PAC at each park location *j* is normalized based on the equation (4):

$$\overline{S_J} = \frac{S_j - min_{j \in J} S_j}{max_{j \in J} S_j - min_{j \in J} S_j} \quad \forall j \in J \tag{4}$$

3.4.2 2SFCA Method

Following Luo & Wang (2003), the first step of the 2SFCA is to create a catchment area around each park *j* with the travel time threshold (d_0) from the youth-informed survey, where each Youth Advisory Council (YAC) member was asked what the maximum time would be they would be willing to walk to a park. The average of all survey responses is used as the travel threshold in this step. From the YAC, we determined a 15.7 min travel threshold.

For each park location *j*, the youth population of all the DA centroid *i* that are within the catchment area is summed up, this is the P_i. The park to population ratio (R_j) is computed using the following equation (5):

$$R_j = \frac{S_j}{\sum_{i \in \{d_{ij} \leq d_0\}} P_i} \tag{5}$$

where S_j is the PAC at park location *j*, d_{ij} is the travel time between population center *i* and park location *j*, and d_0 is the 15.7-minute travel threshold.

The second step is to create another catchment area *i* around each DA centroid *i* using the same time threshold (d_0) and then compute the sum of the park population ratio (R_j) for all park locations *j* within that catchment area. The final accessibility score at population location *i* is calculated following the equation (6):

$$A_i = \sum_{j \in \{d_{ij} \leq d_0\}} R_j \quad (6)$$

where A_i represents the accessibility score of DA *i*, d_{ij} is the travel time form population center *i* to park and R_j is the park-to-population ratio of the park location *j* whose centroid falls within the catchment area. A larger accessibility score of a DA refers to better access to urban parks in that DA. Since the accessibility score is weighted by both park size and park quality, better access to urban parks indicates a greater opportunity for not only larger parks but parks with a higher quality for youth.

3.4.3 Scenario Studies

The resulting accessibility score is an index that represents the level of how accessible parks are in each dissemination area. Following the proposed method, three scenario studies are implemented to explore how the modified method compare to the traditional methods. The **first scenario** is the most applied 2SFCA which considers only park size as the supply level, while the **second scenario** uses park quality solely as the supply level. The **third scenario** incorporates a park size and park quality combined approach.

Scenario I: PAC is a function of park size only ($\gamma_A = 1;\ \gamma_K = 0$)
In this scenario, PAC is only influenced by park size. This is also the case of the traditional 2SFCA method where park size is the only factor at supply level.

Scenario II: PAC is a function of park quality only ($\gamma_A = 0;\ \gamma_K = 1$)

Opposite from scenario I, the section scenario neglects the influence of park size. The PAC is only determined by the youth weighted quality score. The comparison of scenario I and scenario II will be discussed in the following chapter. The result is expected to be obvious and will indicate how park quality influences park accessibility results differently from park size.

Scenario III: PAC is a function of both park size and quality equally ($\gamma_A = \gamma_K = 0.5$). In the third scenario, we propose a method that considers both park size and park quality, and they are equally important. This approach is expected to be moderate compared to the previous two scenarios.

3.5 Social Equity Evaluation Method

Unequal access to services is often associated with socio-economic determinants of the study population (Comber et al., 2008; Liu et al., 2021). Among various socio-economic indicators, income has been proven to be associated with people's health by several Canadian studies (Doughty, 2017; Wilkins et al., 2002). In addition, neighbourhood settings as well as the mobility of populations is linked with income. For example, rich people are more likely to travel further for recreational purposes or own private green spaces (Dai, 2011). Urban parks as public infrastructures should be equally accessible for all residents in modern cities regardless of their income, ethnicity, or race. In this thesis, social equity is explored using median household income, as the study population is youth who mostly reply on family support. This section describes the methodology used to investigate associations between median household income and park accessibility for youth in London and Halifax. The median household income at Dissemination Area (DA) level is extracted from the 2016 Canadian census data and is mapped out using ArcMap 10.8.1.

Figure 3.3 & 3.4 visualize the median household income by DA in London and Halifax respectively, with darker shades representing a higher income and lighter shades for lower income. The maps reveal a mix of lighter and darker areas in the urban centers of both cities. The pattern represents an extreme diversity in household incomes across all DAs in both cities.

Therefore, it is worth investigating potential relationships between median household income and park accessibility at DA level.

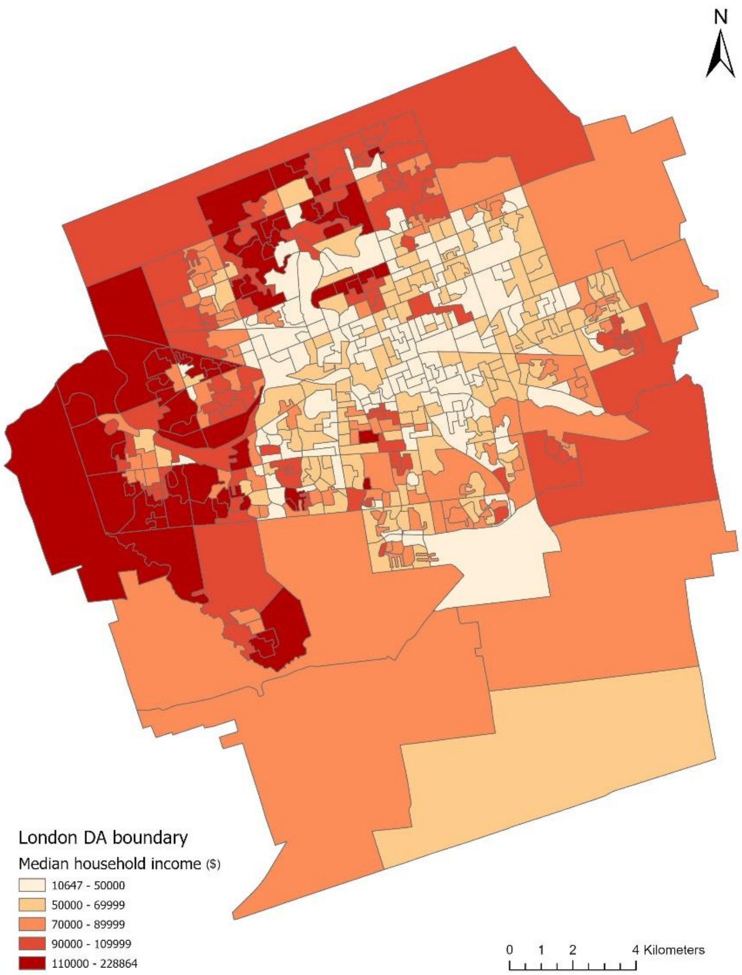

Figure 3.3 - Median household income by Dissemination Area for London (Statistics Canada, 2017)

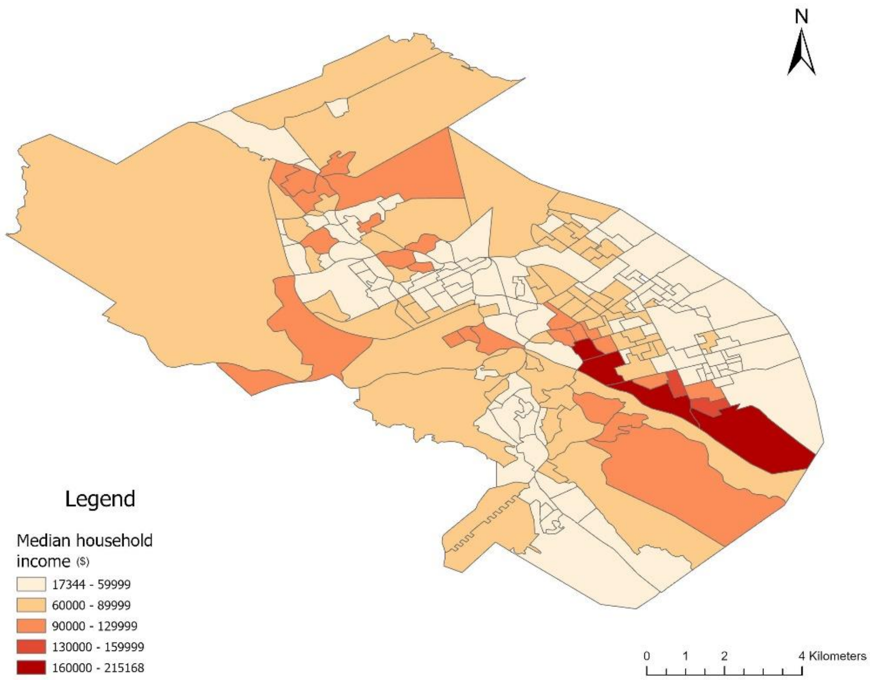

Figure 3.4 - Median household income by Dissemination Area for Halifax (Statistics Canada, 2017)

Since the median household income level appears to be uneven across neighbourhoods in both London and Halifax, we propose the hypothesis that the DAs that have higher median household income would have higher accessibility scores, and DAs that have relatively lower median household income would have lower accessibility score. This hypothesis can be accepted when a positive relationship is observed between median household income and accessibility scores, which means that higher income is associated with better access to quality urban parks. This would make lower income neighbourhoods disadvantaged. However, if results indicate a negative relationship, the hypothesis would be rejected meaning that higher median household income is associated with poor access to quality urban parks. When results are not statistically significant, there's not enough evidence connecting median household income and the level of accessibility. Pearson's correlation test is utilized to achieve this objective. This method determines whether there are significant relationships between multiple variables (Higgins, 2019; Klar et al., 2023; Kwan, 1998). Using median household income data are intended to investigate whether accessibility results from three scenarios are influenced by median household income in the City of London and Halifax from a social equity perspective. Finding associations between median household income and park accessibility, can help reveal disadvantaged neighbourhoods in London and Halifax area.

3.6 Conclusion

An overarching goal of this thesis is to develop a youth-informed and quality-aware 2SFCA method that can be utilized to measure park accessibility that best suits the youth population. This approach consists of three major steps: 1) determining park inventory score; 2) calculating youth-weighted park quality score through surveys; 3) combining youth-weighted park quality score and park size to measure park accessibility index for two study cities.

Since both study cities in this thesis have a large youth population, one of the major contributions of this study is proposing the youth-informed quality score and incorporating it in the measurements of the spatial accessibility. The youth-weighted quality score brings a unique perspective into measuring spatial accessibility with the intention of creating research outcomes that best align with the study population. Following the traditional 2SFCA method, a fixed catchment area determined by the expertise of a group of local youth is utilized. The supply capacity is represented by the PAC which is a sum-up function of park size and park quality. Demand is the youth population by DA and is used to compute the park-to-population ratio. Integrating those three steps, a park quality-oriented accessibility score is calculated for each DA. Results are compared with the measures that considers size only and quality only by implementing three scenario studies. Lastly, correlation analysis is performed to investigate relationships between median household income and accessibility scores from three scenarios.

Chapter 4. Results

4.1 Introduction

This chapter includes the spatial analysis results and the social equity analysis results of this study, which answered the two overarching research questions of this thesis. The first research question, "*How accessible are parks and recreation facilities in London and Halifax for youth of different socioeconomic status?"*, explored the provision, spatial distribution, and accessibility of urban parks in the two study cities, following by the second research question, "*How does the accessibility of parks and recreation facilities for youth vary when park quality is considered?"*. Section 4.2 addresses the spatial distribution of parks and the youth population in London and Halifax. Section 4.3 describes the quality assessment results of this study. The last section includes study results from examining how the accessibility results change when park quality is considered, and how the accessibility results vary according to neighbourhood socioeconomic status. Additionally, section 4.3 is organized by scenarios providing the comparison between the traditional model and the proposed model.

4.2 Maps of Parks and Youth Populations

This chapter reports the distribution of the study parks and youth population in London and Halifax. It provides background information that helps to understand the accessibility results.

London has a total of 538 parks monitored by the city (City of London, 2019), 293 of which has complete park audit data. Those parks were the study samples for this thesis as shown in Figure 4.1. The audit data were then attached to the park spatial data from the City of London using a unique park ID. These datasets consisted of the complete park data for spatial analysis. From visualizing the study parks, most of them were located around natural features such as the river or densely populated neighbourhoods in London.

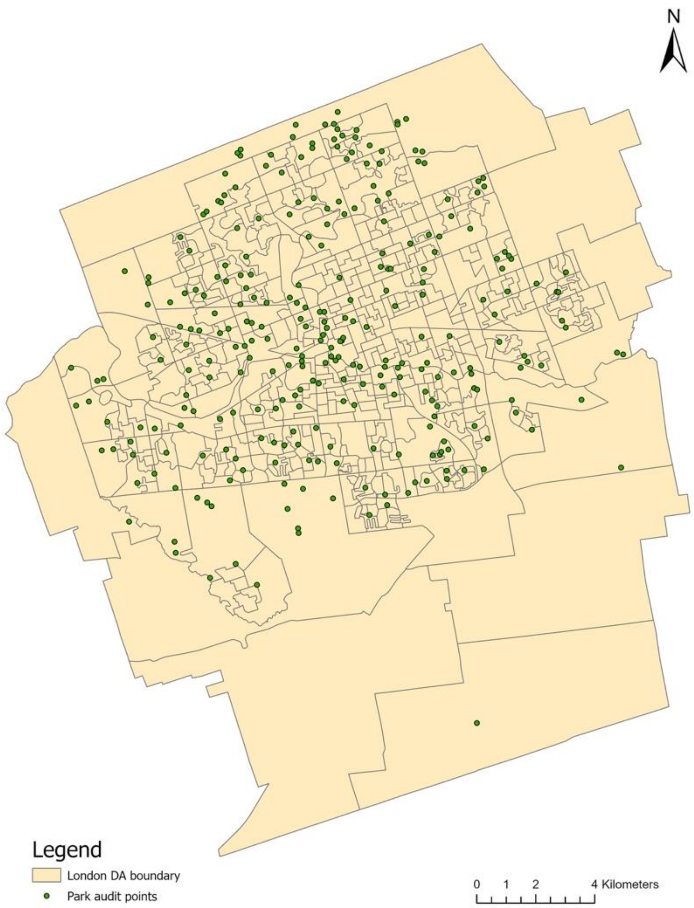

Figure 4.1 - London study area & park audit points (City of London, 2019)

Since this study focuses on the youth population, it is important to showcase youth population at DA level (Figure 4.2). Visually, the DAs that had higher youth population were around the peripheral area rather than the urban core of London. DAs with a larger youth population would have a larger demand for parks, which might influence the accessibility results. However, some of those DAs covered relatively larger area. This might be a potential reason for having higher youth population. Therefore, population density (Figure 4.3) can be helpful to understand where the most youth population is location.

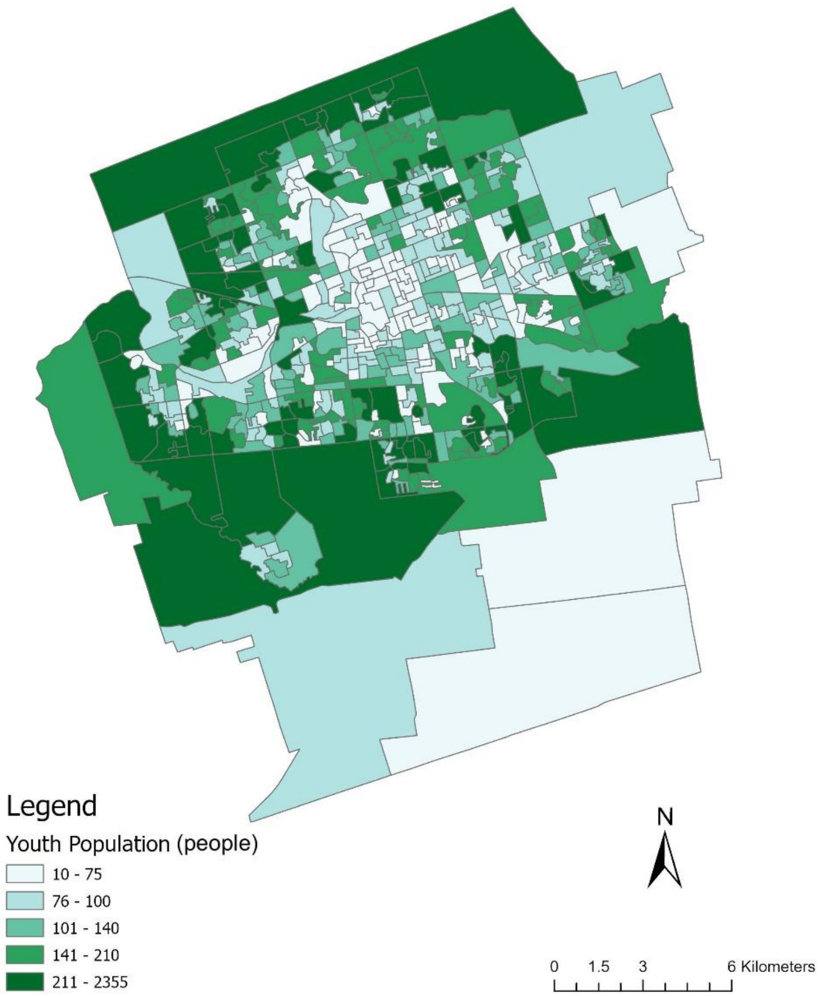

Figure 4.2 - London youth population at DA level (Statistics Canada, 2017)

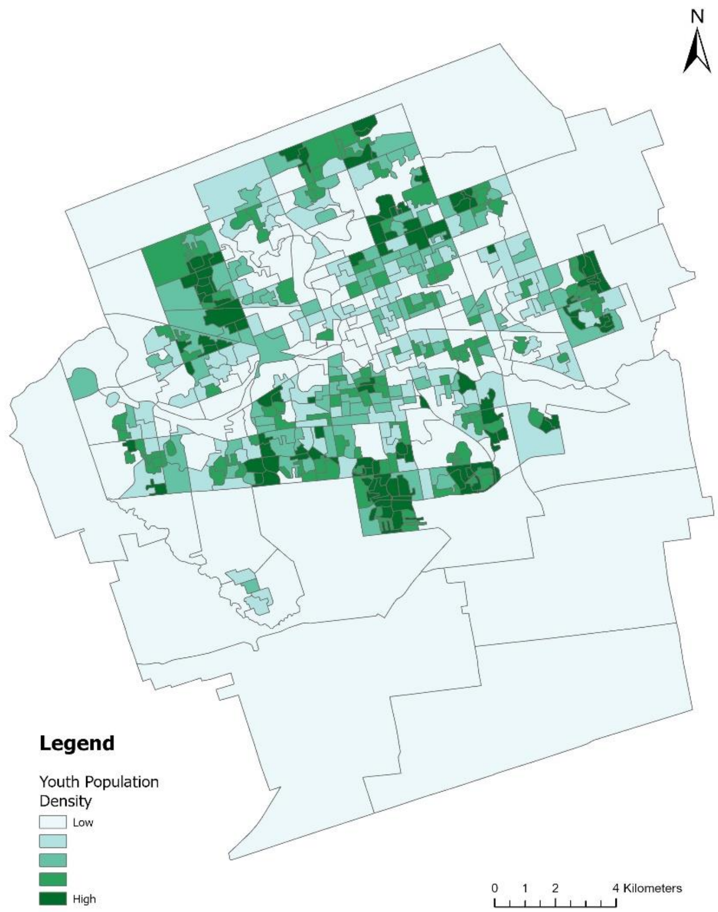

Figure 4.3 - Youth population density (people/square meter) map for London (Statistics Canada, 2017)

There were 123 parks in Halifax area included in the analysis as shown in Figure 4.4. This is not all the parks recognized by Halifax Reginal Municipality (HRM) due to the availability of the park audit data. Additionally, several parks outside of the study boundary were included. This is because, first, all parks that were audited by researchers were used. Second, some of those parks were national parks which were larger in size and had better scenery that might attract visitors to travel further to visit. However, since the chosen travel mode is walking, those parks may not be reachable within the walking time threshold along the road network.

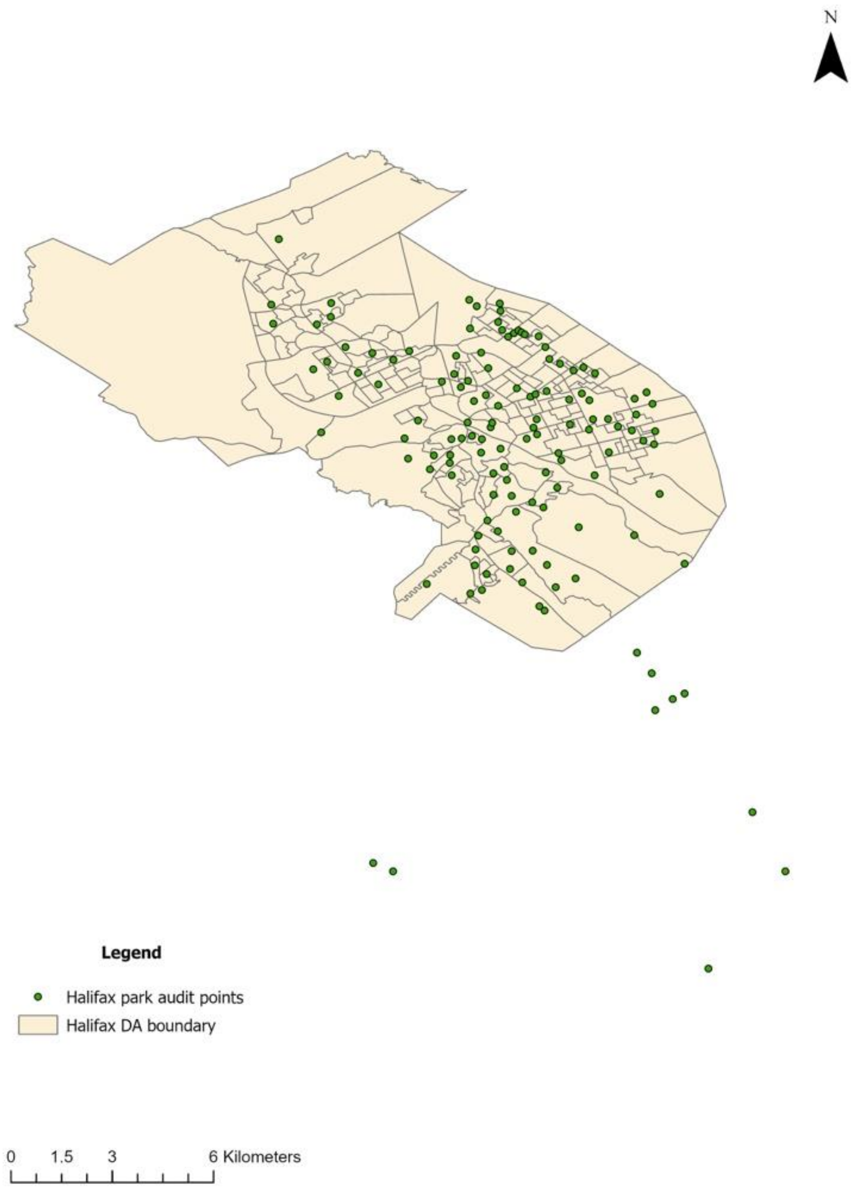

Figure 4.4 - Halifax study area and park audit points (HRM Open Data, 2014)

Similar to London, the youth population at DA level appeared to be uneven across the study area. Figure 4.5 indicated that higher youth population community blocks were located around the peripheral part of the study area, however, the population density map indicated otherwise as shown in Figure 4.6. With the help of the population density map, the DAs that had higher youth population were easily identified.

Figure 4.5 – Halifax area youth population at DA level (Statistics Canada, 2017)

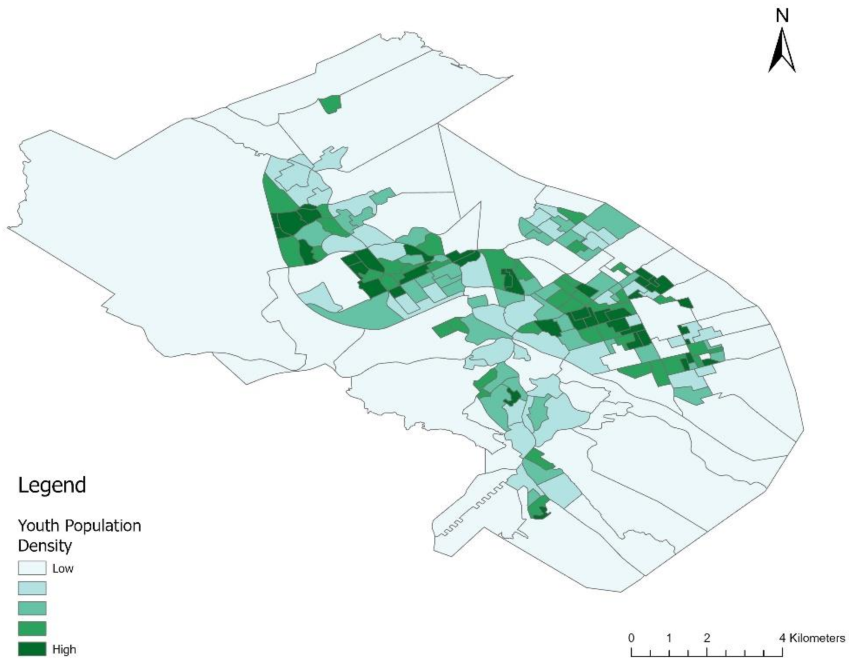

Figure 4.6 – Youth population density (people/square meter) map for Halifax area (Statistics Canada, 2017)

4.3 Park Quality Assessment Results

Park quality in this thesis was represented by the youth-weighted quality score, introduced in the previous chapter. Using this method, the quality of parks was evaluated based on the available amenities favoured by the study population as well as their general condition such as cleanliness, graffiti, and vandalisms that matter the most for youth. Compared to other forms of park quality measurements, this study approach has a more reliable data source and better suits the study population.

The original park quality data came from ParkSeek, a national park research project, where parks were surveyed by trained researchers using a well-established park audit tool from the project. A youth-informed survey was used to collect youth's perspectives on park features (see Appendix A). Participants were asked to rate each park feature by how important they are to them. The results showed that pool (indoor & outdoor) and monitored by staff were the least important features. Whereas sports field, trash cans available, and lack of general litter were the most critical characteristics for youth. The final youth-weighted score was the accumulative score normalized by the total maximum weighted score (114), making the resulted score for each park between 0 to 1. The following two histograms demonstrated the distribution of the youth-weighted quality score for two study cities. For the City of London, 53% of the parks had quality scores lower than the average score of 0.31 (Figure 4.7). With a standard deviation of 0.13, the data were highly clustered around the mean. Compared to London, Halifax had a higher average youth-weighted score of 0.40. However, 62% of the parks in Halifax had scores below average as shown in Figure 4.8. Most of the parks in Halifax had scores closed to the average score as the standard deviation is 0.11. Additionally, more extreme values were observed in Halifax, meaning that the disparity between high and low quality parks were more extreme in Halifax than London.

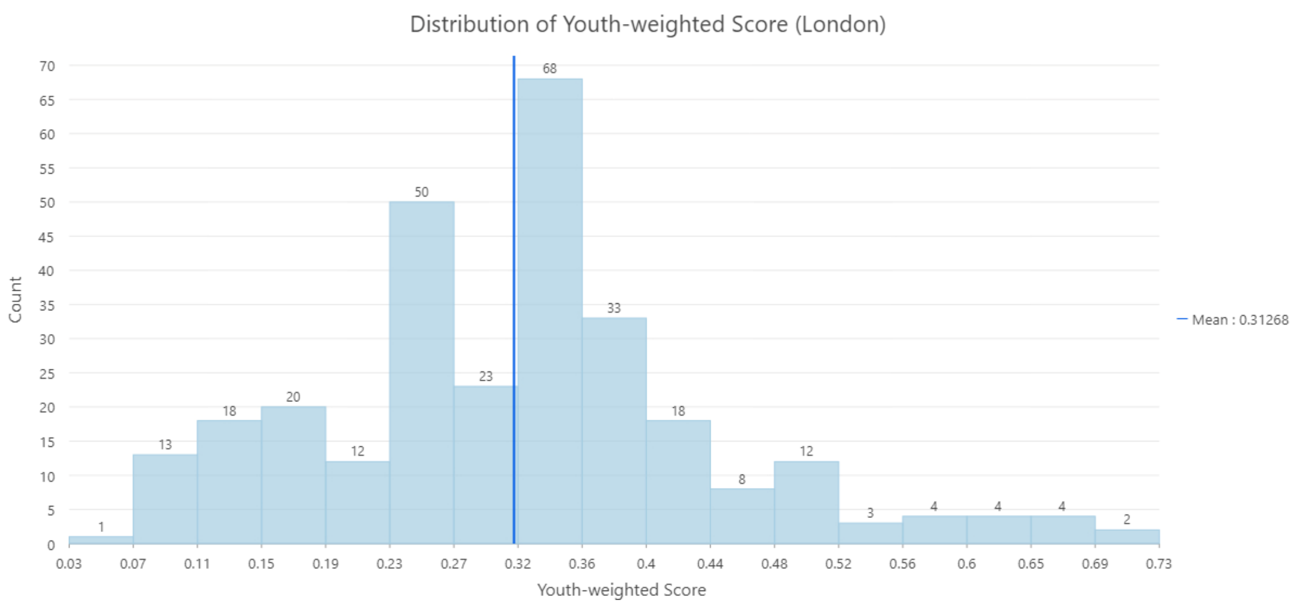

Figure 4.7 - Distribution of youth-weighted score for parks in London (N = 293)

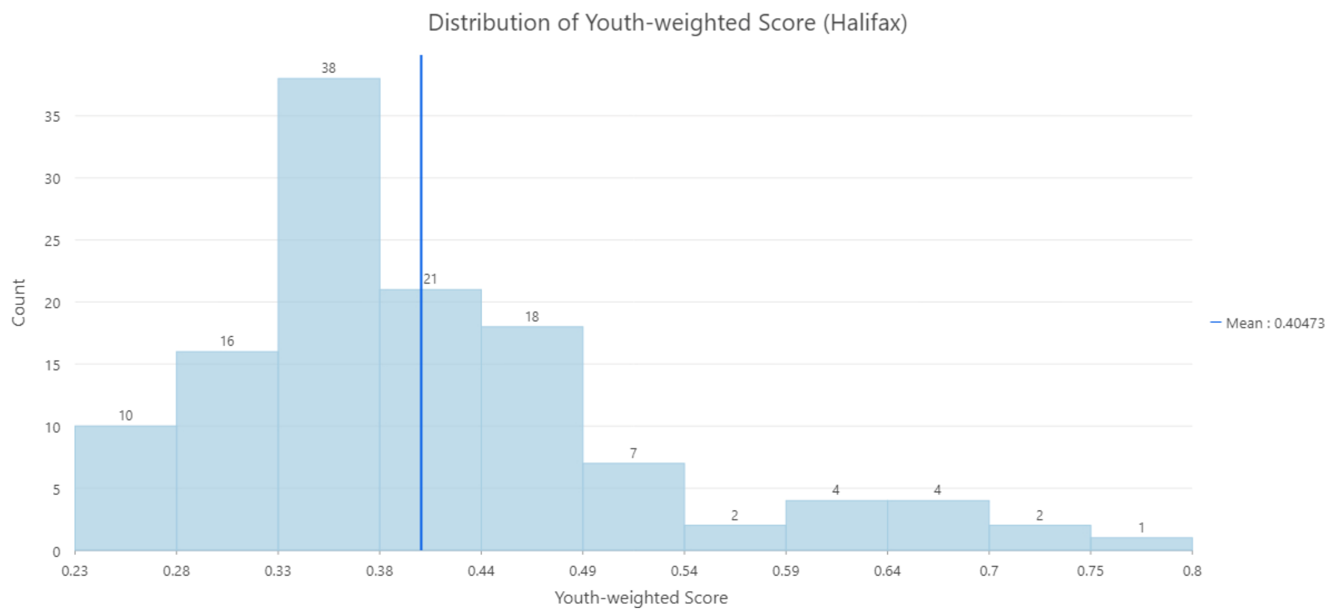

Figure 4.8 - Distribution of youth-weighted score for parks in Halifax area (N = 123)

The relationship between youth-weighted quality score and park size was examined using the Pearson correlation coefficient for both study cities as shown in Figure 4.9 & 4.10. There are two parameters that can describe the correlation between variables, including the R-score and P-value. The R score values range from -1 to 1 representing negative and positive relationships between variables. With a p-value lower than 0.05, the variables can be considered significantly correlated (Akoglu, 2018) at 5% significance level. For the London, test returned an R score of 0.2 and a p-value of less than 0.01 (Figure 4.9), and Halifax area had a R score of 0.51 and a p-value of less than 0.01 (Figure 4.10). The larger the absolute value of the R score, the stronger the correlation will be (Ratner, 2009). A R score of 0.2 demonstrated a weak positive correlation between the park size and youth-weighted quality score for London. Having a R score of 0.51, parks in Halifax demonstrated a relatively stronger relationship between park size and quality. Weak or negative relationships between park quality and park size detected in London indicated that parks with larger sizes are not necessarily better parks. Hence, when measuring spatial accessibility, how to define park attraction should be carefully determined according to local context.

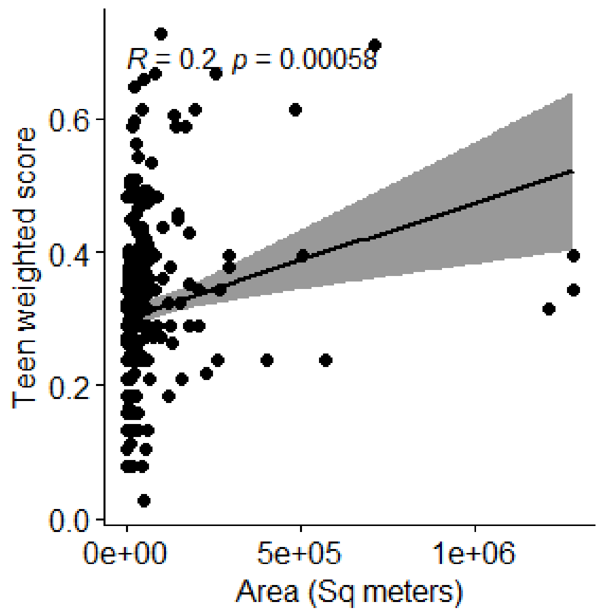

Figure 4.9 - Pearson's correlation result for London

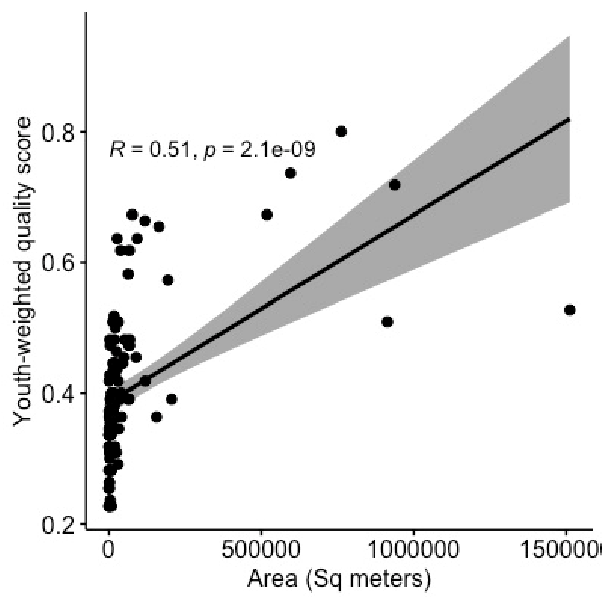

Figure 4.10 - Pearson's correlation result for Halifax

4.4 Accessibility Analysis Results

Accessibility has been used as a common indicator of how physically reachable park facilities are at various neighbourhood levels. The calculated index represented the level of park accessibility in a DA. This section reports the results that reveal how accessible are parks and recreation facilities in London and Halifax for youth with different median household income status. As described in Chapter 5, scenario I represents the traditional 2SFCA method where only park size is considered, scenario II reflects the modified method with only park quality is considered, and scenario II is a park quality and size combined method. Accessibility results of scenario I was first addressed, followed by scenario II & III. When reporting results, the distribution of accessibility scores was plotted in histogram figures using ArcGIS pro 3.1.0, showing the score range, the counts of dissemination area, and the mean accessibility score. Maps of park accessibility were made in ArcGIS pro 3.1.0 using the same scale classification and colour scheme (quantile classification and sequential colours). Having consistent classification and colour scheme made it possible to compare accessibility result across scenarios and study cities. The results for two study cities were visualized in the following maps with the same quantile classification and colour scheme using ArcGIS pro 3.1.0. Darker shade in blue represented higher accessibility values, and lighter shades in blue transitioned to lower accessibility value. Light grey referred to very low to zero accessibility value.

4.4.1 Scenario I

In the first scenario, accessibility was measured using only park size as the supply level, which was the traditional 2SFCA method. In this scenario, with a mean of 0.01947, most of the DAs in London had extremely low to zero accessibility scores according to the distribution histogram in Figure 4.11. An accessibility score of 0 indicates that there was no park accessible in that dissemination area within 15.7 min of walking. As the score became higher, the level of accessibility increased accordingly. Figure 4.12 is the scenario I accessibility results map for London. According to the map, higher accessibility scores were found in only a few DAs in north, west and center to east of the city. This indicated that based on park size, there weren’t many parks that were accessible within 15.7 minutes of walking for most of the DAs in London.

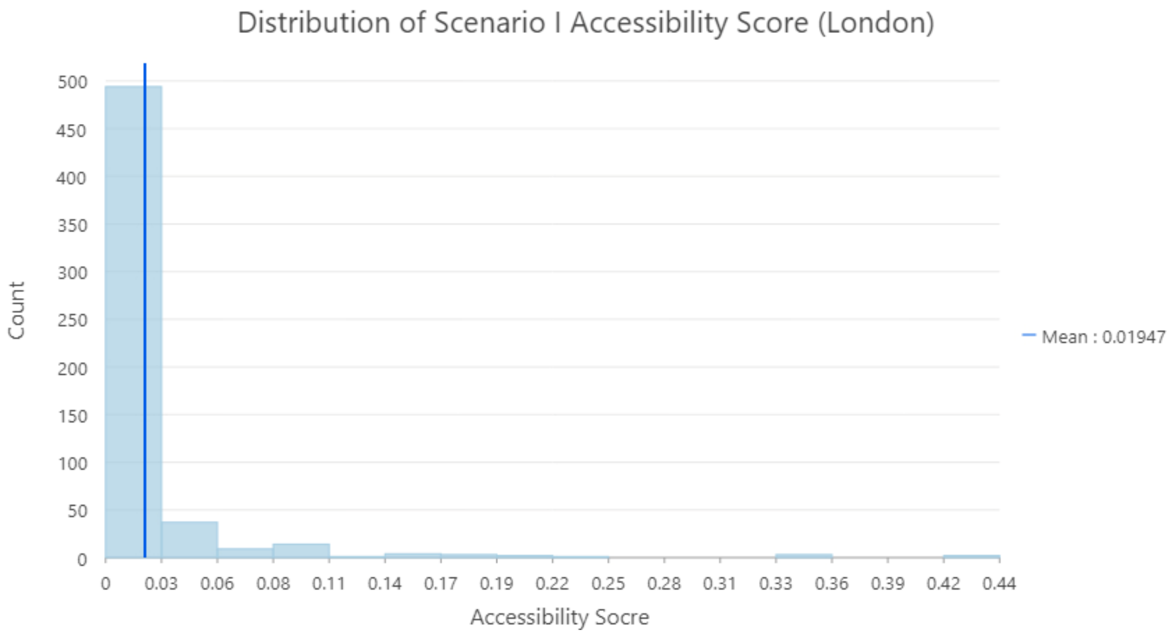

Figure 4.11 - Scenario I accessibility score distribution for London

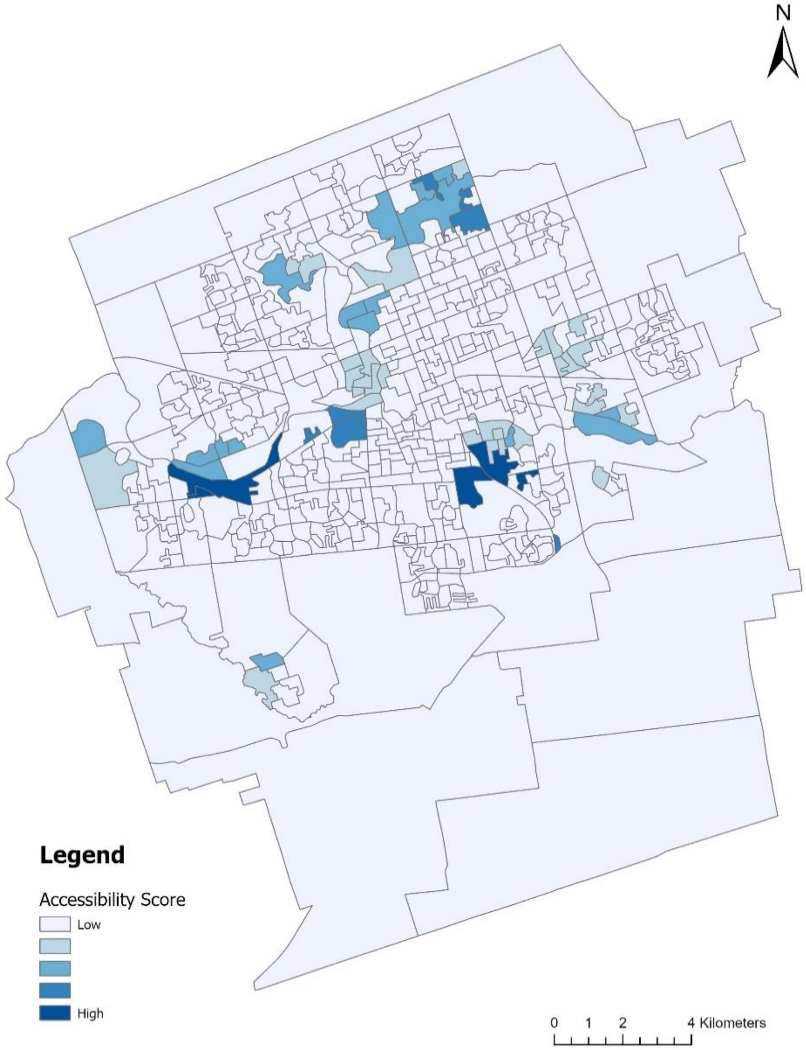

Figure 4.12 - London scenario I accessibility map

Similar pattern was found in Halifax. The distribution graph (Figure 4.13) showed that for scenario I, only two DAs were in the high accessibility class, four in middle ranges, and the remaining DAs had low accessibility score. With a mean value of 0.019 and the highest score of 1.4, scenario I generated low accessibility scores for Halifax as well. Accessibility map showed that the DAs that cover Boulderwood Cove, Purcells Cove, Furgusons Cove and Marlborough Woods had relatively high accessibility scores compared to other neighbourhoods in the city (Figure 4.14).

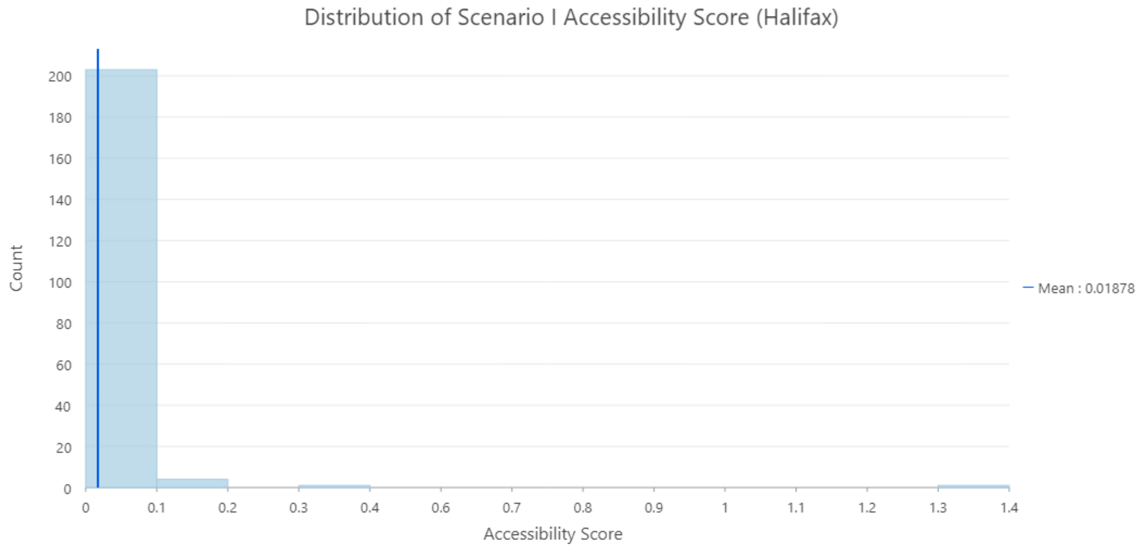

Figure 4.13 - Scenario I accessibility score distribution for Halifax

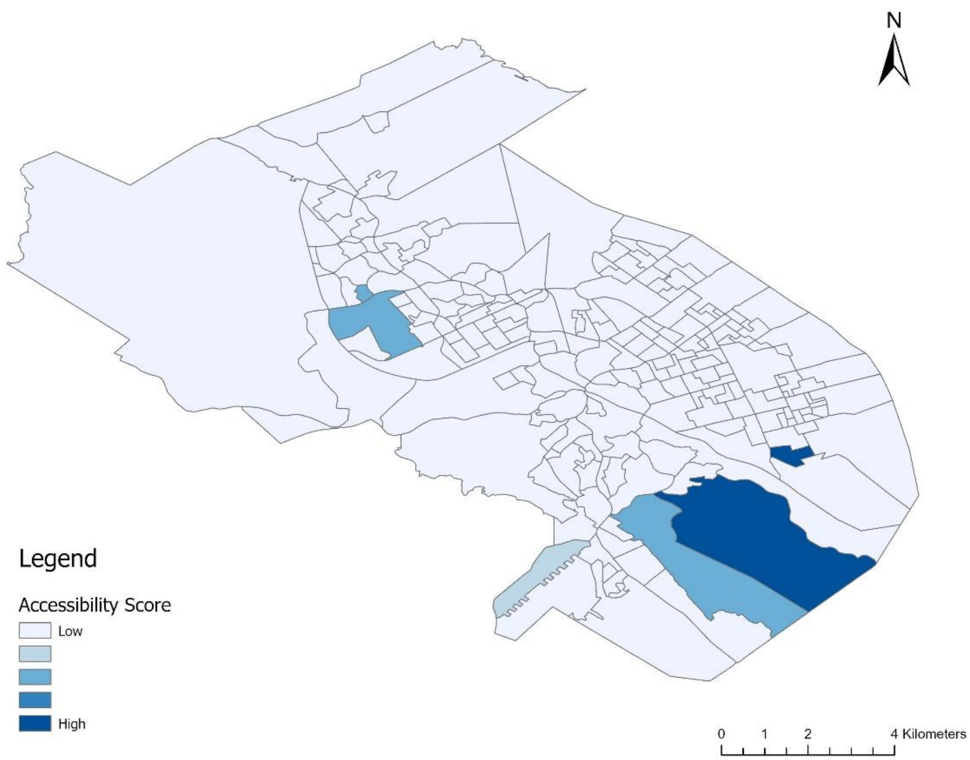

Figure 4.14 - Halifax scenario I accessibility map

When looking at how scenario I accessibility result varies according to median household income at DA level, park accessibility in London was not correlated with median household income. Pearson's coefficient test returned statistically non-significant metrices with a p value over 0.05 (Figure 4.15). However, Halifax had weak positive correlation between median household income and park accessibility scores at DA level (Figure 4.15).

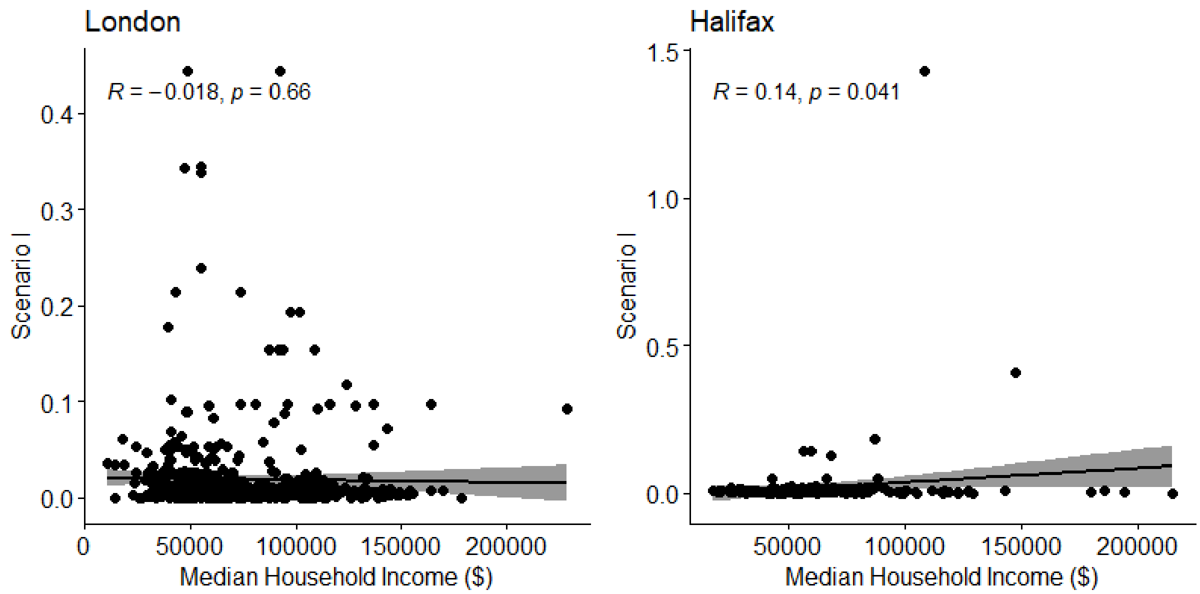

Figure 4.15 - Scenario I vs. Median household income plot

4.4.2 Scenario II

In scenario II, park accessibility was measured using only park quality as the factor that influences park attractiveness. Results showed that scenario II computed much higher accessibility scores overall (Figure 4.16). Although there still were a considerable number of DAs that had very low to zero accessibility scores, many more had higher accessibility scores compared to the scenario I results. The accessibility map (Figure 4.17) helped to better observe this pattern. Drastically differ from scenario I, more dark blue parcels were found in scenario II map. Moreover, the city centre had noticeably higher accessibility values compared to the peripheral area of the city. Since scenario II measured accessibility based on the youth-weighted quality score, results indicated that more neighbourhoods were found to have better access to parks and with higher quality from scenario II than scenario I.

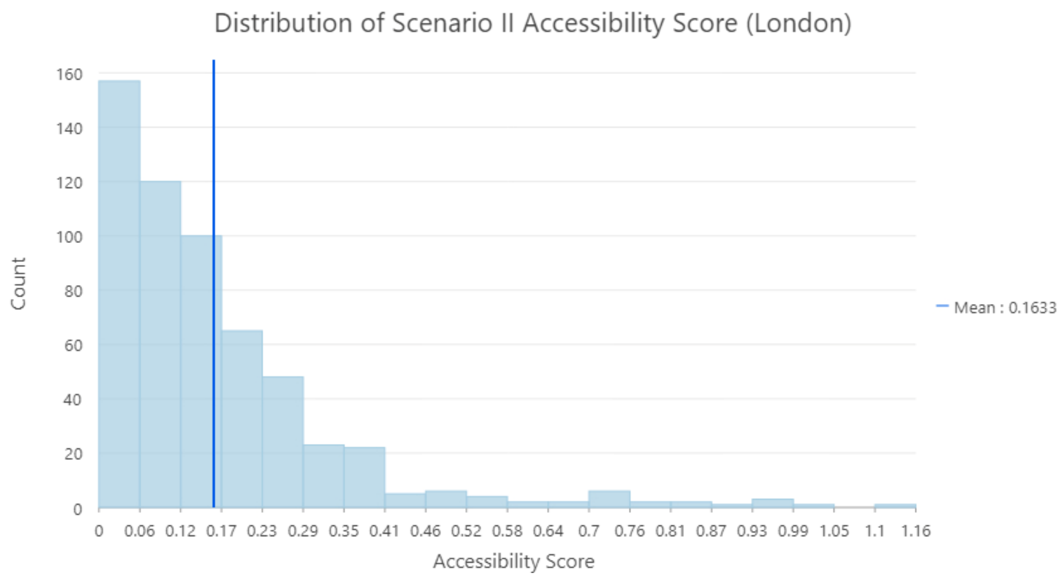

Figure 4.16 - Scenario II accessibility score distribution for London

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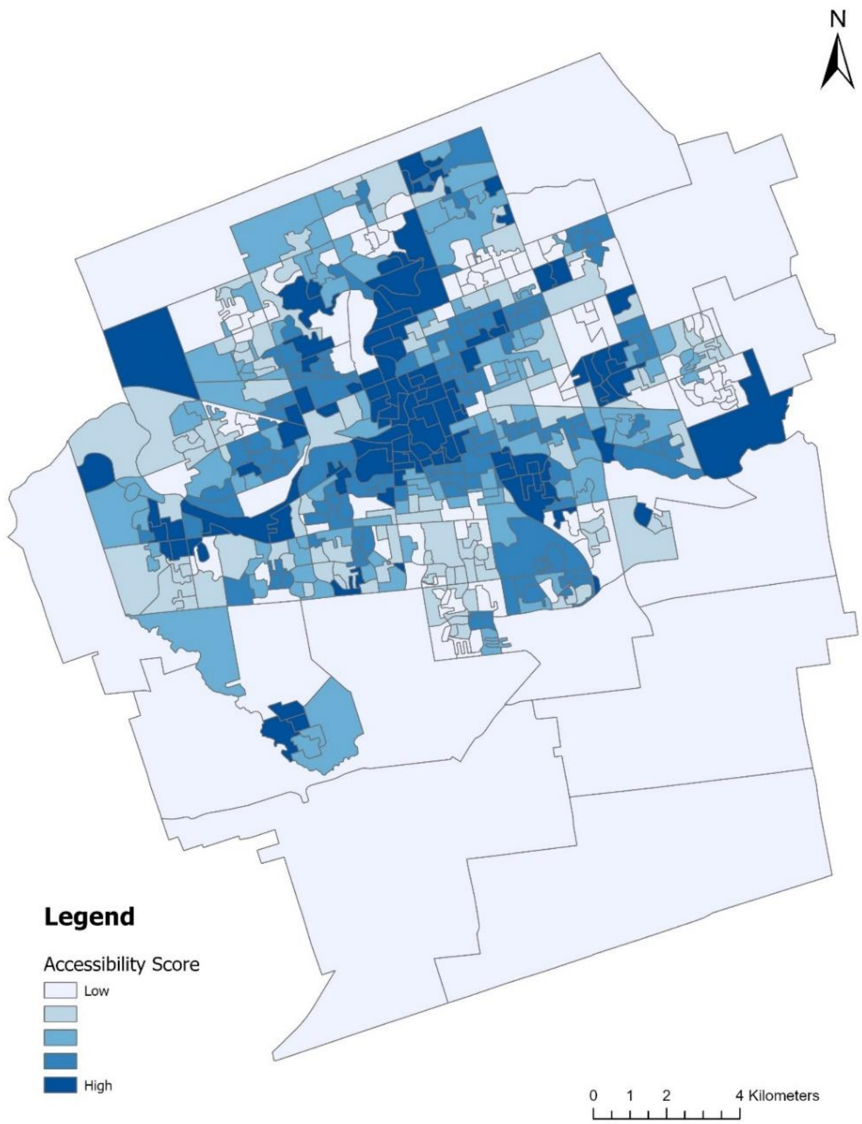

Figure 4.17 - London scenario II accessibility map

Scenario II generated results with similar patterns in Halifax. According to the distribution graph (Figure 4.18), only around 90 DAs had very low to zero accessibility values, much fewer than scenario I which had over 200 zero counts. The accessibility map in Figure 4.19 illustrated where high accessibility DAs were located.

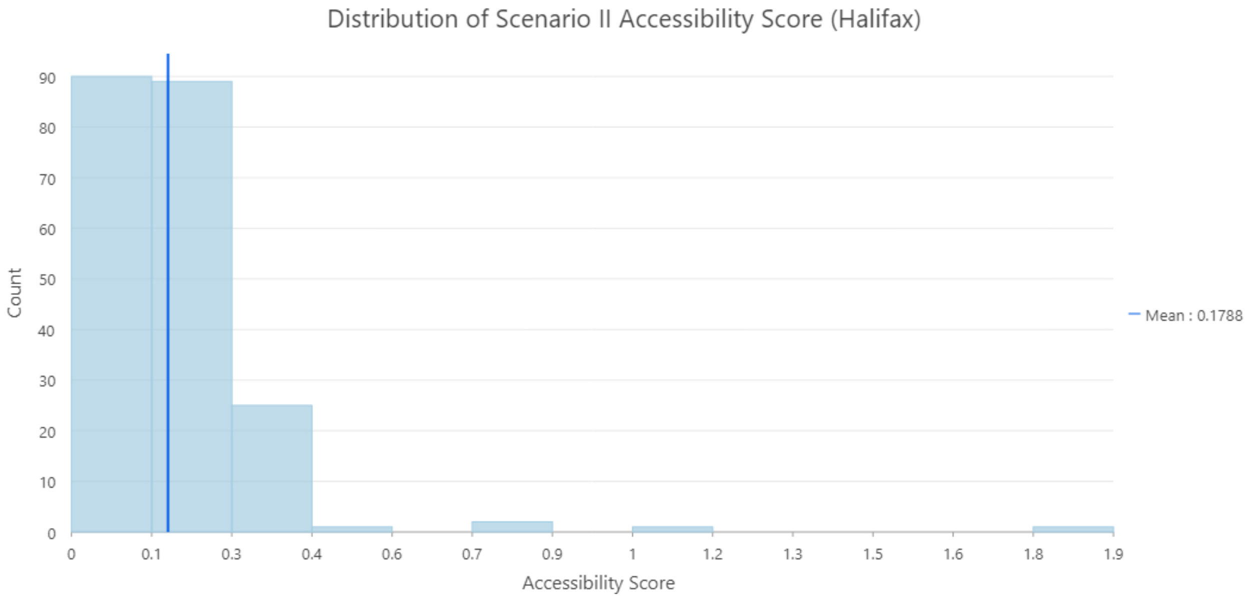

Figure 4.18 - Scenario II accessibility score distribution for Halifax

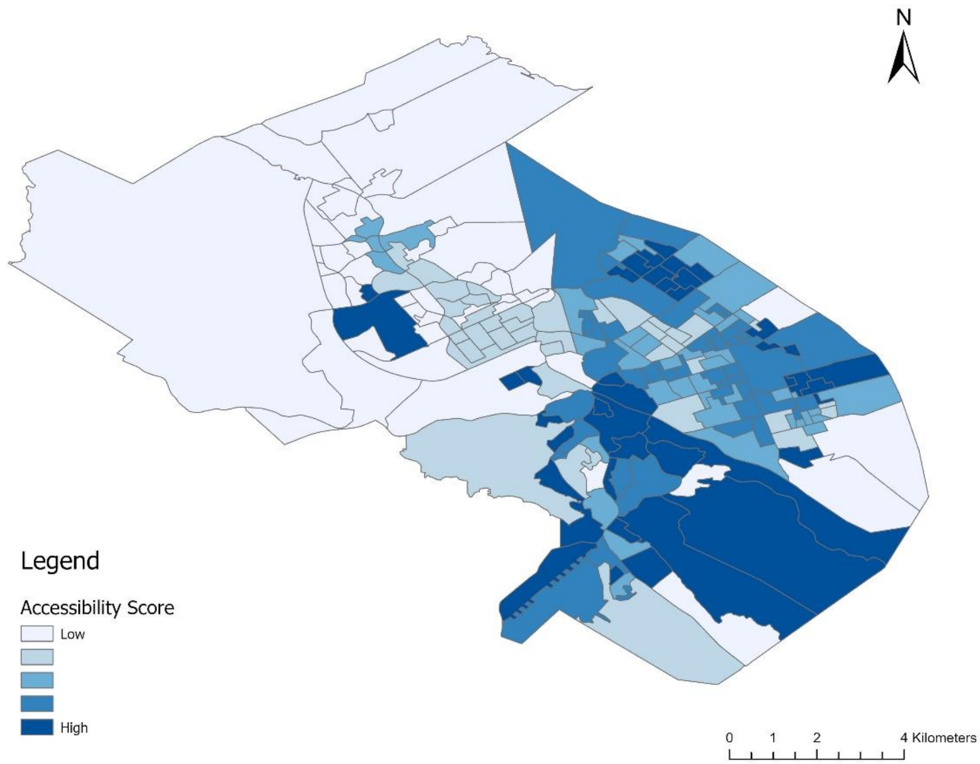

Figure 4.19 - Halifax scenario II accessibility map

4.4.3 Scenario III

Scenario III considers the influence of both park size and park quality equally. For London, the distribution of accessibility scores showed a right skewed pattern similar to scenario II (Figure 4.20). With a mean value (0.08665) smaller than scenario II, the overall accessibility values computed by scenario III situated between scenario I and scenario II for London. The scenario III accessibility results for London were mapped out in Figure 4.21 where high accessibility level DAs were easily identified. According to the map, city centre had the most higher-level accessibility DAs.

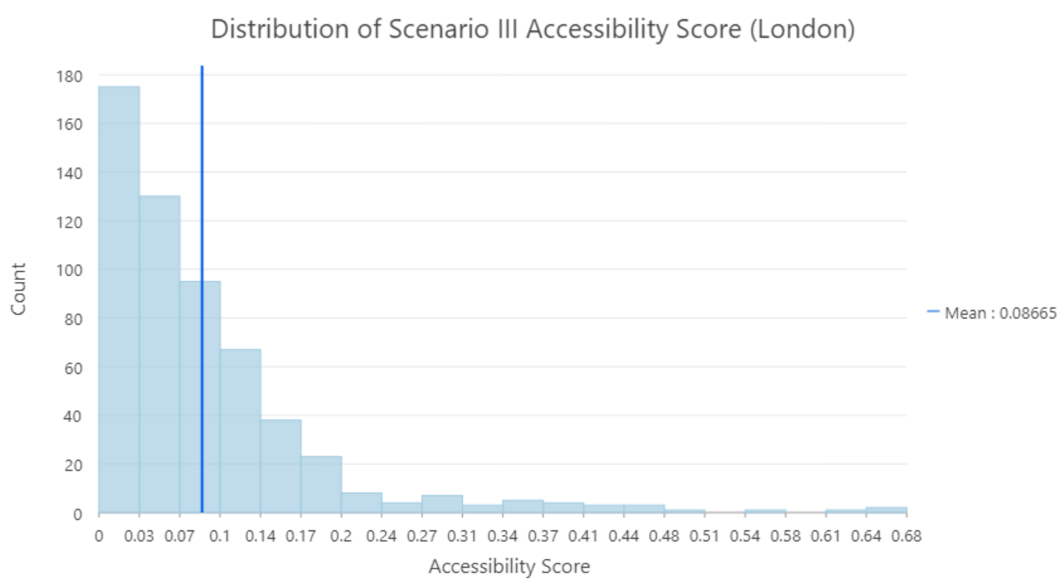

Figure 4.20 - Scenario III accessibility score distribution for London

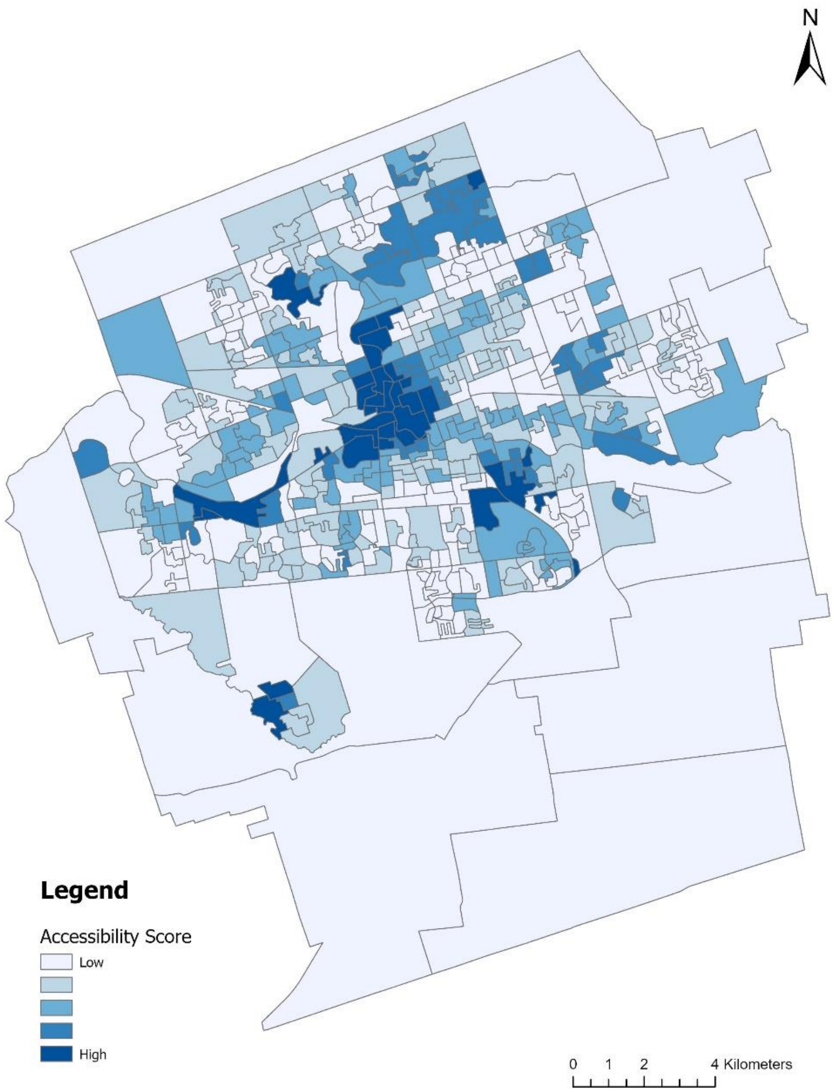

Figure 4.21 – London scenario III accessibility map

For Halifax area, the accessibility score distribution was also heavily right-skewed. With a mean of 0.0931, most DAs had accessibility scores between 0 – 0.1 (Figure 4.22). DAs that had higher accessibility scores were observed around Spryfield, Green Acres, Purcells Cove, and Herring Cove area (Figure 4.23).

Using the same classification, scale, and colour scheme, three scenarios produced different accessibility maps for two study areas. Scenario II computes significantly higher accessibility scores overall compared to scenario I & II, while scenario III can visually better differentiate low and high accessibility values.

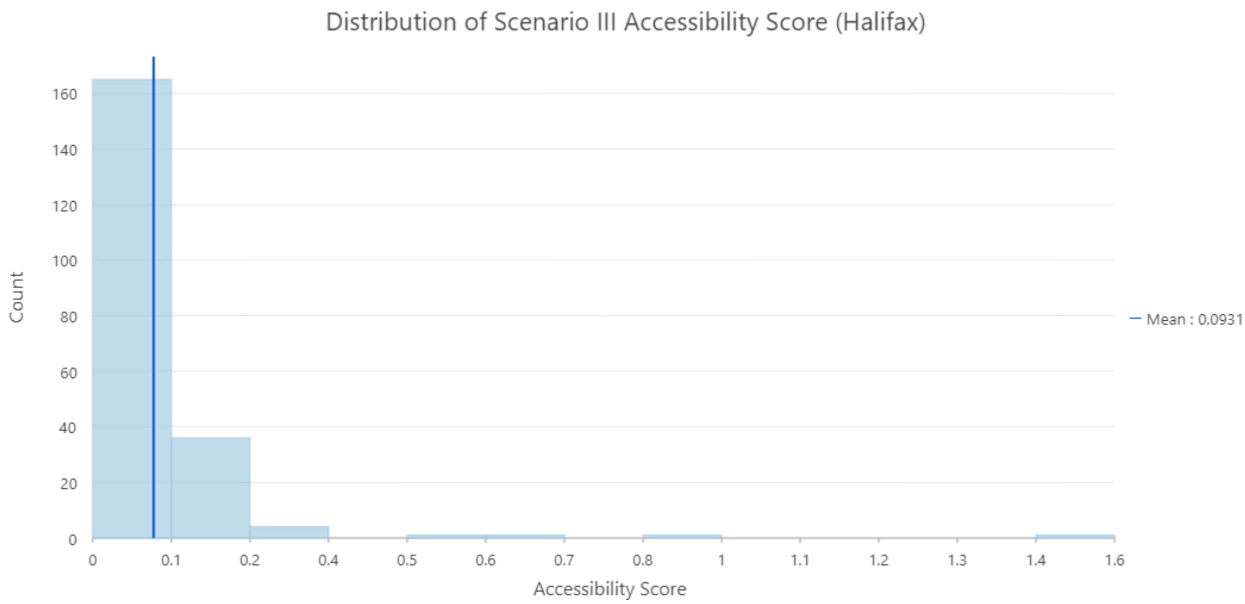

Figure 4.22 - Scenario III accessibility score distribution for Halifax

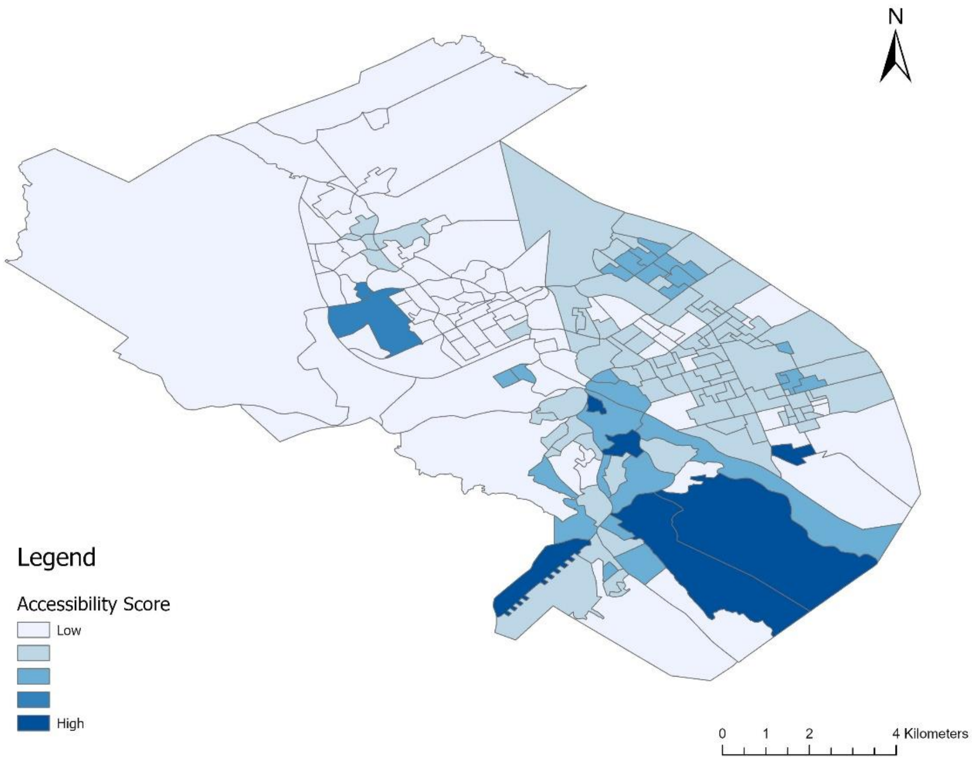

Figure 4.23 - Halifax scenario III accessibility map

Hypothetically, neighbourhoods with higher income would have better access to parks, and neighbourhoods with lower income would have relatively poor access to parks. However, results showed that London had weak to very weak negative correlation between park accessibility (scenarios II and III) and median household income. No statistically significant relationship was found between scenario I and median household income. In contrast, Halifax area demonstrated weak to very weak positive correlation between park accessibility and median household income in scenario I only. Both scenario II and scenario III results were not correlated with median household income.

Table 4.1 - Test results of correlations between median household income and accessibility metrics

	Scenario I (size)	Scenario II (quality)	Scenario III (both)
Median Household Income (London)	Not significant	**Negative** (weak) R = -0.16	**Negative** (weak) R = -0.13
Median Household Income (Halifax)	**Positive** (weak) R = 0.14	Not significant	Not significant

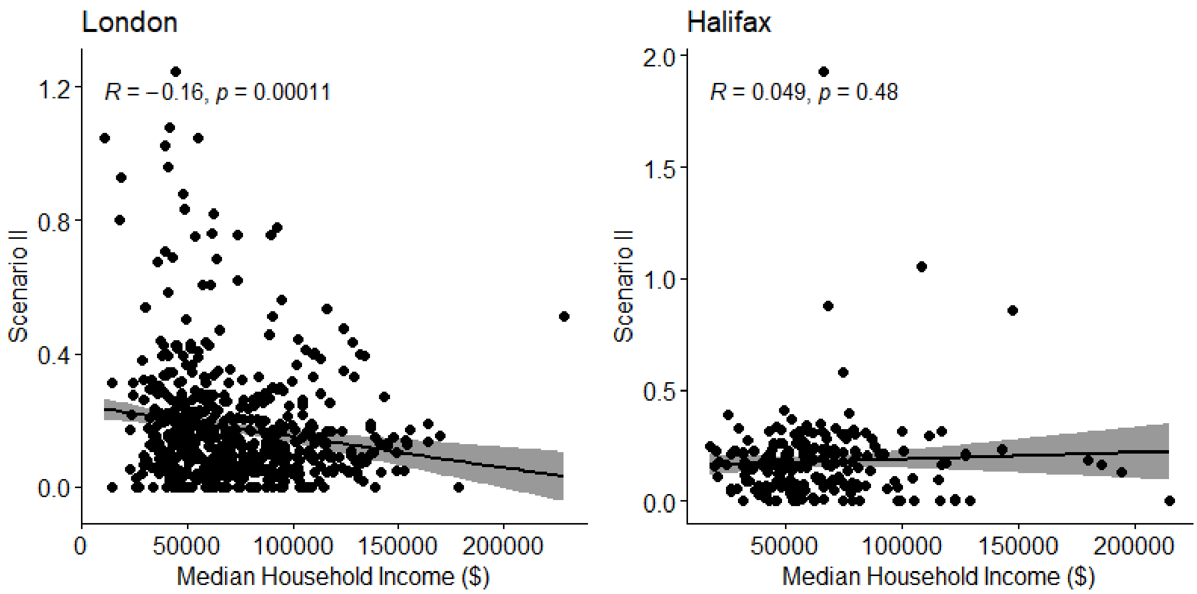

Figure 4.24 - Scenario II vs. Median household income plot

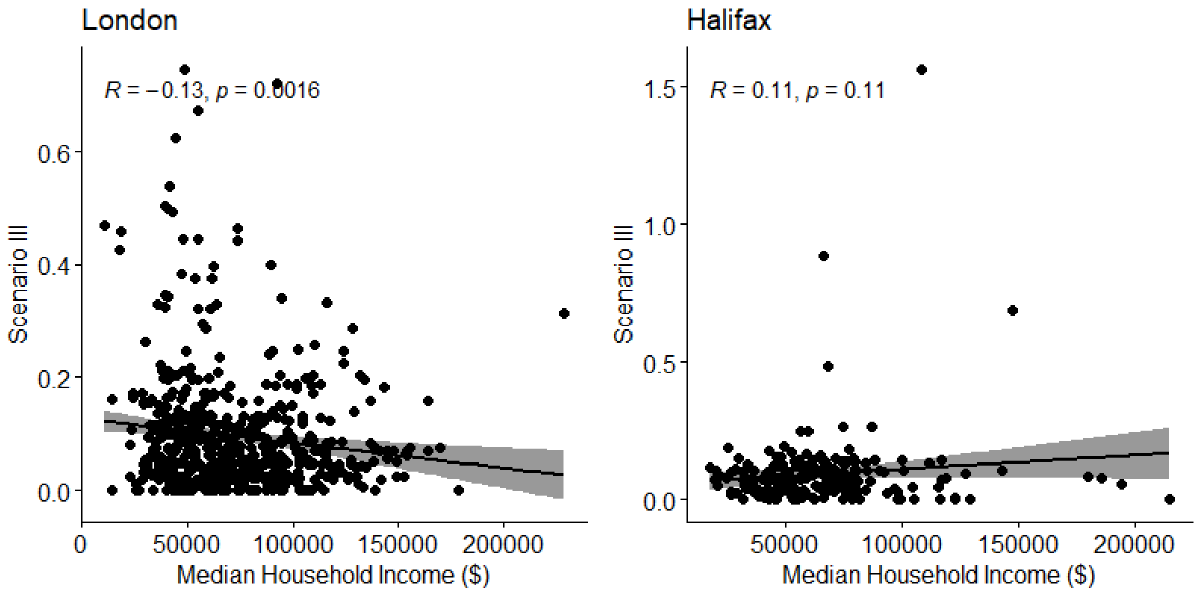

Figure 4.25 - Scenario III vs. Median household income plot

4.5 Conclusion

In summary, this chapter answered the two overarching research questions of this thesis. First, the provision, spatial distribution, as well as the quality of study parks in London and Halifax area showed inconsistent patterns spatially. Some areas in the city adjacent to natural features such as rivers had more parks or parks in larger sizes, whereas other areas had relatively limited parks. The quality of parks also varied drastically across the cities according to the on-site amenities. Accessibility results for both study cities demonstrated that, overall, peripheral DAs had significantly lower-level accessibility to parks, and DAs around urban centres and natural features tended to have higher-level accessibility. However, within urban centres, low accessibility scores were found to be surrounded by higher scores. In addition, by comparing with the population density maps, results showed that DAs with higher youth population densities often didn't have higher-level park accessibility.

This study proposed two alternative methods, measuring accessibility based on quality only as well as quality and size combined. In comparison of the three scenario studies results, the traditional 2SFCA (only based on parks size) reported significantly low accessibility scores, and scenario II (only based on park quality) reported very high accessibility scores. Accessibility results measured using scenario III (quality and size combined) reported scores that helped to better differentiate underserved and well served communities.

With respect to median household income, London demonstrated weak to very weak negative relationships between median household income and scenario II and III results. Halifax demonstrated a weak to very weak positive relationships between median household income and scenario I result. Although those findings were statistically significant, the R scores were quite small, meaning that the correlations were extremely weak.

Chapter 5. Discussion and Conclusion

5.1 Summary of Research

Altogether, the research presented in this thesis uncovered a more comprehensive understanding of the spatial accessibility to urban parks in London and Halifax area for youth. Specifically, this thesis used GIS techniques to generate youth-informed and quality-aware metrics to investigate the accessibility of parks for youth, considering not only park size but also multiple key park characteristics (e.g., the general condition, amenities available, water/vegetation coverage). Additionally, this thesis incorporated youth's perspectives to understand what/how park characteristics influence their choice of parks, which brought valuable input to the research and encouraged youth to be more engaged in research designed for them. This thesis centered around two main research questions that examined the spatial accessibility to urban parks for youth with different median household income status, modified and improved existing methods, and lastly, interrogated how different measures might affect the accessibility results.

To answer these research questions, this study analyzed park geospatial data from the city, park audit data from the ParkSeek project, census of Canada population data, and other open GIS data. Utilizing programming language and GIS software, the results of the data analysis for each research question were presented in the forms of figures and tables in the results chapter. The present chapter summarizes and concludes the key research findings, provides interpretations of the research outcomes, and addresses the limitations. This research brought modified methodology in measuring park accessibility for youth, encouraging more research on youth's park accessibility, and helped to understand how chosen methodology can influence research outcomes and shape our understanding of the study subject.

5.2 Summary of Key Findings

An overarching goal of this thesis is to build a stronger understanding of the youth's accessibility to parks and recreational facilities. This requires examining the spatial distribution and quality of parks to make sure the accessibility results best represent the study population. This section discusses the research findings centred around the two research questions, "*How accessible are parks and recreation facilities in London and Halifax for youth of different socioeconomic* *status?”,* and *“How does the accessibility of parks and recreation facilities for youth vary when park quality is considered?”.*

From visualizing all study parks in two study cities, parks were not uniformly distributed across neighbourhoods. Accessibility results illustrated that neighbourhoods located closer to major natural features such as the river have higher level of accessibility compared to other areas. Those parks are usually larger in size, have more amenities, water, and vegetation coverage, and hence have higher quality scores. Those areas showed consistently high accessibility scores in all the scenarios. Low accessibility scores were mostly observed around the peripheral parts of the city. This might be because rural areas have relatively less population and are further away from urban parks. Since the travel mode under focus is walking, not enough parks were walkable from more distant neighbourhoods. Low accessibility values were also found in more urbanized areas surrounded by higher accessibility values, where underserved communities might be identified. More strikingly, many neighbourhoods that had higher accessibility didn’t have a large youth population. In contrast with being distant from many parks, some neighbourhoods located around urban centres which were close to parks and recreational facilities, still had lower accessibility scores. This might be a result from having lower park quality. Therefore, it suggests that measuring park accessibility incorporating the quality of parks helps to identify more underserved areas for youth.

The quality of parks demonstrated skewed patterns for both study cities, meaning that some neighbourhoods in the city had great quality parks while other neighbourhoods had poor quality parks. Parks and recreational facilities bring enormous potential to improve the physical activity level, mental health conditions as well as social developments for children and teenagers (Ding et al., 2011; Tillmann, Tobin, et al., 2018), yet the provision, accessibility and quality of parks appears to be uneven in both study cities. Ideally, all kids should have easy, equal, and equitable access to all parks and recreational facilities, because children and teenagers have less independent mobility than other age groups. Findings in this thesis highlights some of the disparities in park accessibility for youth. These alarming patterns suggested that planning officials should focus on not only improving the provision but also the quality of parks in the cities.

5.2.1 Advantages of Youth-informed and Quality-aware Accessibility Measures

The extensive health benefits associated with park visitation are linked with the environmental characteristics of parks (Bedimo-Rung et al., 2005), yet most of the GIS-based park accessibility studies have used park size as the sole element that represents park attraction. A major contribution of this thesis is the development of the youth-informed and quality-aware measures using a survey-based 2SFCA method. The measures consider the influence of other park characteristics on park attractiveness when calculating spatial accessibility while incorporating youth's perspective. From the youth-informed survey result, park size is rated as one of the least important park characteristics by youth participants.

This thesis conducted three scenario studies to test and compare how different methods affect study results, answering the second research question "*How does the accessibility of parks and recreation facilities for youth vary when park quality is considered?".* Scenario I refers to the traditional 2SFCA method where only park size is used as the supply level. Scenario II measures accessibility using only park quality as the park attractiveness. Scenario II combines the two, where park attraction is a function of park size and park quality. Overall, scenario I generated accessibility scores much smaller in numbers compared to scenario II. More neighbourhoods with higher levels of accessibility were identified in scenario II than scenario I. Scenario III calculated park accessibility scores ranging between scenario I and scenario II and was able to identify low accessibility values while highlighting higher accessibility values. It can be utilized to better contrast low and high accessibility communities while preserving the nuance within accessibility classes.

Compared to the traditional method (scenario I), accessibility results from the proposed methods (scenario II & III) presented data differently. This highlights the importance of choosing models more carefully and accurately when investigating park accessibility for youth. The proposed methods are not intended to replace any existing method. Building upon existing GIS measurements, this research framework has great potential to be a complete method by itself or an alternative to expand and/or complement existing park accessibility measures for youth specifically. Ultimately, the findings inspire more thinking in how different choice of methodology change the way knowledge is being produced and interpreted.

5.2.2 Social Equity Implications

This study explored the social equity problems associated with park accessibility for youth by looking at median household income. Before running statistical tests, the hypothesis stands that neighborhoods with higher median household income would have better access to urban parks compared to neighbourhoods with lower median household income. However, the hypothesis was rejected based on the test results for London. Median household income at DA level in London had no statistically significant relationship with scenario I accessibility results and had weak negative correlations with scenario II & III accessibility results. These findings indicated that median household income was not positively correlated or not at all correlated with the level of access to parks in London. By contrast, Halifax demonstrated a positive correlation between median household income and scenario I. This correlation was found to be extremely weak according to the Pearson's R correlation scores and P values. The results also revealed no statistically significant relationships between median household income and scenario II & III. These findings for London and Halifax contrasted with previous income-based park accessibility studies in U.S. cities, such as Liu et al.'s (2021) study in Chicago which found that the accessibility of urban green space was found to be the highest among low-income communities.

For London specifically, the median household income map suggests that neighbourhoods that have higher median household incomes are mostly located around the peripheral area of the city. Since income level influences the mobility of population (Corak, 2013; Lucas, 2012), richer households are not likely to rely on public resources to access to recreational facilities. Although median household income doesn't seem to be strongly correlated with youth's park accessibility, future research is encouraged to explore other demographic or socioeconomic factors that may make children and teenagers a vulnerable population group in the study subject.

5.2.3 Park Planning Implications

London is expanding in size and growing in population rapidly. The city has been implementing more urban parks in newly developed neighbourhoods. However, many of them do not contain features favoured by youth according to study results. Since findings emphasized that accessibility results can be significantly influenced when quality is considered, quality should be put into consideration for park planning. If sufficient funding and resources were given to improve the accessibility of urban parks in London, priority would be given to improving the quality of parks for neighbourhoods that have poor accessibility results from Scenario III. Additionally, findings suggested that neighbourhoods with higher levels of park accessibility did not have large youth population. Priority should also be given to planning more quality parks within walkable distance in those neighbourhoods. Lastly, many parks with excellent quality in study cities are not reachable by foot for youth. Therefore, park planners should also consider improving sidewalks for pedestrians to provide safe and walkable routes to parks in underserved neighbourhoods.

5.3 Limitations of Research

Modifiable Areal Unit problem

Modifiable Areal Unit Problem (MAUP) refers to the change in analysis results when using different zoning systems or spatial resolutions (Fotheringham & Wong, 1991; Openshaw & Taylor, 1981). This thesis used dissemination area (DA) as the areal unit for all analysis in this study. Employing other population division units (e.g., census tract, postal code zones) would change the analysis results. In addition, using park entrances or where most park amenities are located as the travel destination would be more suitable than park centroid.

Centroid issue

Geometric centroid is used in this study as the point representation for park and DA. However, it does not consider other characteristics of service facility and population division. On the supply side, some provincial/national parks may have quite large boundaries. Using park entrance as the representation may be more realistic. Amenity-weighted centroid could be another alternative. On the demand side, population weighted centroid could be an alternative.

Public transit issue

This thesis used walking as the travel mode for teenagers. The walking speed is 4.5 km/hr, which assumes that youth all walk in the same speed. This may not be the true representation of the study population. When calculating travel time, the time of the day and crowding issue are not considered. Those two factors may influence the travel time to parks by foot. Besides walking, public transportation, biking and driving may also be used by youth to travel to parks. Those transportation types are not considered in this study.

Water and vegetation coverage

Remote sensing imagery is used when calculating water and vegetation coverage in study parks. All vegetation is treated the same regardless of its type and condition. This is a result of the land classification which only differentiates vegetation from other land cover types. To classify different types of vegetation would require a more sophisticated remote sensing technique which is not the primary focus of this study. Additionally, the calculated water coverage results showed that the water coverage in most parks is minimal in London. This is because much of the water body in the city such as the Thames River is not excluded from the park polygon boundary by the City of London, resulting in parks having very little water coverage but sits beside the largest water body in the city. This can greatly influence water as a visual amenity variable in the quality index. A potential solution is to lower the weight of this variable to eliminate the error.

Audit tool

The audit data are recorded by trained field researchers from the ParkSeek project. Although they were well trained and followed consistent guidelines while conducting park audits, however, the nature of observational data collection involves human errors. Additionally, the conditions of a park may vary depending on the time. For example, some parks might not be available to access during researchers' visits due to maintenance, construction, or natural hazards. In this case no data would be recorded for those parks, and they would be excluded from the study. Moreover, when processing park related data, all empty values are regarded as 0. For example, if a park has no information on a certain park feature, it would be rated as 0, which might not be entirely true.

Youth-informed survey

The youth-informed survey is conducted with the Youth Advisory Council from the HEAL based in London. No participant from Halifax is involved due to the limited research time and resource. Distributing survey on youth from Halifax may produce more appropriate results for Halifax.

5.4 Conclusion

This thesis provided a more comprehensive understanding of the provision, quality, and spatial accessibility to urban parks for youth in two study cities. While identifying the research gap in park accessibility research, this thesis contributes to the existing literature with a new approach that combines park size and quality in park accessibility measures. Additionally, this research recognizes the value of the study population by conducting a youth-informed survey to gain a youth's perspective on park quality. Utilizing public geospatial data and park quality data from the ParkSeek project, spatial disparities in the quality and spatial accessibility to urban parks in two Canadian cities were identified. This thesis emphasizes the need to not only improve urban environments by providing new quality parks, but also park accessibility by improving transportation system (e.g., sidewalks, public transit) to provide better access and opportunities to connect with nature for youth. The research design has great potential to be applied in many other Canadian cities to fill our existing knowledge of Canadian parks for youth.

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Appendices

Appendix A: Youth-informed Park Quality Survey

1. Park features are classified under 6 main categories. Please rank thesis categories by moving them into the order of how important they are to you.

Nature (e.g., water body, shade from trees, trees)

Play facility (e.g., sports court, sports field, playground, pool, walking/biking trail)

Support facilities (e.g., seating, water tap, picnic/barbeque area, restroom)

Maintenance (e.g., cleanliness, monitored by staff, emergency devices)

Safety (e.g., adequate lighting, emergency device, visibility of surrounding roads/houses)

Size (e.g., small neighbourhood park, larger municipal park)

2. Please rank each park feature by how important it is to you on a scale from 0 to 4, with 0 being not important, 4 being extremely important.

	Not at all important		Moderately important		Extremely important
	0	1	2	3	4
Water body					
Vegetation					
Sports court					
Playground					
Pool (including indoor & outdoor)					
Walking/biking trail					
Seating					
Water tap					

Picnic/barbeque area					
Restroom					
Adequate lighting					
Monitored by staff					
Emergency device					
Visibility of surrounding roads					
Visibility of surrounding roads houses					
Trash cans available					
Lack of general litter					
Lack of graffiti					
Lack of vandalism					
Size of the park					

3. Travel behaviour: what is the maximum amount of time (in minutes) you would be willing to walk to a park?

*Answer in numbers only e.g., 15 for 15 minutes

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