COMMUNITY DESIGN INDICATORS AND

NEIGHBOURHOOD POPULATION HEALTH

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ABSTRACT

OBJECTIVE – Healthy community design is an emerging paradigm that unites the fields of Urban Planning and Public Health. This study calculates a comprehensive set of community design indicators (CDIs) using open data sets and links results to a wide range of health measures.

METHODS – A literature review informed creation of a comprehensive CDI framework and indicators were calculated using Geographic Information Systems (GIS) for 106 neighbourhoods in Metro Vancouver, Canada. Correlations were then evaluated between CDIs and both built environment and health measures from the My Health My Community (MHMC) survey.

RESULTS – Several CDIs had moderate correlations with one or more health measures. In particular, there were many associations between CDIs and rates of utilitarian walking and levels of obesity.

DISCUSSION – This study supports professional practice related to evidence-based stakeholder engagement and decision-making, performance-based planning and design, measurement of health, economic and environmental performance of communities, and intersectoral collaborations that create a healthy community design vision and action-oriented implementation strategies.

KEYWORDS

Community Design Indicators; Urban Planning; Population Health; Healthy Built Environments; Neighbourhoods; Metro Vancouver; GIS.

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DEDICATION

I dedicate this project to the late Dr. Clyde Hertzman – a wise and charismatic leader, a Canadian Institutes of Health Research (CIHR) researcher of the year, and founding Director of the Human Early Learning Partnership (HELP) – and to the whole HELP family. I have a core belief that my love for using data to discover patterns and tell stories that can change the world is a direct result of the many years I enjoyed working as a cartographer in the HELP mapping and knowledge translation unit – I am grateful to have been placed in this nourishing environment during a critical period of my development. I hope this study may build on Clyde's legacy and lead to design and creation of healthy neighbourhoods that help children thrive for generations to come.

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1. INTRODUCTION

Healthy community design is an emerging paradigm that unites the fields of Urban Planning and Public Health. This movement relies on evidence-based approaches to evaluate how urban development may impact population health and well-being. Furthermore, this paradigm focuses on strategies to mitigate harmful health effects and enhance protective health effects of planning and design decisions.

Healthy community design objectives are closely aligned with many sustainability objectives such as lower energy use, ecosystem resilience, and economic prosperity. For example integrated land use and transportation planning that leads to increased levels of physical activity and decreased obesity, simultaneously results in reduced greenhouse gas emissions and helps to mitigate climate change (National Centre for Environmental Health, 2016; Shemirani & Hodjati, 2013; Walters & Ewing, 2009). Similarly, healthy communities that protect and enhance parks and natural areas may have more resilient ecosystems that can adapt to climate change. However, there is one important distinction between these two paradigms. Sustainability impacts can be long term and global in scale; while healthy community design can have short term, local and personal health impacts. Therefore, the healthy community design paradigm provides a highly pragmatic framework that may be leveraged to support sustainable urban development.

This new paradigm represents a significant departure from past rational comprehensive planning models that were informed by a small number of powerful decision makers. This new model recognizes the important role that planners and designers play in conducting objective analyses and meaningful stakeholder engagement to collaboratively create a shared healthy community design vision and a rational set of priorities to implement the vision. Community Design Indicators (CDIs) are an important tool to support this new communicative and collaborative planning and design process.

Many urban planning and public health studies have used Geographic Information Systems (GIS) to measure a diverse range of CDIs related to land use, transportation, housing, food and natural areas. Many of these studies have also linked these CDIs to potentially harmful or protective impacts on physical, mental and social health and well-being. However, there is little agreement about the methods that should be used to objectively measure design indicators or how to systematically link a large number of CDIs to a diverse set of health and well-being measures.

For example, indicators including land use mix, street network intersection density, population density, and access to amenities have been linked to physical activity levels and cardiovascular diseases (Frank, 2000; Frumkin et al., 2004; Leslie et al., 2007). Alternatively, the number of grocery stores within a neighbourhood has been linked to consumption of fruits and vegetables and obesity (Black, Macinko, Dixon, & Fryer, 2010; Charreire et al., 2010). There is also a burgeoning focus on how CDIs are related to mental and social health and well-being. For example, increased presence of green space and parkland within walking distance have been linked to lower rates of anxiety and depression and higher levels of social capital and higher sense of community belonging (Lachowycz & Jones, 2011; Wheeler et al., 2015)

A majority of academic studies focus on one or a small number of specialized design indicators, a limited geographic area, or a subset of the total population. Though this approach is useful and somewhat necessary for a systematic exploration of causal links, this approach can make it difficult for interdisciplinary urban planning and public health professionals to gain a broad understanding of how a wide-range of health and well-being indicators may vary across neighbourhood types. Additionally, it is common for academic studies to rely on specialized datasets that are not publically available – this can make replication of results difficult, especially for practicing urban planning professionals. Within this context, this study has two important objectives to address gaps in the current literature.

First, a comprehensive framework for calculating objective CDIs is presented based on a cross-sectional scan of planning and public health literature. Design indicators are grouped within a broad range of planning and design themes such as the following: population and employment density, land use, street intersection density, cycling and public transit networks, and parks and green space. In particular, this review focuses on indicators that can be computed using publicly accessible open data files, to ensure that the design indicators developed in this study can be easily replicated in the future.

Secondly, this study then computes selected design indicators and explores the statistical associations between each CDI and several health outcomes. The Metro Vancouver Area, British Columbia, Canada, is used as a case study for this research, and the health outcome data are taken from the recently completed *My Health My Community* (MHMC) survey. However, the CDI framework is also transferable to other locations and scales of analysis.

1.1. STUDY OUTLINE

The Context section introduces important public health principals, specific factors related to healthy community design, and critically evaluates existing neighbourhood sustainability rating systems and other planning performance measure frameworks. Ongoing intersectoral initiatives that have united the fields of urban planning and public health are also discussed. The Literature Review then provides an overview of methods for using GIS to objectively measure built and natural environments. In addition, this section describes some evidence linking each design theme to health impacts.

The Methods section outlines a comprehensive CDI framework describes the geographic study area, the approach used to compute neighbourhood design indicators and explains the statistical analysis approach used to link CDIs to data obtained from the MHMC survey. The Results section presents design indicator results in a table and a series of complementary maps and statistical associations between a CDIs and a selection of MHMC variables are summarized in two colour-coded correlation matrices.

The Results and Implications section presents a summary of the study objectives and key findings, reviews several study limitations and suggested next steps, and then discusses four implications for professional practice. These implications relate to supporting evidence-based stakeholder engagement and decision-making, informing performance-based planning and design, measuring economic and environmental performance, and inspiring intersectoral healthy community design visions and action-oriented implementation strategies.

2. CONTEXT

This section introduces the public health context for this work and specific evidence-based principles of the healthy community design paradigm. There is also a short critical discussion of existing neighbourhood sustainability rating systems and other planning performance measure frameworks. This section concludes by introducing of relevant intersectoral initiatives such as the Healthy Built Environment Alliance (HBEA) and the MHMC survey that provide resources to help urban planning and public health professionals to collaboratively create healthy communities.

2.1. MEASUREMENT OF HEALTH AND WELL-BEING

According to the *World Health Organization*, health is defined as "the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 2016). However, a majority of health care funding in Canada is devoted to the medical treatment of physical illness and health conditions, with less than 5% of health care funds invested in public health and preventative initiatives (CIHI, 2013). The term well-being is often used to encompass broader social and emotional dimensions of holistic health, and can also reference economic characteristics. The *US Centers for Disease Control* explains that "there is general agreement that well-being includes the presence of positive emotions and moods (e.g., contentment, happiness), the absence of negative emotions (e.g., depression, anxiety), and general satisfaction with life, fulfillment and positive functioning" (CDC, 2016b). Moreover, the *Organization for Economic Cooperation and Development* states that "well-being reflects the level of physical, mental and social well-being of individuals and of populations as it relates to material conditions, quality of life and sustainability of well-being over time." Therefore, both health and well-being are important dimensions of healthy communities.

To understand patterns of health in different communities over time, public health experts commonly monitor patterns of disease and leading causes of death. For example, mortality is a common measure used to compare the average life expectancy of an area or population group. However, this approach does not reflect the underlying morbidity or quality of life experienced by individuals. For more nuanced portraits of health conditions, experts also track the incidence or prevalence of communicable and chronic diseases. Alternatively, to measure broader dimensions of well-being such as a sense of community belonging, social connections, happiness or depression, public health experts often rely on self-reported indicators from large population surveys such as the *Canadian Community Health Survey* or the MHMC survey (MHMC, 2015b).

The wide range of factors that influence population health are generally known as the social determinants of health (Raphael, 2009). These determinants can have both protective and harmful impacts on health through the life course. According to *Health Canada*, key social determinants of health include the following: Income and social status, social support networks, education and literacy, employment and working conditions, social environments, physical environments, personal health practices and coping skills, healthy child development, biology and genetic endowment, health services, gender, and culture (Government of Canada, 2001).

Individual health conditions such as the likelihood of developing a chronic disease, being diagnosed with a type of cancer, or suffering a type of injury are generally related to the following risk factors described by the *Public Health Agency of Canada*: background factors, such as age, sex, and genetic composition; socioeconomic and cultural factors, such as poverty, employment status, norms and values; physical environment factors, such as exposure to air pollution, access to housing, transportation options, or access to green space; and lifestyle factors, such as alcohol and tobacco use, unhealthy diets and physical inactivity (Government of Canada, 2008).

Urban planning and design decisions may have both direct and indirect impacts on many of these population-level determinants and individual risk factors.

2.2. HEALTHY COMMUNITY DESIGN

Just as doctors conduct tests to determine if we are healthy, urban planners can identify elements of community design that may promote healthy lifestyle factors and result in improved physical, mental and health measures. These principles form the foundation of the emerging urban planning paradigm that seeks to enhance protective benefits and mitigate harmful impacts of urban development on population health and well-being. For example, a fact sheet from the *US Centres for Disease Control* lists the following healthy community design principles (CDC, 2016a):

- Encourage a mix of higher density, residential and employment land uses;
- Provide frequent public transit service to reduce dependence upon automobiles;
- Build good pedestrian and bicycle infrastructure, including sidewalks and bike paths;

- Ensure affordable housing is available for people of all income levels;
- Create outlets for fresh fruits and vegetables, such as community gardens and farmers' markets;
- Create vibrant public spaces where people can gather and mingle as part of daily activities; and
- Offer access to green space and parks for recreation and reflection.

Moreover, there is some evidence linking these design principles to the following population health and well-being benefits (CDC, 2016a):

- Increased levels of physical activity;
- Better air quality;
- Lower risk of accidental injuries;
- Healthier eating habits;
- Greater social connections and sense of community; and
- Lower greenhouse gas emissions that contribute to climate change.

For example, in a community that has good quality sidewalks and many destinations located within walking distance of homes, residents drive less, are more physically active, and are less obese. In a community that has access to parks and green space, residents may have lower levels of stress and a greater sense of community belonging. While part of this association can be explained by residential self-selection (i.e., when individuals are able, they often choose their residential neighbourhood based on their lifestyle and travel preferences), research suggests that urban design and land use planning decisions may have a moderate yet direct impact on lifestyle behaviours relating to chronic diseases such as heart disease, diabetes or stroke.

2.3. NEIGHBOURHOOD RATING SYSTEMS AND PERFORMANCE INDICATORS

There are now several evaluation tools to measure 'sustainability performance' of communities using neighbourhood rating systems (Sharifi & Murayama, 2013). However, there are a limited number of rating systems that focus specifically on community design indicators related to health and well-being. Therefore, this section critically reviews the value of these rating systems for achieving healthy community design objectives and then explores alternate public sector initiatives for measuring neighbourhood-scale design indicators.

One well-known neighbourhood certification framework is the LEED-Neighbourhood Development (ND) rating system. The term "LEED" stands for Leadership in Energy and Environmental Design, a program administered by the U.S. Green Building Council, a private, non-profit organization. The LEED-ND rating system was created to measure the sustainability and spatial connectedness of neighborhoods, based on objective and repeatable measures. This rating system uses an approach similar to other building-scale LEED rating systems and awards levels such as gold or platinum based on a number of points achieved on several scales. In particular, LEED-ND contains a set of measurable standards that collectively identify whether a proposed development of two buildings or more can be deemed environmentally superior to the status quo, considering the development's location and access, its internal pattern and design, and its use of green technology and building techniques (USGBC, 2014a). This tool is similar to other standards such as the BREEAM Communities, and CASBEE-UD tools (Sharifi & Murayama, 2013).

Boeing, Church, Hubbard, Mickens, & Rudis, (2014) critically reviewed the LEED-ND rating system and concluded that "although the framework has been adopted by many cities as a de facto measure of 'livable' neighborhood design and used to accelerate development processes [the framework does not] accurately capture livability as defined by residents, and many communities cannot qualify for the certification due to technical requirements". Therefore, Boeing et al. (2014) concluded that the weighted, prescriptive design guidelines [of neighbourhood rating systems] may not be able to reflect the diverse values and desired amenities of different communities.

Alternatively, a recent critical review of seven selected neighborhood sustainability assessment tools by Sharifi & Murayama (2013) concluded that the practice of neighborhood sustainability assessment is, to a large extent, market-driven and characterized by the dominance of the environmental aspects of sustainability. This finding supports the need for alternate approaches that are based on public data and non-commercial interests. Sharifi & Murayama (2013) also found that although many researchers have focused on empirical aspects of building assessment tools, very few have focused on neighborhood-scale sustainability assessment tools. This suggests there is a need for more research – like the current study – that reviews neighbourhood design indicators and systematically evaluates results.

More conceptually, spatial design indicators can be considered an important planning tool to help bridge the gap between healthy community design visions and policy objectives, and more specific design interventions and actions. Kellett & Girling, the creators of an interactive scenario analysis platform called ElementsDB, (2015) explain that “in community design, indicators play a crucial translation role between aspirations and concepts (‘big picture visioning’) and implementable actions, including the design and spatial arrangement of infrastructure, buildings and open space.” Kellett & Girling (2015) summarized the role of CDIs in the community planning process using the conceptual diagram shown in Figure 2.1.

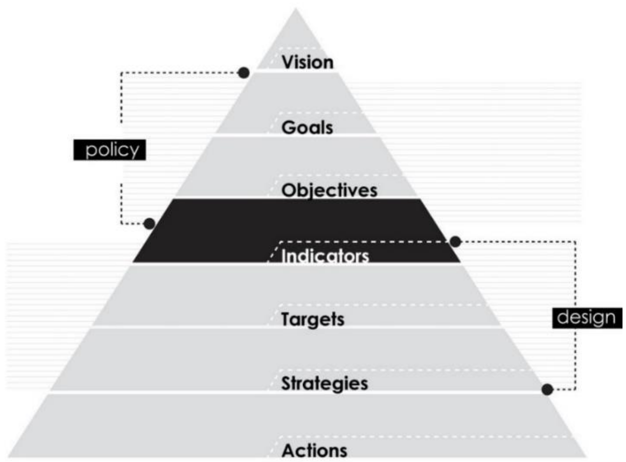

Figure 2.1 - The role of indicators in the planning and design process (Kellett & Girling, 2015).

Over the past few decades, it has also become increasingly common for governments to rely on performance indicator frameworks to evaluate the implementation of planning and design policies and projects. For example, the Government of Ontario (2015) created a set of *Performance Indicators for the Growth Plan for the Greater Golden Horseshoe, 2006* to track provincial land use and transportation policy objectives using GIS (Government of Ontario, 2015). The City of Vancouver created the *Greenest City Action Plan* that includes several specific, measurable targets that can be calculated using GIS (City of Vancouver, 2015). Some municipalities have also created other custom rating systems to directly evaluate new development applications, such as the framework created by the City of Vaughan (2016) that integrates several measures from the LEED-ND rating system into a more open and flexible framework for evaluating sustainability performance.

Some jurisdictions now require a Health Impact Assessment (HIA) in addition to a traditional Environmental Assessment (EA), to evaluate specific impacts on health and well-being that may be associated with the development of new planning and design projects, such as industrial developments or rapid transit investments (National Center for Environmental Health, 2015).

Similarly, there have been a small number of custom HIA scenario evaluation tools created to measure potential health impacts of planning decisions. For example, Toronto Public Health developed a 'Health and Environment Enhanced Land Use Planning Tool' that provides health-related indicators such as levels of physical activity and travel choices based on built environment variables such as housing density, distance to transit stops, the length of cycling facilities, and intersection density based on future land use and transportation scenarios (Toronto Public Health, 2013). This tool is publically available, but unfortunately, it does require costly software and advanced knowledge to implement.

These public sector examples provide a more local, nuanced set of criteria that can be used for measuring CDIs, however to date a majority of these initiatives have focused on environmental and economic performance measures. Therefore, the current study integrates several measures from the frameworks identified above, along with other design indicators identified in public health and planning literature focused on CDIs that have been linked to potential population health impacts.

2.4. INTERSECTORAL COLLABORATION

To successfully bridge the gap between planning and successful implementation, it is useful for urban planning and design professionals to actively seek opportunities to partner with local public health experts. A recent paper summarized the benefits of intersectoral collaboration, and found that the recent Healthy Canada By Design initiative "demonstrated the potential for public health organizations to partner with municipal and regional planning departments, provincial governments, federal government agencies, researchers, community groups and NGOs […] to influence the built environment determinants of cancer and chronic diseases" (Miro, Kishchuk, Perrotta, & Swinkels, 2015).

To support this type of intersectoral collaboration the BC Provincial Health Services Authority (PHSA) has brought together several urban planners and public health professionals in the *British Columbia Healthy Built Environment Alliance (HBEA)*. One of the biggest opportunities this group has focused on is the need to create a shared vocabulary and evidence base to facilitate conversations between health practitioners, urban planning and design professionals, and other stakeholders.

For example, the HBEA recently summarized the strength of peer-reviewed evidence linking planning decisions to potential health impacts and released a document called the *Healthy Built Environment (HBE) Linkages Toolkit* (PHSA, 2014). This Toolkit outlines a useful conceptual model for understanding how land use, housing, transportation networks, food systems, and natural area planning and design decisions have been linked to both direct health impacts and secondary health-related outcomes (PHSA, 2014). However, the *Toolkit* does not include any objective planning and design indicators that can be used to evaluate the current performance of different communities or measure changes over time. Therefore, the current study may provide a useful extension of this work, and further enhance the framework outlined in the *Toolkit.*

The MHMC survey is another recent initiative that can support intersectoral collaboration between population health experts and urban planners. The survey was created in a collaboration between Vancouver Coastal Health and Fraser Health Authorities, in partnership with the University of British Columbia eHealth Strategy Office (MHMC, 2015a). The survey was designed to provide timely, geographically precise self-reported health and built environment data. Measures from the MHMC survey have already been used to establish a statistical association between Body Mass Index (BMI) and WalkScore ratings (Klar et al., 2015), but there remains a significant opportunity to link more diverse CDIs to survey results.

Appendix A lists all the MHMC survey domains and variables that were publically released from the MHMC survey, along with a summary of overall results for the Metro Vancouver Region. These data were obtained from the website www.myhealthmycommunity.org. In addition, the methods section of this report describes how neighbourhood-scale measures from the MHMC survey related to built environment and health were linked to neighbourhood-scale CDIs in the current study.

In conclusion, intersectoral collaboration is considered to be an essential process that can help unite diverse stakeholders in across the 22 distinct municipal governments and additional administrative areas in Metro Vancouver – and other communities, cities, and regions around the world. This process relies on the creation of a shared, intersectoral healthy community design vision to guide future growth and development priorities.

3. LITERATURE REVIEW

This literature review summarizes best practices for calculating CDIs using GIS and provides a brief summary of evidence that links each design indicator to potential impacts on healthy lifestyles and physical, social and mental health and well-being.

To focus the scope of this review, it is important to contextualize the characteristics of the CDIs that are considered in this study. Broadly speaking, the type of CDIs considered in this review may also be referred to as healthy built environment or performance indicators. This review focuses on neighbourhoods-scale analysis methods; however, evidence from individual scale studies is also considered. In these cases, individual indicators have may be based on circular buffers or network-based walksheds surrounding a home location. This approach provides a 'custom' neighbourhood for each resident that may improve the accuracy of measurement and better reflect individual exposure to local residential environments. In other cases, this review considers methods originally described for larger study areas such as city centres or municipalities.

This review focuses on evidence from a wide range of Canadian and North American urban areas, therefore many indicators and potential health impacts may not be relevant to more rural communities. Finally, this review is focused on methods that can be implemented using open datasets that are currently available for the Metro Vancouver region.

3.1. DESIGN INDICATOR METHODS AND HEALTH IMPACTS

This section summarizes a scoping review of planning and public health research that relied on objective measures of community design calculated using GIS. Five planning and design themes were selected to align with the *HBE Linkages Toolkit* (PHSA, 2014) to ensure results of this study are useful to support future intersectoral collaboration. For reference, a short summary of the Toolkit framework is included in Appendix B. A total of 13 planning and design categories were identified during this review, shown in the following list grouped by theme:

- **Land Use** - Population and Employment Density, Balance of Jobs and Residents, Land Use, Focused Growth Areas and Distance to Cities
- **Transportation** - Walking Network, Cycling Network, Transit Network, and Major Road Network
- **Housing** - Dwelling Types

- **Food Access** - Grocery Stores and Protected Agricultural Land
- **Natural Areas -** Parks, Green space, and Trails

Each section provides a brief description of existing peer-reviewed literature and public reports that have considered each indicator category, along with a summary of how each indicator was linked to potential direct and indirect health impacts. Where appropriate any specific critical thresholds or optimal ranges for CDIs are also discussed.

3.2. LAND USE

3.2.1. Population and Employment Density Indicators

INTRODUCTION: Population and employment density indicators describe the number of people, jobs or combined number of people and jobs within a specific area of land. Some studies also focus on the density of dwellings, which may be considered a closely related measure, although various dwelling sizes make this measure less directly related to overall population density. Alternatively, gross density generally includes all land within areas, while net density is often calculated based on the specific area of residential and/or employment lands, excluding road right of ways and parks or open space.

CRITICAL THRESHOLDS: There is some indication that a minimum density of approximately 30 people per hectare is required to support ridership levels that make a local bus route viable while areas with greater than 100 people per hectare can generally make frequent transit service viable (Government of Ontario, 2012). However, this viability measure may be impacted by local travel behaviour characteristics related to employment rates, car ownership, and general distance from a city centre. Density measures are also an important element of the Government of Ontario's *Growth Plan for the Greater Golden Horseshoe* that established density targets ranging from 150 to 400 people and jobs *combined* per hectare to encourage "focused growth that supports regional focal points and more compact, mixed-use, transit-supportive and energy efficient communities in the region" (Government of Ontario, 2015).

DISCUSSION: A recent systematic review of built environment factors related to physical activity and obesity risk found a consistent relationship between higher density development and increased levels of physical activity, primarily walking, although associations with other forms of physical activity were less common, and there were a limited number of studies that linked density to healthy body weights (Durand, Andalib, Dunton, Wolch, & Pentz, 2011).

3.2.2. Balance of Jobs and Residents Indicators

INTRODUCTION: This indicator describes the ratio of people who work in an area relative to the number of jobs in the area.

DISCUSSION: Several studies have compared the balance of residents and employees in each neighbourhood to evaluate the potential for employees to live and work in close proximity, potentially resulting in lower overall commuting distances and lower vehicle kilometres travelled (VKT). For example, Frank et al. (2006) found a significant link between this indicator and lower overall travel distances and higher rates of physical activity.

Miller (2011) also found that jobs-housing balance has a statistically significant impact on commute-related travel, specifically, he used a longitudinal regression analysis and found that that the average impact of the US state of Virginia improving its balance by 20% was associated with a reduction in commuting time of 2.2 min (7% of the average urban value). Peng (1997) investigated relationship between the jobs-housing ratio and urban commuting patterns in terms of vehicle miles travelled (VMT) and trip length – this study used “a dynamic buffering process” in GIS to measure the jobs-housing ratio within a floating catchment areas of a 5-7 mile (8.05-11.27 km) radius as opposed to pre-defined and arbitrary jurisdictional boundaries. This study found a non-linear relationship between the jobs-housing ratio and VMT and trip length in the Portland, Oregon metropolitan area (Peng, 1997). These findings confirm the suggestion that both low and high scores on this indicator may result in longer trips and potentially lower levels of physical activity related to walking or cycling.

3.2.3. Land Use Indicators

INTRODUCTION: This set of indicators evaluates the percentage of the total area of each neighbourhood that is designated for specific land uses. These indicators are somewhat dependent on the data that are available for each community. For example, the following categories evaluated by the Government of Ontario (2015):

- Rural residential;
- Single family, duplex, and townhouse, residential
- Apartment residential;
- Mixed-use apartment;
- Commercial;
- Institutional;
- Industrial; and
- Parks and open space.

It is also useful to calculate land use mix indicators that provide a single measure to describe the relative number of land use types and balance of total areas in each category within a study area. One commonly cited land use mix measure was outlined by Frank et. al. (2006). However, this method only evaluates the mix of residential, commercial, institutional and green space. An alternate method is outlined by the Government of Ontario (2015). This approach is similar but uses the widely known ecology-based Simpson Diversity Index (SDI) to measures the relative proportion of seven types of land use including the following: commercial, institutional, industrial, mixed-use, parks and open space (including recreational), low-rise residential and multiple-family residential. The index is calculated for a specific geographic area by comparing the amount of land in each land use category to the amount of land occupied by all land uses (Government of Ontario, 2015). Values for the index range from 0 to 1: a value closer to 0 has a low diversity while a value of 1 may be a very diverse number of uses with an equal distribution of areas. The formula for this index is presented below:

$$D = 1 - \left(\frac{\Sigma\, n(n-1)}{N(N-1)} \right)$$

DISCUSSION: The presence of and balance of specific land uses in a neighbourhood may increase the potential for a complete community where residents can live, work and play within walking distance. However, certain land uses such as industrial or agricultural areas may be a barrier for movement and negatively impact the vibrancy of a community, or have other negative or protective impacts on health.

A majority of research related to single land use areas is focused on the connections between industry and environmental risk. For example, Nixon, Lejano, & Funderburg (2006) used GIS to develop measures related to spatial distribution and clustering of industrial land uses and made recommendations for land use planning related to the separation of ‘dirty’ industries from residential areas.

A unique study by Chum, O'Campo, & Matheson (2015) found a positive associations between sleep problems/duration and commercial density, residential density, and industrial land use, however, these associations were fully attenuated after controlling for traffic levels and self-rated noise, which suggests that land use was associated with elevated levels of noise and traffic, which in turn negatively impacted sleep. This finding relates to a study that randomly selected locations in mixed use and residential areas in the Halifax region of Canada and based on GIS analysis found that average noise levels were in the moderate to serious annoyance range with the potential to obscure normal conversation and cause sleep disturbance (King, Roland-Mieszkowski, Jason, & Rainham, 2012).

Conversion of natural areas to high-intensity uses such as commercial, mixed use and high-density residential land uses is associated with greater areas of impermeable surfaces that limit the ability of rainwater to infiltrate on site. This can negatively impact local water quality, result in decreased aquifer recharge and lead to a higher risk of flooding during extreme weather events (Lin, Hong, Wu, & Lin, 2007). These impacts may be mitigated using on-site stormwater management techniques, often referred to as green infrastructure (Jia, Tang, Luo, Li, & Zhou, 2016).

Land use mix is often calculated for local walksheds surrounding home locations since land uses outside a local area may have a lower impact on individual behaviour. Oliver, Schuurman, & Hall (2007) compared circular and network buffers to examine the influence of land use on walking for leisure and errands and found a significant relationship between walking and built environment based on land use mix within 800-metre network-based buffers. However, the scale of analysis may have a significant impact on research findings as discussed by Duncan et al. (2010) who found that "Relationships between land use mix (LUM) and physical activity have not been apparent in some studies, which may be because geographical scale". In particular, Duncan et al. (2010) explain that administrative or neighbourhood boundaries can reduce the accuracy of walking environment measures.

Health impacts related to land use mix include links between higher diversity and increased walking and cycling for utilitarian trips, lower automobile dependence, higher physical activity, lower obesity, and reduced risk of chronic disease (Frank et al., 2006; Toronto Public Health, 2013). Similarly, Durand et al. (2011) identified this measure being used more consistently than any other built environment measure - 107 times of the 204 papers included in their systematic review of built environment literature. The authors found a consistent positive relationship between higher land use mix and increased levels of physical activity and walking in particular. Additionally, there is some indication that higher land use mix may indirectly lead to a reduction in mental health problems like depression due to lower overall commuting time (Frank et al., 2006).

3.2.4. Focused Growth Area Indicators (Growth Planning Areas)

INTRODUCTION: Urban containment policies encourage new development to be focused within prescribed planning areas, such as urban growth centres, or within some sort of outer containment boundary. The Metro Vancouver Regional Growth Strategy for 2040 includes a hierarchy of planning growth areas, ranging from Urban Centres with higher density, Frequent Transit Development Areas (FTDAs) where moderate density transit oriented development (TOD) is encouraged, and an Urban Containment Boundary (UCB) that is intended to focus future growth within or adjacent to existing built-up areas and limit urban sprawl. To understand how current neighbourhoods are situated in the planning fabric, it is possible to evaluate the percentage of residents in a study area or neighbourhood who live within each of these planning boundaries.

DISCUSSION: These indicators are also inversely related to urban sprawl, marked by homes located outside designated growth areas and far from any destinations. These residents likely rely on cars for most daily activities. Auto dependence was evaluated within 37 international cities by Newman & Kenworthy (1999), who found that cities with the most car use, road provision, and urban sprawl have the highest road expenditure, the least transit cost recovery, the most spent on commuting, the highest external costs from road deaths and emissions, and the largest proportion of city wealth going into transportation.

Aytur, Rodriguez, Evenson, & Catellier (2008) compared a number of cities and found “strong urban containment policies were associated with higher population levels of leisure time physical activity and rates of walking/bicycling to work. Numerous studies have found that people living in sprawling auto-dependent areas are much more likely to have a higher body mass index and have high blood pressure (Frank, Andresen, & Schmid, 2004; Frumkin, Frank, & Jackson, 2004). Alternatively, longer commute times associated with urban sprawl may lead to a lower sense of community belonging and levels of depression and aggression (Frank et al., 2004; Hystad & Carpiano, 2012).

3.2.5. Distance to City Indicators (Urban-Rural Spectrum)

INTRODUCTION: This indicator category relates to the contextual location of a community relative to a city centre or the central business district (CBD). Within the Metro Vancouver context, there are two distance measures that can be considered to provide a means to evaluate the neighbourhood location relative to the downtown core and regional urban centres. These measures are intended to primarily reflect the extent to which communities may be considered urban or rural, a spectrum that can impact health and well-being in many ways. The current study area may be considered entirely urban because all neighbourhoods are within the Greater Vancouver Census Metropolitan Area, however, there are still important inter-urban variations worthy of consideration.

DISCUSSION: The health impacts of this indicator are primarily related to car-dependant lifestyles and longer average commuting distances – that are very similar to the evidence presented in the previous section focused on urban sprawl and lower levels of physical activity. Lopez-Zetina, Lee, & Friis (2006) reviewed the link between vehicle miles travelled in California and observed a significant association between obesity and physical inactivity and commute time. There are also more specific lifestyle differences in rural settings. Itoi, Yamada, Watanabe, & Kimura (2012) compared objectively measured levels of physical activity and rates of obesity among sixth-grade children and found the obesity prevalence was significantly higher in rural areas compared to urban children. This finding is aligned with meta-analysis paper that confirmed "the prevalence of obesity is higher among rural youth than urban youth" based on research related to diets and physical activity levels (McCormack & Meendering, 2016).

Past research has explored how variations in levels of access to important community services decline in more rural areas across British Columbia. For example, a recent project completed by the Human Early Learning Partnership, evaluated various levels of 'remoteness', based on access to a range of health services across the Province of BC (Smith, 2011). For example, rural locations were linked to reduced access to dental services (Poon, Hetzman, Holley, & Smith, 2012), and regional variations in the use of contraception (Soon, Leung, Smith, & Shoveller, 2011). Similar studies have also been focused on a wider range of patterns related to alcohol use, accidental injury and rates of cancer (Gregory, 2009; Pong, DesMeules, & Lagacé, 2009).

Rurality has also been linked to a higher sense of community belonging – although this finding may be related to the higher rates of home ownership and longer length of residence in a specific location in rural contexts (Hystad & Carpiano, 2012; Kitchen, 2012) – and better air quality. However, these findings are aligned with concepts related to natural areas that are discussed in a later section of this review.

3.3. TRANSPORTATION

3.3.1. Walking Network Indicators

INTRODUCTION: The number of street intersections per square kilometre provides a measure related to the network connections that are available to provide direct walking routes between locations – the more intersections, the greater is the degree of connectivity of the network which can result in greater opportunities to walk. In addition, intersections along highways and highway ramps are generally excluded from all analysis as these would confound the indicator results with non-walkable connections. However, intersection density is distinct from walkability, which includes other measures such as access to amenities in addition to raw network intersection density (Klar et al., 2015).

CRITICAL THRESHOLDS: This indicator is discussed in the Ontario Ministry of Transportation's *Transit-Supportive Guidelines* (Government of Ontario, 2012) that recommends municipalities achieve a street intersection density of greater than 0.3 intersections per hectare, with higher street intersection densities of over 0.6 intersections per hectare in mixed-use nodes and corridors. Alternatively, the LEED-Neighbourhood Design rating system rewards areas with 0.4-0.5, 0.5-0.6 or over 0.6 intersections per hectare with sequentially higher points (National Centre for Environmental Health, 2016).

DISCUSSION: Health impacts associated with this indicator are related to evidence that people who live in communities with a well-connected street network that makes it safe and convenient to walk or bike to daily activities like shopping, work, school, and recreation are generally more physically active (Government of Ontario, 2015). Moreover, incorporating physical activity in daily routines helps reduce our risk from leading chronic diseases such as stroke, cardiovascular disease, and some types of cancer such as colon and breast cancer (CDC, 2016a). On the other hand, the health risk of low physical fitness may be greater than the risks of hypertension, high cholesterol, diabetes, and smoking (CDC, 2016a).

There is some debate about whether people who prefer to walk generally move into neighbourhoods where they can walk, or if the presence of connected road networks actually cause people to walk. However, some recent work has begun to disentangle this relationship and show a causal link between greater connectivity and marginal walking (Riva, Gauvin, Apparicio, & Brodeur, 2009). In general, it is believed that as connectivity increases, travel distances decrease and route options increase, creating a more accessible network that supports these complete community principles. Research by Vancouver Coastal Health has also established a significant correlation between lower obesity measured by the MHMC survey and higher walkability as measured by WalkScore rankings.

Alternatively, there is some research focused on the harmful consequences of higher walking rates, especially due to potential increases in the inhalation of pollutants as the population walking or cycling in polluted environments increases (de Nazelle, Rodríguez, & Crawford-Brown, 2009).

3.3.2. Cycling Network Indicators

INTRODUCTION: This indicator relates to the density of various types of cycling facilities such as the following: off-street multi-use pathways, protected cycletracks, painted bike lanes, sharrows, or signed routes with no physical markings. Alternatively, some studies have focused on the population that has access to these facilities within a given distance.

CRITICAL THRESHOLDS: The LEED-ND rating system rewards developments that have a protected cycling route or painted bike lane within 400 metres of a project location. This threshold is supported by others who have found that cyclists are generally willing to detour 400 metres from their shortest route to access a protected cycling facility for many types of cycling trips (Wahlgren & Schantz, 2012).

DISCUSSION: The presence of cycling routes can encourage higher levels of cycling activity, that both increase physical activity and reduce motor vehicle emissions. For example, Dill (2009) made the general conclusion that “bicycle-specific infrastructure can encourage more bicycling among adults”; while Fraser & Lock (2011) conducted “a systematic review of the effect of the environment on cycling” and found the presence of dedicated cycle routes or paths and separation of cycling from other traffic were generally related to higher levels of cycling behaviour. In addition, Fraser & Lock (2011) found that of the seven studies which focused primarily on the impact of cycle routes, four demonstrated a statistically significant positive association between route density and levels of cycling behaviour.

To further investigate the potential cause and effect of adding a new protected cycling route, Mitra, Ziemba, & Hess (2015) used an innovative street-intercept survey to evaluate the impact of a new protected cycletrack in Toronto and found that the presence of the new infrastructure had a positive impact on inducing cycling behaviour.

The presence of protected cycletracks has also been linked to lower rates of accidental injury and premature death (Cycling in Cities, 2013). Several studies have evaluated the potential to suffer direct physical injury from a collision or fall while cycling, and how the presence of a well-connected minimum grid of cycling infrastructure can mitigate these risks of injury (Reynolds, Harris, Teschke, Cripton, & Winters, 2009; Teschke et al., 2012). A nuanced consideration is a distinction between actual and perceived safety, which has led some compare injury data in relation to perceived safety and the role perceived safety plays in route selection (Winters et al., 2012).

3.3.3. Public Transit Network Indicators

INTRODUCTION: This indicator category includes a range of metrics related to density, access, and frequency of service for both regular bus networks and for rapid transit networks such as light rail or subways. For example, measures may relate to the density of transit stops or rapid transit stations per square kilometre within a study area. Alternatively, since there may be several bus routes that service a single stop, it is also possible to measure the number of routes per unit area within a neighbourhood. It can also be useful to evaluate the percentage of population within a neighbourhood that live within walking distance to one or more transit networks. If data related to the frequency of service at each stop is available, this data can be used to construct measures related to the level of service in each neighbourhood. Many cities now provide open data in General Transit Feed Specification (GTFS) format that can be obtained and mapped to construct these measures. It is important to standardize these measures by dividing by the area of each neighbourhood, to construct a measure such as the number of vehicle stops, per day, per square kilometre.

CRITICAL THRESHOLDS: There is a general rule of thumb that that traveller are generally willing to walk up to 400 metres to access a bus network though many may walk up to 800 metres to access a rapid transit station (Government of Ontario, 2012). This set of cut-offs is also used within the LEED-ND rating system (USGBC, 2014b).

DISCUSSION: A review of GIS methods for measuring transit access revealed that many measures fail to integrate any temporal frequency measures. For example, Biba, Curtin, & Manca (2010) claim that the use of GIS in determining transit service areas has not progressed far beyond simple buffering operations. Lei & Church (2010) also explain that "accessibility is a concept that is not entirely easy to define, Gould (1969) once stated that it is a 'slippery notion … one of those common terms that everyone uses until faced with the problem of defining and measuring it". To address this difficulty and lack of advanced analysis methods, Lei & Church (2010) proposed an extended GIS data structure to handle temporal elements of transit service that included integration of transit schedule information related to the frequency of service.

Lei & Church (2010) also conducted an extended review of existing methods for measuring transit access and described the following six types of analysis that can be conducted using GIS:

- *System Accessibility* relates to physical access to a system, based on distance or time from home locations to transit facilities – often based on circular buffers;
- *System Facilitated Accessibility* measures the ability to get to a destination and takes into account the travel time or cost spent in reaching their destination based on the shortest paths;
- *Integral Accessibility* is based on a combined measure related to the first two types;
- *Space-Time Accessibility* accounts for real world factors like facility operating hours and network properties such as one-way streets and turn restrictions and recognises individual time budgets;
- *Utility Accessibility* considers users as consumers and alternatives of travel as the choice set; and
- *Relative Accessibility* is based on comparing access between modes or types of users

Health impacts of transit include a relationship between transit stop density and higher rates of physical activity (Frank et al., 2006). Morency, Trépanier, & Demers (2011) presented empirical evidence that modal shift from car to transit contributes to the volume of daily physical activity, based on the finding that use of transit requires higher levels of walking to access transit facilities – this study found that an average route trip using transit in Montreal "requires 2,500 steps, which accounts for 25% of the recommended volume of physical activity per day".

Access to transit is an important measure of social equity since transit provides mobility to citizens who cannot walk, cycle or drive to meet their transportation needs. Huang & Wei (2002) found that most "existing research on accessibility and spatial mismatch deal with commutes via private automobile, and low-income inner-city residents, who tend to have lower rates of car ownership, rely more heavily on public transport for commuting". Huang & Wei (2002) conclude that improving urban accessibility is an important public policy topic to address problems of joblessness, residential segregation, and poverty.

Suzuki, Cervero, & Iuchi (2013) describe opportunities for effective coordination of transport infrastructure and urban development as one of the most promising strategies for advancing environmental sustainability, economic competitiveness, and socially inclusive development. Suzuki et al. (2013) also explain that Transit Oriented Development (TOD) can radically transform development patterns at the neighborhood level to support the creation of more sustainable cities. These transformations are related to a wide range of environmental benefits including reduced greenhouse gas emissions and local air pollution from automobile trips if citizens substitute cars for this sustainable mode.

3.3.4. Major Road Indicators (Air Quality)

INTRODUCTION: This indicator provides a measure of the density of major roads within a community, based on the total length of all arterial roads and highways divided by the land area. For the purposes of this review, this measure is intended to represent the potential exposure to local air pollution, noise, and risk of accidental injury or death due to a pedestrian or cyclist being involved in a collision with a motor vehicle.

CRITICAL THRESHOLDS: Brugge, Durant, & Rioux (2007) studied air quality within urban areas and found that "people living or otherwise spending substantial time within about 200 metres of highways are exposed to these pollutants more so than persons living at a greater distance, even compared to living on busy urban streets"

DISCUSSION: According to the CDC, motor vehicles contribute more than 50% of air pollution in urban areas. (CDC, 2009). Moreover, transportation-related pollutants are "one of the largest contributors to unhealthy air quality; exposure to traffic emissions has been linked to many negative health effects including exacerbation of asthma symptoms, diminished lung function, heart attacks, adverse birth outcomes such as low birth weight, and increased risk for childhood cancer" (CDC, 2009).

Marshall et. al. (2009) conducted detailed modelling of local air pollutants from motor vehicles in the Metro Vancouver Area, and found that intensity of local air pollution was directly related to the location of major roadways and trucking routes. Common transportation-related air pollutants include carbon monoxide, nitrogen dioxide, and particulate matter; alternatively, Ozone – formed when nitrogen dioxide and sunlight react – is also a common pollutant (Marshall et al., 2009). Particulate matter and ozone are known respiratory irritants that can aggravate asthma either by themselves or when combined with other environmental factors, and recent health studies also suggest that particulate matter is a risk factor for cardiovascular disease (CDC, 2009).

This measure was utilized by Mitra & Buliung (2012) in a study related to active school travel – the authors evaluated the length of major roads including expressways, arterials, and collector roads normalized per square kilometre of the area at a range of different scales of geographic analysis. This study found the density of major roads was not a statistically significant predictor of active school travel rates at any scale (Mitra & Buliung, 2012).

3.4. HOUSING

3.4.1. Dwelling Type Indicators

INTRODUCTION: This indicator category focuses on the percentage of dwellings within a study area that fall within specific typologies, such as the following groupings of typologies measured on the Statistics Canada *National Household Survey*:

- Ground-oriented dwellings including single-detached, semi-detached, duplex and row houses;
- Low-rise apartments that have fewer than five storeys; and
- High-rise apartments that have five or more storeys.

DISCUSSION: Durand et al. (2011) investigated eleven studies that included metrics related to the Smart Growth principle “create a range of housing opportunities and choices” and found a consistent association between communities with higher levels of dwelling diversity and increased levels of physical activity and walking in particular.

Health benefits of more diverse housing options include more vibrant and complete communities that meet the needs of a range of incomes and age groups. Although a range of housing types may not directly result in more affordable housing, a range of options will likely result in increased supply of some more compact units that can accommodate people with lower incomes and create a more diverse community.

A recent survey of Metro Vancouver residents by the Vancouver Foundation (2012), found a significant correlation between people who reported living in high-rise towers and higher levels of social isolation, lower levels of community belonging, and lower overall quality of life.

A greater diversity of housing types based on census information has also been linked to healthier child development outcomes. Carpiano, Lloyd, & Hertzman (2009) found that children from neighbourhoods in Vancouver with a wider range of incomes had higher holistic health measures based on a population level-survey called the Early Development Instrument.

3.5. FOOD

3.5.1. Grocery Store Indicators (Access to Amenities)

INTRODUCTION: Complete communities that can meet residents' needs without the requirement to drive must include a full range of community amenities including grocery stores. It would also be desirable to include measures related to a broader range of amenities such as cafes, restaurants, farmers' markets, and other food assets, and more general amenities such as community centres, child care, schools, theatres etc. Many of these types of features are considered within more general walkability indexes – but it is difficult to access reliable databases for all these amenity types at a regional scale such as Metro Vancouver.

CRITICAL THRESHOLDS: The LEED-ND framework rewards developments for including a range of basic amenities including grocery stores within an 800-metre network-based walkshed (USGBC, 2014b).

DISCUSSION: General health impacts of this indicator are related to the reality that pedestrian oriented communities that provide a mix of amenities to which residents can easily walk or cycle are widely associated with higher rates of walking (Government of Ontario, 2015).

Story, Kaphingst, Robinson-O'Brien, & Glanz (2008) also found that "individual behavior to make healthy choices can occur only in a supportive environment with accessible and affordable healthy food choices" Alternatively, 'food deserts' have been associated with higher risk of obesity and chronic disease (Jennifer L. Black, Macinko, Dixon, & Fryer, 2010; J. L. Black & Macinko, 2010). Similarly, Minaker et al., (2014) investigated patterns of food purchasing from farmers' markets found a significant relationship with reduced weight and better diets in a population-based sample.

Additionally, Story et al. (2008) conducted a review of methods for using GIS to evaluate food environments based on a review of 29 papers. They concluded that there are two basic approaches including the following: 1. the density approach quantifies the availability of food outlets using the buffer method, kernel density estimation or spatial clustering and 2. the proximity approach assesses the distance to food outlets by measuring distances or travel times (Story et al., 2008).

3.5.2. Protected Agricultural Land Indicators

INTRODUCTION: This theme of indicators relates to the area of land in a community that is protected agricultural land, and the percentage of the population who live within these land areas. In the Metro Vancouver Context, this measure can generally be related to the land designated to be within the Agricultural Land Reserve (ALR) although not all these lands are actively used for food production.

DISCUSSION: Access to locally grown food can lead to healthier diet choices, therefore, land area and percent of the population living within protected ALR area was considered to be a good measure of local food production potential. These lands are provincially regulated and protected, although not all areas are actively used for food production.

There is limited evidence supporting this indicator. For example, the greenbelt in the Greater Toronto area has improved air and water quality, and other quality of life indicators (Government of Ontario, 2015). Alternatively, there are important differences between health practices of farmers, for example, Earle-Richardson, Scribani, Scott, May, & Jenkins (2015) compared the health practices of farm-based population and found their overall lifestyle and health outcomes have improved over the past 20 years, but health prevention remains notably lower than nonfarm populations in the united states.

More research in this area is needed, and there may be potential benefits related to community resiliency and food security over the longer term and other benefits related to enhanced food literacy. For example, a recent work evaluated the potential environmental and population health impacts of local urban food systems under climate change (Hall et al., 2014).

3.6. NATURAL AREA

3.6.1. Parks, Green Space, and Trails Indicators

INTRODUCTION: Geographically speaking, parks, green space, and trails are very distinct areas, and area and access measures can be calculated separately for each. However, there is often significant overlap between these features. Parks include a spectrum of spaces ranging from highly programmed areas for public gatherings and active recreation to more passive spaces for quiet reflection or play spaces, to wild or natural landscapes that are set aside for ecological protection and nature-based recreation. Trails intersect both these typologies of space and are found in both urban and natural environments.

CRITICAL THRESHOLDS: The City of Vancouver Greenest City Action Plan includes an indicator related to the percentage of the population that lives within a 5-minute walk (based on a 400-metre buffer) to a community park. Additionally, many studies focus on access to a park or green space greater than one hectare, to ensure that access is provided to a space that is large enough to facilitate active recreation.

DISCUSSION: There are numerous health benefits linked to parks, green space, and trails. For example, there a long tradition of designing large urban parks to provide positive impacts on mental and social health (Hewitt & Szczygiel, 2000). Moreover, in 1865, Frederick Law Olmsted of Central Park design fame called it ‘a scientific fact’ that nature ‘is favorable to the health and vigor of men” (Jaffe, 2015).

Many review studies have summarized the benefits of parks, green space, and trails. The most relevant review was completed by Toronto Public Health, in a recent report called *Green City: Why Green space Matters for Health* (Toronto Public Health, 2015). This report included a systematic literature review of evidence linking parks and green space to the following health outcomes and health promoting behaviours: Mental Health, Physical Activity, Well-being, Physical Health, Social Connectivity, Cardiovascular Disease, All-Cause Mortality, Weight status and Birth Outcomes.

Parks and green space have also been linked to improvements in the local air and water quality (David Suzuki Foundation, 2015). This effect is caused by the fact that trees and vegetation are well-known for removing a number of air-borne pollutants, including ozone, sulphur dioxide, nitrogen dioxide and particulate matter. Nowak, Hirabayashi, Bodine, & Hoehn (2013) also summarized a large body of evidence focused on the ability of trees to improve air quality at local sites and across cities

Other health benefits of parks include a strong connection to mitigating the Urban Heat Island effect and providing shade and cooling opportunities that can provide relief during extreme heat events (David Suzuki Foundation, 2015). There is also a wide range of evidence linking parks to improved mental health (Annerstedt van den Bosch, Östergren, Grahn, Skärbäck, & Währborg, 2015) and higher levels of community belonging and social capital (Wheeler et al., 2015).

3.7. SUMMARY

Most studies described in this review focused on one or a small number of specialized design indicators, a limited geographic area, or a subset of the total population. Although this approach is useful to narrow the scope of analysis, a drawback is that it can be difficult for interdisciplinary urban planning and public health professionals to gain a comprehensive understanding of available design indicators, or understand the complex linkages between CDIs and a wide-range of health and well-being measures. Many of the papers that were reviewed made very little mention of the geographic data sources that were used for the study, however, in many cases, studies relied on proprietary information of some kind related to land use, transportation data, analysis of land cover, or health survey information.

To address these opportunities, this study describes and calculates a comprehensive set of CDIs based primarily on open data sets, and then examines the linkages between each design indicator and a wide range of built environment, and health measures that are publically available from the MHMC survey.

4. METHODS

This section presents a comprehensive design indicator framework, describes the study area and geographic units of analysis for this study, and explains the GIS-based approach used to compute CDIs based primarily on open datasets. This section also describes the statistical analysis methods that were used to evaluate the CDI framework and link results to health measures from the MHMC survey.

4.1. COMMUNITY DESIGN INDICATOR FRAMEWORK

Based on the knowledge explored in the literature review, a comprehensive set of 44 CDIs were identified to evaluate the built and natural environments. These indicators are listed in Table 4.1, nested within 16 planning and design categories and 5 themes.

Table 4.1 - List of community design indicators

Theme	**Category**	**Indicator** (Unit of Measure)
Land Use	Population and Employment Density	Gross Population Density *(per ha.)*
		Net Population Density *(per ha.)*
		Gross Employment Density *(per ha.)*
		Net Employment Density *(per ha.)*
		Gross Population and Employment Density *(per ha.)*
		Net Population and Employment Density *(per ha.)*
	Balance of Jobs & Residents	Number of Jobs per 100 Residents *(index)*
	Land Use Areas	Rural Residential *(% of area)*
		Single Family, Duplex and Townhouse *(% of area)*
		Apartment Residential Areas *(% of area)*
		Mixed-Use Apartment Areas *(% of area)*
		Commercial Areas *(% of area)*
		Institutional Areas *(% of area)*
		Industrial Areas *(% of area)*
		Parks and Open Space Areas *(% of area)*
	Land Use Mix	Land Use Mix Index (Simpson's Diversity Index)
	Focused Growth (Planning Areas)	Population within Urban Centres *(% of pop.)*
		Population within TOD area *(% of pop.)*
		Population within UCB area *(% of pop.)*
	Distance to City (Urban-Rural Spectrum)	Distance to an Urban Centre *(distance in kilometres)*
		Distance to CBD (distance in km.)
Transportation	Walking Network	Intersection Density *(per sq. km.)*
	Cycling Network	Cycling Route Density (length in m. per sq. km.)
		Cycling Route Access *(% of pop. in 400 m.)*

Theme	**Category**	**Indicator** (Unit of Measure)
Transportation (continued)	Public Transit Network	Transit Stop Density *(per sq. km.)*
		Transit Access (% of pop. in 400 m. walkshed)
		Rapid Transit Stop Density *(per sq. km.)*
		Rapid Transit Access (% of pop. in 800 m. walkshed)
		Transit Route Density (length in m. per sq. km.)
		Transit Service Frequency (pickups per sq. km. per day)
	Major Roads	Arterial Road and Highway Density *(length in m. per sq. km.)*
Housing	Dwelling Types	Ground-Oriented Dwellings *(% of dwellings)*
		Low-Rise Dwellings with 1-4 levels *(% of dwellings)*
		High-Rise Dwellings with 5+ levels *(% of dwellings)*
Food Access	Grocery Stores	Grocery Store Density (*stores per sq. km.)*
		Grocery Store Access (% of pop. in 400 m. walkshed)
	Protected Agricultural Land	Agricultural Land Area *(% of area in ALR)*
		Agricultural Land Access *(% of pop. in ALR)*
Natural Areas	Parks	Park Area (% of area)
		Park Access (% of pop. in 400 m.)
	Green space	Green space Area *(% of area)*
		Green space Access (% of pop. in 400 m.)
	Trails	Trails Density (length in m. per sq. km.)
		Trail Access (% of pop. in 400 m.)

4.2. STUDY AREA AND GEOGRAPHIC UNITS OF ANALYSIS

Although these design indicators may be appropriate for multiple scales of analysis in a wide range of geographic contents or time periods, the current study focuses on a case study within the Metro Vancouver region of British Columbia, Canada. Figure 4.1 illustrates the natural landscape of the study area, administrative boundaries, urban centres, major roadways and rapid transit network. In total, the region covers 2,877 square kilometres of land surrounded by mountains to the north, the Pacific Ocean to the west and the United States border to the south. The Urban Containment Boundary (UCB) area is also an important growth management policy feature that directs future population and employment intensification. This area is home to nearly 2.5 million residents within 21 municipalities, an Electoral Area, and several first nation communities.

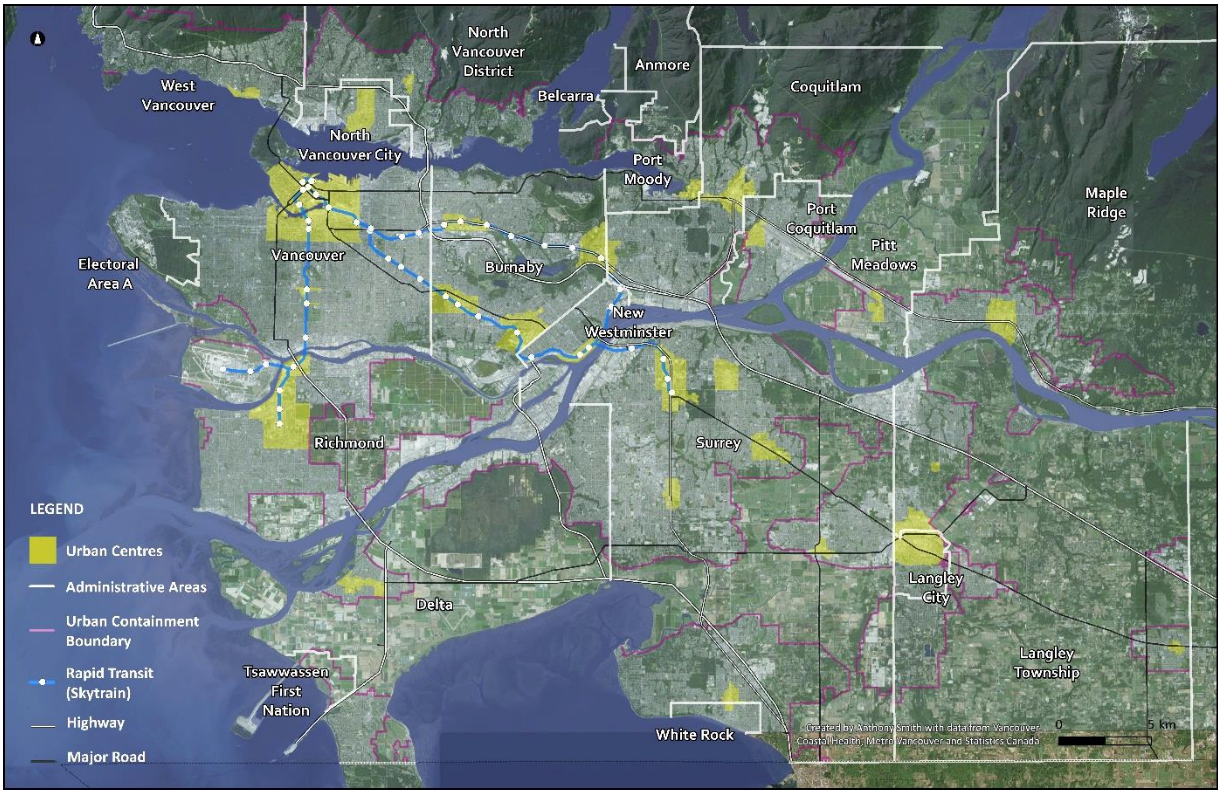

Figure 4.1 - Map of the Metro Vancouver region.

Design indicators were calculated based on 106 neighbourhood areas that are illustrated in Figure 4.2. The current neighbourhood boundaries align with the files used to aggregate individual MHMC results into neighbourhood-scale health measures. This ensures both datasets are directly comparable for statistical analysis. A full list of community names from the MHMC survey results is also included in Appendix C. It is of note that although CDIs were calculated for all 106 areas, MHMC data were suppressed for a small number of neighbourhoods with low survey participation or small populations. These areas are grouped with ID numbers 100-106 and are indicated with an * in Appendix C.

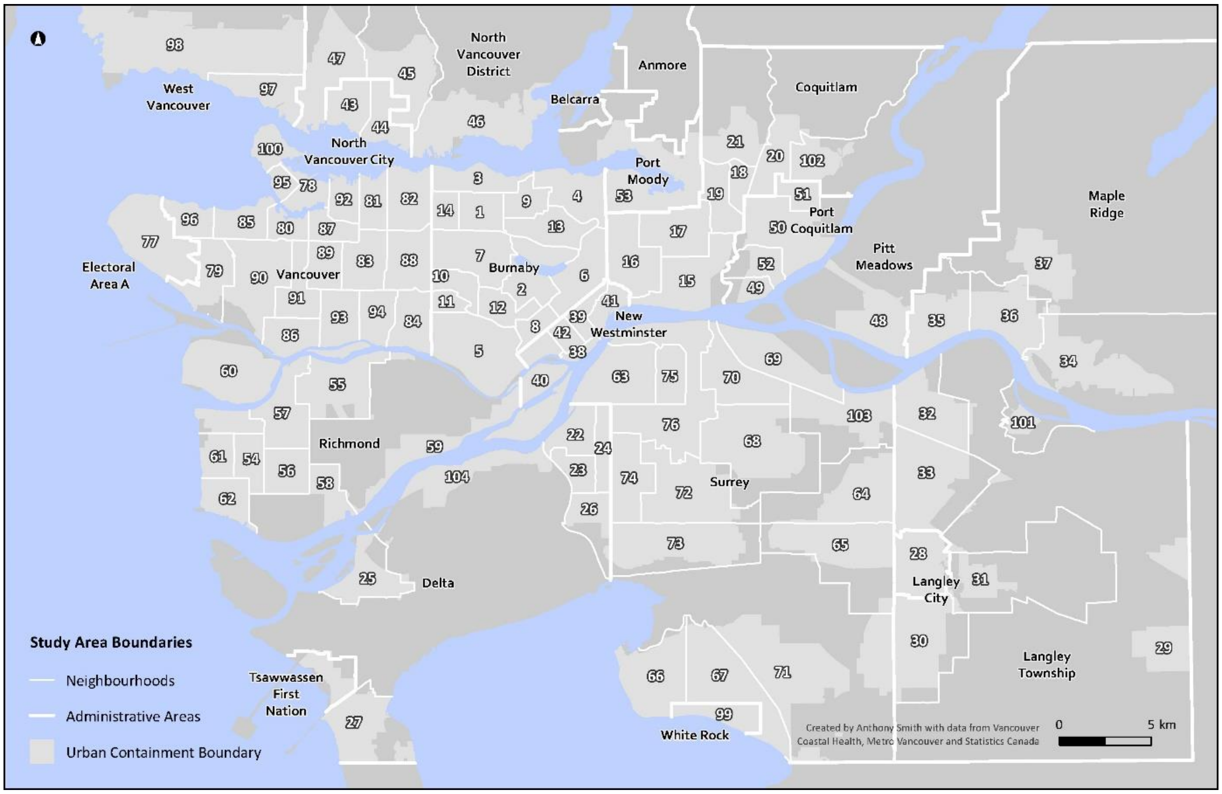

Figure 4.2 - My Health My Community survey neighbourhoods within the Metro Vancouver region.

4.3. COMPUTATION OF COMMUNITY DESIGN INDICATORS

Neighbourhood-scale design indicators were calculated using ArcMap 10.3 GIS software from Environmental Systems Research Institute (ESRI). These calculations were conducted using several open data files including recently released parcel-scale land use data from Metro Vancouver and several other files, including a public transit dataset from the regional transit agency (TransLink), a road network dataset from the Government of British Columbia (BC), population data from Statistics Canada, and cycling and park datasets from a 'crowd-sourced' website called OpenStreetMap.com. A full list of the specific datasets that were used for the computation of each CDI is included in Appendix D.

Each indicator was calculated using fine-grained spatial data but results were then aggregated into neighbourhood boundaries. The following technical decisions were integrated into the computation of CDIs based on considerations described in the literature review, and technical considerations of available datasets:

- Land Use Mix Index was calculated based on the following land use areas: 1. Single family, duplex, and townhouse, 2. Mixed-use apartment areas, 3. Commercial, 4. Institutional, 5. Industrial, and 6. Parks and Open Space 7. All other areas combined, including rural residential areas;
- Distance to Central Business District was based on the City of Vancouver CBD;
- Intersection Density was calculated excluding intersections along highways and ramps;
- Cycling Network Access was computed based on routes longer than 200 metres in length;
- All Transit measures were considered within the UCB land area as this is the primary focus for transit service, and inclusion of large areas would erode the accuracy of the calculation;
- Calculations of density related to cycling routes, major roads, and grocery stores were all calculated only within residential, commercial, mixed use, industrial and institutional land areas, to more accurately reflect the true density of these features without including large areas of uninhabited land that are common in several mountain edge and rural neighbourhoods;
- Dwelling type indicator related to Ground Oriented Dwellings included single family, duplex, and row house categories from the National Household Survey;
- Park and Green space Access indicators were computed based on areas greater than one hectare; and
- Trail Access was computed based on trails longer than 200 metres.

4.4. MY HEALTH MY COMMUNITY SURVEY METHODS

Data collection for the MHMC survey was conducted from June 2013 to July 2014 by Vancouver Coastal Health (VCH) and Fraser Health Authorities, in partnership with the University of British Columbia e-Health Strategy Office (MHMC, 2015a). Survey questions were selected from validated sources such as the Canadian Community Health Survey, the Canadian Health Measures Survey, the Ontario Health Study, and the Canadian Census where possible, and were developed through extensive consultation with stakeholders and partners (MHMC, 2015a).

Survey participants were 18 years of age or older and responded either online, in both English and Chinese, or via printed versions in English, Chinese, and Punjabi (MHMC, 2015a) To ensure that all segments of the population were represented, a field outreach team also administered the survey in person at community events, seniors groups, and homeless shelters. It is also important to note that sampling targets for each municipality were set to ensure a demographically representative number of surveys were collected in each survey zone. In total 33,075 survey responses were collected, covering 80 questions grouped within the following domains: sociodemographics, health status, lifestyle, primary care access, built environments and community resiliency (MHMC, 2015b).

To protect the privacy of survey participants, individual-level survey data was grouped into neighbourhood-scale measures that were publically released in March 2016. To aggregate results, survey results were geocoded based on the home postal code and grouped within geographic neighbourhood boundaries. Aggregated results were also weighted based on the most recent census data (2011) to ensure findings are representative of the age, sex and education characteristics of the population (MHMC, 2015b).

4.5. STATISTICAL ANALYSIS OF CORRELATIONS

The analytical approach involved evaluation of statistical associations between all CDIs and all self-reported neighbourhood environment and health measures from the MHMC survey. This analysis was conducted using IBM SPSS Statistics software version 23. Variables were prepared for analysis by converting all measures to z-scores with a mean of zero and a standard deviation of 1. This step was implemented because CDIs had a wide range of data ranges and distributions, so conversion to standard z-scores allowed for analysis using a consistent scale. Bivariate linear Pearson correlations were calculated and a correlation matrix was created to summarise the extent to which each of the 44 CDI variables is related to all of the MHMC survey variables. The statistical test was performed at $\alpha = .05$, and remaining significant associations were displayed in a series of two final correlation matrices.

The first correlation matrix show associations between all CDIs and a selection of subjective built environment perception measures. This analysis was conducted to validate the CDI framework as a useful tool to evaluate built environment characteristics of neighbourhoods based on open data. This analysis considered nine built environment measures grouped within three themes that were created based on consideration of the available built environment measures from the MHMC results in relation to the general planning and design concepts identified during the literature review. The selected themes are 1. Local Amenities, Access to Food, and Natural Areas; 2. Active and Sustainable Transportation Options; and 3. Automobile Use.

The second correlation matrix shows all CDIs and a selection of health measures were evaluated. This analysis considered four health and well-being themes that were created based on consideration of the available health measures from the MHMC results in relation to health concepts identified during the literature review. This section investigated 16 MHMC variables, grouped within the following health themes: 1. Healthy Lifestyles including walking, physical activity and healthy diets; 2. Physical Health including body weights, chronic conditions, and general health; 3. Mental Health including stress and overall mental health; and 4. Social Health including peer connections and sense of community belonging.

Results from this analysis are presented in Chapter 5.

5. RESULTS

Findings from this project are described in five distinct sections. First, a series of maps are presented to visualise the regional patterns of data related to each CDI theme. Secondly, descriptive statistics of each design indicator are presented and briefly discussed. Next, statistical associations or 'linkages' between CDIs and the built environment measures from the MHMC survey are considered to establish the validity of the CDI framework. Similarly, linkages between CDIs and MHMC health measures are then presented in a correlation matrix and described.

5.1. GEOGRAPHIC DATA VISUALISATION

This section presents a series of maps in Figures 5.1-5.14 that illustrate the detailed geographic datasets that form the basis for the design indicators outlined in the CDI framework. These maps are presented for reference purposes support understanding of the spatial patterns in each dataset, and to aid in interpretation of CDI results that are summarized in the following section. In addition, Figure 5.15 provides a contextual reference to illustrate patterns related to the percent of the population within each neighbourhood that is overweight or obese based on data from the MHMC survey.

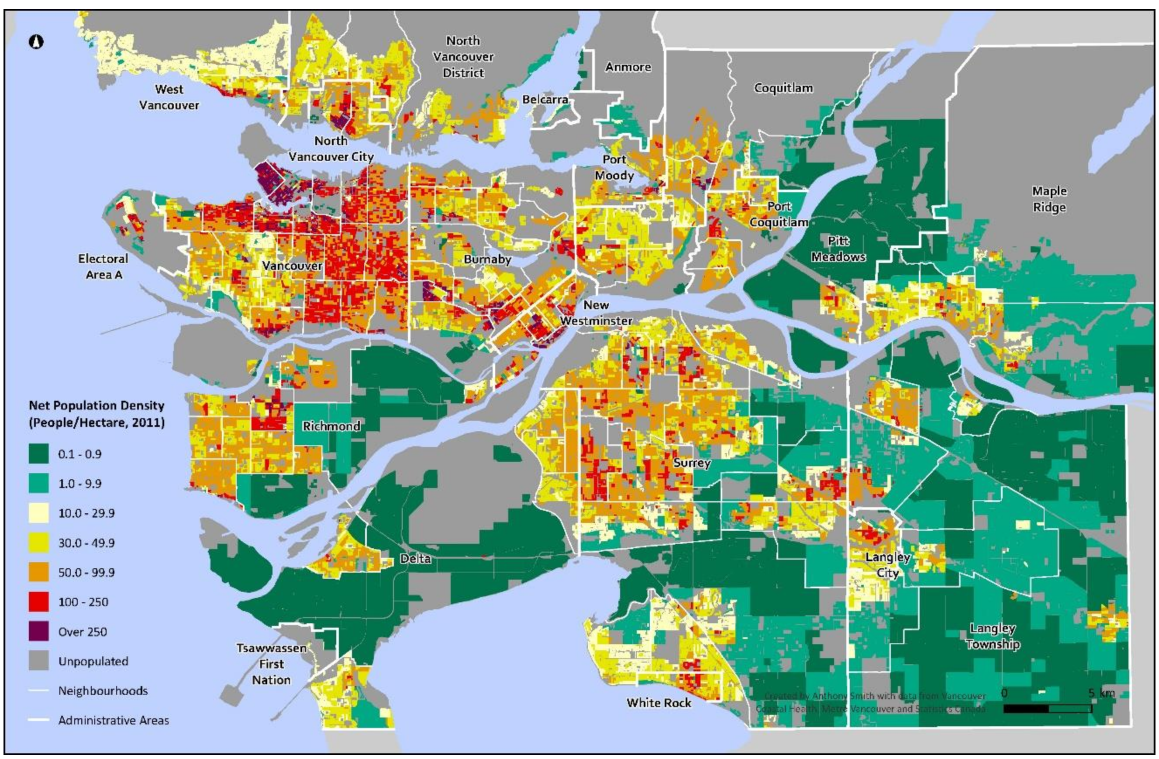

Figure 5.1 - Map of net population density based on data from Statistics Canada.

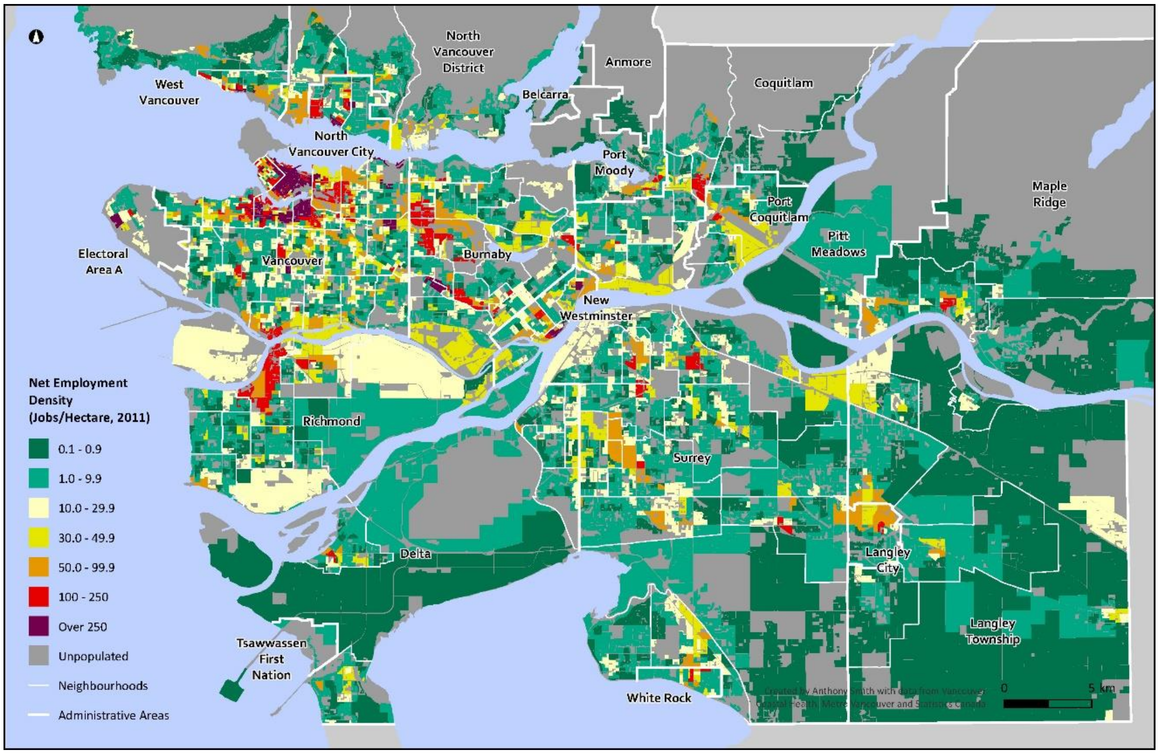

Figure 5.2 - Map of net employment density based on data from Census Plus.

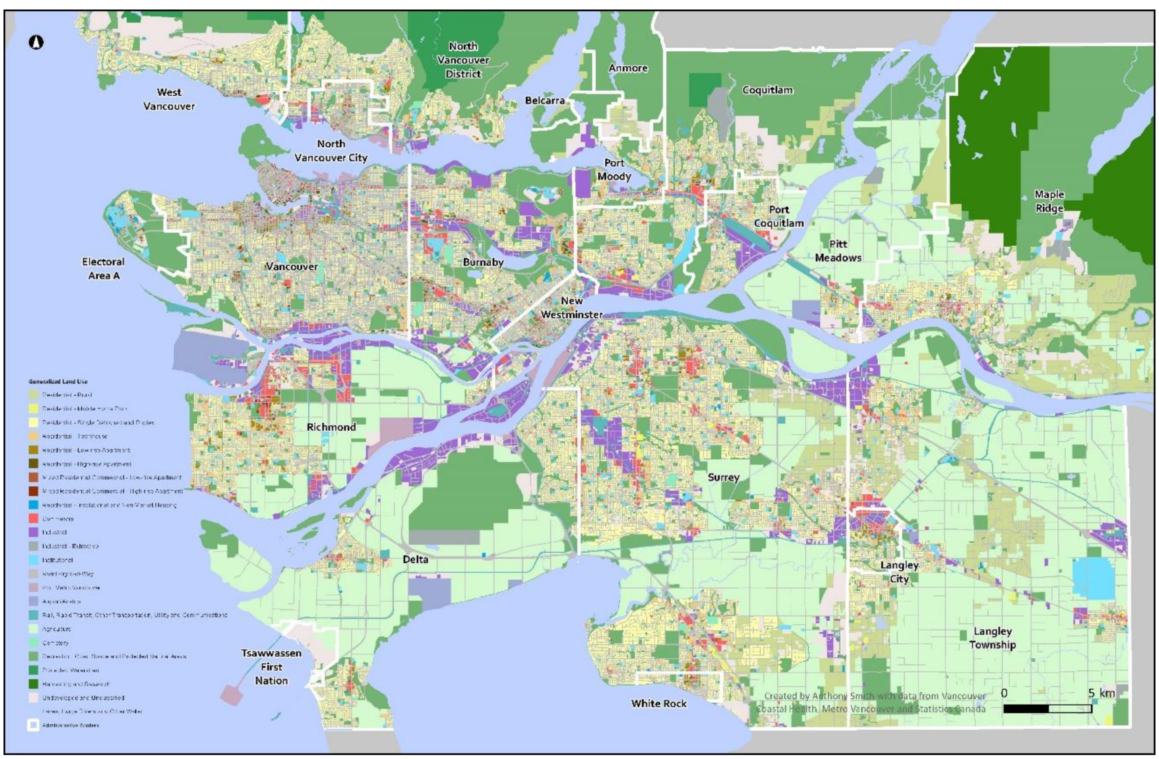

Figure 5.3 - Map of land use designation based on data from Metro Vancouver.

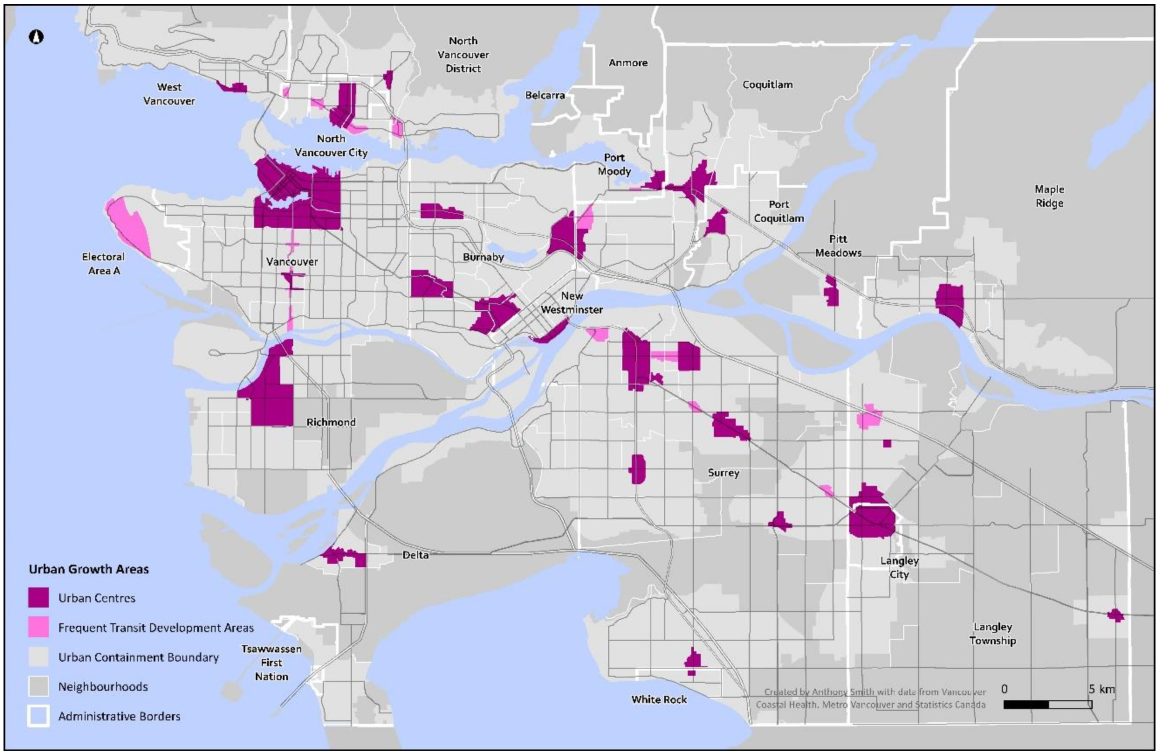

Figure 5.4 - Map of designated planning areas based on data from Metro Vancouver.

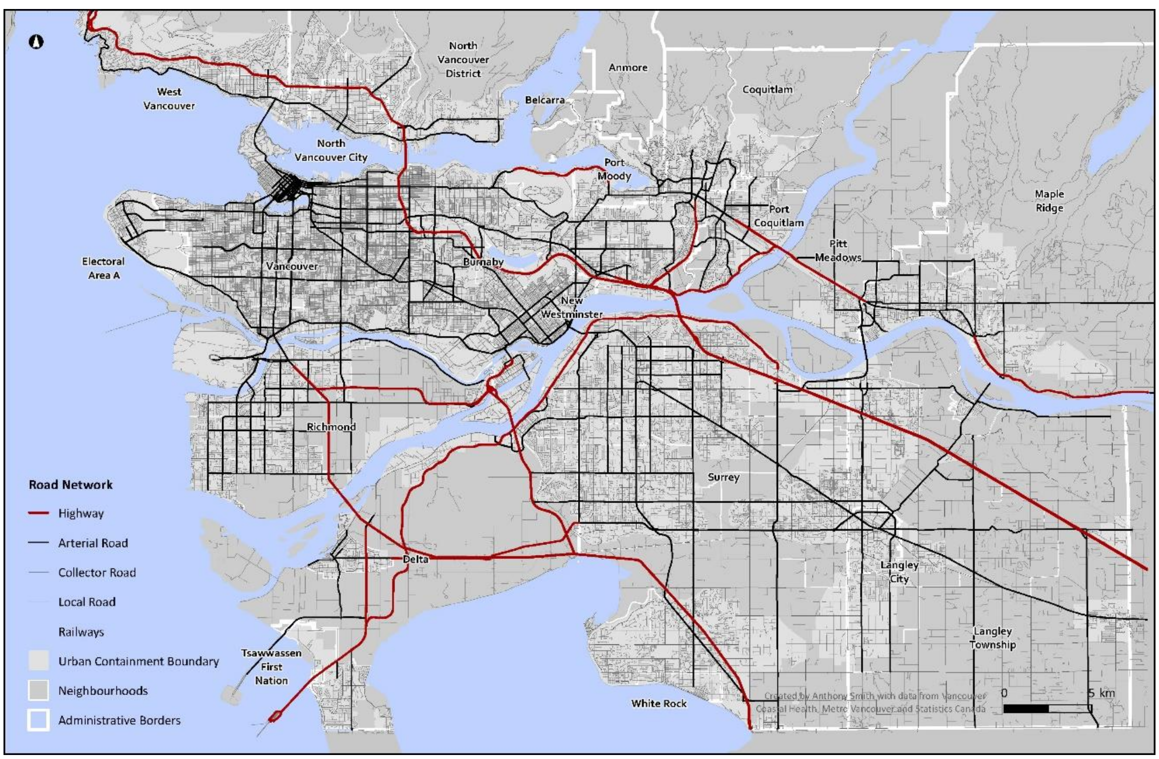

Figure 5.5 - Map of road network hierarchy based on data from the Government of BC.

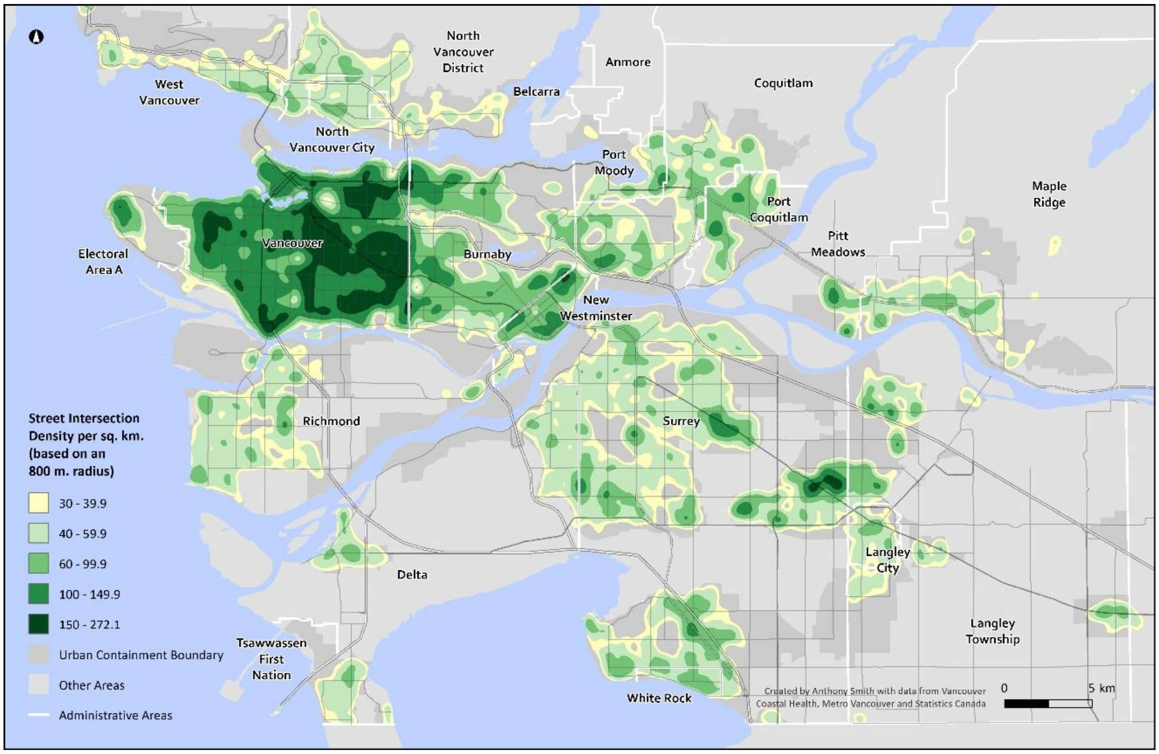

Figure 5.6 - Map of road network intersection density based on data from the Government of BC.

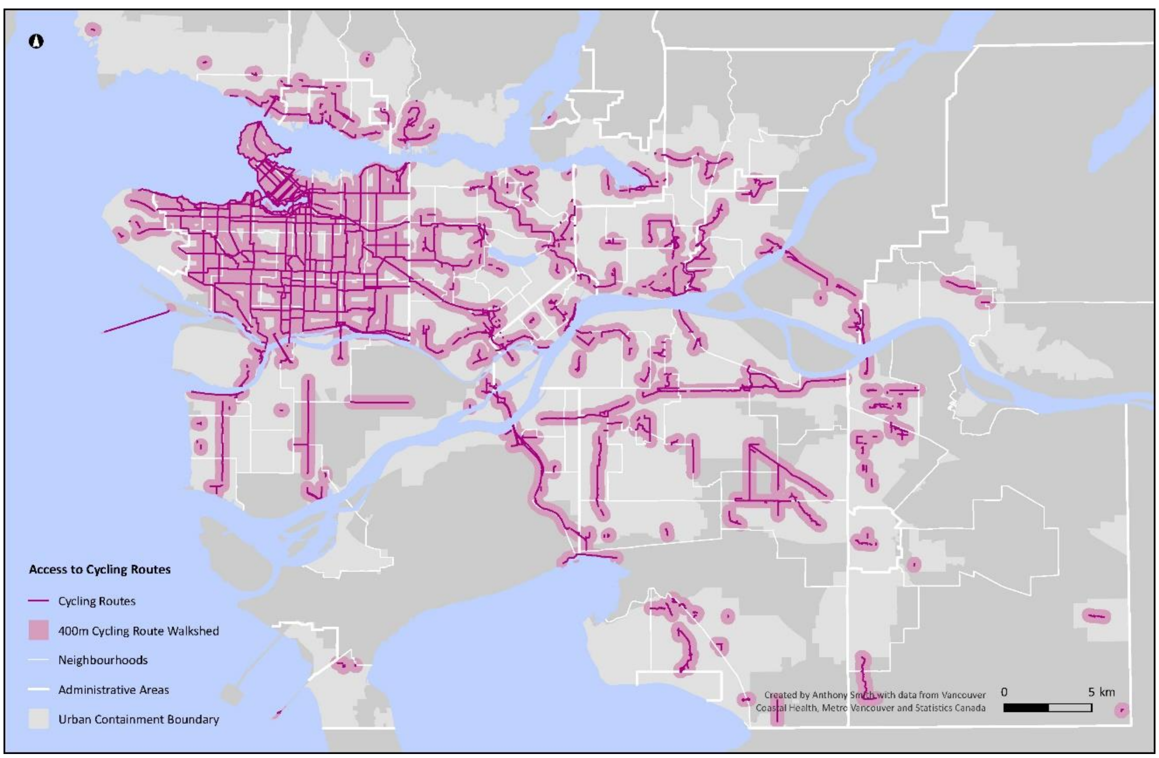

Figure 5.7 - Map of cycling routes based on data from Open Street Map.

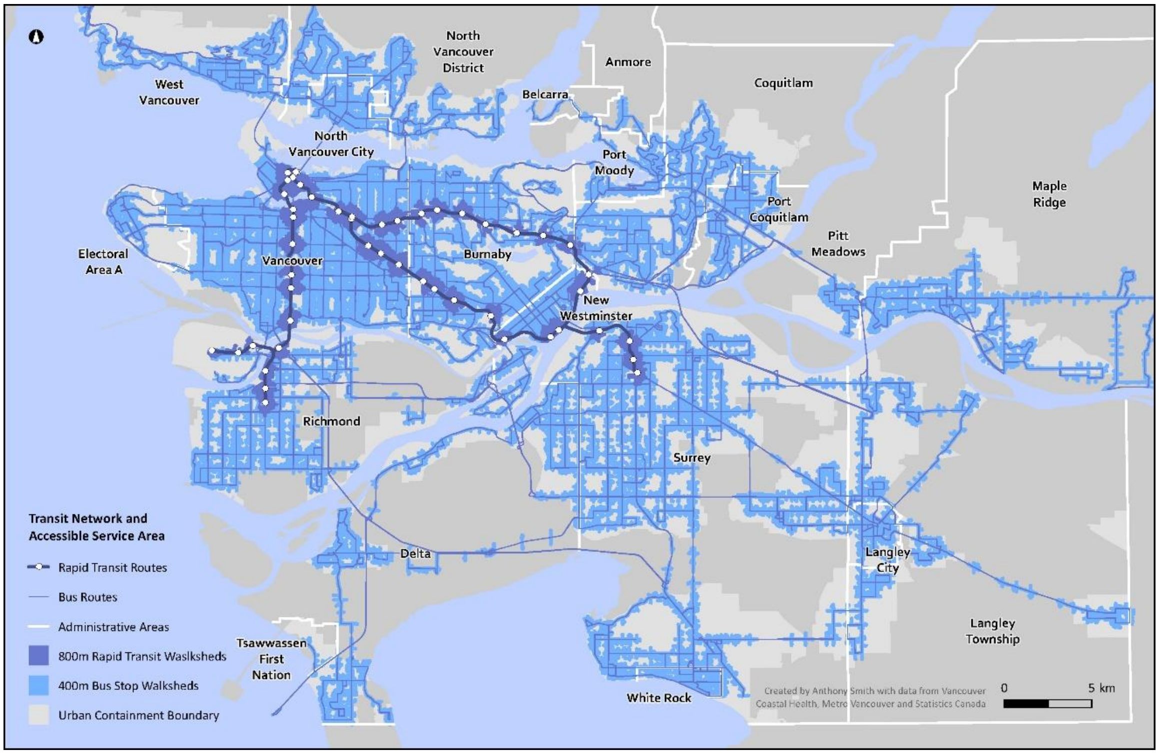

Figure 5.8 - Map of access to transit based on GTFS data from TransLink and walksheds.

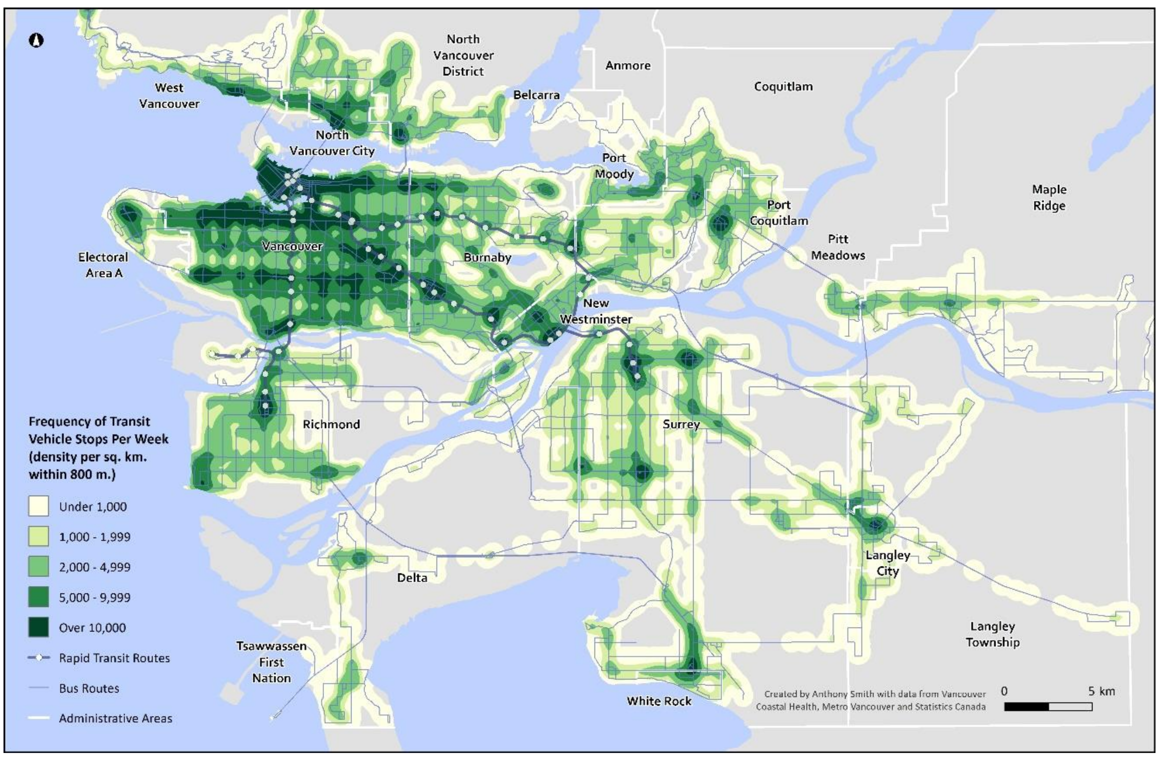

Figure 5.9 - Map of the frequency of transit service based on GTFS data from TransLink.

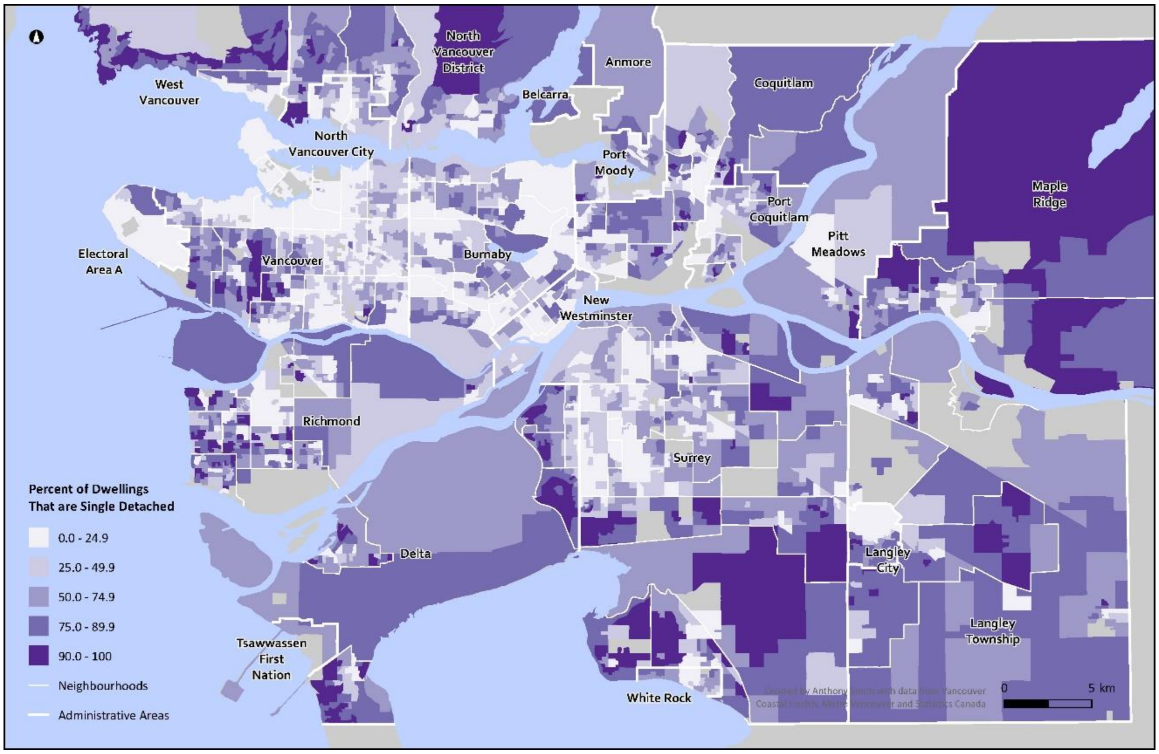

Figure 5.10 - Map of single family dwellings based on data from Statistics Canada.

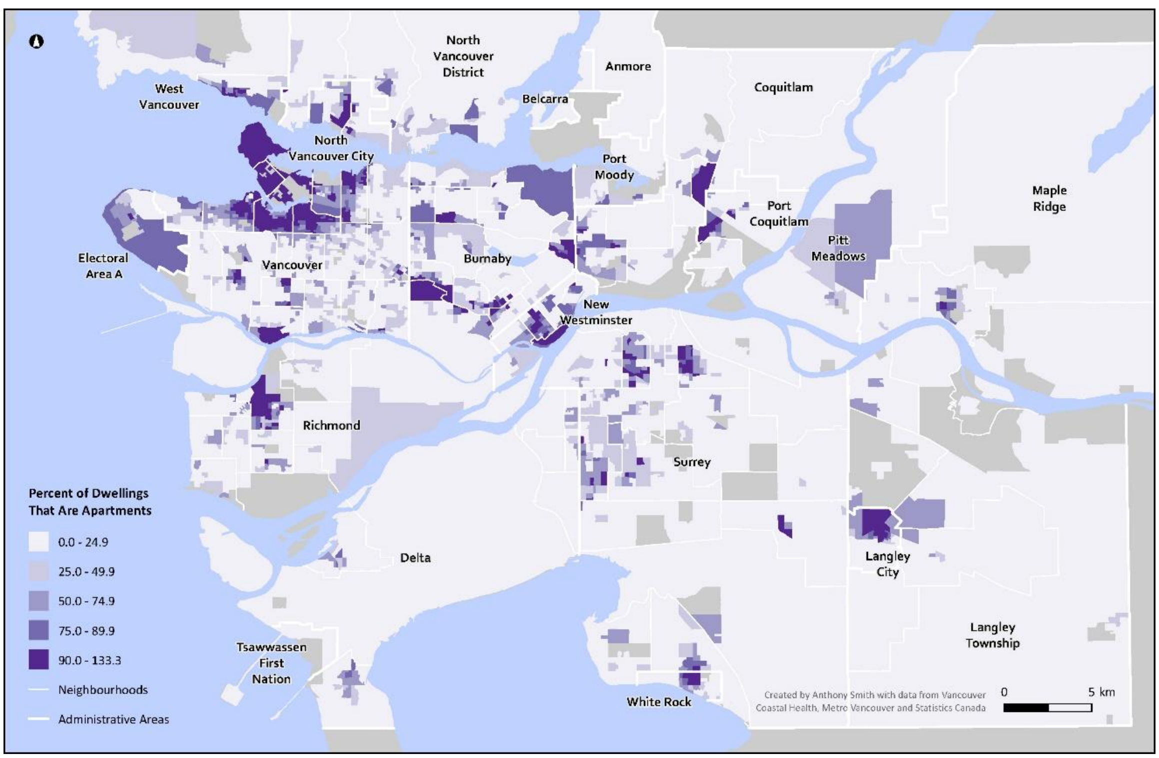

Figure 5.11 - Map of apartment dwellings based on data from Statistics Canada.

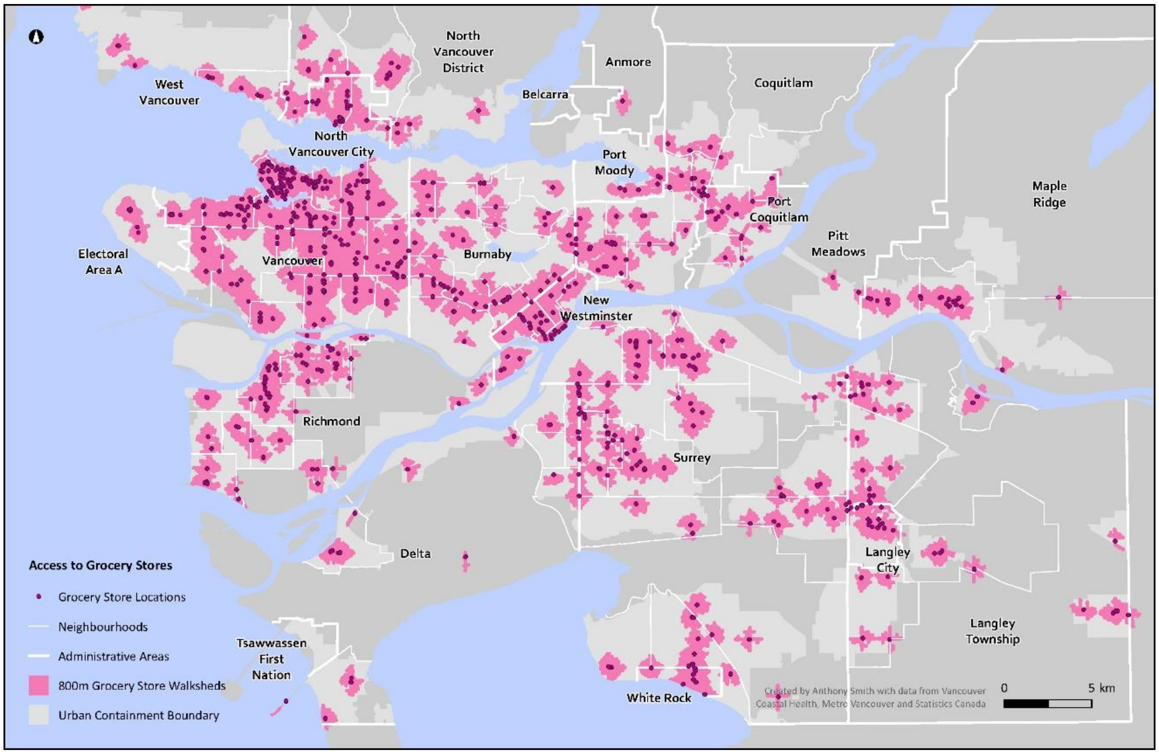

Figure 5.12 - Map of access to grocery stores and 800 m. network-based walksheds.

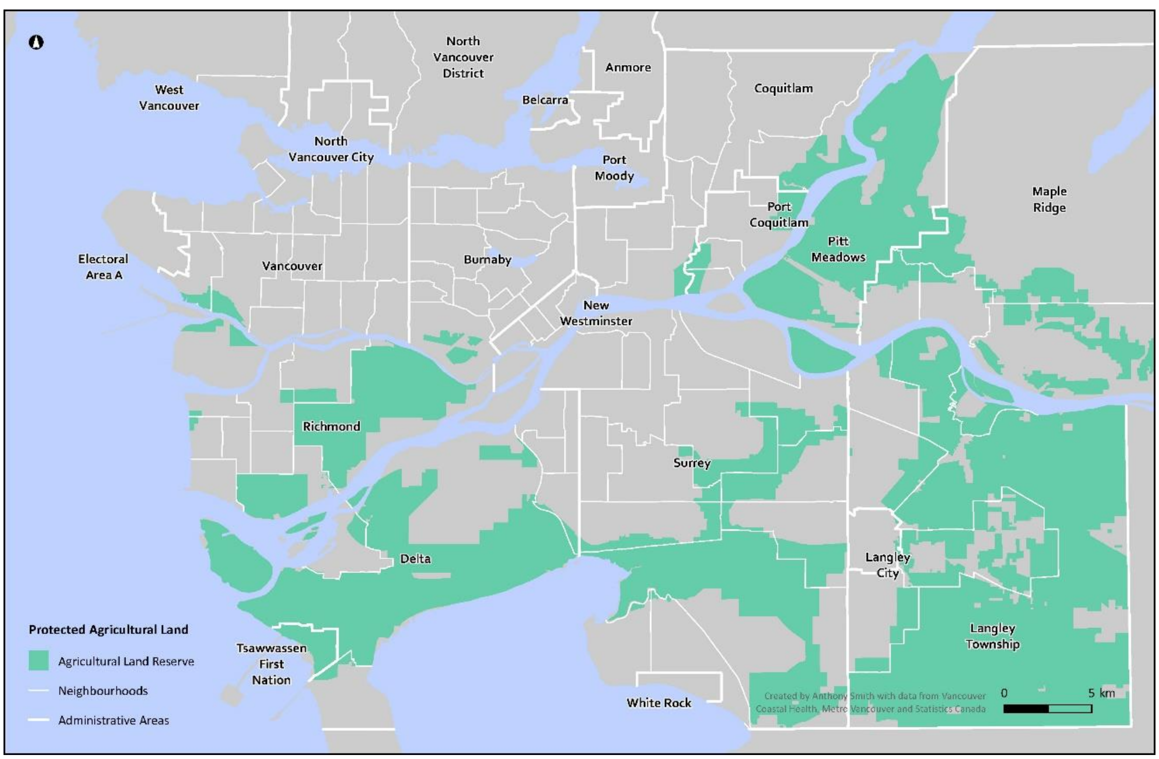

Figure 5.13 - Map of protected agricultural land based on data from the Government of BC.

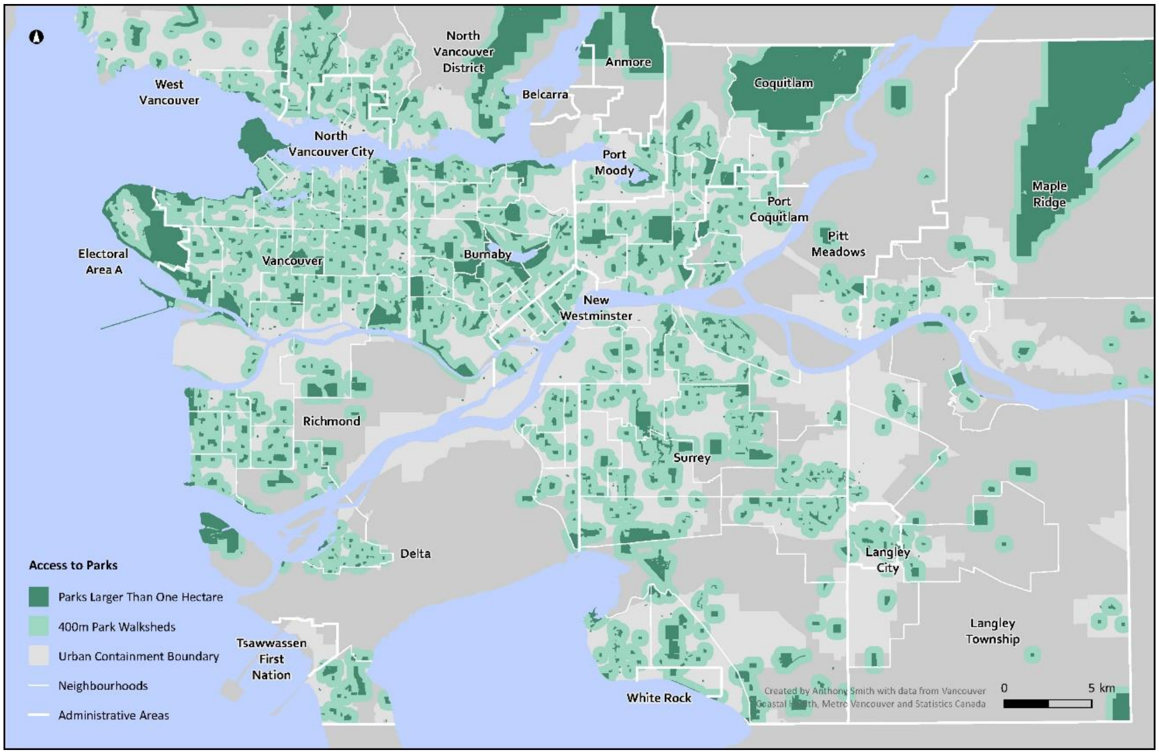

Figure 5.14 - Map of access to parks based on data from Open Street Map.

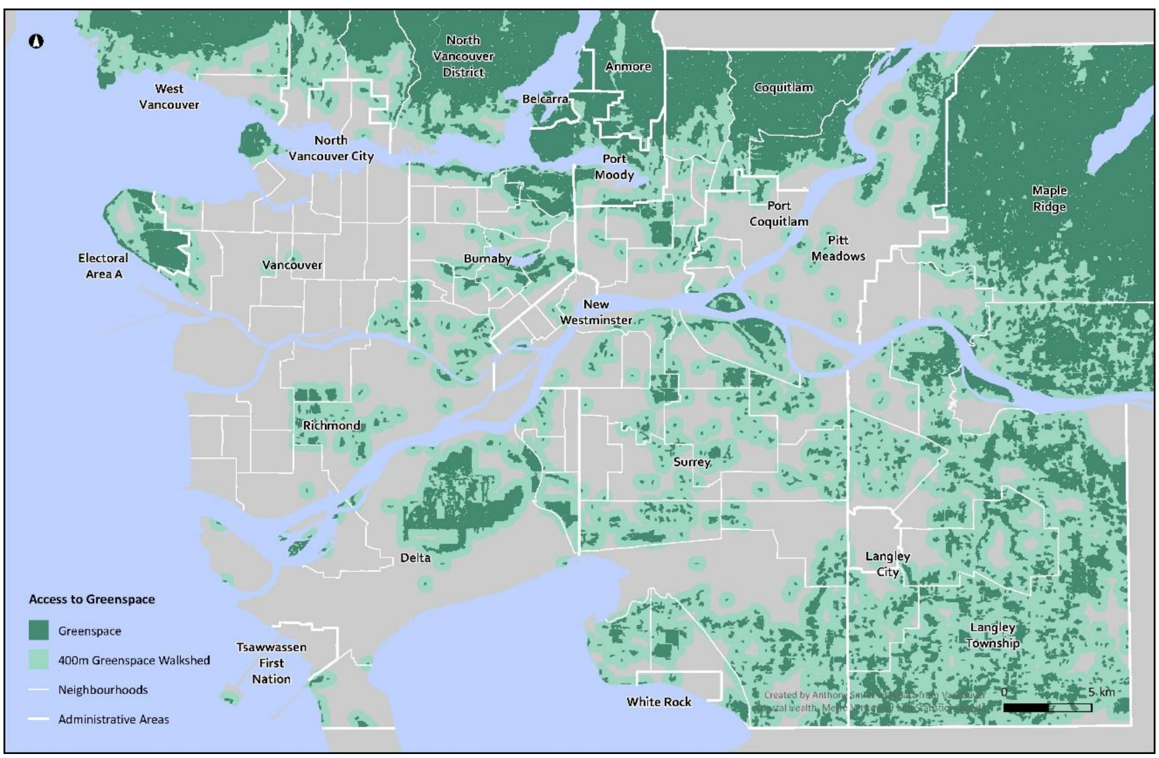

Figure 5.15 - Map of access green space based on data from Natural Resources Canada.

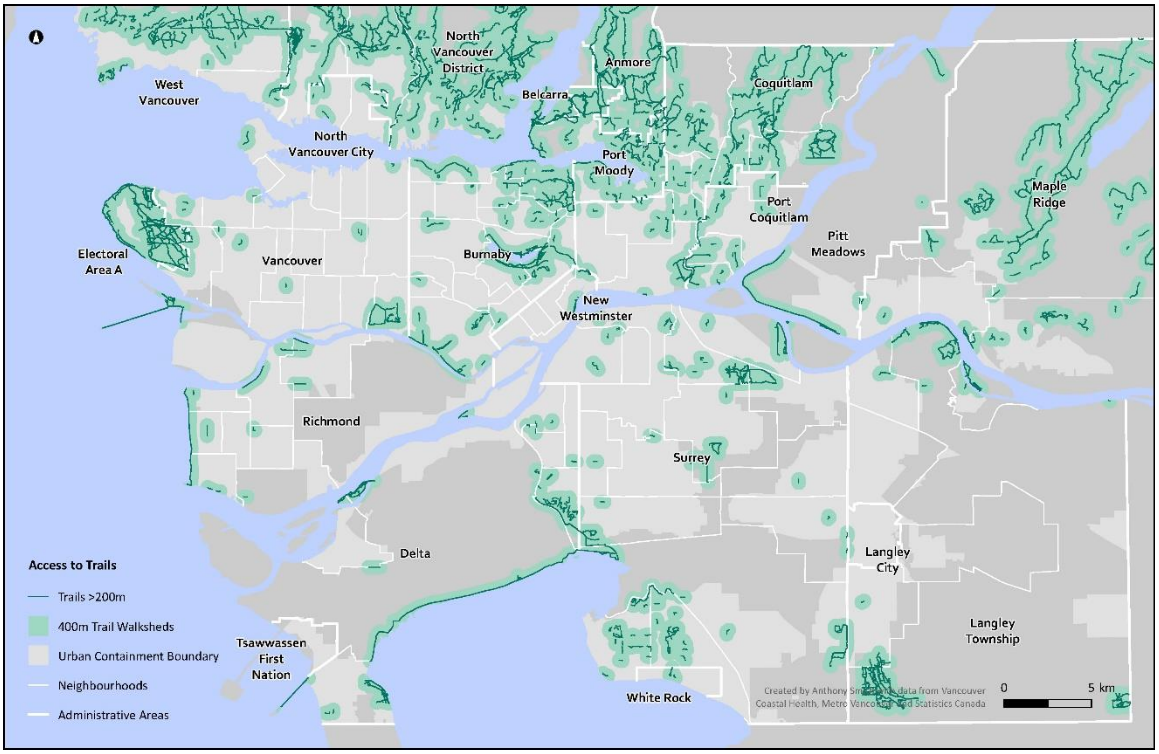

Figure 5.16 - Map of access to trails based on data from Open Street Map.

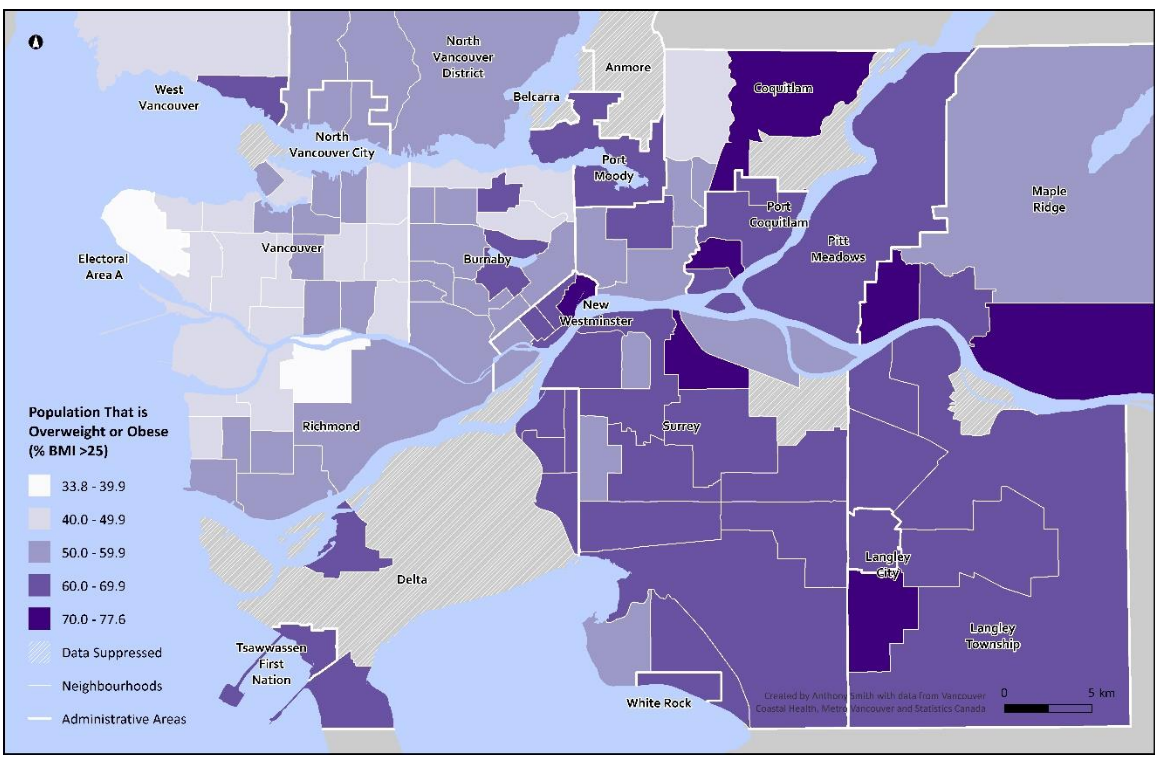

Figure 5.17 - Map of the population that is overweight or obese based on MHMC survey data.

5.2. DESCRIPTIVE STATISTICS OF DESIGN INDICATORS

Table 5.1 presents descriptive statistics based on the computation of design indicators for 106 neighbourhoods, including the range, minimum and maximum values, and mean and standard deviation of results. In addition, Appendix E includes a full listing of CDI results for each neighbourhood.

Table 5.1 - Descriptive statistics of community design indicators

	Category	Indicator (Unit of Measure)	Min	Max.	Rang	Mean	SD
Land Use	Population and Employment Density	Gross Population Density *(per ha.)*	0.0	224.8	224.8	30.2	31.2
		Net Population Density *(per ha.)*	0.0	409.8	409.8	69.0	67.7
		Gross Employment Density *(per ha.)*	0.0	469.9	469.9	19.0	49.8
		Net Employment Density *(per ha.)*	0.0	954.1	954.1	36.6	100.
		Gross Population and Employment Density *(per ha.)*	0.0	617.2	617.2	49.1	74.6
		Net Population and Employment Density *(per ha.)*	0.0	1253.	1253.	93.6	146.
	Job-Pop. Balance	Number of Jobs per 100 Residents *(index)*	0.0	656.0	656.0	56.8	83.0
	Land Use Areas	Rural Residential *(% of area)*	0.0	39.9	39.9	2.5	7.5
		Single Family, Duplex and Townhouse *(% of area)*	0.0	65.0	65.0	27.3	17.7
		Apartment Residential Areas *(% of area)*	0.0	35.4	35.4	3.2	5.6
		Mixed-Use Apartment Areas *(% of area)*	0.0	14.8	14.8	0.6	2.9
		Commercial Areas *(% of area)*	0.0	21.8	21.8	3.6	4.7
		Institutional Areas *(% of area)*	0.0	10.8	10.8	2.3	2.0
		Industrial Areas *(% of area)*	0.0	32.3	32.3	4.4	6.6
		Parks and Open Space Areas *(% of area)*	3.3	93.1	89.7	21.5	18.7
	Land Use Mix	Land Use Mix Index (Simpson's Diversity Index)	0.1	0.8	0.7	0.7	0.1
	Growth Planning Areas	Population within Urban Centres *(% of pop.)*	0.0	100.0	100.0	16.0	30.0
		Population within TOD area *(% of pop.)*	0.0	68.6	68.6	1.3	7.0
		Population within UCB area *(% of pop.)*	0.0	100.0	100.0	91.6	21.6
	Urban-Rural Spectrum	Distance to an Urban Centre *(distance in kilometres)*	0.0	6.4	6.4	1.7	1.6
		Distance to CBD (distance in km.)	0.0	52.7	52.7	18.5	11.7
Transportation	Walking Network	Intersection Density *(per sq. km.)*	1.7	302.9	301.2	106.9	74.7
	Cycling Network	Cycling Route Density *(length in m. per ha.)*	0.0	148.7	148.7	16.0	21.8
		Cycling Route Access *(% of pop. in 400 m.)*	0.0	100.0	100.0	45.0	30.9
	Transit Network	Transit Stop Density *(per sq. km.)*	0.0	99.0	99.0	20.1	15.4
		Transit Access (% of pop. in 400 m. walkshed)	0.0	100.0	100.0	68.5	25.3
		Rapid Transit Stop Density *(per sq. km.)*	0.0	4.4	4.4	0.2	0.6
		Rapid Transit Access (% of pop. in 800 m. walkshed)	0.0	87.2	87.2	8.6	17.9
		Transit Route Density (length in m. per sq. km.)	0.0	28.4	28.4	3.7	4.6
		Transit Service Frequency (pickups per sq. km. per day)	0.3	879.1	878.8	70.7	106.
	Major Roads	Arterial and Highway Density *(length in m. per sq. km.)*	0.0	184.1	184.1	35.9	31.2
Housing	Dwelling Types	Ground-Oriented Dwellings *(% of dwellings)*	0.5	55.1	54.7	24.6	11.8
		Low-Rise Dwellings with 1-4 levels *(% of dwellings)*	0.0	70.0	70.0	20.0	16.8
		High-Rise Dwellings with 5+ levels *(% of dwellings)*	0.0	67.7	67.7	9.0	14.8
Food	Grocery Stores	Grocery Store Density (*stores per sq. km.)*	0.0	15.2	15.2	1.5	2.3
		Grocery Store Access (% of pop. in 400 m. walkshed)	0.0	100.0	100.0	50.3	30.6
	Protected Agricultural Land	Agricultural Land Area *(% of area in ALR)*	0.0	91.3	91.3	11.2	20.6
		Agricultural Land Access *(% of pop. in ALR)*	0.0	92.4	92.4	4.3	12.6
Natural Areas	Parks	Park Area (% of area)	0.0	1.0	1.0	0.1	0.1
		Park Access (% of pop. in 400 m.)	5.7	100.0	94.3	66.1	23.1
	Green space	Green space Area *(% of area)*	0.0	88.1	88.1	14.4	23.3
		Green space Access (% of pop. in 400 m.)	0.0	103.3	103.3	36.5	31.8
	Trails	Trails Density (length in m. per sq. km.)	0.0	60.0	60.0	4.8	8.9
		Trail Access (% of pop. in 400 m.)	0.0	100.0	100.0	24.2	27.9

5.3. ASSOCIATIONS BETWEEN CDIS AND BUILT ENVIRONMENT MEASURES

Results of the correlation analysis linking objective CDIs to subjective MHMC built environment perception measures are presented in Table 5.2. Statistically significant positive relationships are highlighted in green while negative relationships are highlighted in blue. Additionally, the light shades show weak correlations less than 0.3, middle shades show moderate correlations between 0.3-0.6, and dark shades show strong correlations greater than 0.6.

Table 5.2 - Correlation matrix of CDIs (rows) and built environment perception measures (columns).

			Local Amenities, Food and Greenspace			Walking, Cycling and Public Transit Options				Automobile Use	
			Amenities within walking/cycling distance	Large selection of fruits/vegetables	Many attractive natural sites around	Sidewalks well maintained	Lanes/pathways for cyclists & walking	Transit stop within 5 min walk of home	Commute - public transit	Commute - car	Do errands - car
Land Use	Population and Employment Density	Gross Population Density	0.57	0.45		0.27	0.25	0.49	0.52	-0.64	-0.76
		Net Population Density	0.54	0.39		0.30	0.30	0.52	0.58	-0.71	-0.79
		Gross Employment Density	0.33	0.23		0.21	0.29	0.32	0.30	-0.47	-0.55
		Net Employment Density	0.32	0.22		0.22	0.30	0.30	0.29	-0.47	-0.53
		Gross Pop. and Emp. Density	0.46	0.34		0.25	0.30	0.42	0.41	-0.58	-0.68
		Net Pop. and Emp. Density	0.43	0.31		0.28	0.32	0.40	0.41	-0.58	-0.66
	Job Balance	Employment-Population Balance								-0.38	-0.33
	Land Use Areas	Rural Residential Areas	-0.27	-0.21				-0.32	-0.24	0.38	0.28
		SF, Duplex and TH Res. Areas		0.22							
		Apartment Residential Areas	0.54	0.41		0.26	0.21	0.40	0.43	-0.56	-0.68
		Mixed-Use Apartment Areas	0.40	0.28		0.23	0.32	0.36	0.34	-0.53	-0.64
		Commercial Areas	0.45	0.30				0.31	0.35	-0.46	-0.51
		Institutional Areas	0.23	0.24		0.25		0.28		-0.39	-0.33
		Industrial Areas			-0.24						
		Parks and Open Space Areas	-0.27	-0.30	0.50	0.24					0.25
	Land Use Mix	Land Use Mix Index	0.32	0.24				0.41	0.28	-0.23	-0.31
	Focused Growth	Urban Centres	0.46	0.33				0.29	0.41	-0.52	-0.59
		Transit Oriented Development									
		Urban Containment Boundary	0.52	0.44		0.41	0.26	0.62	0.32	-0.43	-0.38
	Distance to City	Distance to an Urban Centre									
		Distance to CBD						-0.27	-0.36	0.34	0.30
Transportation	Walking Network	Intersection Density	0.56	0.42		0.33	0.23	0.60	0.70	-0.76	-0.78
	Cycling Network	Cycling Routes	0.40	0.27		0.37	0.45	0.46	0.49	-0.68	-0.72
		Cycling Route Access	0.53	0.44		0.39	0.42	0.56	0.64	-0.70	-0.72
	Transit Network	Transit Stop Density	0.53	0.38		0.30	0.22	0.59	0.59	-0.70	-0.74
		Transit Access	0.59	0.45		0.31		0.81	0.64	-0.66	-0.68
		Rapid Transit Stop Density	0.28					0.21	0.45	-0.42	-0.42
		Rapid Transit Access	0.38	0.24				0.27	0.66	-0.57	-0.56
		Transit Route Density	0.49	0.36		0.27	0.27	0.41	0.55	-0.69	-0.72
		Transit Service Frequency	0.46	0.33		0.28	0.34	0.44	0.52	-0.67	-0.73
	Major Roads	Arterial Roads and Highways	0.26			0.22		0.23	0.36	-0.54	-0.44
Housing	Dwelling Types	Ground-Oriented Dwellings	-0.30	-0.23	-0.38						0.27
		Low-Rise Dwellings	0.56	0.45		0.27		0.46	0.41	-0.62	-0.65
		High-Rise Dwellings	0.47	0.38	0.22	0.25	0.20	0.33	0.48	-0.61	-0.62
Food	Grocery Stores	Grocery Stores Density	0.49	0.37		0.21	0.25	0.43	0.43	-0.60	-0.74
		Grocery Store Access	0.62	0.50		0.24		0.60	0.67	-0.77	-0.80
	Protected Agricultural Land	Agricultural Land Area	-0.33	-0.24	-0.21	-0.22		-0.48	-0.35	0.47	0.41
		Agricultural Land Access	-0.46	-0.38		-0.39	-0.24	-0.57	-0.24	0.38	0.34
Natural Areas	Parks	Park Area			0.35		0.23				
		Park Access	0.43	0.32	0.20	0.43	0.27	0.54	0.26	-0.39	-0.38
	Greenspace	Greenspace Area	-0.44	-0.39	0.37			-0.35	-0.21	0.24	0.32
		Greenspace Access	-0.53	-0.39	0.30			-0.50	-0.35	0.47	0.55
	Trails	Trails Density			0.41		0.24				
		Trail Access	-0.23		0.51	0.27	0.27				0.29

5.3.1. Local Amenities, Food and Green Space

In total 29 of the 44 design indicators had strong or moderate correlations with the subjective MHMC perception measures related to 'amenities within walking/cycling distance'. These included ten strong positive correlations with gross and net population density, apartment residential land use area, population within the urban containment boundary, intersection density, cycling route access, transit stop density and access, low-rise dwellings, and grocery store access. Alternatively, amenities had moderate positive correlations with gross and net employment density, gross and net combined population and employment density, mixed use and commercial land use areas, land use mix index, population within urban centres, cycling route density, rapid transit access, transit route density, transit service frequency, high-rise dwellings, grocery store density and park access. Finally, there was a strong negative correlation between amenities and green space access, and moderate negative correlations with green space area and agricultural land areas and access.

Overall, the subjective measure of a 'large selection of fruits/vegetables' had a very similar relationship to all CDIs, however, the strength of the correlations was somewhat lower. Finally, the measure of 'many attractive sites around' had a moderate positive correlation with parks and open space land use areas, park area, green space area, and both trail density and trail access – and a negative moderate correlation with ground-oriented dwellings.

5.3.2. Walking, Cycling and Public Transit

In total 28 of the 44 CDIs had strong or moderate correlations with the subjective measure related to 'commuting by public transit'. These included strong positive correlations with gross and net population density, intersection density, cycling route density and access, transit stop density and access, rapid transit access, transit route density, transit service frequency, and grocery store access. There were moderate positive correlations between public transit commuting and combined gross and net population and employment density, apartment/mixed use apartment and commercial land use areas, population in urban centres and the urban containment boundary, cycling route density, arterial roads and highway density, low- and high-rise dwellings, and grocery store density. Finally, there were moderate negative correlations with distance to the Vancouver CBD, agricultural land area, and green space access.

Correlations between the MHMC measure of 'transit stop within a 5-minute walk of home' showed very similar correlation patterns, though lower overall strength. However, there were somewhat higher moderate correlations between this measure and the gross and net employment density, population within the urban containment boundary, and park access design indicators; and strong negative correlations with agricultural land access and green space access which makes sense given there are fewer transit stops in rural areas.

Next, there were several moderate positive correlations between the subjective measure of 'lanes/pathways for cycling and walking' and net population density, net employment density, net combined density, cycling route density and access, and transit service frequency CDIs. Finally, the following CDIs had a moderate positive correlation with 'sidewalks well maintained': net population density, the population within the urban containment boundary, intersection density, cycling route density and access, transit stop density and access, and park access. There was also a moderate negative correlation between the sidewalk measure and agricultural land access.

5.3.3. Automobile Use

This set of two subjective built environment measures has the greatest relationship to CDIs, with 34 strong or moderate correlations for 'doing errands by car' and 33 with 'commute by car' measure. The following CDIs had a strong negative correlation with auto use for errands: all population and employment density measures, apartment/mixed use apartment and commercial areas, population in urban centres, intersection density, cycling route density and access, all transit network measures except rapid transit density, low- and high-rise dwellings and grocery store density and access. Additionally, the following measures had moderate negative correlations with the car for errands measure: employment-population balance, institutional land area, land use mix, the population in the urban containment boundary, rapid transit stop density, and park access. Alternatively, one strong positive correlation with this measure was green space, and four moderate positive correlations included distance to the CBD, agricultural land area and access, and green space area.

5.3.4. Framework Validation and Discussion

Based on the substantial number of strong correlations observed, the objective CDI framework is considered to be a valid tool to objectively calculate neighbourhood design indicators. However, there were some CDIs that had low or no correlations to the MHMC built environment data that were explored. For example, single-family, duplex, and townhouse, institutional, and industrial land use area indicators had a limited number of low correlations with CDIs. This is likely due to the fact these areas have a somewhat random distribution and neighbourhoods may be too large a unit to be sensitive to these patterns. However, these measures may be useful in future studies that evaluate CDIs based on smaller study areas such as walksheds surrounding home locations.

The Transit Oriented Development (TOD) measure calculated based on the percent of people living within an FTDA has no significant relationships. However, it is important to note that in this context these areas represent a very small fraction of the population. There were also no correlations between MHMC measures and the distance to an urban centre indicator. This is likely due to the nodal pattern of development in Metro Vancouver that has many urban centres distributed across the region.

Finally, findings showed that overall population access measures had higher correlations than the alternate measures based on the density of the land area. For example, both trail access and transit stop access had some strong associations, while their density based alternative measurements had a lower number of significant linkages. Similarly, net measures of population, employment, and combined density all had higher correlations compared to the gross density measures. This suggests that net density can be considered a priority approach if data are available to calculate this indicator.

5.4. ASSOCIATIONS BETWEEN CDIS AND HEALTH MEASURES

Table 5.3 shows the statistical associations between CDIs and the 16 selected health and well-being measures from the MHMC. Significant positive relationships are highlighted in green while negative relationships are in blue. The colouring of this table is identical to the approach used for Table 5.2.

Table 5.3 - Correlation matrix of CDIs (rows) and selected health measures (columns).

			Healthy Lifestyles					Physical Health						Mental Health			Social Health	
			Leisure walking - 30+ min/day	Utilitarian walking - 30+ min/day	Total walking - 30+ min/day	Physically active - 150+ min/week	Fruits and vegetables – 5+ servings/day	Healthy weight (BMI 18.5 to 24.9)	Overweight/obese (BMI 25+)	Obese (BMI 30+)	High blood pressure	One or more chronic conditions	General health – excellent/very good	Mental health – excellent/very good	Mood or anxiety disorder	Stress - extremely/quite stressed	4+ people to confide in/turn to for help	Strong sense of community belonging
Land Use	Population and Employment Density	Gross Population Density	0.29	0.55	0.47			0.25	-0.25	-0.30	-0.28							
		Net Population Density	0.30	0.56	0.48			0.34	-0.35	-0.36	-0.28			-0.21				
		Gross Employment Density	0.23	0.34	0.36			0.25	-0.25	-0.25	-0.28							
		Net Employment Density	0.21	0.33	0.34			0.26	-0.27	-0.25	-0.27	-0.20						
		Gross Pop. and Emp. Density	0.28	0.46	0.43			0.27	-0.28	-0.29	-0.31							
		Net Pop. and Emp. Density	0.24	0.43	0.41			0.29	-0.30	-0.30	-0.30	-0.21						
	Job Balance	Employment-Population Balance		0.23				0.30	-0.33	-0.21								-0.21
	Land Use Areas	Rural Residential Areas	-0.20	-0.27				-0.38	0.39	0.31					0.25			
		SF, Duplex and TH Res. Areas										0.22			-0.21	-0.26		
		Apartment Residential Areas	0.22	0.50	0.47										0.25			
		Mixed-Use Apartment Areas	0.27	0.36	0.40			0.26	-0.26	-0.27	-0.30				0.22		0.27	
		Commercial Areas	0.20	0.48	0.35	-0.22	-0.23						-0.22					-0.20
		Institutional Areas			0.22			0.21	-0.21									
		Industrial Areas											-0.26				-0.33	
		Parks and Open Space Areas	-0.29	-0.20	-0.21							-0.27	0.30					
	Land Use Mix	Land Use Mix Index		0.26											0.23			
	Focused Growth	Urban Centres		0.52	0.45										0.26			-0.22
		Transit Oriented Development						0.24	-0.22			-0.21	0.23					
		Urban Containment Boundary		0.34				0.22	-0.22	-0.25						-0.29		
	Distance to City	Distance to an Urban Centre		0.20														
		Distance to CBD						-0.31	0.32	0.43	0.23	0.32						
Transportation	Walking Network	Intersection Density		0.40	0.32			0.45	-0.44	-0.44	-0.26			-0.34		-0.24		
	Cycling Network	Cycling Routes		0.29	0.31		0.26	0.44	-0.43	-0.46	-0.43	-0.33			0.21		0.35	-0.21
		Cycling Route Access		0.33	0.22			0.44	-0.43	-0.46	-0.32	-0.23		-0.27				-0.22
	Transit Network	Transit Stop Density	0.21	0.48	0.46			0.35	-0.35	-0.34								
		Transit Access	0.22	0.41	0.31			0.35	-0.35	-0.36				-0.24		-0.26		
		Rapid Transit Stop Density		0.31	0.29													
		Rapid Transit Access		0.47	0.39			0.25	-0.24	-0.23								-0.35
		Transit Route Density		0.52	0.43			0.28	-0.29	-0.27	-0.21				0.23			-0.21
		Transit Service Frequency	0.24	0.44	0.43			0.37	-0.37	-0.36	-0.28	-0.20			0.21		0.22	-0.21
	Major Roads	Arterial Roads and Highways		0.38	0.30			0.23	-0.24									-0.26
Housing	Dwelling Types	Ground-Oriented Dwellings			-0.25		-0.30						-0.38	-0.25	-0.25		-0.24	
		Low-Rise Dwellings	0.20	0.46	0.42			0.22	-0.22						0.35			-0.22
		High-Rise Dwellings		0.48	0.42			0.24	-0.25	-0.22								-0.21
Food	Grocery Stores	Grocery Stores Density	0.33	0.49	0.44			0.22	-0.23	-0.25	-0.25				0.24			
		Grocery Store Access		0.45	0.33			0.41	-0.40	-0.34	-0.27			-0.29	0.20			-0.24
	Protected Agricultural Land	Agricultural Land Area		-0.34	-0.23			-0.32	0.30	0.32						0.26		
		Agricultural Land Access		-0.30				-0.23	0.22	0.26						0.26		
Natural Areas	Parks	Park Area						0.23	-0.26			-0.21	0.24					
		Park Access		0.27				0.27	-0.29	-0.31						-0.32		
	Greenspace	Greenspace Area		-0.29		0.25						-0.20	0.32					
		Greenspace Access	-0.37	-0.43	-0.27			-0.24	0.25	0.23			0.28	0.26		0.22		
	Trails	Trails Density	-0.20				0.20	0.24	-0.22			-0.22	0.34					
		Trail Access	-0.34	-0.23	-0.21								0.26					

5.4.1. Healthy Lifestyles

Overall, the most significant finding from this analysis is the strong correlation between rates of utilitarian walking and many design indicator categories. In total, there were 24 strong and moderate correlations between CDIs and MHMC measure of ‘utilitarian walking – 30+ minutes per day’. In particular, gross and net population density, apartment residential areas, populations living within urban centres, and transit route density had strong positive relationships with utilitarian walking; gross and net employment density and combined density, mixed-use apartment and commercial land use areas, population in an urban containment boundary, intersection density, cycling route access, all transit measures except transit route density, arterials and roads, low- and high-rise dwellings, and access to and density of grocery stores had moderate positive relationships. There were also negative correlations between utilitarian rates of walking and agricultural land area and green space access. Rates of total walking showed a very similar pattern overall, although the relationships were lower.

Alternatively, rates of ‘leisure walking – 30+ minutes per day’ had only a few moderate positive correlations with net population density, grocery store access and a few moderate negative correlations with green space access and trail access. These last two were surprising since one may expect areas with more trails would have higher walking rates – not lower. This is likely the result of confounding of results by one or more sociodemographic characteristics that will be discussed in the limitations section of this study.

Correlations between CDIs and both ‘physically active - 150+ minutes /week’, ‘and fruits and vegetables - 5+ services/day’ had a limited number of low correlations that are below the threshold of consideration. However, given this finding, it is worth considering the fact that grocery store access was strongly related to both a wide variety of fruits and vegetables and access to local amenities measures discussed in the previous section of this report – this finding suggests that diet choices may involve a broader set of social and cultural factors beyond simple access to healthy options. Again this may be related to the potential influence of confounding sociodemographic characteristics.

5.4.2. Physical Health

There were 12 moderate correlations between CDIs and ‘healthy body weight’, ‘overweight/obese’, and ‘obese’ measures. In particular, the ‘overweight/obese’ measures had a moderate negative correlation with net population density, employment-balance, intersection density, cycling routes, cycling route access, transit stop density and access, and transit stop frequency. Alternatively, the 'overweight/obesity' measure had a moderate positive correlation with rural residential areas, distance to the CBD, and agricultural land area. Similarly, the 'obesity' measure had virtually identical findings as listed above, although it did not have a relationship to job-employment balance and it did have a moderate negative correlation with park access, which confirms past evidence suggesting access to parks may be associated with lower levels of obesity.

Other physical health measures such as the 'high blood pressure' measure had moderate negative correlations with gross combined population and employment-population density, and cycling routes density and access. The 'one or more chronic conditions' measure had a moderate positive correlation with distance to the CBD and an inverse relationship to cycling route density. Finally, 'general health' had a moderate positive correlation with park and opens space land use areas, green space access, and trail access, and one moderate negative correlation with ground-oriented dwellings.

5.4.3. Mental Health

There were a limited number of linkages between CDIs and mental health indicators, however, there was a moderate negative correlation between 'excellent/very good mental health' and intersection density – this is particularly interesting as it suggests that dense, walkable communities may have a lower quality of mental health overall. There was also a moderate positive correlation between 'mood or anxiety disorders' and low-rise dwellings, and finally – and perhaps most interesting in this section – there was a moderate negative correlation between the measure of being 'extremely/quite stressed' and park access. However, mental health is known to be strongly associated with socioeconomic factors, and housing affordability in areas with park access may be a factor worthy of further study.

5.4.4. Social Health

In this final section of health impacts, the measure of '4+ people to confide in/turn to for help' had a moderate negative correlation with industrial land areas in a neighbourhood, and a moderate positive correlation with cycling routes. There was also a moderate negative relationship between 'strong sense of community belonging' and the rapid transit access design indicator. This finding is particularly interesting, however, not unexpected as there is some evidence to suggest sense of community belonging is generally higher in suburban households with higher rates of home ownership and time in a residence (Kitchen, 2012).

6. CONCLUSION & PROFESSIONAL IMPLICATIONS

This section presents a summary of the study objectives and key findings, reviews several study limitations and suggested next steps, and then discusses the implications of this work for professional urban planning practice.

This study has completed the following two primary research objectives: it has outlined a comprehensive framework for calculating objective CDIs using publically accessible open data, and it has explored the statistical associations between each CDI and several built environment and health measures from the MHMC survey. Furthermore, this work was situated within the emerging healthy community design paradigm, and a brief summary of the public health and urban planning context of this project was described. A scoping review of planning and public health literature was conducted to identify existing methods for calculating CDIs using GIS and to summarize existing evidence linking design indicators to harmful and protective health impacts. The methods section then described the geographic computation of CDIs for neighbourhoods in the Metro Vancouver region, and then correlation analysis was conducted to explore significant associations between CDIs and MHMC measures.

Overall, the CDI framework was validated by a high number of strong correlations between design indicators and subjective built environment perception measures from the MHMC survey measures focused on local amenities, healthy food options, green space, active and sustainable transportation options and automobile use. Many strong and moderate correlations between objective design indicators and health measures from the MHMC survey were also identified. These measures related to healthy lifestyles and physical, mental and social health and well-being. The highest number of statistical associations were observed with health measures related to utilitarian walking and levels of obesity.

6.1. STUDY LIMITATIONS

There are several important limitations to the statistical analysis conducted in this study. The most important consideration is the fact the current statistical analysis of associations between CDIs and MHMC measures is based on a cross-sectional, ecological study design and so findings cannot infer a causal relationship between variables. It is also important to consider the fact that the correlations in this study are not adjusted for potential intermediate confounding socioeconomic factors such as age, sex, income, ethnicity, or education differences between neighbourhoods. It is also important to control for health status factors such as underlying rates of chronic disease since 60-80% of individuals that have diabetes are also overweight or obese based on data from the MHMC results.

The neighbourhood-scale analysis is also potentially problematic for three reasons. First, the use of neighbourhood population health measures may obscure statistical variability that could only be identified using individual health data. This is particularly important when considering individual chronic disease risk factors and social determinants of health that may have a wide range of measures within any one specific neighbourhood, especially in Metro Vancouver where there are a high number of immigrants and transient residents in some areas. This drawback is related to the ecological fallacy that describes the fact that aggregated results do not represent the true characteristics of any one individual within the study area.

Secondly, the neighbourhood boundary files require consideration of the Modifiable Areal Unit Problem (MAUP) that describes the fact that different scales of geographic analysis can create arbitrary variations in results. For example, if the same analysis were repeated using census tracts, it is possible that a different set of results could be found. The impact of the MAUP by use of a grid-based analysis with equally spaced cells, or by the use of walksheds surrounding individual home locations.

A third consideration related to the boundary files is the fact that several neighbourhoods include large areas of uninhabited land. Many CDIs effectively mitigate the effect of large empty spaces by calculating indicators based on a subset of the total neighbourhood area (such as net population density), or by focusing on a population-based access indicator (such as access to grocery stores that is calculated based on 800-metre network-based walksheds). However, some other indicators such as gross population density and land area percentages may be impacted by uninhabited areas.

Additionally, there are currently several gaps in publically available datasets. For example, there were several missing or misclassified features in the cycling networks and parks files that were obtained from OpenStreetMap.com. Where possible, significant errors or gaps were corrected based on local knowledge. However, these datasets are rapidly improving and it is expected open data will become increasingly reliable over time.

The CDI framework outlined in this project can easily be replicated to evaluate comparable city regions, to inform neighbourhood-scale analysis and planning initiatives, however, it will be important to critically review the utility of each CDI based on local knowledge in other jurisdictions. Adjustments may have to be made to calculation methods based on spatial data availability.

Despite some limitations, this study has strong implications for future research and professional planning practice.

6.2. NEXT STEPS

There are many exciting research questions that can be explored based on the CDI framework and health measures outlined in this project. For example, CDIs could be calculated and compared for neighbourhoods in other city regions, or for multiple time periods. Data may also be linked to other measures related to economic prosperity or environmental sustainability of communities.

Regression modelling could be conducted to explore relationships between CDIs and MHMC Data while controlling for several socio-economic factors. To accomplish this task, a series of regression models could be created with a fixed set of independent socio-demographic control variables. Each CDI could then be added as an additional independent variable to determine the marginal explanatory power of the CDI in relation to each health measure. Results could be summarized by calculation of elasticity measures for each CDI, to describe how a change in each design indicator is related to a percentage change in related health measures.

Finally, there is potential to develop a set of individual-scale neighbourhood design indicators based on areas surrounding home postal code locations. These data could then be linked to individual health measures collected using the MHMC survey in a secure research environment.

6.3. IMPLICATIONS FOR PLANNING AND DESIGN

This final section discusses implications of this work for professional urban planners and designers. The discussion is organized by the following four themes: supporting evidence-based community engagement and decision-making, informing performance-based planning and design, measuring economic and environmental performance; and inspiring intersectoral healthy community design visions and action-oriented implementation strategies.

6.3.1. Evidence-Based Community Engagement and Decision-Making

To respect the needs and desires of diverse stakeholders, successful healthy community design must incorporate opportunities for meaningful public engagement and participation. To facilitate this process, the comprehensive CDI framework outlined in this project may help describe the characteristics of the current built and natural environments, and inform stakeholders about how planning and design decisions may impact these indicators.

CDI data can also support effective communication of planning and design objectives to help build a community consensus of support for new projects or initiatives. In these cases, data about the direct impacts of planning and design decisions, and potential health and well-being outcomes of decisions, may increase the zone of agreement between stakeholders and align diverse social, economic and environmental interests by focusing on a shared vision of a healthy community. This type of meaningful community engagement depends on objective indicators that can redirect focus away from short-term thinking and emotional reactions to change. CDI data can also help stakeholders understand complicated planning principles and re-frame black and white thinking about design decisions as a series of trade-offs that seek to maximize the public benefits overall.

CDIs may be particularly useful during challenging community engagement activities to reduce emotional or political influences interfering with the successful implementation of planning and design that may lead to important public benefits. For example, urban development projects that may be controversial or expensive may gain a social license and political support through the creation of a shared vision of a healthy community. CDIs may help build support for potentially disruptive but important city building projects such as rapid transit networks and cycling network investments. One particularly salient example is the recent Metro Vancouver transit referendum that failed to secure public support for a long-term transit investment plan. The failure of this referendum is widely blamed on the fact a majority of media and public attention was focused on the economic funding model of the proposal while there was relatively limited discussion about the population health and environmental benefits of the plan. Therefore, future public transit investments must clearly outline the direct and indirect public health benefits of a proposal to help the public understand the diverse benefits of public transit investments.

In cases when planning and design decisions are subject to political support, objective performance indicators can be an essential tool to help moderate the influences of powerful stakeholders and vocal minority groups in the political process. Ultimately, the CDI framework outlined in this study may help bridge the gap from planning and design to successful project implementation.

6.3.2. Performance-Based Planning and Design

There is a common saying that states: "what gets measured is what matters". Based on this understanding, there may be significant utility in deploying the comprehensive CDI framework outlined in this project to evaluate how planning policy relates to actual land use, transportation, housing, food and natural area indicators for a wide range of community types. Additionally, these indicators may be tracked over time or generated based on modelled future scenarios to evaluate the impacts of planning and design decisions. New performance standards for urban planning and design may also benefit from consideration of the *Performance Measures for the Growth Plan* (Government of Ontario, 2015). Although this framework includes a smaller number of indicators compared to the current study, it does present a well-reasoned custom framework related to the Ontario policy context, and it includes several interesting design indicators that focus on community changes through time.

There is also an important opportunity to officially deploy many of the CDIs in this study in the Metro Vancouver region. The Greater Vancouver Regional District Board recently adopted a new regional growth strategy called *Metro Vancouver 2040: Shaping Our Future* (Greater Vancouver Regional District Board, 2011), however, this strategy does not directly reference any design indicator framework, aside from general sustainability goals. Therefore, this study may inform future development of a performance-based planning and design framework for Metro Vancouver.

6.3.3. Economic Prosperity and Environmental Sustainability

Many of the CDIs developed for this study and related to health and well-being measures may also have a significant impact on economic prosperity due to lower infrastructure costs for municipalities, greater productivity of citizens, and lower health care costs over time. In addition, there is a very large body of evidence linking compact, complete and connected community design principles to reduced environmental impacts due to smaller development footprints and lower energy use for transportation and housing (National Centre for Environmental Health, 2016; Shemirani & Hodjati, 2013; Walters & Ewing, 2009). Investing in healthy community design can pay dividends through reduced greenhouse gas emissions and help communities mitigate the impacts of climate change through increased ecological resilience. Therefore, the CDI framework developed for this project may have much wider implications beyond the scope of this current study.

To advance the public benefits of healthy communities, planners and designers are advised to pay close attention to complementary benefits of CDIs related to financial and environmental outcomes. For example, planners must 'do the math' and communicate how healthy community designs may result in lower costs associated avoiding the need for costly investment in new water, sanitary and transportation infrastructure. Alternatively, communication may also focus on lower GHG emissions that may result from the development of compact, complete and well-connected places to live, work, and play.

6.3.4. Creating a Healthy Community Design Vision and Implementation Strategy

This study is intended to enhance intersectoral collaboration between urban planners and public health professionals. These sectors may then work collaboratively and in consultation with local stakeholders to create a shared vision of a healthy community along with an action-oriented implementation strategy for each local context. The evidence in this study that links several CDIs to health measures may be particularly practical to the creation of this type of intersectoral vision.

Therefore, a summary infographic, shown in Figure 6.1 was created to highlight statistically significant correlations between design indicators and health measures. Linkage lines indicate if one or more CDIs in each planning and design theme had a moderate or strong correlation with each health measure. Additionally, the line colour indicates if the correlation was positive (green) or negative (blue). It is very important to restate that these linkages do not represent a causal relationship, rather they summarize the direct unadjusted association between each dataset.

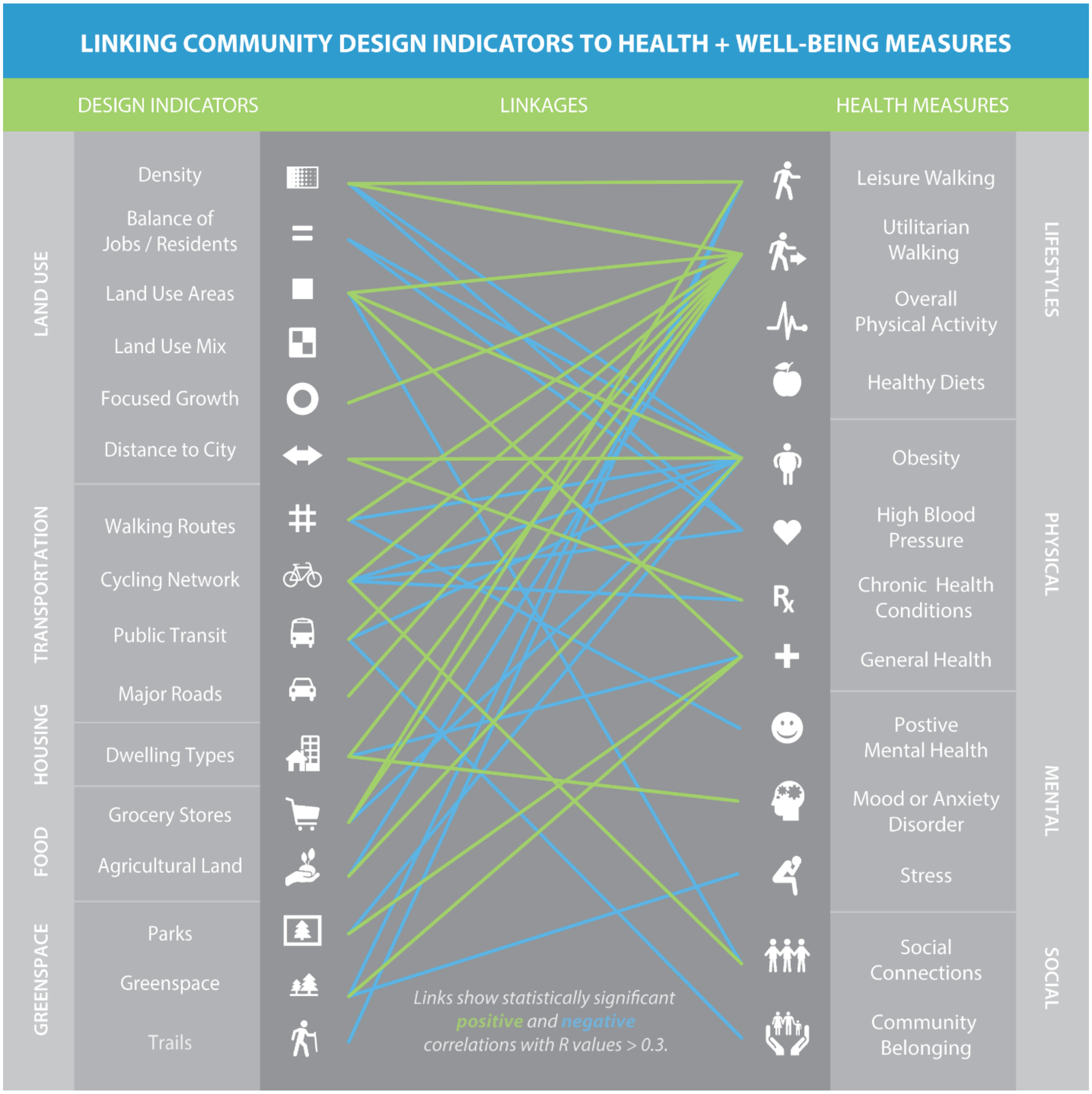

Figure 6.1 - Infographic of correlations between design indicators and health measures.

The evidence summarized in this study suggests that a healthy community design vision may benefit from a focus on improving physical health by increasing opportunities to walk, cycle or use public transit to meet the transportation needs and desires of daily life. This focus may lead to increased opportunity for people to be physically active with a reduced risk of becoming obese or developing a chronic disease.

A successful vision may also integrate a holistic focus on physical, social and ecological health, through the creation of a continuous landscape of green space, punctuated by interconnected networks of lush and ecologically resilient parks and natural areas. This type of green infrastructure investment can promote opportunities for active recreation and leisure, reduce exposure to air pollution, build and strengthen social ties, increase levels of community belonging, enhance the resilience of local ecosystems, and mitigate the impacts of global climate change.

Intersectoral collaborations may also focus on the creation of vibrant, mixed-use urban centres that place diverse people at the heart of each community. These places must integrate both residential and employment areas within close proximity, and provide a mix of complementary light industrial, institutional and mixed use spaces. At the same time, these decisions may also result in lower levels of stress and anxiety, and increased levels of happiness associated with mixed land uses and shorter daily commutes.

To successfully bridge the gap between planning and implementation of healthy communities, planners, designers and health professionals must place a special focus on the needs of children, the elderly and lower income groups and other sensitive populations to ensure communities meet the diverse needs of people of all ages and abilities.

This study builds on the emerging healthy community design paradigm that links the fields of urban planning and public health, and the objective CDI framework outlined in this study provides a new evidence-based approach to evaluating planning and design decisions that may improve the health and well-being of communities both today and for generations to come.

APPENDIX A: MY HEALTH MY COMMUNITY SURVEY MEASURES

Domain	Measure	Metro Vancouver (%)
Built Environment	Amenities within walking/cycling distance	69.5
	Commute - car	55.1
	Commute - public transit	28.2
	Do errands - car	66.1
	Exposed to second-hand smoke in public places	26.6
	Feel safe walking after dark	58.3
	Lanes/pathways for cyclists & walking	67.3
	Large selection of fruits/vegetables available	75.3
	Lived in neighbourhood for 5+ years	62.4
	Many attractive natural sites around	75.3
	One-way commute 30+ min	56.0
	See a lot of people walking/biking	69.9
	Sidewalks well maintained	75.5
	Traffic in the area makes walking difficult	25.2
	Transit stop within 5 min walk of home	84.0
Health Behaviors	Binge drinking - 1+ times/month	20.7
	Binge drinking - never/infrequently	79.3
	Fast food - 2+ times/week	25.9
	Fruits and vegetables – 5+ servings/day	24.9
	High physical wellness score (10-16)	37.7
	Leisure walking - 30+ min/day	39.5
	No alcohol - past 12 months	22.5
	Physically active - 150+ min/week	44.1
	Screen time - 2+ hours/day	47.8
	Sleep – 6 hours or less/day	23.1
	Smoker – daily/occasional	10.6
	Sugary beverage - 3+ times/week	14.1
	Total walking - 30+ min/day	68.2
	Utilitarian walking - 30+ min/day	34.4
Community Resiliency	4+ people to confide in or turn to for help	45.0
	Emergency supplies for 3+ days	26.7
	Strong sense of community belonging	55.9
Health Care Access and Utilization	Dental visit – past 12 months	72.2
	Flu Shot - past 12 months	42.6
	Have a family doctor	83.1
	Healthcare visit – past 12 months	80.4
	Healthcare visit – physician appointment	75.0
	Mammogram - past 12 months	48.4
	Pap test – past 12 months	43.1

Domain	Measure	Metro Vancouver (%)
Health Status	Arthritis	13.1
	General health – excellent/very good	48.5
	Healthy weight (BMI 18.5 to 24.9)	41.4
	High blood pressure	17.9
	Mental health – excellent/very good	56.5
	Mood or anxiety disorder	16.3
	Obese (BMI 30+)	21.7
	One or more chronic conditions	28.6
	Overweight/obese (BMI 25+)	56.9
	Stress - extremely/quite stressed	17.8
Demographic	Age - 18 to 39 years	38.4
	Age - 40 to 64 years	45.5
	Age – 65+ years	16.2
	Born in Canada	63.6
	Chinese	16.8
	Immigration Status - Citizen	91.2
	Live Alone	19.2
	Male	48.1
	Married/Common-law	57.7
	Parent(s) with child under 18	25.9
	Parent(s) with child under 5	10.2
	South Asian	8.2
	Visible Minority	37.1
	White/Caucasian	58.8
Social and Economic	Dwelling owned (with/without mortgage)	63.8
	Education - Bachelor's degree or more	29.3
	Education - High School or less	38.0
	Employed	64.7
	Household income - $100,000+	29.3
	Household income - under $40,000	31.7

APPENDIX B: HEALTHY BUILT ENVIRONMENT LINKAGES TOOLKIT SUMMARY

Provincial Health Services Authority
Province-wide solutions. Better health.

VERSION 1.1 - October 2014

PLANNING PRINCIPLES
FOR A HEALTHY BUILT ENVIRONMENT

Healthy Neighbourhood Design

1. Enhance neighbourhood walkability
2. Create mixed land use
3. Build complete and compact neighbourhoods
4. Enhance connectivity with efficient and safe networks
5. Prioritize new developments within or beside existing communities

Vision: *Neighbourhoods where people can easily connect with each other and with a variety of day-to-day services.*

Healthy Transportation Networks

1. Enable mobility for all ages and abilities
2. Make active transportation convenient and safe
3. Prioritize safety
4. Encourage use of public transit
5. Enable attractive road, rail and waterway networks

Vision: *Safe and accessible transportation systems that incorporate a diversity of transportation modes and place priority on active transport (e.g., cycling, walking and transit) over the use of private vehicles.*

Healthy Natural Environments

1. Preserve and connect open space and environmentally sensitive areas
2. Maximize opportunities to access and engage with the natural environment
3. Reduce urban air pollution
4. Mitigate urban heat island effect

Vision: *A built environment where natural environments are protected and natural elements are incorporated, and are experienced by and accessible to all.*

Healthy Food Systems

1. Enhance agricultural capacity
2. Increase access to healthy foods in all neighbourhoods
3. Improve community-scale food infrastructure and services

Vision: *A built environment that can support access to and availability of healthy foods for all.*

Healthy Housing

1. Increase access to affordable housing through provision of diverse housing forms and tenure types
2. Ensure adequate housing quality for all segments of society
3. Prioritize housing for the homeless, elderly, low income groups, and people with disabilities
4. Site and zone housing developments to minimize exposure

Vision: *Affordable, accessible, and good quality housing for all that is free of hazards and enables people to engage in activities of daily living while optimizing their health.*

The order in which the physical features and principles are listed is not necessarily an indication of their priority or strength of eevidence.

HEALTHY BUILT ENVIRONMENT LINKAGES
A TOOLKIT FOR DESIGN • PLANNING • HEALTH
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APPENDIX C: LIST OF MHMC SURVEY NEIGHBOURHOOD NAMES

ID	Neighbourhood Name	Municipality
1	Brentwood	Burnaby
2	Buckingham/Lakeview/Gov't Road	Burnaby
3	Burnaby Heights/Capitol Hill	Burnaby
4	Burnaby Mountain	Burnaby
5	Burnaby South/Sussex/Nelson	Burnaby
6	Cariboo/Second Street/Stoney Creek	Burnaby
7	Cascade-Schou/Douglas	Burnaby
8	Edmonds	Burnaby
9	Lochdale/Westridge	Burnaby
10	Marlborough/Garden Village	Burnaby
11	Metrotown	Burnaby
12	Middlegate/Windsor	Burnaby
13	Sperling/Broadway/Lake City	Burnaby
14	Willingdon Heights	Burnaby
15	Cape Horn/River Heights	Coquitlam
16	Cariboo/Burquitlam/Maillardville	Coquitlam
17	Central Coquitlam	Coquitlam
18	Coquitlam Town Centre	Coquitlam
19	Eagle Ridge/Ranch Park	Coquitlam
20	Hockaday/Nestor	Coquitlam
21	Westwood Plateau	Coquitlam
22	Annieville/Sunbury/Nordel	Delta
23	Burns View	Delta
24	Jarvis/Kennedy	Delta
25	Ladner	Delta
26	Sunshine Hills	Delta
27	Tsawwassen	Delta
28	Langley City	Langley City
29	Aldergrove/Rural Langley	Langley Township
30	Brookswood/Fernridge	Langley Township
31	Hopington/Murrayville	Langley Township
32	Walnut Grove	Langley Township
33	Willoughby/Willowbrook	Langley Township
34	Albion/Whonnock	Maple Ridge
35	Hammond	Maple Ridge
36	Haney	Maple Ridge
37	Maple Ridge North	Maple Ridge
38	Downtown New Westminster	New Westminster
39	Queen's Park	New Westminster
40	Queensborough/West End/Connaught Heights	New Westminster
41	Sapperton	New Westminster
42	Uptown New Westminster	New Westminster
43	North Vancouver CY West	North Vancouver - City
44	North Vancouver CY East	North Vancouver - City
45	North Vancouver DM Central	North Vancouver - District
46	North Vancouver DM East	North Vancouver - District
47	North Vancouver DM West	North Vancouver - District
48	Pitt Meadows	Pitt Meadows
49	Citadel Heights	Port Coquitlam
50	Central Port Coquitlam	Port Coquitlam
51	Lincoln Park/Oxford	Port Coquitlam
52	Mary Hill/Kilmer Park	Port Coquitlam

ID	Neighbourhood Name	Municipality
53	Port Moody	Port Moody
55	Bridgeport/East Cambie/West Cambie	Richmond
56	Broadmoor	Richmond
57	City Centre	Richmond
58	Gilmore/Shellmont	Richmond
59	Hamilton/East Richmond/Fraser Lands	Richmond
60	Sea Island/Thompson	Richmond
61	Seafair	Richmond
62	Steveston	Richmond
63	Cedar Hills/Royal Heights	Surrey
64	Clayton	Surrey
65	Cloverdale	Surrey
66	Crescent Beach/Ocean Park	Surrey
67	Elgin/Semiahmoo	Surrey
68	Fleetwood	Surrey
69	Fraser Heights	Surrey
70	Guildford	Surrey
71	Morgan Creek/South East Surrey	Surrey
72	Newton	Surrey
73	Panorama Ridge	Surrey
74	Strawberry Hills	Surrey
75	Surrey Central	Surrey
76	Whalley	Surrey
77	UBC	UBC
78	Downtown	Vancouver
79	Dunbar-Southlands	Vancouver
80	Fairview	Vancouver
81	Grandview-Woodland	Vancouver
82	Hastings-Sunrise	Vancouver
83	Kensington-Cedar Cottage	Vancouver
84	Killarney	Vancouver
85	Kitsilano	Vancouver
86	Marpole	Vancouver
87	Mount Pleasant	Vancouver
88	Renfrew-Collingwood	Vancouver
89	Riley Park	Vancouver
90	Shaughnessy/Arbutus Ridge/Kerrisdale	Vancouver
91	South Cambie/Oakridge	Vancouver
92	Strathcona	Vancouver
93	Sunset	Vancouver
94	Victoria-Fraserview	Vancouver
95	West End	Vancouver
96	West Point Grey	Vancouver
97	West Vancouver Lower	West Vancouver
98	West Vancouver Upper	West Vancouver
99	White Rock	White Rock
100	Stanley Park*	Vancouver
101	Hopington/Murrayville*	Langley Township
102	Downtown & Central Port Coquitlam*	Port Coquitlam
103	Port Kells*	Surrey
104	Rural Delta*	Delta
105	Anmore*	Anmore
106	Belcarra*	Belcarra

APPENDIX D: DESIGN INDICTOR GEOGRAPHIC DATA SOURCES

	Indicator (Unit of Measure)	Spatial Data Source	Year
Land Use	Gross Population Density *(per ha.)*	Statistics Canada Census of Population	2011
	Net Population Density *(per ha.)*	Statistics Canada Census of Population	2011
	Gross Employment Density *(per ha.)*	Census Plus from Geographic Research Inc. (GRI)	2011
	Net Employment Density *(per ha.)*	Census Plus from Geographic Research Inc. (GRI)	2011
	Gross Population and Employment Density *(per ha.)*	Statistics Canada Census of Population Census Plus from Geographic Research Inc. (GRI)	2011 2011
	Net Population and Employment Density *(per ha.)*	Statistics Canada Census of Population and Census Plus from Geographic Research Inc. (GRI)	2011 2011
	Number of Jobs per 100 Residents *(index)*	Statistics Canada Census of Population and Census Plus from Geographic Research Inc. (GRI)	2011 2011
	Rural Residential *(% of area)*	Metro Vancouver Open Data Land Use	2011
	Single Family, Duplex and Townhouse *(% of area)*	Metro Vancouver Open Data Land Use	2011
	Apartment Residential Areas *(% of area)*	Metro Vancouver Open Data Land Use	2011
	Mixed-Use Apartment Areas *(% of area)*	Metro Vancouver Open Data Land Use	2011
	Commercial Areas *(% of area)*	Metro Vancouver Open Data Land Use	2011
	Institutional Areas *(% of area)*	Metro Vancouver Open Data Land Use	2011
	Industrial Areas *(% of area)*	Metro Vancouver Open Data Land Use	2011
	Parks and Open Space Areas *(% of area)*	Metro Vancouver Open Data Land Use	2011
	Land Use Mix Index (Simpson's Diversity Index)	Metro Vancouver Open Data Land Use	2011
	Population within Urban Centres *(% of pop.)*	Metro Vancouver Open Data Urban Centres	2015
	Population within TOD area *(% of pop.)*	Metro Vancouver Open Data FTDAs	2015
	Population within UCB area *(% of pop.)*	Metro Vancouver Open Data UCB	2015
	Distance to an Urban Centre *(distance in kilometres)*	Metro Vancouver Open Data Urban Centres	2015
	Distance to CBD (distance in km.)	Metro Vancouver Open Data Urban Centres	2015
Transportation	Intersection Density *(per sq. km.)*	Province of British Columbia Open Data	2015
	Cycling Route Density (length in m. per sq. km.)	Open Street Map	2015
	Cycling Route Access *(% of pop. in 400 m.)*	Open Street Map	2015
	Transit Stop Density *(per sq. km.)*	TransLink GTFS Open Data	2015
	Transit Access (% of pop. in 400 m. walkshed)	TransLink GTFS Open Data	2015
	Rapid Transit Stop Density *(per sq. km.)*	TransLink GTFS Open Data	2015
	Rapid Transit Access (% of pop. in 800 m. walkshed)	TransLink GTFS Open Data	2015
	Transit Route Density (length in m. per sq. km.)	TransLink GTFS Open Data	2015
	Transit Service Frequency (pickups per sq. km. per day)	TransLink GTFS Open Data	2015
	Major Roads Density (length in m. per sq. km.)	TransLink GTFS Open Data	2015
Housing	Ground-Oriented Dwellings *(% of dwellings)*	Statistics Canada National Household Survey	2011
	Low-Rise Dwellings with 1-4 levels *(% of dwellings)*	Statistics Canada National Household Survey	2011
	High-Rise Dwellings with 5+ levels *(% of dwellings)*	Statistics Canada National Household Survey	2011
	Residents per Dwelling *(pop. per dwellings)*	Statistics Canada Census of Population	2011
Food	Grocery Store Density (*stores per sq. km.)*	Canadian Business Listings from Geographic Research Inc.	2015
	Grocery Store Access (% of pop. in 400 m. walkshed)	Canadian Business Listings from Geographic Research Inc.	2015
	Agricultural Land Area *(% of area in ALR)*	Province of British Columbia Open Data	2015
	Agricultural Land Access *(% of pop. in ALR)*	Province of British Columbia Open Data	2015
Natural Areas	Park Area (% of area)	Open Street Map	2015
	Park Access (% of pop. in 400 m.)	Open Street Map	2015
	Green space Area *(% of area)*	Natural Resources Canada (CANVEC)	2015
	Green space Access (% of pop. in 400 m.)	Natural Resources Canada (CANVEC)	2015
	Trails Density (length in m. per sq. km.)	Open Street Map	2015
	Trail Access (% of pop. in 400 m.)	Open Street Map	2015

APPENDIX E: CDIS FOR NEIGHBOURHOODS IN METRO VANCOUVER

Neighbourhood Number	Neighbourhood Name	Neighbourhood Municipality	Gross Population Density	Net Population Density	Gross Employment Density	Net Employment Density	Gross Pop. and Emp. Density	Net Pop. and Emp. Density	Employment-Population Balance	Rural Residential Areas	SF, Duplex and TH Residential Areas	Apartment Residential Areas	Mixed-Use Apartment Areas	Commercial Areas	Institutional Areas	Industrial Areas	Parks and Open Space Areas	Land Use Mix Index	Urban Centres	Transit Oriented Development	Urban Containment Boundary	Distance to an Urban Centre	Distance to CBD	Intersection Density	Cycling Routes	Cycling Route Access
1	Brentwood	Burnaby	35.6	69.4	12.2	19.8	47.8	77.5	34.2	0.0	42.0	3.7	0.3	6.9	2.4	6.2	11.1	0.66	32.0	0.0	100.0	6.1	8.6	116.6	1.7	15.7
2	Buckingham/Lakeview/Gov't Road	Burnaby	13.5	35.8	7.0	14.6	20.6	42.7	52.0	0.0	36.9	0.0	0.0	0.3	0.6	10.3	26.3	0.73	0.0	0.0	100.0	2.6	41.8	79.0	4.4	36.6
3	Burnaby Heights/Capitol Hill	Burnaby	22.7	77.3	5.6	10.3	28.2	52.3	24.6	0.0	25.3	1.9	0.3	1.4	0.7	24.2	21.7	0.78	0.0	0.0	100.0	0.2	52.7	120.0	4.6	20.2
4	Burnaby Mountain	Burnaby	3.8	62.4	3.2	28.3	7.0	61.4	85.8	0.0	0.8	1.0	0.2	0.4	4.2	4.0	71.0	0.46	3.9	0.0	100.0	3.9	19.6	87.9	41.8	21.9
5	Burnaby South/Sussex/Nelson	Burnaby	15.0	42.4	11.6	22.3	26.6	50.9	77.7	0.0	20.7	0.9	0.0	1.4	1.5	16.9	19.6	0.75	20.5	0.0	100.0	0.4	9.5	74.7	14.6	55.5
6	Cariboo/Second Street/Stoney Creek	Burnaby	33.0	79.1	7.6	18.0	40.7	95.8	23.2	0.0	29.3	4.2	0.2	3.5	3.5	0.2	35.3	0.74	54.9	0.0	100.0	4.1	41.2	142.4	17.7	78.6
7	Cascade-Schou/Douglas	Burnaby	14.6	53.5	28.6	65.4	43.3	98.8	195.4	0.0	19.1	0.8	0.0	9.0	7.8	6.5	27.3	0.79	0.0	0.0	100.0	1.3	12.7	117.3	31.1	45.5
8	Edmonds	Burnaby	56.2	117.6	13.0	22.2	69.2	117.8	23.2	0.0	34.7	5.5	0.6	5.2	4.2	8.4	10.2	0.76	74.8	0.0	100.0	2.0	9.1	114.1	17.2	53.0
9	Lochdale/Westridge	Burnaby	29.7	56.3	2.6	5.0	32.3	61.6	8.8	0.0	47.4	2.4	0.1	1.2	1.4	0.0	23.2	0.67	0.0	0.0	100.0	2.1	14.6	124.9	11.6	73.4
10	Marlborough/Garden Village	Burnaby	55.7	102.5	17.5	31.2	73.2	130.9	31.3	0.0	40.9	8.1	0.9	2.7	2.4	0.6	16.8	0.73	50.0	0.0	100.0	0.8	3.7	201.5	7.3	71.0
11	Metrotown	Burnaby	73.7	203.4	69.4	183.2	143.1	378.0	94.1	0.0	1.0	19.5	2.3	13.3	1.8	0.0	44.7	0.72	100.0	0.0	100.0	2.9	10.1	166.0	32.7	97.5
12	Middlegate/Windsor	Burnaby	47.4	96.2	26.1	44.6	73.5	125.6	55.1	0.0	37.4	5.6	0.3	5.5	1.0	7.9	15.0	0.76	38.7	0.0	100.0	0.1	8.2	143.9	10.7	63.4
13	Sperling/Broadway/Lake City	Burnaby	16.0	56.6	9.2	15.1	25.2	41.6	57.1	0.0	27.0	0.4	0.0	0.1	0.8	32.3	23.1	0.75	0.0	0.0	100.0	0.7	5.9	70.6	9.4	26.1
14	Willingdon Heights	Burnaby	41.8	110.8	36.2	61.1	78.0	131.5	86.7	0.0	28.4	4.6	0.5	8.6	0.6	16.6	3.3	0.75	37.2	0.0	100.0	4.0	10.3	165.8	4.5	79.6
15	Cape Horn/River Heights	Coquitlam	12.8	39.9	12.8	21.9	25.6	43.8	99.5	0.2	24.0	0.3	0.0	2.9	10.8	19.3	20.0	0.81	0.0	0.0	97.8	0.4	5.3	58.2	16.1	37.1
16	Cariboo/Burquitlam/Maillardville	Coquitlam	32.0	62.0	11.3	19.7	43.2	75.5	35.2	0.0	39.2	4.6	0.1	7.6	2.0	2.4	16.9	0.74	15.0	17.2	100.0	1.8	6.7	102.3	6.5	38.1
17	Central Coquitlam	Coquitlam	16.6	36.4	2.7	5.8	19.3	42.2	16.1	0.0	40.8	0.0	0.0	0.6	3.9	0.0	37.6	0.67	0.0	0.0	100.0	0.4	5.9	77.1	8.9	37.4
18	Coquitlam Town Centre	Coquitlam	40.8	138.1	32.5	67.8	73.3	153.1	79.5	0.0	11.6	9.7	0.0	19.5	5.1	1.9	26.8	0.81	76.0	0.0	100.0	0.9	12.6	123.7	15.5	44.7
19	Eagle Ridge/Ranch Park	Coquitlam	29.2	52.6	6.2	10.4	35.4	59.5	21.2	0.0	48.1	1.5	0.0	3.6	3.9	1.8	16.3	0.68	11.9	0.0	100.0	4.8	21.0	92.6	5.0	31.4
20	Hockaday/Nestor	Coquitlam	2.9	32.5	0.1	0.9	3.0	33.4	2.8	4.8	4.0	0.2	0.0	0.0	0.1	0.0	82.0	0.32	8.5	0.0	91.2	3.2	21.3	70.1	1.6	41.5
21	Westwood Plateau	Coquitlam	8.6	65.7	0.7	5.1	9.3	70.4	7.9	0.4	12.1	0.1	0.0	0.1	0.4	0.0	57.3	0.58	0.0	0.0	94.6	0.8	18.0	86.8	0.6	33.5
22	Annieville/Sunbury/Nordel	Delta	24.8	44.9	4.5	7.6	29.3	50.1	17.9	0.0	53.1	0.0	0.0	1.1	2.1	0.0	14.7	0.62	0.0	0.0	100.0	0.4	15.6	73.7	5.9	55.5
23	Burns View	Delta	30.2	46.9	1.6	2.5	31.8	50.5	5.1	0.0	60.7	0.0	0.0	0.0	2.3	0.0	13.1	0.56	0.0	0.0	92.5	1.3	9.7	84.1	16.5	47.7
24	Jarvis/Kennedy	Delta	42.0	59.9	11.0	15.6	53.0	75.3	26.1	0.0	57.1	2.8	0.2	7.0	2.4	0.7	5.1	0.61	0.0	0.0	100.0	1.9	19.8	86.4	3.1	20.4
25	Ladner	Delta	23.4	40.0	6.3	10.4	29.7	48.9	27.0	0.1	40.4	1.4	0.3	2.3	3.7	0.1	14.4	0.68	18.0	0.0	98.6	1.8	20.2	79.7	0.0	0.0
26	Sunshine Hills	Delta	16.6	41.6	3.4	8.4	20.0	49.8	20.4	0.0	34.8	0.0	0.0	2.1	1.4	0.0	39.0	0.68	0.0	0.0	93.5	2.2	24.9	89.8	16.8	19.6
27	Tsawwassen	Delta	9.8	22.5	2.2	4.3	12.0	23.5	22.4	0.0	24.3	0.8	0.1	0.9	0.7	0.0	15.7	0.59	0.0	0.0	91.6	0.0	38.9	45.3	0.9	12.1
28	Langley City	Langley City	24.6	52.3	17.0	28.1	41.6	68.6	69.4	0.2	30.6	5.8	0.3	12.6	2.4	8.1	19.2	0.81	54.9	0.0	98.6	2.3	34.2	76.2	2.4	36.7
29	Aldergrove/Rural Langley	Langley Township	1.4	1.7	0.7	0.8	2.1	2.5	51.0	3.1	1.1	0.0	0.0	0.2	2.7	1.1	7.5	0.29	1.6	0.0	38.9	0.5	34.6	1.8	0.2	12.6
30	Brookswood/Fernridge	Langley Township	6.6	9.2	1.0	1.4	7.6	10.6	15.5	30.0	16.7	0.0	0.0	0.6	0.7	0.0	12.1	0.80	0.0	0.0	94.4	0.0	23.5	23.3	0.7	0.3
31	Hopington/Murrayville	Langley Township	4.3	5.2	1.6	1.9	5.9	6.9	37.7	30.8	5.8	0.0	0.0	0.4	1.3	1.6	5.3	0.70	0.0	0.0	45.9	3.7	32.4	6.7	0.0	3.5
32	Walnut Grove	Langley Township	18.2	40.0	11.2	16.2	29.4	42.5	61.6	0.0	30.7	0.1	0.3	3.0	1.8	20.9	11.9	0.76	0.0	8.3	99.2	0.0	17.2	59.3	9.1	75.9
33	Willoughby/Willowbrook	Langley Township	9.5	14.2	6.3	8.8	15.8	21.9	66.9	30.9	9.6	0.0	0.1	4.2	1.4	2.2	4.4	0.77	9.4	0.5	93.5	1.0	26.0	38.4	4.1	40.5
34	Albion/Whonnock	Maple Ridge	3.1	4.6	0.5	0.7	3.6	4.9	16.7	39.9	3.5	0.0	0.0	0.1	0.2	1.7	13.6	0.82	0.0	0.0	71.6	0.0	22.4	7.4	0.0	3.3
35	Hammond	Maple Ridge	15.7	23.5	7.7	10.7	23.3	32.4	49.0	0.0	35.8	0.3	0.0	3.0	2.1	4.3	6.4	0.64	0.0	0.0	95.7	0.0	14.4	48.3	3.3	3.3
36	Haney	Maple Ridge	23.3	36.0	6.3	9.5	29.6	44.7	27.2	1.6	41.4	2.4	0.2	3.9	2.1	0.3	11.2	0.68	33.7	0.0	96.1	0.0	35.2	70.1	2.5	16.5
37	Maple Ridge North	Maple Ridge	0.5	4.0	0.1	0.7	0.6	4.4	18.4	5.6	1.0	0.0	0.0	0.0	0.2	0.1	35.7	0.55	0.0	0.0	35.6	0.0	27.7	5.9	0.0	0.9
38	Downtown New Westminster	New Westminster	101.6	298.3	94.6	196.0	196.2	406.4	93.1	0.0	3.3	20.0	2.4	18.1	4.3	0.0	7.8	0.73	95.0	0.0	100.0	2.2	27.1	260.8	28.5	73.6
39	Queen's Park	New Westminster	35.2	65.5	6.6	12.3	41.8	77.8	18.7	0.0	47.1	2.1	0.1	1.6	2.9	0.0	17.3	0.67	0.0	0.0	100.0	0.3	9.4	239.1	17.0	64.4
40	Queensborough/West End/Connaught Heights	New Westminster	26.2	74.1	8.4	15.8	34.6	65.3	32.0	0.0	31.3	1.0	0.3	6.2	1.0	9.1	10.6	0.72	0.0	0.0	100.0	0.4	26.0	128.6	20.0	62.2
41	Sapperton	New Westminster	31.9	94.6	30.1	55.2	62.0	113.8	94.3	0.0	22.0	5.1	0.4	2.6	2.5	15.0	13.5	0.76	0.0	0.0	100.0	2.7	34.9	114.2	23.3	59.3
42	Uptown New Westminster	New Westminster	83.8	142.0	28.4	46.6	112.1	184.1	33.9	0.0	26.7	20.1	3.0	5.2	5.2	0.0	9.4	0.79	0.0	0.0	100.0	0.0	38.7	159.3	2.5	50.7
43	North vancouver CY West	North Vancouver - City	52.2	120.4	38.0	72.0	90.3	171.1	72.8	0.0	24.1	10.2	1.2	9.0	3.4	4.7	16.0	0.80	67.8	3.1	100.0	2.0	17.2	103.4	22.8	85.1
44	North Vancouver CY East	North Vancouver - City	29.1	71.4	11.5	19.6	40.6	68.9	39.6	0.0	36.1	3.1	0.0	1.5	2.2	2.1	13.2	0.68	25.9	13.3	100.0	1.8	25.6	74.9	7.9	59.8
45	North Vancouver DM Central	North Vancouver - District	10.3	47.5	1.4	6.6	11.7	54.1	13.9	0.0	19.8	0.7	0.0	0.4	0.7	0.0	68.2	0.49	2.8	1.2	91.4	2.3	42.2	70.7	2.5	8.3
46	North Vancouver DM East	North Vancouver - District	2.7	43.5	1.0	12.2	3.7	46.3	36.0	1.0	4.7	0.2	0.0	0.3	0.4	0.8	49.1	0.57	0.0	3.3	94.1	3.8	21.3	62.0	10.4	32.3
47	North Vancouver DM West	North Vancouver - District	8.9	42.8	4.3	18.9	13.2	57.5	49.1	0.0	19.0	0.6	0.0	0.8	0.5	2.0	25.1	0.64	0.0	1.7	97.0	0.0	21.2	84.2	4.7	20.8
48	Pitt Meadows	Pitt Meadows	2.1	3.2	0.7	1.1	2.8	4.2	35.1	6.8	2.9	0.1	0.0	0.4	0.1	0.6	20.6	0.49	21.4	0.0	90.4	2.3	26.7	7.3	1.5	44.6
49	Citadel Heights	Port Coquitlam	14.9	62.3	0.5	2.3	15.5	64.6	3.7	0.0	22.9	0.0	0.0	0.2	0.9	0.0	63.4	0.54	0.0	0.0	99.9	2.4	11.9	86.1	31.3	22.2
50	Central Port Coquitlam	Port Coquitlam	18.3	45.0	11.4	21.4	29.8	55.6	62.3	0.0	19.1	2.0	0.1	4.2	2.2	11.6	14.6	0.72	23.5	0.0	93.9	2.5	40.2	78.4	7.5	32.0
51	Lincoln Park/Oxford	Port Coquitlam	26.8	51.7	2.5	4.7	29.3	55.6	9.2	0.2	49.6	0.0	0.0	0.6	2.1	0.0	25.7	0.65	0.0	0.0	100.0	0.9	25.2	115.3	18.0	59.3
52	Mary Hill/Kilmer Park	Port Coquitlam	19.7	57.4	5.7	13.4	25.4	59.4	29.1	0.0	33.4	0.2	0.0	0.1	0.6	8.6	38.5	0.70	0.0	0.0	83.7	0.0	9.7	97.2	16.4	22.7
53	Port Moody	Port Moody	12.5	58.7	3.0	9.3	15.6	47.4	24.3	1.6	16.4	1.2	0.3	0.9	1.5	9.9	47.5	0.70	21.1	0.0	95.6	0.4	12.4	75.5	7.2	50.7
54	Blundell	Richmond	39.5	56.3	5.4	7.6	44.8	63.9	13.6	0.0	65.0	0.9	0.0	1.0	2.9	0.0	8.0	0.53	0.0	0.0	100.0	2.8	36.5	67.0	5.1	23.1
55	Bridgeport/East Cambie/West Cambie	Richmond	15.9	64.9	11.8	19.9	27.8	46.6	74.2	0.0	18.9	0.6	0.0	12.6	0.9	26.1	16.7	0.80	0.0	0.0	100.0	0.3	26.2	47.0	6.5	9.4
56	Broadmoor	Richmond	38.8	56.7	5.1	7.4	43.9	63.3	13.2	0.0	61.8	2.8	0.1	1.6	2.9	0.0	8.5	0.56	0.0	0.0	100.0	1.7	27.6	66.2	0.0	12.9
57	City Centre	Richmond	51.6	117.8	43.7	71.7	95.3	156.5	84.6	0.0	17.5	11.8	0.9	19.3	2.4	8.6	13.8	0.83	100.0	0.0	100.0	0.2	32.3	84.1	5.5	11.2
58	Gilmore/Shellmont	Richmond	8.1	11.6	7.7	9.8	15.8	20.1	94.5	0.1	11.9	0.2	0.0	2.7	1.0	6.6	7.5	0.49	0.0	0.0	93.9	1.4	16.1	14.9	4.5	51.7
59	Hamilton/East Richmond/Fraser Lands	Richmond	1.9	2.7	7.7	9.1	9.6	11.4	396.6	0.1	1.5	0.0	0.0	0.5	0.9	5.9	5.7	0.26	0.0	0.0	53.8	1.6	16.3	4.2	2.1	32.5
60	Sea Island/Thompson	Richmond	7.6	61.7	6.5	11.1	14.1	24.2	84.5	0.2	10.4	0.5	0.0	0.8	1.5	2.6	16.7	0.51	1.6	0.0	97.8	1.4	17.4	27.8	9.0	55.5
61	Seafair	Richmond	36.8	57.2	2.4	3.6	39.2	59.6	6.5	0.0	58.9	3.5	0.0	0.7	2.4	0.0	15.3	0.60	0.0	0.0	93.1	1.8	13.4	67.9	4.9	67.8
62	Steveston	Richmond	43.1	71.6	5.9	9.0	48.9	75.6	13.6	0.0	53.0	3.1	0.4	1.4	2.3	4.2	11.7	0.65	0.0	0.0	96.7	2.0	23.4	93.3	6.5	41.9
63	Cedar Hills/Royal Heights	Surrey	18.7	51.0	6.3	10.3	25.0	40.9	33.7	0.0	33.4	0.3	0.1	1.1	1.7	12.3	7.3	0.68	0.1	0.0	100.0	4.1	22.9	61.3	7.3	12.8
64	Clayton	Surrey	12.5	18.1	1.9	2.7	14.4	20.3	15.2	22.0	14.7	0.5	0.0	0.7	0.6	1.8	13.9	0.75	0.0	6.7	91.1	0.0	22.1	51.2	6.9	40.9
65	Cloverdale	Surrey	12.6	20.5	5.8	8.6	18.5	27.1	46.1	2.8	25.0	0.4	0.1	1.5	1.8	6.2	10.2	0.66	4.4	0.0	95.6	6.4	28.3	49.3	3.3	42.5
66	Crescent Beach/Ocean Park	Surrey	13.2	21.7	1.9	3.1	15.1	24.7	14.3	0.0	58.6	0.3	0.0	0.6	1.3	0.0	18.0	0.59	0.0	0.0	98.4	1.0	16.1	67.8	0.1	8.0
67	Elgin/Semiahmoo	Surrey	17.8	34.9	7.0	13.4	24.8	47.6	39.3	0.0	40.5	1.8	0.0	4.5	1.8	0.1	20.6	0.70	9.9	0.0	99.3	2.7	35.9	101.2	8.6	39.8
68	Fleetwood	Surrey	22.7	33.8	3.4	5.0	26.1	38.6	15.0	0.2	38.0	0.2	0.1	2.1	1.9	0.1	15.8	0.66	16.0	0.2	96.8	1.5	23.4	57.2	6.3	18.9
69	Fraser Heights	Surrey	8.8	19.3	1.9	3.8	10.7	21.6	21.4	0.5	20.9	0.0	0.0	0.1	1.1	1.3	32.2	0.67	0.0	0.0	99.3	0.8	23.1	33.4	2.1	13.1
70	Guildford	Surrey	33.5	71.7	12.7	25.2	46.2	91.3	38.1	0.0	34.3	5.5	0.1	7.3	3.4	0.0	25.2	0.76	36.4	2.7	100.0	0.2	36.3	79.3	5.0	45.1
71	Morgan Creek/South East Surrey	Surrey	2.3	3.1	0.3	0.3	2.6	3.4	11.4	12.3	8.1	0.0	0.1	0.4	0.6	1.1	8.1	0.51	0.0	0.0	84.3	0.2	7.6	8.6	0.8	16.0
72	Newton	Surrey	32.1	58.6	11.6	17.5	43.8	65.7	36.2	0.7	39.0	0.9	0.1	3.8	3.0	10.9	11.6	0.74	3.3	0.0	99.1	0.7	36.9	60.5	0.8	9.5
73	Panorama Ridge	Surrey	16.0	26.9	4.5	7.4	20.5	33.5	28.2	0.1	40.8	0.1	0.0	1.4	1.9	1.7	16.6	0.67	0.0	0.0	96.8	3.4	17.2	56.9	2.6	21.7
74	Strawberry Hills	Surrey	43.1	95.9	16.3	25.5	59.5	92.6	37.9	0.0	35.7	1.6	0.2	5.6	3.6	17.5	10.3	0.77	0.0	0.0	100.0	2.5	15.1	79.6	8.4	43.3
75	Surrey Central	Surrey	43.7	84.1	18.5	31.2	62.3	104.9	42.4	0.0	31.0	8.8	0.8	15.4	1.8	0.4	8.9	0.76	85.1	0.0	100.0	1.0	14.9	105.3	7.4	60.2
76	Whalley	Surrey	24.6	60.5	5.7	11.9	30.3	62.8	23.4	0.0	35.1	0.5	0.0	2.0	2.9	6.5	24.8	0.74	0.5	3.7	100.0	2.4	10.6	79.6	12.5	38.4
77	UBC	UBC	8.8	65.9	18.6	96.5	27.4	142.1	211.5	0.0	5.9	1.6	0.1	0.0	8.3	0.0	67.6	0.51	0.0	68.6	100.0	0.0	12.1	181.4	20.1	76.0
78	Downtown	Vancouver	147.3	400.1	469.9	954.1	617.2	1253.1	319.1	0.0	0.0	7.3	14.8	21.8	2.8	0.0	12.5	0.75	100.0	0.0	100.0	1.2	15.2	235.7	148.7	100.0
79	Dunbar-Southlands	Vancouver	25.5	53.0	3.9	8.1	29.4	61.0	15.4	0.0	43.5	0.1	0.3	0.6	1.8	0.0	25.7	0.67	0.0	0.0	98.9	2.6	16.3	163.7	33.4	89.2
80	Fairview	Vancouver	96.0	182.6	107.9	185.3	203.9	350.2	112.4	0.0	6.0	23.4	5.8	13.9	6.2	2.3	8.4	0.80	100.0	0.0	100.0	1.7	10.6	216.6	67.2	92.2
81	Grandview-Woodland	Vancouver	61.2	144.9	31.5	51.7	92.7	152.1	51.5	0.0	25.8	10.4	1.5	3.9	2.4	6.7	4.7	0.72	0.0	0.0	100.0	6.4	15.3	228.4	33.1	98.5
82	Hastings-Sunrise	Vancouver	42.5	96.8	24.0	49.3	66.5	136.8	56.4	0.0	38.9	1.1	0.5	2.4	1.9	1.8	15.7	0.69	0.0	0.0	100.0	2.1	5.3	262.6	31.8	71.7
83	Kensington-Cedar Cottage	Vancouver	65.4	115.4	12.4	21.5	77.8	134.9	19.0	0.0	49.0	1.0	1.7	2.8	2.8	0.3	7.7	0.64	0.3	0.0	100.0	1.2	4.1	263.3	39.8	98.2
84	Killarney	Vancouver	42.8	98.4	4.5	9.9	47.2	104.5	10.4	0.0	38.0	2.9	0.4	1.1	2.0	0.3	26.5	0.71	0.0	0.0	100.0	0.0	5.3	248.1	39.4	74.1
85	Kitsilano	Vancouver	75.6	139.9	44.3	79.8	119.9	215.8	58.7	0.0	36.0	11.2	2.8	3.7	1.6	0.2	9.7	0.73	0.0	0.0	100.0	1.1	4.9	229.5	64.1	98.6
86	Marpole	Vancouver	42.5	100.9	21.8	37.7	64.3	111.4	51.2	0.0	31.1	5.5	0.4	4.7	2.6	12.5	7.0	0.75	0.0	3.5	100.0	1.8	6.7	213.9	40.4	90.1
87	Mount Pleasant	Vancouver	72.1	163.6	84.9	152.2	157.0	281.3	117.9	0.0	19.4	12.2	3.8	9.8	3.8	6.7	5.0	0.78	99.9	0.0	100.0	1.1	9.1	289.6	81.0	98.6
88	Renfrew-Collingwood	Vancouver	62.2	123.8	22.2	38.0	84.4	144.4	35.7	0.0	43.6	1.9	1.1	5.1	3.2	3.3	7.8	0.69	0.0	0.0	100.0	2.9	7.7	263.5	32.5	92.4
89	Riley Park	Vancouver	44.3	95.3	10.5	21.9	54.7	114.8	23.6	0.0	42.7	0.9	1.4	1.4	1.2	0.0	15.5	0.66	1.1	1.8	100.0	1.3	7.0	302.9	53.9	84.8
90	Shaughnessy/Arbutus-Ridge/Kerrisdale	Vancouver	27.2	47.2	9.2	15.7	36.4	62.0	33.8	0.0	48.5	3.0	0.4	1.0	1.8	0.0	13.3	0.65	0.0	0.0	98.9	1.2	7.8	176.2	30.3	92.4
91	South Cambie/Oakridge	Vancouver	32.5	58.9	25.8	44.4	58.3	100.1	79.6	0.0	43.0	2.5	0.6	3.6	8.3	0.0	13.5	0.71	8.0	5.9	100.0	3.1	6.4	199.5	36.0	87.8
92	Strathcona	Vancouver	31.3	169.8	63.1	114.8	94.4	171.8	201.3	0.0	5.1	3.9	1.9	8.1	2.9	17.4	5.4	0.66	100.0	0.0	100.0	4.2	6.5	151.3	25.7	93.3
93	Sunset	Vancouver	57.8	119.6	12.5	19.7	70.3	110.9	21.6	0.0	43.0	1.0	0.7	4.0	2.5	12.2	5.3	0.70	0.0	0.0	100.0	1.3	3.8	211.8	38.2	90.2
94	Victoria-Fraserview	Vancouver	57.6	98.7	9.3	15.3	67.0	110.0	16.2	0.0	51.8	2.0	0.6	0.9	3.6	1.2	5.6	0.61	0.0	0.0	100.0	0.0	2.3	254.0	38.2	88.9
95	West End	Vancouver	224.8	409.8	144.7	258.4	369.5	659.7	64.4	0.0	2.4	35.4	5.7	8.9	3.5	0.0	7.7	0.73	100.0	0.0	100.0	0.0	2.6	208.1	80.0	100.0
96	West Point Grey	Vancouver	28.9	51.2	7.2	12.5	36.2	62.4	25.0	0.0	45.0	1.6	0.7	0.9	9.9	0.0	16.1	0.70	0.0	0.0	100.0	0.0	0.0	148.5	48.4	97.7
97	West Vancouver Lower	West Vancouver	25.0	50.5	17.8	33.8	42.8	81.1	71.3	0.0	36.3	4.4	1.0	5.4	4.9	0.2	13.7	0.73	26.7	0.0	100.0	0.0	1.4	99.7	20.9	39.0
98	West Vancouver Upper	West Vancouver	3.2	19.8	0.6	3.7	3.8	23.4	19.0	0.0	30.9	0.2	0.0	0.2	0.3	0.0	37.9	0.67	0.0	0.0	92.1	0.0	2.1	60.2	0.7	11.9
99	White Rock	White Rock	37.8	61.1	13.7	22.0	51.4	82.9	36.2	0.0	48.0	7.7	1.3	2.0	2.5	0.0	9.8	0.68	5.4	0.0	100.0	2.1	5.6	108.9	0.0	13.3
100	Stanley Park	Vancouver	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.1	0.13	0.0	0.0	0.0	4.2	40.7			0.0
101	Hopington/Murrayville	Langley Township	3.9	5.7	1.6	2.3	5.6	7.8	42.1	0.1	10.4	0.1	0.1	0.6	0.4	0.0	17.3	0.46	0.0	0.0	83.9	3.5	27.6	12.7	0.0	0.0
102	Downtown & Central Port Coquitlam	Port Coquitlam	0.8	2.2	0.0	0.0	0.8	2.2	2.0	17.6	1.6	0.0	0.0	0.2	0.1	0.0	34.6	0.67	0.0	0.0	89.8	3.6	31.5	17.8	0.0	20.0
103	Port Kells	Surrey	1.1	1.8	6.9	9.4	8.0	10.9		26.8	0.0	0.0	0.0	0.2	0.3	14.2	9.8	0.74	0.0	0.0	71.8	6.0	17.4	8.3	7.5	21.8
104	Rural Delta	Delta	0.2	0.3	2.1	3.3	2.3	3.6		0.1	0.0	0.0	0.0	0.1	0.1	6.3	23.6	0.46	0.0	0.0	0.2	3.4	18.4	1.7	1.5	1.3
105	Anmore	Anmore	0.7	6.7	0.1	0.6	0.7	7.1	8.9	9.6	0.0	0.0	0.0	0.0	0.1	0.0	76.7	0.40	0.0	0.0	0.0	5.4	16.9		0.0	0.0
106	Belcarra	Belcarra	2.0	11.3	0.0	0.0	2.0	10.9	0.0	17.2	0.0	0.0	0.0	0.0	1.0	0.0	74.4	0.44	0.0	0.0	0.0	0.9	3.0		2.7	36.9

Neighbourhood Number	Neighbourhood Name	Neighbourhood Municipality	Transit Stop Density	Transit Access	Rapid Transit Stop Density	Rapid Transit Access	Transit Route Density	Transit Service Frequency	Major Roads	Ground-Oriented Dwellings	Low-Rise Dwellings	High-Rise Dwellings	People per Home	Grocery Stores Density	Grocery Store Access	Agricultural Land Area	Agricultural Land Access	Park Area	Park Access	Greenspace Area	Greenspace Access	Trails Density	Trail Access
1	Brentwood	Burnaby	24.9	82.0	0.0	37.0	5.2	70.5	33.1	20.9	27.0	17.7	2.4	0.2	34.8	0.0	0.0	0.1	50.9	0.2	17.6	0.8	4.1
2	Buckingham/Lakeview/Gov't Road	Burnaby	13.7	64.3	0.0	1.9	2.2	36.8	37.8	26.7	7.1	0.0	3.0	0.0	20.8	0.0	0.0	0.3	80.3	13.2	64.0	11.4	32.1
3	Burnaby Heights/Capitol Hill	Burnaby	18.6	91.3	3.6	0.0	3.4	39.2	15.2	26.5	27.0	6.2	2.4	0.0	39.8	0.0	0.0	0.2	80.1	17.4	37.3	8.5	45.7
4	Burnaby Mountain	Burnaby	20.1	18.0	0.0	0.0	8.5	98.6	148.5	17.1	36.3	39.6	2.3	0.1	62.6	0.0	0.0	0.1	18.0	69.8	100.0	25.9	100.0
5	Burnaby South/Sussex/Nelson	Burnaby	18.1	71.2	0.3	19.5	1.3	40.3	20.5	28.4	23.8	12.5	2.7	0.3	52.8	14.2	1.2	0.1	90.2	6.6	55.4	6.4	27.9
6	Cariboo/Second Street/Stoney Creek	Burnaby	25.0	81.0	1.2	32.6	5.1	56.9	54.6	30.2	22.2	29.8	2.5	1.1	73.2	0.0	0.0	0.1	87.8	17.8	37.2	13.9	41.9
7	Cascade-Schou/Douglas	Burnaby	22.4	81.9	0.0	0.7	2.1	69.6	75.3	39.1	28.8	2.5	2.6	0.3	69.9	0.0	0.0	0.2	83.9	2.3	20.9	1.4	7.1
8	Edmonds	Burnaby	35.6	97.4	0.0	35.2	6.6	132.7	55.8	37.7	26.4	18.5	2.6	1.1	91.1	0.0	0.0	0.0	46.9	0.0	7.7	1.1	19.3
9	Lochdale/Westridge	Burnaby	19.8	87.9	0.0	0.0	3.8	48.0	37.1	33.2	19.0	6.3	2.6	1.0	44.6	0.0	0.0	0.0	66.6	15.1	34.9	4.3	45.5
10	Marlborough/Garden Village	Burnaby	30.3	97.3	0.0	39.7	6.8	84.5	53.7	20.6	37.2	30.5	2.3	1.9	88.4	0.0	0.0	0.0	64.3	6.6	16.5	0.0	7.5
11	Metrotown	Burnaby	75.5	100.0	0.0	72.1	21.4	347.6	101.0	1.5	47.2	51.4	2.0	3.3	100.0	0.0	0.0	0.5	100.0	21.1	47.8	1.1	18.5
12	Middlegate/Windsor	Burnaby	17.5	80.3	0.0	4.1	3.8	51.5	26.4	25.9	30.8	26.3	2.4	2.9	89.9	0.0	0.0	0.1	90.2	7.5	29.0	0.0	4.9
13	Sperling/Broadway/Lake City	Burnaby	20.0	85.9	0.0	10.8	2.4	41.2	26.0	51.3	11.5	5.8	2.7	0.7	68.8	0.0	0.0	0.1	82.5	6.1	48.9	3.3	55.9
14	Willingdon Heights	Burnaby	26.8	87.7	0.0	31.8	8.2	95.3	61.6	24.8	13.9	40.6	2.3	1.9	85.9	0.0	0.0	0.1	74.2	0.0	0.0	0.1	16.5
15	Cape Horn/River Heights	Coquitlam	15.8	61.6	0.0	0.0	1.1	18.7	44.2	29.8	7.8	0.2	2.8	0.5	31.1	12.6	2.2	0.1	93.7	4.9	47.1	4.8	3.4
16	Cariboo/Burquitlam/Maillardville	Coquitlam	18.8	69.6	0.0	5.6	3.0	44.0	48.2	19.7	38.8	7.5	2.3	2.1	73.3	0.0	0.0	0.1	70.3	1.2	24.5	0.5	12.8
17	Central Coquitlam	Coquitlam	18.7	68.9	0.0	0.0	1.6	32.1	19.3	19.3	1.6	0.0	2.8	0.4	36.7	0.0	0.0	0.2	68.6	30.8	52.2	3.0	26.9
18	Coquitlam Town Centre	Coquitlam	37.5	83.3	0.0	0.0	14.0	112.7	140.1	5.9	44.9	40.6	2.1	4.6	61.9	0.0	0.0	0.2	91.5	3.3	78.8	4.1	92.3
19	Eagle Ridge/Ranch Park	Coquitlam	21.2	80.4	0.0	0.0	4.6	40.2	42.2	35.7	10.0	0.0	2.9	0.5	45.3	0.0	0.0	0.0	68.2	2.1	37.7	5.0	83.9
20	Hockaday/Nestor	Coquitlam	9.1	53.4	0.0	0.0	1.7	13.2	17.9	26.6	7.5	0.0	3.0	0.1	19.4	0.0	0.0	0.7	69.8	88.1	97.6	13.0	91.6
21	Westwood Plateau	Coquitlam	23.4	63.9	0.0	0.0	2.0	38.9	10.7	33.4	11.0	5.7	3.1	0.4	46.2	0.0	0.0	0.0	70.9	63.5	95.2	9.0	82.5
22	Annieville/Sunbury/Nordel	Delta	21.7	78.8	0.7	0.0	2.2	22.6	37.3	22.6	1.9	0.0	3.1	0.4	24.8	0.0	0.0	0.0	71.8	4.0	55.4	1.3	30.2
23	Burns View	Delta	8.5	59.1	0.0	0.0	2.4	10.9	8.3	28.8	4.1	0.0	3.1	0.0	4.0	0.2	0.0	0.1	54.0	1.5	42.8	1.0	9.4
24	Jarvis/Kennedy	Delta	14.4	49.1	0.0	0.0	4.3	31.1	43.8	34.7	17.6	4.5	3.0	2.0	64.8	0.0	0.0	0.0	55.0	0.0	0.0	0.8	13.7
25	Ladner	Delta	20.3	80.4	0.2	0.0	2.8	23.7	33.4	23.6	17.9	0.4	2.6	0.8	29.4	14.5	1.3	0.0	88.1	1.4	4.6	1.9	5.6
26	Sunshine Hills	Delta	8.8	33.1	0.0	0.0	2.8	16.1	60.8	15.3	0.9	0.0	3.1	0.7	50.2	15.8	3.5	0.1	55.7	20.9	77.4	16.9	60.0
27	Tsawwassen	Delta	11.9	69.5	0.0	0.0	0.7	13.8	16.7	9.4	22.5	1.1	2.4	0.3	23.8	28.5	8.8	0.1	75.8	2.5	22.0	4.4	17.8
28	Langley City	Langley City	19.2	61.5	0.1	0.0	2.6	38.6	46.8	18.6	56.6	0.3	2.1	1.5	47.9	4.3	1.4	0.0	79.5	0.1	12.6	0.0	5.4
29	Aldergrove/Rural Langley	Langley Township	0.2	16.7	0.0	0.0	0.0	0.3	4.8	22.8	5.9	0.0	2.6	0.6	19.2	91.3	56.9	0.0	20.8	25.8	61.0	2.4	1.1
30	Brookswood/Fernridge	Langley Township	4.3	43.0	0.0	0.0	0.4	5.3	9.7	11.2	0.6	0.0	2.6	0.4	20.9	27.7	5.6	0.0	12.4	15.6	70.8	2.3	10.2
31	Hopington/Murrayville	Langley Township	1.6	29.5	0.0	0.0	0.1	1.4	9.5	24.4	9.3	0.0	2.6	0.6	25.2	58.4	28.6	0.0	25.5	17.0	59.6	0.0	0.0
32	Walnut Grove	Langley Township	7.5	58.7	0.0	0.0	0.9	9.0	15.8	38.0	11.6	0.0	2.7	0.9	30.3	12.1	0.8	0.0	43.0	0.8	27.2	0.6	5.9
33	Willoughby/Willowbrook	Langley Township	5.6	38.3	0.0	0.0	1.0	9.2	20.0	10.6	6.7	0.0	2.7	0.6	35.0	26.3	7.5	0.0	20.5	7.8	79.4	0.0	0.0
34	Albion/Whonnock	Maple Ridge	3.6	41.1	0.0	0.0	0.2	1.5	8.5	10.7	0.3	0.0	3.0	0.1	3.2	30.9	16.1	0.0	11.5	48.9	101.4	1.7	16.7
35	Hammond	Maple Ridge	11.9	68.5	0.0	0.0	0.8	14.7	27.3	26.9	6.3	0.0	2.7	0.9	37.4	30.3	4.3	0.0	60.6	0.1	3.6	0.5	13.3
36	Haney	Maple Ridge	13.5	56.0	0.0	0.0	1.3	17.2	26.0	25.2	20.6	4.6	2.3	1.4	38.4	14.8	3.9	0.0	26.0	6.4	51.0	1.0	1.7
37	Maple Ridge North	Maple Ridge	1.2	7.6	0.0	0.0	0.2	0.9	6.0	10.7	0.4	0.0	2.9	0.1	0.0	8.1	35.6	0.3	28.3	84.7	103.3	4.8	32.3
38	Downtown New Westminster	New Westminster	69.7	100.0	0.0	76.6	19.7	330.3	133.1	3.1	31.2	65.1	1.7	8.6	100.0	0.0	0.0	0.0	72.9	0.0	8.3	0.0	1.3
39	Queen's Park	New Westminster	27.6	96.0	0.0	7.4	4.5	45.2	68.0	17.7	20.5	16.0	2.3	0.7	99.2	0.0	0.0	0.2	86.0	1.2	30.8	0.0	4.4
40	Queensborough/West End/Connaught Heights	New Westminster	22.5	87.7	1.0	14.5	4.5	63.8	56.3	34.0	23.5	3.6	2.6	1.4	89.5	0.0	0.0	0.0	42.1	1.1	2.6	0.0	1.5
41	Sapperton	New Westminster	32.7	77.5	0.0	38.1	7.1	76.8	44.8	17.5	38.8	23.6	2.1	1.0	69.0	0.0	0.0	0.1	97.5	0.9	21.7	7.3	23.7
42	Uptown New Westminster	New Westminster	45.5	99.2	0.0	15.6	5.9	139.4	59.4	7.4	53.8	31.1	1.7	4.9	100.0	0.0	0.0	0.1	89.7	0.0	0.0	0.0	0.0
43	North vancouver CY West	North Vancouver - City	33.8	92.6	4.4	0.0	4.6	129.3	34.0	13.6	44.1	23.3	1.8	3.8	94.2	0.0	0.0	0.1	74.2	4.6	20.8	2.2	21.2
44	North Vancouver CY East	North Vancouver - City	17.5	78.4	0.0	0.0	3.0	50.3	20.2	37.3	30.6	0.7	2.3	0.3	68.4	0.0	0.0	0.1	65.4	2.2	26.4	3.0	20.1
45	North Vancouver DM Central	North Vancouver - District	20.3	74.7	0.0	0.0	1.8	44.1	11.4	28.0	13.6	3.5	2.7	0.7	47.2	0.0	0.0	0.0	70.2	65.4	63.2	14.0	54.1
46	North Vancouver DM East	North Vancouver - District	17.7	51.2	0.4	0.0	1.6	42.7	29.9	30.6	14.7	8.1	2.7	0.3	12.8	0.0	0.0	0.3	55.6	80.4	86.3	13.7	65.1
47	North Vancouver DM West	North Vancouver - District	20.1	80.6	0.0	0.0	1.8	45.6	7.5	18.1	6.6	11.1	2.6	0.6	45.7	0.0	0.0	0.1	86.4	54.2	76.7	16.7	48.9
48	Pitt Meadows	Pitt Meadows	1.3	66.0	0.2	0.0	0.1	1.9	5.1	28.6	19.7	0.5	2.5	0.2	11.2	78.2	19.7	0.0	49.8	12.7	24.2	1.4	13.5
49	Citadel Heights	Port Coquitlam	17.9	65.5	0.0	0.0	1.7	23.4	68.1	24.8	0.2	0.0	2.9	0.0	0.0	20.9	0.0	0.1	95.4	25.5	38.8	7.0	70.9
50	Central Port Coquitlam	Port Coquitlam	17.4	82.7	0.0	0.0	1.8	37.4	37.5	29.4	41.2	0.0	2.4	1.1	61.0	19.7	5.3	0.1	85.8	2.0	31.6	2.1	38.7
51	Lincoln Park/Oxford	Port Coquitlam	18.8	82.1	0.3	0.0	2.2	33.5	17.3	28.6	1.3	0.0	2.9	0.3	38.3	0.2	0.0	0.1	61.5	13.2	80.3	3.3	40.2
52	Mary Hill/Kilmer Park	Port Coquitlam	15.7	68.5	1.0	0.0	3.3	24.8	37.6	42.3	4.9	0.2	2.8	0.9	36.7	29.7	16.3	0.0	82.4	8.9	46.7	7.6	66.8
53	Port Moody	Port Moody	19.8	76.2	1.1	0.0	1.5	38.1	18.9	26.5	8.6	0.5	2.5	0.4	37.0	0.0	0.0	0.0	52.7	53.2	81.1	19.4	89.3
54	Blundell	Richmond	21.4	61.3	0.4	0.0	1.2	49.5	32.6	28.0	6.4	3.0	3.0	0.7	31.8	0.0	0.0	0.1	82.7	0.0	0.0	0.0	1.6
55	Bridgeport/East Cambie/West Cambie	Richmond	12.6	63.3	0.0	0.0	2.3	25.2	45.4	39.2	7.5	0.0	3.2	2.0	72.6	14.2	0.0	0.1	63.2	8.2	20.0	1.5	18.9
56	Broadmoor	Richmond	17.0	70.8	0.6	0.0	1.4	33.8	16.0	23.2	17.7	0.0	2.9	0.7	40.5	0.0	0.0	0.1	74.4	0.0	2.1	0.4	5.8
57	City Centre	Richmond	28.7	79.7	0.5	22.1	4.2	89.0	58.5	21.3	39.7	29.6	2.2	3.6	48.3	6.3	0.0	0.0	56.0	0.0	4.0	2.7	1.2
58	Gilmore/Shellmont	Richmond	6.0	55.5	0.0	0.0	1.3	15.9	5.5	36.1	6.7	0.0	2.9	0.6	20.0	65.1	6.1	0.1	86.2	0.1	22.9	0.2	3.0
59	Hamilton/East Richmond/Fraser Lands	Richmond	1.9	35.2	0.0	0.0	0.5	4.2	15.1	40.2	5.3	0.0	3.0	0.4	30.3	79.6	46.4	0.0	12.4	4.8	42.4	0.0	0.2
60	Sea Island/Thompson	Richmond	4.5	43.1	0.0	0.0	0.5	9.6	16.0	27.2	20.4	1.7	2.8	0.1	48.8	10.4	2.2	0.1	86.7	0.0	0.0	7.0	8.1
61	Seafair	Richmond	7.8	41.3	0.0	0.0	0.7	23.4	13.8	23.2	17.7	2.4	2.8	0.7	33.3	7.2	6.9	0.1	91.8	0.0	0.0	6.3	46.3
62	Steveston	Richmond	24.4	63.0	0.0	0.0	1.3	66.1	15.2	19.5	10.1	0.1	2.7	1.1	43.1	0.0	0.0	0.1	65.5	0.0	0.0	3.8	28.2
63	Cedar Hills/Royal Heights	Surrey	11.9	72.3	0.0	2.9	2.1	27.5	38.6	35.2	20.5	0.0	2.9	0.2	37.5	0.0	0.0	0.0	48.5	2.6	29.3	0.9	17.3
64	Clayton	Surrey	3.2	55.3	0.0	0.0	0.5	5.7	12.2	38.7	4.9	1.4	2.6	0.6	21.8	41.3	8.9	0.0	71.5	6.8	65.7	0.1	4.7
65	Cloverdale	Surrey	6.4	51.4	0.0	0.0	0.5	10.3	20.1	26.6	11.5	0.0	2.8	0.6	39.5	33.8	4.4	0.0	74.8	6.6	19.1	0.3	4.7
66	Crescent Beach/Ocean Park	Surrey	12.3	60.2	0.0	0.0	0.6	13.6	0.0	10.3	7.9	0.1	2.6	0.2	20.3	1.7	0.8	0.0	65.8	10.0	74.7	6.7	42.3
67	Elgin/Semiahmoo	Surrey	14.8	68.7	0.0	0.0	1.5	35.4	37.0	24.6	23.6	0.0	2.3	0.5	43.9	1.2	0.7	0.1	60.0	15.9	43.6	4.6	35.2
68	Fleetwood	Surrey	7.0	55.9	0.0	0.0	0.6	14.6	18.3	37.9	8.6	0.1	3.1	0.3	19.2	30.0	3.2	0.1	52.6	4.8	55.4	2.2	10.3
69	Fraser Heights	Surrey	1.7	42.2	0.0	0.0	0.5	4.4	17.8	14.6	0.4	0.1	3.5	0.2	16.9	28.9	0.7	0.0	83.9	15.9	55.4	3.1	10.8
70	Guildford	Surrey	15.2	62.0	0.0	0.0	2.2	49.0	56.3	25.9	46.0	4.7	2.6	1.0	60.6	0.0	0.0	0.0	70.8	11.3	43.0	10.8	35.8
71	Morgan Creek/South East Surrey	Surrey	0.7	19.9	0.0	0.0	0.2	1.2	7.3	17.4	9.3	0.0	2.6	0.1	28.2	61.3	14.6	0.0	37.4	10.3	83.1	1.3	13.7
72	Newton	Surrey	13.0	62.0	0.0	0.0	1.3	32.5	29.9	41.0	17.3	0.0	3.3	0.9	33.7	9.2	0.9	0.1	69.8	2.2	43.9	0.3	3.5
73	Panorama Ridge	Surrey	7.8	55.8	0.0	0.0	0.9	11.7	34.1	24.5	4.7	0.0	3.1	0.3	22.2	26.4	3.2	0.1	58.0	11.8	73.8	2.3	13.1
74	Strawberry Hills	Surrey	15.3	58.5	0.0	0.0	2.9	32.6	33.2	38.8	46.1	1.0	3.3	1.5	49.9	0.0	0.0	0.0	63.9	0.4	19.7	0.2	13.8
75	Surrey Central	Surrey	35.2	81.5	0.0	56.4	8.6	119.2	57.0	17.8	42.4	29.3	2.0	2.5	87.0	0.0	0.0	0.0	49.0	0.2	20.5	0.0	0.1
76	Whalley	Surrey	16.7	59.7	0.0	0.2	3.0	27.7	49.6	39.7	18.6	1.1	3.2	0.6	28.2	0.0	0.0	0.1	68.9	11.3	45.0	0.7	7.8
77	UBC	UBC	27.8	86.1	0.0	0.0	6.1	120.3	102.6	14.4	36.5	18.7	2.2	0.3	55.1	0.0	0.0	0.5	60.9	50.4	80.0	53.7	84.3
78	Downtown	Vancouver	99.0	100.0	0.0	87.2	28.4	879.1	184.1	1.2	2.1	47.2	1.6	12.7	100.0	0.0	0.0	0.1	76.6	0.0	0.0	0.0	0.0
79	Dunbar-Southlands	Vancouver	18.0	72.4	0.0	0.0	2.4	91.1	14.0	23.4	5.7	0.0	2.7	1.1	75.4	13.4	1.1	0.2	74.2	3.1	35.5	1.2	21.7
80	Fairview	Vancouver	43.0	100.0	0.0	27.1	12.1	256.1	52.6	4.9	65.2	29.6	1.6	4.6	92.8	0.0	0.0	0.0	68.1	0.0	0.0	0.0	1.7
81	Grandview-Woodland	Vancouver	29.4	96.5	0.0	28.2	8.1	165.4	26.9	18.9	62.1	4.1	1.8	4.7	100.0	0.0	0.0	0.0	79.3	0.0	0.0	0.0	0.0
82	Hastings-Sunrise	Vancouver	27.5	94.2	0.0	13.7	5.4	103.8	62.4	44.8	17.3	1.2	2.6	1.1	54.5	0.0	0.0	0.1	76.4	0.2	0.6	0.4	0.1
83	Kensington-Cedar Cottage	Vancouver	30.6	98.3	0.0	16.7	4.1	131.1	29.5	46.1	23.2	2.2	2.6	3.0	99.3	0.0	0.0	0.1	92.7	0.0	0.0	0.8	7.5
84	Killarney	Vancouver	32.3	93.2	0.0	1.6	3.3	97.2	38.9	50.3	18.4	7.4	2.7	0.9	56.1	0.0	0.0	0.3	88.5	3.7	54.5	11.8	47.1
85	Kitsilano	Vancouver	33.9	98.9	0.0	0.0	5.6	207.2	21.8	18.9	59.1	4.1	1.7	4.4	98.7	0.0	0.0	0.1	79.1	0.0	0.0	0.4	8.4
86	Marpole	Vancouver	22.3	88.8	0.0	21.9	3.1	111.6	53.6	20.8	50.2	2.3	2.3	1.1	75.4	0.0	0.0	0.1	59.7	0.0	0.0	0.0	0.0
87	Mount Pleasant	Vancouver	36.2	98.8	0.0	40.1	7.3	221.5	55.5	12.2	70.0	17.7	1.7	5.5	100.0	0.0	0.0	0.0	92.3	0.0	0.0	0.0	0.0
88	Renfrew-Collingwood	Vancouver	35.6	95.9	0.0	59.6	3.8	140.3	38.8	39.3	19.5	7.9	2.7	2.6	96.5	0.0	0.0	0.0	78.7	0.0	0.0	0.0	0.4
89	Riley Park	Vancouver	29.8	96.1	0.0	20.7	4.3	119.1	26.5	36.7	29.5	1.7	2.4	1.4	98.3	0.0	0.0	0.2	86.3	0.6	2.3	0.0	0.0
90	Shaughnessy/Arbutus-Ridge/Kerrisdale	Vancouver	20.6	88.6	0.0	0.0	1.5	83.7	20.0	11.4	25.0	14.3	2.5	0.3	58.2	11.6	1.1	0.1	82.6	0.3	3.4	0.4	9.1
91	South Cambie/Oakridge	Vancouver	26.6	89.9	0.0	46.6	3.3	111.2	41.0	19.9	28.3	12.6	2.5	1.1	50.4	0.0	0.0	0.1	89.0	0.0	2.7	0.3	16.4
92	Strathcona	Vancouver	31.4	100.0	0.0	13.0	11.7	196.5	56.2	14.2	32.9	26.3	2.1	4.9	99.9	0.0	0.0	0.1	98.8	0.0	0.0	0.0	0.0
93	Sunset	Vancouver	25.4	93.6	0.0	0.4	2.8	113.6	22.7	55.1	21.5	0.0	3.0	2.5	82.8	0.0	0.0	0.0	80.4	0.0	0.0	0.0	0.0
94	Victoria-Fraserview	Vancouver	29.3	99.9	0.0	0.0	3.4	115.5	17.8	38.4	20.0	0.0	3.1	2.3	71.1	0.0	0.0	0.0	73.6	0.0	1.5	0.0	6.3
95	West End	Vancouver	52.3	100.0	0.0	13.0	19.8	333.4	27.7	0.5	18.9	67.7	1.4	15.2	100.0	0.0	0.0	0.1	100.0	0.0	0.0	0.0	0.0
96	West Point Grey	Vancouver	22.6	97.8	0.0	0.0	5.5	88.6	22.4	24.5	22.7	8.2	2.2	0.7	84.6	0.0	0.0	0.2	88.4	3.0	40.6	1.3	42.1
97	West Vancouver Lower	West Vancouver	23.9	82.6	0.0	0.0	4.3	83.4	35.1	10.7	12.2	42.0	2.0	1.2	55.1	0.0	0.0	0.1	79.2	2.2	22.8	3.5	14.2
98	West Vancouver Upper	West Vancouver	16.6	52.5	0.0	0.0	0.7	17.5	39.7	12.7	2.6	2.0	2.5	0.1	9.1	0.0	0.0	0.2	36.2	71.7	81.9	12.0	30.1
99	White Rock	White Rock	33.7	97.9	0.0	0.0	4.1	49.5	3.8	16.6	42.1	9.5	1.8	1.8	78.1	0.0	0.0	0.0	43.1	2.6	14.8	1.7	8.3
100	Stanley Park	Vancouver	0.0	0.0	0.0	0.0	0.0							0.0	0.0	0.0	0.0	1.0		60.0	0.0	2.4	0.0
101	Hopington/Murrayville	Langley Township	2.8	50.4	0.0	0.0	0.3	3.1	10.9	9.9	2.9	0.0	2.6	1.1	64.0	75.3	16.1	0.1	76.1	20.8	31.5	7.6	30.0
102	Downtown & Central Port Coquitlam	Port Coquitlam	0.9	29.9	0.0	0.0	0.4	1.8	0.0	25.0	0.0	0.0	2.6	0.0	0.0	33.1	0.0	0.0	35.7	57.3	89.8	13.4	91.7
103	Port Kells	Surrey	1.4	1.9	0.0	0.0	0.4	1.8	26.1	44.8	0.8	0.0	2.5	0.3	0.3	35.3	28.2	0.0	14.6	9.3	74.6	2.7	10.4
104	Rural Delta	Delta	1.5	11.2	0.0	0.0	0.2	1.9	13.7	8.8	6.4	0.0	2.9	0.2	0.2	66.8	92.4	0.0	16.1	12.1	7.7	1.9	6.6
105	Anmore	Anmore	6.5	3.7	0.0	0.0	0.6	5.0	0.0	15.7	0.0	0.0	3.0		0.0	0.0	0.0	0.0	5.7	86.4	99.8	19.1	99.5
106	Belcarra	Belcarra	18.9	42.4	0.0	0.0	3.4	13.6	0.0	15.3	0.0	0.0	2.2		0.0	0.0	0.0	0.0		82.7	100.0	60.0	100.0

APPENDIX F: CORRELATION MATRIX OF CDIS AND ALL MHMC MEASURES

			Health Behaviors													
			Leisure walking - 30+ min/day	Utilitarian walking - 30+ min/day	Total walking - 30+ min/day	Physically active - 150+ min/week	Sugary beverage - 3+ times/week	Fast Food 2+ Times per week	Fruits and vegetables – 5+ servings/day	Smoker – daily/occasional	No alcohol - past 12 months	Binge drinking - never/infrequently	Binge drinking - 1+ times/month	Screen time - 2+ hours/day	Sleep – 6 hours or less/day	High physical wellness score (10-16)
Land Use	Population and Employment Density	Gross Population Density	0.29	0.55	0.47							-0.35	0.34	0.42		
		Net Population Density	0.30	0.56	0.48					0.25		-0.38	0.38	0.37		
		Gross Employment Density	0.23	0.34	0.36							-0.40	0.42	0.21		
		Net Employment Density	0.21	0.33	0.34							-0.39	0.40			
		Gross Pop. and Emp. Density	0.28	0.46	0.43							-0.41	0.42	0.31		
		Net Pop. and Emp. Density	0.24	0.43	0.41							-0.41	0.42	0.29		0.20
	Job Balance	Employment-Population Balance		0.23						0.35						
	Land Use Areas	Rural Residential Areas	-0.20	-0.27							-0.21					
		SF, Duplex and TH Residential Areas								-0.27	0.21	0.32	-0.34			
		Apartment Residential Areas	0.22	0.50	0.47							-0.35	0.34	0.49		
		Mixed-Use Apartment Areas	0.27	0.36	0.40							-0.47	0.48	0.24		0.25
		Commercial Areas	0.20	0.48	0.35	-0.22		0.25	-0.23	0.37				0.40		
		Institutional Areas			0.22											
		Industrial Areas					0.22			0.31	0.28	0.23				
		Parks and Open Space Areas	-0.29	-0.20	-0.21			-0.25			-0.23					
	Land Use Mix	Land Use Mix Index		0.26						0.23				0.25		
	Focused Growth	Urban Centres		0.52	0.45					0.42		-0.25	0.23	0.42		
		Transit Oriented Development														
		Urban Containment Boundary		0.34			-0.23			0.24						
	Distance to City	Distance to an Urban Centre		0.20						0.31						
		Distance to CBD					0.22									-0.26
Transportation	Walking Network	Intersection Density		0.40	0.32									0.33		0.21
	Cycling Network	Cycling Routes		0.29	0.31		-0.21		0.26			-0.44	0.46			0.30
		Cycling Route Access		0.33	0.22							-0.21		0.21		0.22
	Transit Network	Transit Stop Density	0.21	0.48	0.46							-0.26	0.26	0.38		0.24
		Transit Access	0.22	0.41	0.31									0.35		0.23
		Rapid Transit Stop Density		0.31	0.29									0.21		
		Rapid Transit Access		0.47	0.39			0.20						0.36		
		Transit Route Density		0.52	0.43					0.33		-0.34	0.34	0.30		
		Transit Service Frequency	0.24	0.44	0.43							-0.39	0.40	0.28		0.22
	Major Roads	Arterial Roads and Highways		0.38	0.30					0.37				0.24		
Housing	Dwelling Types	Ground-Oriented Dwellings			-0.25			0.23	-0.30		0.46	0.37	-0.34	-0.27		-0.21
		Low-Rise Dwellings	0.20	0.46	0.42					0.21				0.43		
		High-Rise Dwellings		0.48	0.42							-0.24	0.23	0.41		0.22
Food	Grocery Stores	Grocery Stores Density	0.33	0.49	0.44					0.28		-0.46	0.46	0.40		
		Grocery Store Access		0.45	0.33					0.21				0.35		
	Protected Agricultural Land	Agricultural Land Area		-0.34	-0.23		0.22	0.24						-0.20		
		Agricultural Land Access		-0.30			0.27									
Natural Areas	Parks	Park Area					-0.23	-0.23								
		Park Access		0.27												
	Greenspace	Greenspace Area		-0.29		0.25		-0.29		-0.21	-0.32					
		Greenspace Access	-0.37	-0.43	-0.27						-0.27			-0.37		
	Trails	Trails Density	-0.20				-0.26	-0.26	0.20	-0.27	-0.21					
		Trail Access	-0.34	-0.23	-0.21			-0.24			-0.29			-0.28		

			Health Status										Community Resiliency		
			General health – excellent/very good	Healthy weight (BMI 18.5 to 24.9)	Overweight/obese (BMI 25+)	Obese (BMI 30+)	High blood pressure	One or more chronic conditions	Arthritis	Mental health – excellent/very good	Mood or anxiety disorder	Stress - extremely/quite stressed	4+ people to confide in/turn to for help	Strong sense of community belonging	Emergency supplies for 3+ days
Land Use	Population and Employment Density	Gross Population Density		0.25	-0.25	-0.30	-0.28		-0.22						-0.36
		Net Population Density		0.34	-0.35	-0.36	-0.28			-0.21					-0.38
		Gross Employment Density		0.25	-0.25	-0.25	-0.28								-0.27
		Net Employment Density		0.26	-0.27	-0.25	-0.27	-0.20							-0.25
		Gross Pop. and Emp. Density		0.27	-0.28	-0.29	-0.31								-0.33
		Net Pop. and Emp. Density		0.29	-0.30	-0.30	-0.30	-0.21							-0.31
	Job Balance	Employment-Population Balance		0.30	-0.33	-0.21								-0.21	
	Land Use Areas	Rural Residential Areas		-0.38	0.39	0.31					0.25				
		SF, Duplex and TH Residential Areas						0.22			-0.21	-0.26			
		Apartment Residential Areas									0.25				-0.34
		Mixed-Use Apartment Areas		0.26	-0.26	-0.27	-0.30				0.22		0.27		-0.30
		Commercial Areas	-0.22											-0.20	-0.36
		Institutional Areas		0.21	-0.21										
		Industrial Areas	-0.26										-0.33		
		Parks and Open Space Areas	0.30					-0.27							0.28
	Land Use Mix	Land Use Mix Index									0.23				-0.32
	Focused Growth	Urban Centres									0.26			-0.22	-0.38
		Transit Oriented Development	0.23	0.24	-0.22			-0.21							
		Urban Containment Boundary		0.22	-0.22	-0.25						-0.29			-0.31
	Distance to City	Distance to an Urban Centre													
		Distance to CBD		-0.31	0.32	0.43	0.23	0.32							
Transportation	Walking Network	Intersection Density		0.45	-0.44	-0.44	-0.26		-0.23	-0.34		-0.24			-0.29
	Cycling Network	Cycling Routes		0.44	-0.43	-0.46	-0.43	-0.33	-0.28		0.21		0.35	-0.21	-0.27
		Cycling Route Access		0.44	-0.43	-0.46	-0.32	-0.23	-0.31	-0.27				-0.22	-0.37
	Transit Network	Transit Stop Density		0.35	-0.35	-0.34									-0.35
		Transit Access		0.35	-0.35	-0.36				-0.24		-0.26			-0.38
		Rapid Transit Stop Density													-0.22
		Rapid Transit Access		0.25	-0.24	-0.23								-0.35	-0.29
		Transit Route Density		0.28	-0.29	-0.27	-0.21				0.23			-0.21	-0.34
		Transit Service Frequency		0.37	-0.37	-0.36	-0.28	-0.20			0.21		0.22	-0.21	-0.33
	Major Roads	Arterial Roads and Highways		0.23	-0.24									-0.26	
Housing	Dwelling Types	Ground-Oriented Dwellings	-0.38							-0.25	-0.25		-0.24		
		Low-Rise Dwellings		0.22	-0.22						0.35			-0.22	-0.42
		High-Rise Dwellings		0.24	-0.25	-0.22								-0.21	-0.29
Food	Grocery Stores	Grocery Stores Density		0.22	-0.23	-0.25	-0.25				0.24				-0.35
		Grocery Store Access		0.41	-0.40	-0.34	-0.27			-0.29	0.20			-0.24	-0.36
	Protected Agricultural Land	Agricultural Land Area		-0.32	0.30	0.32						0.26			
		Agricultural Land Access		-0.23	0.22	0.26						0.26			0.23
Natural Areas	Parks	Park Area	0.24	0.23	-0.26			-0.21							
		Park Access		0.27	-0.29	-0.31						-0.32			
	Greenspace	Greenspace Area	0.32					-0.20							0.33
		Greenspace Access	0.28	-0.24	0.25	0.23				0.26		0.22			0.28
	Trails	Trails Density	0.34	0.24	-0.22			-0.22							0.24
		Trail Access	0.26												0.25

			Built Environment														
			Amenities within walking/cycling distance	Large selection of fruits/vegetables	Exposed to second-hand smoke in public	See a lot of people walking/biking	Many attractive natural sites around	Feel safe walking after dark	Sidewalks well maintained	Lanes/pathways for cyclists & walking	Transit stop within 5 min walk of home	Commute - public transit	Commute - car	Do errands - car	Traffic in the area makes walking difficult	One-way commute 30+ min	Lived in neighbourhood for 5+ years
Land Use	Population and Employment Density	Gross Population Density	0.57	0.45	0.51				0.27	0.25	0.49	0.52	-0.64	-0.76			-0.46
		Net Population Density	0.54	0.39	0.57	0.23			0.30	0.30	0.52	0.58	-0.71	-0.79			-0.53
		Gross Employment Density	0.33	0.23	0.32	0.24			0.21	0.29	0.32	0.30	-0.47	-0.55			-0.45
		Net Employment Density	0.32	0.22	0.31	0.25			0.22	0.30	0.30	0.29	-0.47	-0.53			-0.46
		Gross Pop. and Emp. Density	0.46	0.34	0.43	0.24			0.25	0.30	0.42	0.41	-0.58	-0.68			-0.49
		Net Pop. and Emp. Density	0.43	0.31	0.41	0.26			0.28	0.32	0.40	0.41	-0.58	-0.66			-0.51
	Job Balance	Employment-Population Balance											-0.38	-0.33			-0.36
	Land Use Areas	Rural Residential Areas	-0.27	-0.21	-0.30						-0.32	-0.24	0.38	0.28			
		SF, Duplex and TH Residential Areas		0.22													0.35
		Apartment Residential Areas	0.54	0.41	0.44	0.22			0.26	0.21	0.40	0.43	-0.56	-0.68			-0.57
		Mixed-Use Apartment Areas	0.40	0.28	0.32	0.32		0.21	0.23	0.32	0.36	0.34	-0.53	-0.64			-0.47
		Commercial Areas	0.45	0.30	0.50						0.31	0.35	-0.46	-0.51	0.33		-0.57
		Institutional Areas	0.23	0.24					0.25		0.28		-0.39	-0.33			
		Industrial Areas			0.22	-0.21	-0.24										
		Parks and Open Space Areas	-0.27	-0.30			0.50		0.24					0.25	-0.43		
	Land Use Mix	Land Use Mix Index	0.32	0.24	0.33						0.41	0.28	-0.23	-0.31			
	Focused Growth	Urban Centres	0.46	0.33	0.51						0.29	0.41	-0.52	-0.59	0.26		-0.61
		Transit Oriented Development															-0.27
		Urban Containment Boundary	0.52	0.44	0.41				0.41	0.26	0.62	0.32	-0.43	-0.38			
	Distance to City	Distance to an Urban Centre															
		Distance to CBD			-0.22						-0.27	-0.36	0.34	0.30			
Transportation	Walking Network	Intersection Density	0.56	0.42	0.49				0.33	0.23	0.60	0.70	-0.76	-0.78			-0.36
	Cycling Network	Cycling Routes	0.40	0.27	0.34	0.38		0.30	0.37	0.45	0.46	0.49	-0.68	-0.72		-0.22	-0.38
		Cycling Route Access	0.53	0.44	0.43	0.24			0.39	0.42	0.56	0.64	-0.70	-0.72			-0.44
	Transit Network	Transit Stop Density	0.53	0.38	0.52				0.30	0.22	0.59	0.59	-0.70	-0.74			-0.53
		Transit Access	0.59	0.45	0.48				0.31		0.81	0.64	-0.66	-0.68			-0.33
		Rapid Transit Stop Density	0.28		0.34						0.21	0.45	-0.42	-0.42	0.25		-0.44
		Rapid Transit Access	0.38	0.24	0.48						0.27	0.66	-0.57	-0.56	0.35		-0.52
		Transit Route Density	0.49	0.36	0.51	0.21			0.27	0.27	0.41	0.55	-0.69	-0.72			-0.61
		Transit Service Frequency	0.46	0.33	0.44	0.27			0.28	0.34	0.44	0.52	-0.67	-0.73			-0.54
	Major Roads	Arterial Roads and Highways	0.26		0.48				0.22		0.23	0.36	-0.54	-0.44			-0.48
Housing	Dwelling Types	Ground-Oriented Dwellings	-0.30	-0.23		-0.35	-0.38	-0.36						0.27			0.34
		Low-Rise Dwellings	0.56	0.45	0.46				0.27		0.46	0.41	-0.62	-0.65	0.21		-0.56
		High-Rise Dwellings	0.47	0.38	0.46		0.22		0.25	0.20	0.33	0.48	-0.61	-0.62			-0.59
Food	Grocery Stores	Grocery Stores Density	0.49	0.37	0.47	0.26			0.21	0.25	0.43	0.43	-0.60	-0.74			-0.51
		Grocery Store Access	0.62	0.50	0.56				0.24		0.60	0.67	-0.77	-0.80	0.27		-0.51
	Protected Agricultural Land	Agricultural Land Area	-0.33	-0.24	-0.42		-0.21		-0.22		-0.48	-0.35	0.47	0.41			
		Agricultural Land Access	-0.46	-0.38	-0.39				-0.39	-0.24	-0.57	-0.24	0.38	0.34			
Natural Areas	Parks	Park Area					0.35			0.23					-0.22		
		Park Access	0.43	0.32	0.33		0.20		0.43	0.27	0.54	0.26	-0.39	-0.38			
	Greenspace	Greenspace Area	-0.44	-0.39	-0.26		0.37				-0.35	-0.21	0.24	0.32	-0.32		
		Greenspace Access	-0.53	-0.39	-0.36		0.30				-0.50	-0.35	0.47	0.55	-0.26	0.22	
	Trails	Trails Density				0.21	0.41			0.24					-0.37		
		Trail Access	-0.23			0.22	0.51	0.22	0.27	0.27				0.29	-0.43	0.25	

			Demographic														Social and Economic					
			Age - 18 to 39 years	Age - 40 to 64 years	Age – 65+ years	Born in Canada	Chinese	Immigration Status - Citizen	Live Alone	Male	Married/Common-law	Parent(s) with child under 18	Parent(s) with child under 5	South Asian	Visible Minority	White/Caucasian	Dwelling owned (with/without mortgage)	Education - Bachelor's degree or more	Education - High School or less	Employed	Household income - $100,000+	Household income - under $40,000
Land Use	Population and Employment Density	Gross Population Density	0.39	-0.54					0.61	0.33	-0.57	-0.68	-0.36	-0.31			-0.64				-0.46	0.33
		Net Population Density	0.44	-0.55				-0.23	0.69	0.41	-0.62	-0.68	-0.29	-0.31			-0.68	0.25			-0.42	0.28
		Gross Employment Density	0.35	-0.40					0.56	0.34	-0.40	-0.51	-0.21	-0.24			-0.43	0.23				
		Net Employment Density	0.36	-0.39					0.53	0.34	-0.39	-0.48		-0.24			-0.43	0.25				
		Gross Pop. and Emp. Density	0.40	-0.49					0.62	0.37	-0.51	-0.62	-0.29	-0.29			-0.55	0.23			-0.32	
		Net Pop. and Emp. Density	0.41	-0.47					0.60	0.37	-0.48	-0.59	-0.25	-0.29			-0.54	0.28			-0.28	
	Job Balance	Employment-Population Balance	0.24	-0.24				-0.20	0.46	0.34	-0.33	-0.36		-0.23			-0.34	0.22				
	Land Use Areas	Rural Residential Areas				0.35		0.22		-0.22	0.32	0.30	0.31		-0.23	0.30	0.26	-0.24		0.26	0.23	-0.24
		SF, Duplex and TH Residential Areas	-0.25		0.24		0.26		-0.32				-0.25	0.22						-0.28		
		Apartment Residential Areas	0.33	-0.46			-0.27		0.67	0.22	-0.52	-0.65	-0.28	-0.37			-0.62	0.21			-0.46	0.31
		Mixed-Use Apartment Areas	0.35	-0.43			-0.22		0.61	0.33	-0.44	-0.57	-0.28	-0.29			-0.50	0.26			-0.21	
		Commercial Areas	0.36	-0.48				-0.25	0.59		-0.52	-0.51		-0.28			-0.46				-0.44	0.22
		Institutional Areas		-0.28				-0.20	0.27		-0.33	-0.29					-0.34	0.32		-0.21	-0.23	0.20
		Industrial Areas												0.33		-0.25			0.23			
		Parks and Open Space Areas		0.23					-0.22		0.26	0.37	0.21					0.34	-0.29		0.34	
	Land Use Mix	Land Use Mix Index		-0.30			-0.25		0.35		-0.30	-0.29					-0.25				-0.23	
	Focused Growth	Urban Centres	0.36	-0.43				-0.22	0.65	0.29	-0.55	-0.56		-0.38			-0.53				-0.36	
		Transit Oriented Development						-0.26					0.25				-0.21	0.31				
		Urban Containment Boundary	0.20	-0.37		-0.33		-0.27	0.21		-0.42	-0.32	-0.21		0.20	-0.25	-0.33	0.26		-0.29		
	Distance to City	Distance to an Urban Centre		-0.22										0.25								
		Distance to CBD							-0.23			0.22					0.30	-0.33				
Transportation	Walking Network	Intersection Density	0.34	-0.53					0.46		-0.57	-0.61	-0.31	-0.41			-0.65	0.34			-0.28	
	Cycling Network	Cycling Routes	0.42	-0.48					0.51	0.36	-0.47	-0.55	-0.28	-0.35			-0.57	0.43	-0.21			
		Cycling Route Access	0.37	-0.49					0.42	0.22	-0.53	-0.52		-0.36			-0.64	0.38			-0.27	
	Transit Network	Transit Stop Density	0.36	-0.54				-0.23	0.64	0.30	-0.59	-0.66	-0.28	-0.41			-0.64	0.33			-0.32	0.21
		Transit Access		-0.46					0.51		-0.57	-0.61	-0.33	-0.39			-0.60	0.27			-0.30	
		Rapid Transit Stop Density	0.33	-0.34					0.42	0.29	-0.33	-0.41		-0.24			-0.31					
		Rapid Transit Access	0.42	-0.47	-0.20				0.45	0.31	-0.46	-0.52		-0.38			-0.45				-0.29	
		Transit Route Density	0.45	-0.52				-0.26	0.68	0.38	-0.55	-0.62		-0.30			-0.65	0.30			-0.31	
		Transit Service Frequency	0.42	-0.52					0.63	0.39	-0.55	-0.63	-0.25	-0.33			-0.62	0.34			-0.27	
	Major Roads	Arterial Roads and Highways	0.45	-0.42	-0.24	-0.23		-0.38	0.46	0.35	-0.45	-0.36		-0.21		-0.21	-0.44	0.26			-0.26	
Housing	Dwelling Types	Ground-Oriented Dwellings				-0.22	0.32		-0.52			0.26		0.41	0.36	-0.39		-0.32	0.43			
		Low-Rise Dwellings	0.39	-0.58				-0.28	0.51		-0.59	-0.54					-0.67			-0.23	-0.52	0.36
		High-Rise Dwellings	0.37	-0.51				-0.34	0.62	0.29	-0.55	-0.58		-0.40			-0.58	0.34	-0.24		-0.31	
Food	Grocery Stores	Grocery Stores Density	0.36	-0.48			-0.25		0.71	0.36	-0.55	-0.66	-0.29	-0.32			-0.60				-0.39	0.23
		Grocery Store Access	0.40	-0.59				-0.20	0.59	0.32	-0.68	-0.64	-0.23	-0.45			-0.74	0.30			-0.42	0.31
	Protected Agricultural Land	Agricultural Land Area		0.31		0.31		0.24	-0.28		0.36	0.24	0.24				0.41	-0.32		0.28		
		Agricultural Land Access		0.33		0.32		0.25			0.35	0.24	0.27			0.21	0.30	-0.30		0.29		
Natural Areas	Parks	Park Area								-0.22								0.40	-0.27			
		Park Access		-0.22		-0.25			0.20		-0.32	-0.40	-0.31	-0.30		-0.22	-0.27	0.25			-0.21	
	Greenspace	Greenspace Area		0.29					-0.25		0.35	0.46	0.26			0.22	0.23	0.21	-0.24	0.23	0.40	-0.29
		Greenspace Access		0.43		0.22	-0.23		-0.36	-0.21	0.48	0.58	0.36	0.30		0.27	0.45		-0.24	0.34	0.48	-0.39
	Trails	Trails Density						-0.27				0.31	0.25					0.43	-0.28		0.25	
		Trail Access		0.30					-0.28		0.24	0.34					0.20	0.32	-0.32	0.21	0.34	-0.24

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