Characterisation of Travel Behaviour and Accessibility in Halifax, Nova Scotia, Canada

by

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Abstract

Car-dependent travel has posed economic, environmental, and social concerns worldwide. Existing transportation policy promotes a shift toward sustainable transportation through enhancing transit and active transportation infrastructure and creating mixed-use, more connected communities. Exploratory analyses that characterise travel behaviour and accessibility offer significant insight for transportation and land use policy. Interestingly, Halifax residents desire to be sustainable, as reflected by their positive attitudes toward transit and active transport, but their travel behaviour is auto-dependent. Halifax residents travel primarily via automobile for all trip purposes but mainly walk for school trips. Residents of the Regional Centre, which is most accessible to all service destinations, travel more sustainably than residents of Suburban areas and the Rural Commutershed. There are considerable spatial differences in accessibility across the Halifax region. Although the Regional Centre is most accessible, accessibility to all destinations by all modes is considerably lower on the Dartmouth side of the Regional Centre when compared to the Halifax Peninsula. Halifax is most accessible to health services, restaurants, and general shopping destinations. Accessibility by active travel modes is low for Suburban areas and poor for the Rural Commutershed. The methods and findings of this study also contribute to the limited research on multi-modal, multi-destination accessibility measures. This study employs a unique, Composite Network-distance-based Accessibility Measure (CNAM), informed by transportation experts, which can be scaled to generate accessibility indicators for any aggregate spatial unit of interest. The CNAM signifies the density of service destinations that are proximate to a parcel of land. A higher CNAM reveals greater proximity to a higher number of destinations. The parcel-level estimation yields finer-grained results, but accessibility at the dissemination area (DA) level was also estimated, revealing that the majority of DAs in Halifax have a relatively low accessibility to service destinations, particularly by active travel modes. The findings of this study reveal that diversification and densification of land use activities should be concentrated in the Regional Centre and bordering Suburban areas, particularly in Dartmouth where accessibility scores are lower.

List of Abbreviations Used

CBD	Central Business District
CNAM	Composite Network-distance-based Accessibility Measure
CT	Census Tract
DA	Dissemination Area
DalTRAC	Dalhousie Transportation Collaboratory
DMTI	Desktop Mapping Technologies Incorporated
EPOI	Enhanced Points of Interest
GIS	Geographic Information Systems
GSS	General Social Survey
HMTS	Household Mobility and Travel Survey
NHS	National Household Survey
SIC	Standard Industrial Classification
TAZ	Transportation Analysis Zone

Glossary

Accessibility	A measure of how proximate all service destinations are from a parcel, in terms of driving, biking, and walking distances
Regional Centre	The "Peninsula Halifax and Dartmouth between the Circumferential Highway and Halifax Harbour" (Halifax, 2014, p.7)
Rural Commutershed	The 2012 Halifax tax designation boundary for rural areas
Suburban Areas	The 2012 Halifax urban and suburban tax designations boundaries, except the area within the Regional Centre boundary
Sustainable transportation planning	Designing more connected communities to increase accessibility to service destinations, promoting an increase in transit ridership, an increase in active travel such as biking and walking, and a reduction in car travel
Sustainable travel behaviour	Includes travelling via modes that consume less non-renewable energy such as taking public transit, walking, and biking
Travel behaviour	How people travel to participate in activities that are situated in different locations

Acknowledgements

This thesis would not have been possible without the help of many individuals. Firstly, I would like to express my sincere gratitude to my supervisor, Dr. Muhammad Ahsanul Habib for his mentorship and enthusiasm throughout this journey. He introduced me to transportation planning when I began working as a research assistant for Dalhousie Transportation Collaboratory (DalTRAC) and supported me to attend research conferences in Atlanta, Georgia and Washington, D.C.

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Chapter 1
Introduction

Researchers and practitioners need to find ways that encourage a shift toward sustainable travel behaviour due to increasing concerns of rising energy costs and consumption levels, health problems, and greenhouse gas emissions associated with motor vehicle travel. The transportation sector accounts for a considerable percentage of the total energy consumption for Canada and greenhouse gas emissions in Nova Scotia. As a result, the 2013 Nova Scotia Sustainable Transportation Strategy strives to provide residents with alternative travel choices; however, the automobile remains the predominant travel mode in the Province. Researchers note that socio-economic attributes, land use activity, and attitudinal preferences influence travel behavioural choices. There is a need to find correlations between these factors and travel behaviour to better understand the travel choices and patterns characteristic of the region.

Some researchers recognise that a strong link between travel behaviour and land use exists and suggest exploring these characteristics of a region. Travel behaviour refers to how people move from one place to another; it is generated by a need to participate in activities. The land use-travel relationship is a topic of interest for both researchers and practitioners seeking to shift travel behaviour toward more sustainable activity by creating more mixed use, denser, and more accessible communities. Sustainable transportation planning includes designing more connected communities to increase accessibility to service destinations, which promotes an increase in transit ridership and active travel, as seen in Figure 1.

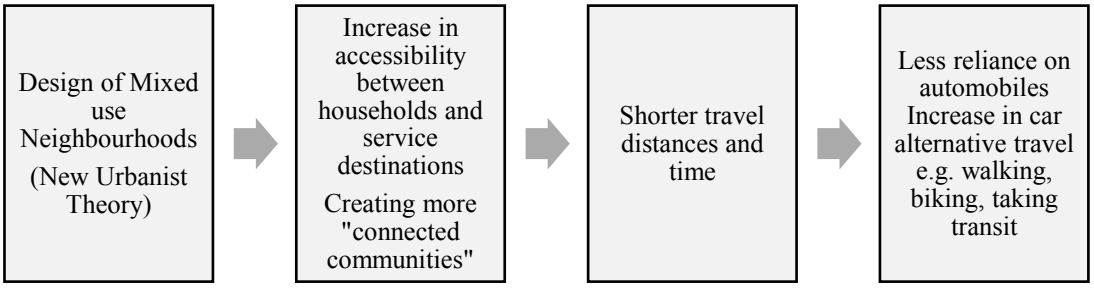


Figure 1: Sustainable transportation planning - the land use-travel relationship

Previous studies suggest a need to investigate travel behaviour and accessibility collectively to inform transportation planning policy. In this study, accessibility is defined as how proximate most service destinations are from a parcel, in terms of driving, biking, and walking distances. The current study conducts an exploratory analysis of travel behaviour in Halifax, Nova Scotia, similar to other studies found from Toronto, Vancouver, and Calgary. Moreover, this study

develops a comprehensive, composite accessibility measure that contributes to the existing literature of multi-destination, multi-modal accessibility frameworks. There are existing policies in Halifax that promote mixed use and New Urbanist design principles; however, no existing studies conduct a comprehensive study of accessibility to service destinations for Halifax. Accessibility measures in the literature typically consider accessibility to a few service destinations by automated transportation modes. Previous studies often employ distance-based measures of accessibility at the census tract (CT) or dissemination area (DA) level. Researchers note that aggregation errors affect accessibility analyses and they suggest utilising smaller areal units. Limited studies develop composite accessibility measures at a finer-grained disaggregate level. Hence, this study attempts to develop a Composite Network-Distance-Based Accessibility Measure (CNAM) at a finer-grained disaggregate level that estimates accessibility to a variety of service destinations by automated and active travel modes. Furthermore, the CNAM contributes to the literature by defining a comparative accessibility scale from very high to very poor accessibility, informed by planning, engineering, and public health experts, and producing a finer-grained accessibility measure that can be aggregated to any spatial unit of interest.

1.1 Goals and Objectives

The overarching goal for this thesis is to characterise travel behaviour and accessibility in Halifax, Nova Scotia, Canada that contribute to the 2013 Nova Scotia Sustainable Transportation Strategy's notion of tracking progress toward sustainable transportation. This study addresses the following four objectives to achieve the project goal:

1. Conduct an exploratory analysis of travel behaviour in Halifax that identifies travel behavioural patterns;
2. Examine multi-modal accessibility to key service destinations in Halifax using Geographic Information Systems;
3. Develop a composite measure of accessibility at a finer-grained disaggregate level informed by expert consultations to evaluate relative spatial differences of accessibility in Halifax; and
4. Synthesise research and policy implications of the travel behaviour and accessibility patterns identified in this study.

1.2 Study Area

The study area of Halifax is the capital of the Province of Nova Scotia. From 2006 to 2011, Halifax recorded a 4.7% population increase to 390,328, representing the largest populated area

in Nova Scotia and ranked 14th in Canada (Statistics Canada, 2014). This study identifies spatial differences in travel behaviour and accessibility between three sub-regions of Halifax: the Regional Centre, Suburban Areas, and the Rural Commutershed. As shown in Figure 2, the Regional Centre is defined by the 2014 Halifax Regional Plan as the "Peninsula Halifax and Dartmouth between the Circumferential Highway and Halifax Harbour" (p.7). The second sub-region, Suburban Areas, is defined as the 2012 Halifax urban and suburban tax designations boundaries, except the area within the Regional Centre boundary. The Rural Commutershed is the 2012 Halifax tax designation boundary for rural areas.

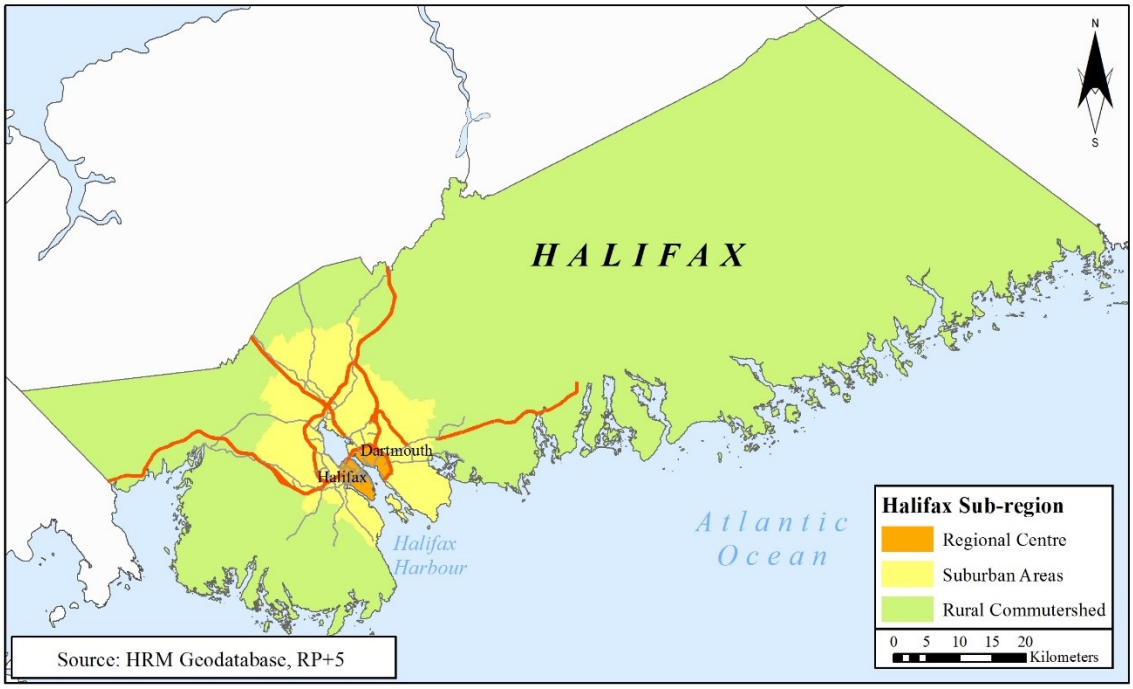


Figure 2: Study area of Halifax, Nova Scotia

1.3 Thesis Outline

The thesis comprises four chapters. The second chapter describes the travel behavioural patterns in Halifax based on socio-economic characteristics, household location, and attitudinal preferences. The third chapter presents a Composite Network-Distance-Based Accessibility Measure (CNAM) which incorporates accessibility to a variety of service destinations and travel modes, informed by transportation experts. The fourth and final chapter summarises the findings of this thesis and discusses the implications of the research and recommendations for future research.

Chapter 2
Characterisation of Travel Behaviour

2.1 Introduction

The growing dependence on the automobile for travel has led to economic, social, and environmental concerns worldwide (Gärling & Fujii, 2009). For instance, transportation accounts for 25% of the world's carbon dioxide emissions (Sperling, 2010). Nova Scotia also recognizes these concerns, as the current transportation patterns and land use development heavily rely on car travel (Nova Scotia, 2013). As a response to the growing demand for automobiles and their impacts, Nova Scotia's Sustainable Transportation Strategy (2013) aims to provide residents with sustainable travel choices. Furthermore, the strategy encourages the use of sustainable travel choices as energy consumption and costs are high, rates of health issues such as asthma and obesity are increasing, and greenhouse gas emissions are greatest in the transportation sector in Canada (Environment Canada, 2013). It is important to monitor travel behaviour patterns as sustainable initiatives (alternatives to the automobile) are implemented to track progress toward sustainable transportation.

Exploratory travel behavioural analyses provide significant insight for transportation policies that promote sustainable transportation by identifying linkages between lifestyle characteristics and travel behaviour. As transportation planning initiatives that promote sustainable transportation are implemented, it is essential to monitor travel behaviour to identify any trends toward sustainable transportation. Previous studies have identified linkages between socio-economic characteristics, land use, attitudes toward travel behaviour, and travel behaviour. This chapter presents an exploratory analysis of the 2012 Household Mobility and Travel Survey (HMTS) as part of the Nova Scotia Sustainable Transportation Strategy's (2013) notion to identify travel behavioural patterns and track progress toward sustainable transportation. This study uses the results of the HMTS to characterise travel behaviour of Halifax residents, which offer critical insight for sustainable transportation planning.

2.2 Literature Review

Travel behaviour refers to how people move from one place to another. It occurs as a result of the need for individuals to participate in activities (such as healthcare, work, school, and shopping) that are situated in different locations (Maat, van Wee & Stead, 2005; Næss, 2006). Many researchers and practitioners recognise a need to shift travel behaviour toward more sustainable

activity due to a heavy reliance on automobile travel, because of its adverse effects on society and the environment. Sustainable travel behaviour includes travelling via modes that consume less non-renewable energy such as taking public transit, walking, and biking (Nova Scotia, 2013). High levels of automobile use are associated with environmental pollution, oil dependence and high energy costs, traffic congestion, and health issues (e.g., Anable, 2005; Buehler, 2010).

Recent transportation policies encourage changes in travel behaviour toward more sustainable activity (e.g., Halifax, 2014; Nova Scotia, 2013). Travel behavioural analyses, therefore, should be performed regularly to identify patterns and monitor trends as part of tracking progress toward sustainable travel behaviour (Goodwin et al., 2004; Nova Scotia, 2013). Attributes of travel behaviour analyses typically include modal split, mobility tool ownership, travel distance and time, and travel expenditure. Recent literature also emphasises to explore attitudes and lifestyle choice preferences in travel behaviour analyses (e.g., Anable, 2005).

Many researchers suggest that travel behaviour reflects individuals' socio-economic characteristics such as age, gender, household size, and household income (e.g., Hanson & Hanson, 1981; Lu & Pas, 1999; Manaugh & El-Geneidy, 2012). Exploratory analyses of travel behaviour identify a wide variety of linkages between travel behaviour characteristics and socio-economic attributes. Table 1 notes examples of relations between socio-economic characteristics and travel behaviour from other exploratory analyses of travel behaviour. Survey respondents from other cities predominantly travel via car all days of the week; however, transit ridership and non-motorized travel notably decrease on the weekends (e.g., Collia, Sharp, & Giesbrecht, 2003; Löchl, Axhausen, & Schönfelder, 2005). Transit ridership is often related to no drivers' license and no car ownership (e.g., Data Management Group, 2011). Car ownership increases as household size and income increases. As expected, many studies report that respondents older than 30 travel mainly by car (e.g., Data Management Group, 2011; City of Calgary, 2013). Interestingly, respondents travel by different modes for specific trip purposes; a higher percentage of respondents use car alternatives for discretionary trips (e.g., Oregon Department of Transportation, 2002).

Table 1: Examples of findings from exploratory analyses of travel behaviour

City	Data Source	Characteristics Included in Analysis	Key Findings
Canada			
Toronto, ON	2011 Transportation Tomorrow Survey (TTS)	Age Gender Mobility tool ownership Trip frequency	Younger respondents, females, and those without a driver's license take transit more often. Respondents 30-50 years of age travel via car for more than 70% of total daily trips.
Vancouver, BC	2011 Metro Vancouver Regional Trip Diary Survey	Age Gender Trip frequency	People 40-50 years of age make the most trips, which suggests that people with children require more trips for their activities. Women, specifically 30-50 years old, make more daily trips than men, possibly due to child care and shopping errands.
Calgary, AB	2013 Calgary and Region Travel and Activity Survey (CARTAS)	Household size Income Age Mobility tool ownership	As household size and household income increases, auto ownership increases. A higher percentage of adults 35-54 years of age own cars compared to all other cohorts.
United States of America			
Nationwide	2001 National Household and Travel Survey	Age Gender Trip frequency Primary mode Daily vs. long-distance trips Trip purpose Trip time	Older adults take fewer trips than the rest of the US population. The primary mode of travel is via personal vehicle including a car, pickup truck, van, or sport utility vehicle (SUV). A lower percentage of women drive than men. A large proportion of trips are taken for shopping, errands, and recreation purposes.
Puget Sound, Seattle, WA	1989-1997 Puget Sound Transportation Panel Survey	Employment status Vehicle availability Household composition Trip characteristics Mode choice Travel decisions Attitudes	The majority of respondents travel via single occupant vehicle. The highest percentage of respondents work 5-10miles away from their household location. Respondents mainly change their route to work slightly if they hear of traffic problems before leaving.
Oregon	1996 Oregon Travel Behaviour Survey	Demographic characteristics Mode choice Travel time	Socio-economic characteristics explain approximately 50% of the variation in home-based work and school trips. Mode choice differs by trip purpose; the majority of respondents drive alone for work trips and use alternatives for non-work trips. Respondents travel approximately 17 minutes for all trip purposes.

City	Data Source	Characteristics Included in Analysis	Key Findings
Switzerland			
Thurgau	2003 Swiss National Longitudinal Travel Survey (replication and improvement of 1999 Mobidrive Survey)	Household type Trip destinations Mode and route choice Mobility tool ownership Employment status Household size Household income	Travel distance is longer for rural areas. The share of work/school, shopping and errands, and leisure trips are similar for weekdays whereas leisure and shopping trips increase on the weekend. Most trips during the week and on weekends are via car. There is a notable decrease in transit ridership and non-motorised travel on the weekends.

Emerging efforts in land use and transportation planning promote changes in travel behaviour toward more sustainable activity. Many cities in North America implement New Urbanist design theory, which suggests developing neo-traditional, transit-oriented, mixed use neighbourhoods in an attempt to increase sustainable travel behaviour (Boarnet & Sarmiento, 1998; Krizek, 2003; Cervero & Duncan, 2006; Gärling & Fujii, 2009; Lawson, 1998; Maat, van Wee & Stead, 2005; Næss, 2006). Many studies conclude that land use policy and diversification of land uses can influence individual or aggregate travel behaviour; however, there are also conflicting empirical results to this theory (Boarnet & Crane, 2001; Boarnet & Sarmiento, 1998; Dieleman, Dijst, & Burghouwt, 2002; Kockelman, 1996; Krizek, 2003; Maat, van Wee, & Stead, 2005).

Policies that promote the creation of mixed use neighbourhoods are associated with an increase in accessibility (in terms of travel distance, time, and cost) to land use activities (Krizek, 2003). Kockelman (1996) mentions that accessibility had a "dramatic" influence on travel behaviour. For example, Krizek (2003) notes that individuals living in neighbourhoods with greater accessibility travel shorter distances (including vehicular travel) and have a lower number of trips per tour. The ADONIS research project (1998) concludes that people in European countries are generally positive to substituting short car trips with walking and cycling. However, the effect of accessibility on mode split and trip generation is still undetermined (Krizek, 2003).

Apart from urban design, researchers note that personal attitudes influence travel behaviour, particularly mode choice (e.g., Anable, 2005; Beirão & Cabral, 2007; Dieleman et al., 2002; Lu & Pas, 1999). One study suggests that changes in individuals' cognitive skills, attitudes, beliefs, and values are necessary to achieve sustainable travel behaviour (Gärling & Fujii, 2009). For example, Beirão and Cabral (2007) suggest that automobile use is not just linked to its

attractiveness, reliability, and instrumental use; feelings of superiority, freedom, convenience, comfort, and sensation also play an integral role in the extensive use of automobiles. Nilsson & Küller (2000) argue that people's values and lifestyles should be studied further as determinants of travel behaviour. It is therefore important to investigate individuals' attitudes when analysing travel behaviour.

The literature suggests that travel behavioural patterns can be grouped based on individuals' environmental concerns, perceived risk of environmental degradation, and, to a lesser extent, knowledge of the adverse effects human activities have on the environment (Ajzen & Fishbein, 1980; Anable, 2005; Eagly & Chaiken, 1993; Nilsson & Küller, 2000). Anable (2005) identifies six segment profiles of individuals based on "instrumental, situational and psychological factors affecting travel choice" (p.65). For example, Anable's (2005) first segment profile, Malcontented Motorists, are individuals who own cars but are unhappy with car travel, feel morally obligated to change their travel behaviour, but perceive numerous constraints to public transit. Secondly, Complacent Car Addicts are those individuals who do not feel morally compelled to using alternative modes. Other profiles defined in Anable's (2005) study include Aspiring Environmentalists, Die Hard Drivers, Car-less Crusaders, and Reluctant Riders. The current study attempts to group attitudinal statements, similar to Anable, and characterise travel behaviour based on lifestyle choice preferences.

In order to encourage individuals to use public transit more often, Beirão & Cabral (2007) advise to improve the level of service of the transit system to a desirable quality for regular and potential transit users. Potential users include individuals who are open to alternative modes, have a positive attitude towards public transit, are less dependent on the automobile, but may still own an automobile. People may still be resistant to using public transit due to negative opinions of others or a lack of knowledge about the bus system. Consequently, there is a need to change individuals' attitudes towards the public transit system possibly by evaluating the attractiveness of transit (Beirão & Cabral, 2007). The current study examines respondents' attitudes toward transit and compares those to their primary mode of transport.

Many studies conduct explanatory analyses of travel behaviour that estimate how, for example, socio-economic characteristics, land use and accessibility, and attitudinal preferences affect travel behaviour (e.g., Anable, 2005; Beirão & Cabral, 2007; Boarnet & Sarmiento, 1998; Dieleman et al., 2002; Lu & Pas, 1999). However, the current study better suits an exploratory analysis of travel behaviour (similar to the studies noted in Table 1) because it attempts to characterise travel behaviour in Halifax by identifying patterns in travel activity. The current research can provide

critical information on the recent travel behaviour, attitudes, and socio-economic characteristics that contribute to the current patterns of travel behaviour in Halifax. The results can be used to inform transportation policy and investment in infrastructure, as suggested by Manaugh and El-Geneidy (2012).

2.3 Methodology

2.3.1 Data Preparation

This empirical study offers an exploratory analysis of the travel behaviour characteristics of Halifax through a descriptive statistical analysis of the Household Mobility and Travel Survey (HMTS). Researchers of Dalhousie Transportation Collaboratory (DalTRAC) in Halifax, Nova Scotia conducted the retrospective, web-based HMTS in 2012 (Wave 1) and 2013 (Wave 2). The DalTRAC researchers used a stratified sampling approach by distributing the survey through major organizations and institutions in Halifax including the Halifax Regional Municipality, Ecology Action Centre, Capital Health, the Halifax Regional School Board, Metro News, and the Federation of Community Organizations. Additionally, the survey link was posted to social media sites, blogs, and newsletters. The survey results included a total of 475 responses - 324 from Wave 1 and 151 responses from Wave 2. An earlier study reported the findings of Wave 1 (Peterlin & Habib, 2012); this study reports the findings of both waves of data collection, similar to the reporting of Wave 1.

The HMTS is important for research in Halifax as it offers extensive disaggregated information, some of which is not available in existing databases. Figure 3 shows that the HMTS collected socio-economic characteristics, travel behaviour, mobility tool ownership, and additional information from Halifax residents that

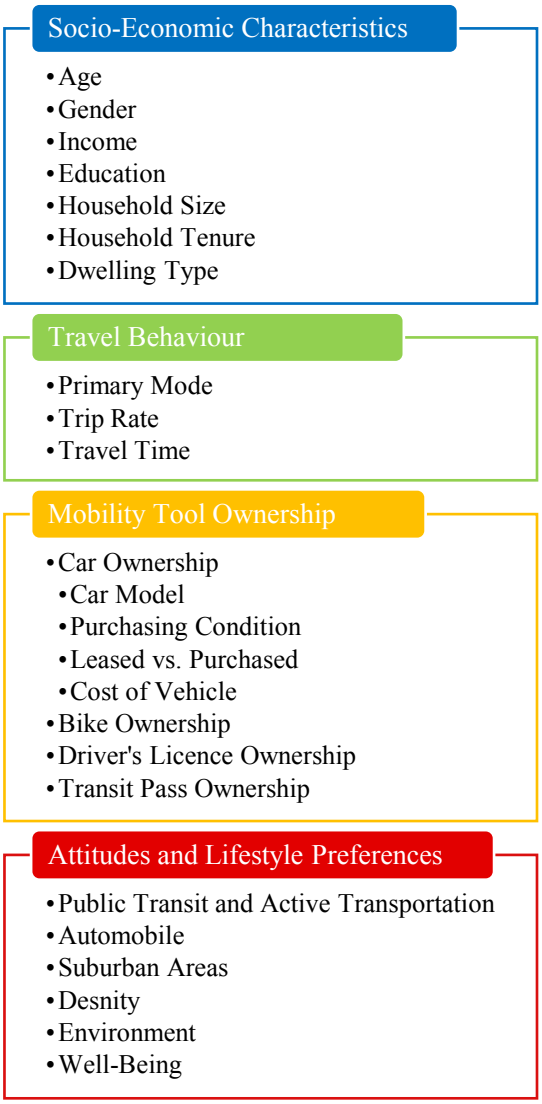


Figure 3: HMTS data collected

is not available in existing databases including the National Household Survey (NHS) or General Social Survey (GSS). For example, attitudes and lifestyle preferences are available in the HMTS but not in the NHS and GSS. The survey also collected participants' home and work addresses.

The first step in the data preparation involved processing the raw data into a cleaned and coded Microsoft Access database. Respondents' home and work addresses were geocoded using longitude and latitude coordinates produced by an online service, BatchGeo. Subsequently, the distances from home to work and home to the nearest transit stop were calculated using the Network Analyst tool in ArcGIS 10.1. The results of the survey were compared to the 2006 Canadian Census and 2011 NHS for validation.

2.4 HMTS Sample Characteristics

This section characterises the sample used in this study by identifying and describing socio-economic characteristics of the sample including household income, gender, household income, and household size. Additionally, the sample characteristics are compared to the 2006 and 2011 censuses for validation.

2.4.1 Socio-economic Characteristics

2.4.1.1 Age

The highest percentage of residents (21%) is between 15 and 24 years of age. Figure 4 illustrates that the HMTS sample mainly comprises of younger individuals of working age (i.e. 15-64 years old). Only 5% of residents are 65 years or older.

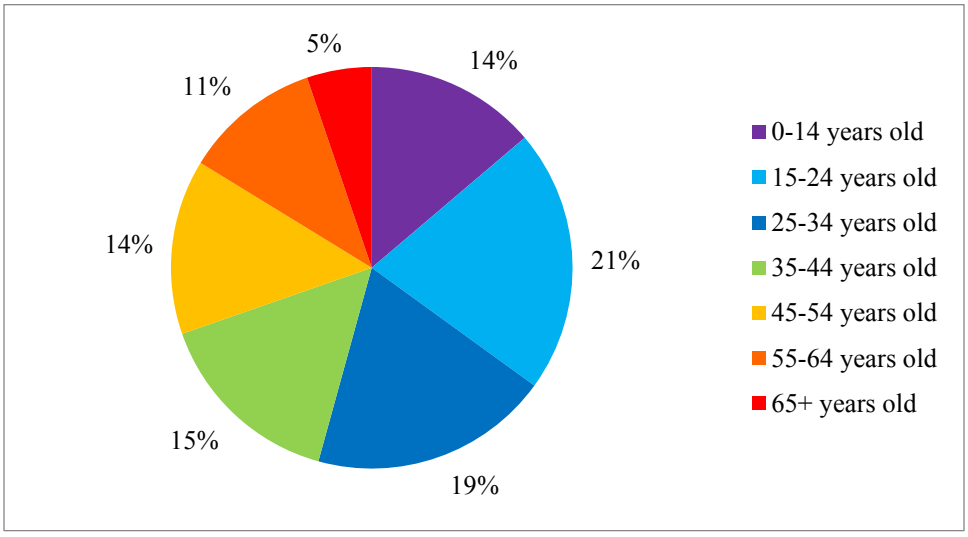


Figure 4: Age of residents

2.4.1.2 Household Income

Overall, respondents earn a moderate to high household income. The majority of households earn an approximate annual household income above $50,000. However, a significant percentage (16%) of households earns an annual income below $25,000 (see Figure 5).

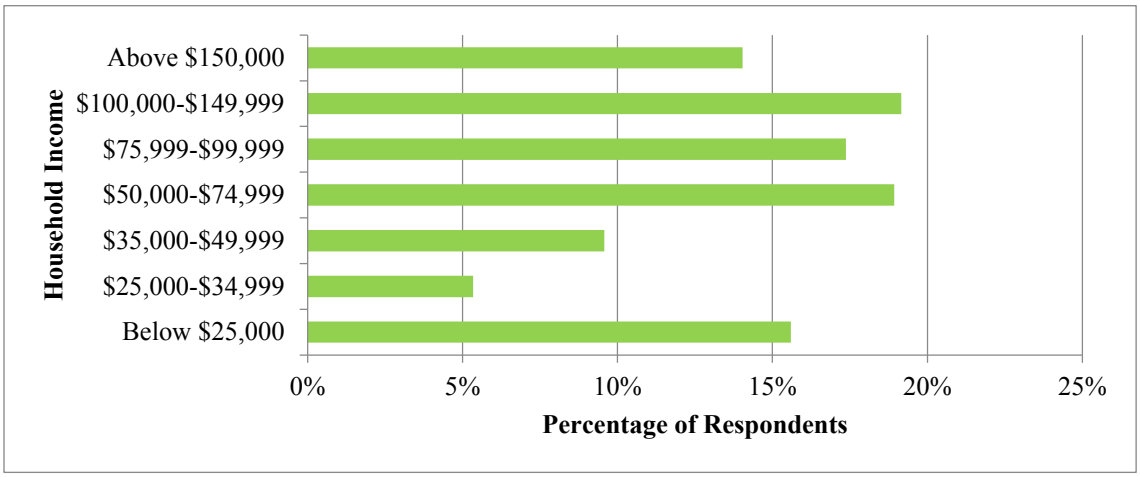


Figure 5: Household annual income

2.4.1.3 Gender

Female primary workers account for 53% of responses. Figure 6 shows that the highest percentage of female primary workers (24%) are 45-54 years old, whereas the highest percentage of male primary workers (25%) are 25-34 years old. A notable percentage of male primary workers (20%) are 55-64 years of age.

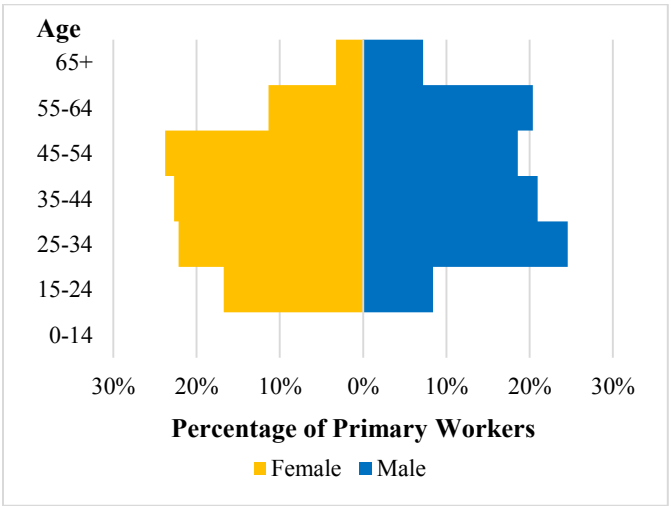


Figure 6: Gender and age of primary worker

A higher percentage of secondary workers are female, accounting for 59% of all responses. Although the highest percentage of female secondary workers (26%) are 45-54 years old, a significant percentage (24%) are 25-34 years of age (see Figure 7). Male secondary workers are generally between 25-54 years of age.

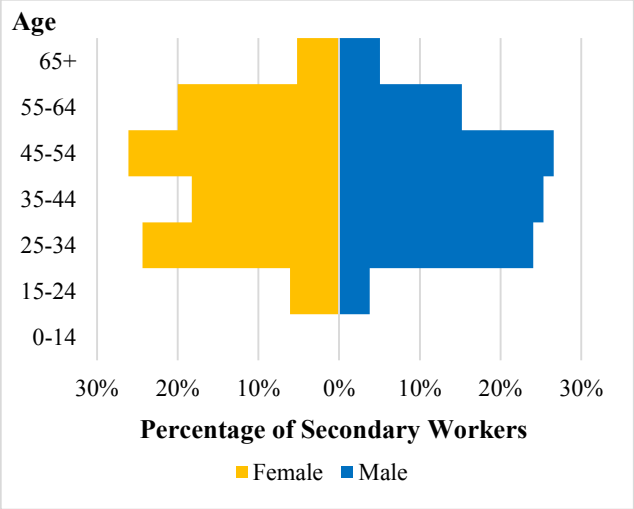


Figure 7: Gender and age of secondary worker

2.4.1.4 Education

The majority of HMTS primary and secondary workers have post-secondary education. The highest percentage of primary and secondary workers have a Bachelor degree, representing 38% and 43% respectively. A significant percentage of workers have a Master's degree or higher, accounting for 36% of primary workers and 24% of secondary workers (see Figure 8). These observations may account for the fact that there are more than three tertiary institutions in Halifax.

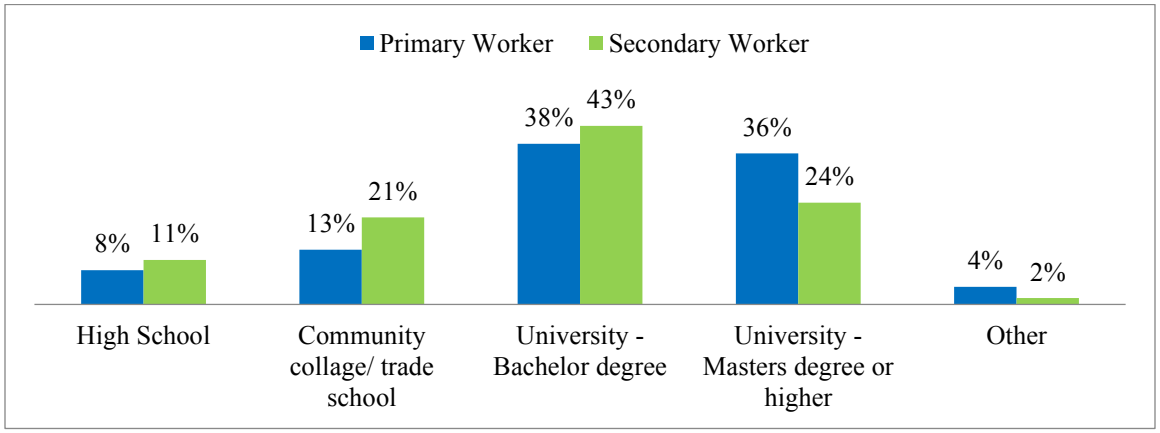


Figure 8: Highest level of education

2.4.1.5 Employment Status

The majority of primary workers (87%) and secondary workers (79%) are full-time employees (see Figure 9), which suggests that large student population in Halifax is not affecting the sample.

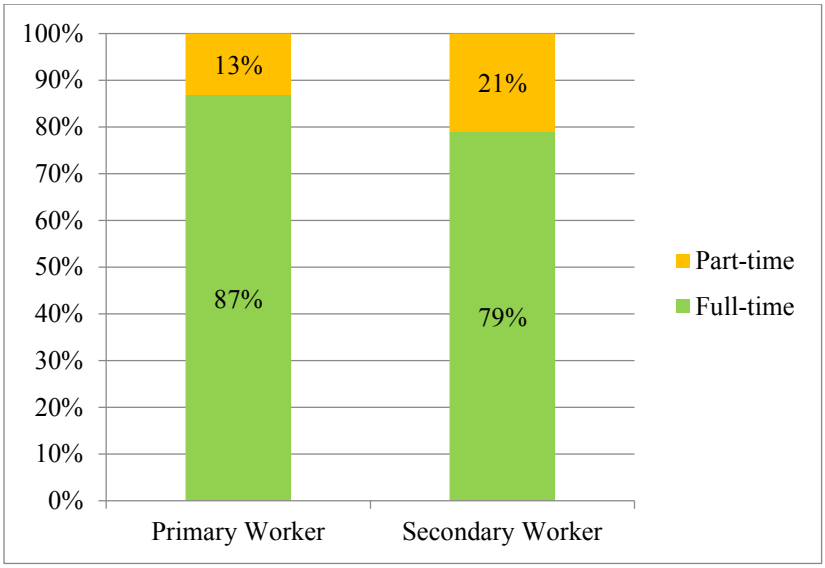


Figure 9: Employment Status of Primary and Secondary Workers

2.4.1.6 Household Size

The highest percentage (38%) of households represents two-person households. A relatively high percentage of households (22%) have four people living in the household (see Figure 10).

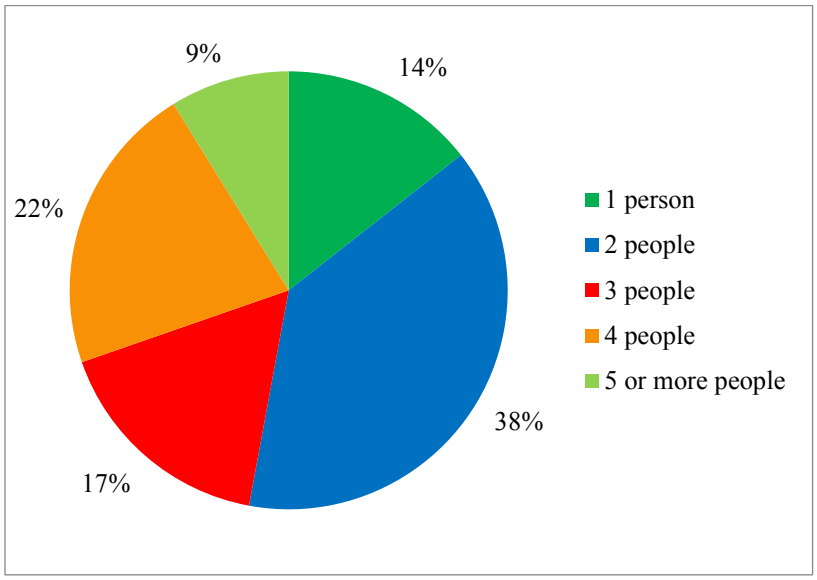


Figure 10: Number of people in household

A noteworthy percentage of households (70%) do not have children. Approximately 17% of households have one or two children and less than 4% have three or more children (see Figure 11).

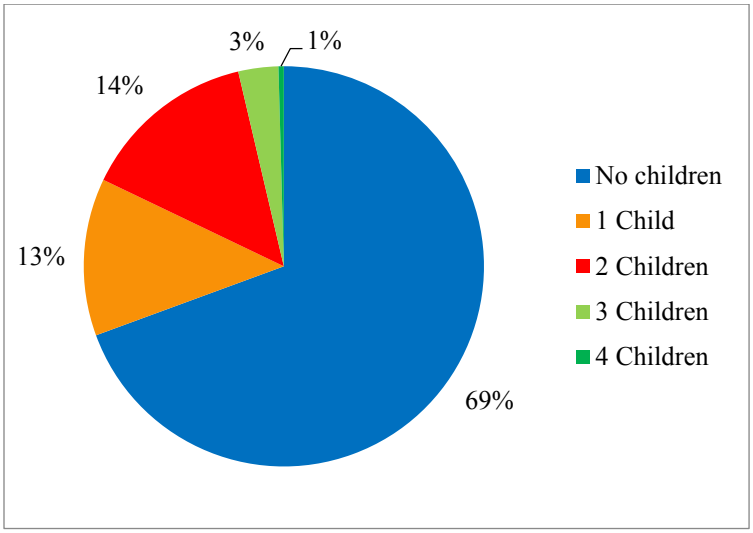


Figure 11: Number of children in household

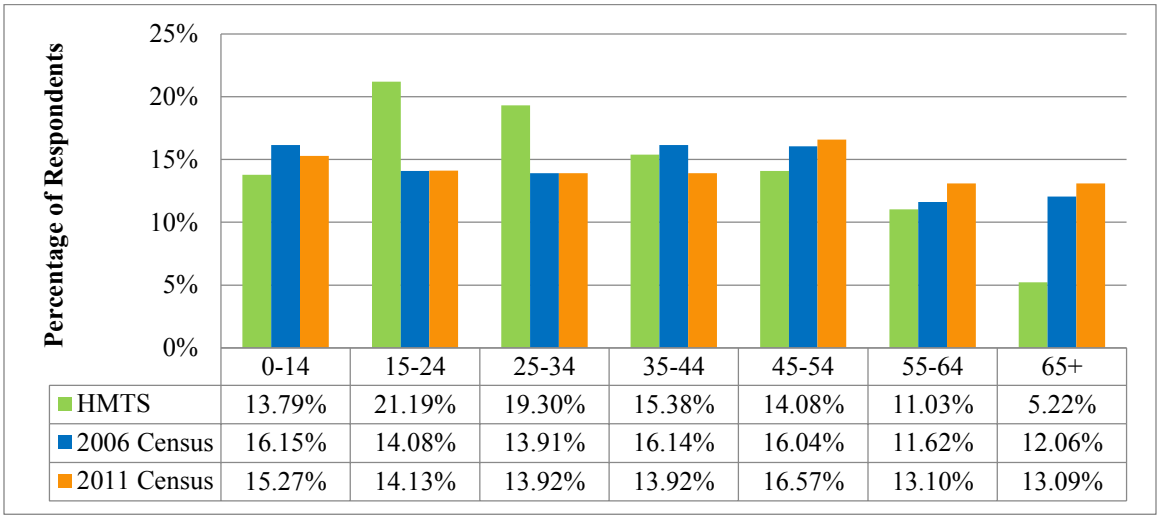
2.4.2 Data Validation

The HMTS is considered a reasonably representative sample of Halifax. This study defines a reasonably representative sample as one in which the majority of stratums are within a 3% variability of the 2006 and 2011 Censuses and 2011 NHS. For example, individuals 35-64 years old are well represented in the sample. Moreover, the percentages of two-person and three-person households in the survey mirrored the percentages found in the Census and NHS. The sample includes a group of respondents from various socio-economic backgrounds. The few minor variations in the sample are inherent of web-based surveys (Fricker & Schonlau, 2002; Solomon, 2001), and were not considered to significantly affect the travel behaviour analysis. Hence, the HMTS results were not weighted in this analysis.

2.4.2.1 Household Residents' Age

The majority of age cohorts of the sample are representative of Halifax. The percentage of HMTS residents 35-44 years old are within a 1.5% variability of the censuses; residents 45-54 years old are within 2.5% of the censuses; and residents 55-64 years old are within 2.1% of the censuses. Furthermore, Figure 12 shows that residents 0-14 are well accounted for in the sample, i.e., within a 2.4% variability of the censuses. There is, however, a slight over-representation of the 15-34 age groups and under-representation of the elderly, 65 and over cohort; these minor differences

may occur because a younger population cohort tends to have easier access to the internet and, thus, web-based surveys.

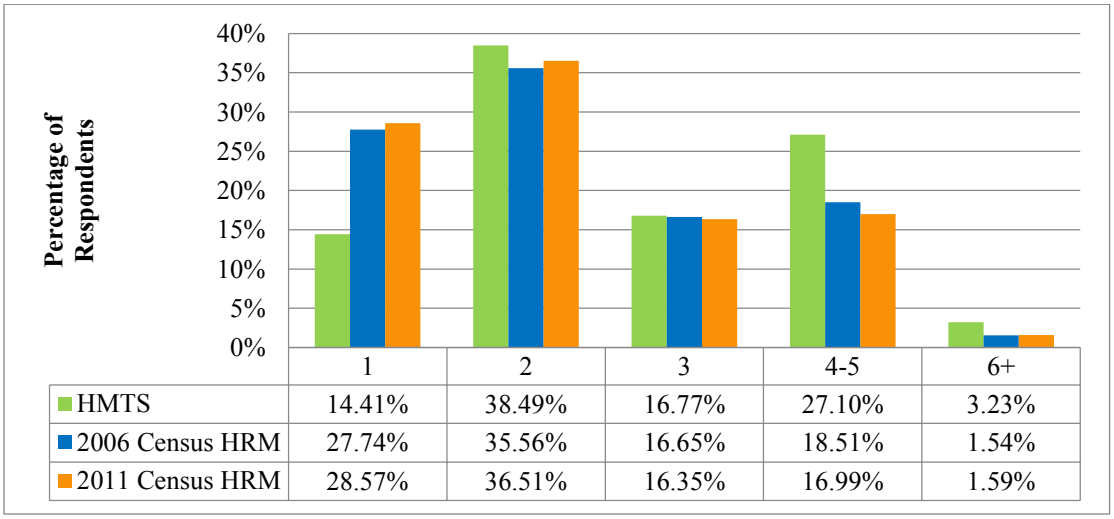


	0-14	15-24	25-34	35-44	45-54	55-64	65+
HMTS	13.79%	21.19%	19.30%	15.38%	14.08%	11.03%	5.22%
2006 Census	16.15%	14.08%	13.91%	16.14%	16.04%	11.62%	12.06%
2011 Census	15.27%	14.13%	13.92%	13.92%	16.57%	13.10%	13.09%

Figure 12: Age validation

2.4.2.2 Household Size

Household size collected in the HMTS is generally comparable to the census data. Two-person and six-or-more-person households are all well represented in the sample, i.e., within 3% of those cohorts for the 2006 and 2011 Censuses. The percentage of three-person households for the sample is very well represented in the sample; it almost mirrors that of the census with less than 0.5% variability of the censuses (see Figure 13). There is a slight underrepresentation of one-person households and a minor overrepresentation of 4-5 person households.



	1	2	3	4-5	6+
HMTS	14.41%	38.49%	16.77%	27.10%	3.23%
2006 Census HRM	27.74%	35.56%	16.65%	18.51%	1.54%
2011 Census HRM	28.57%	36.51%	16.35%	16.99%	1.59%

Figure 13: Household size validation

2.4.2.3 Household Income

A comparison of annual household income between HMTS responses and the census proved challenging because the income segments were considerably different. Table 2 offers an aggregated comparison of household income. Moderate-income households (receiving an approximate annual household income $50,000-$100,000) are well represented in the sample as shown in Table 2. There is a slight over-representation of high-income households (i.e. receiving an approximate annual household income above $100,000) and a small underrepresentation of low-income households when compared to the 2006 and 2011 censuses. Arguably, high-income households might have better access to the internet.

Table 2: Household income validation

Household Income	HMTS	2006 Census		2011 NHS	
		Halifax	NS	Halifax	NS
Below $50,000	30.51%	46.32%	53.57%	40.41%	46.71%
$50,000-$100,000	36.30%	35.03%	33.39%	33.81%	33.60%
Above $100,000	33.18%	18.65%	13.04%	25.78%	19.69%

2.4.2.4 Household Tenure

Household tenure is analogous to the 2006 census and the 2011 NHS (see Figure 14). The percentages of owned and rented homes are within 3% of the census and NHS and are, therefore, representative of Halifax.

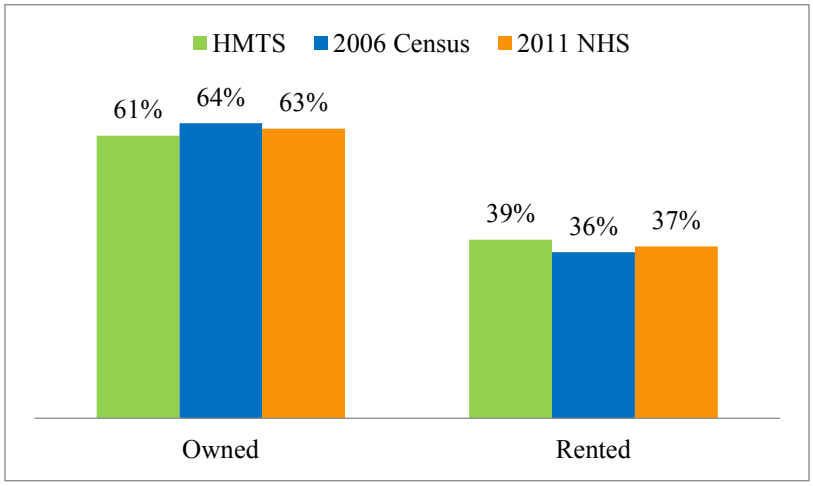
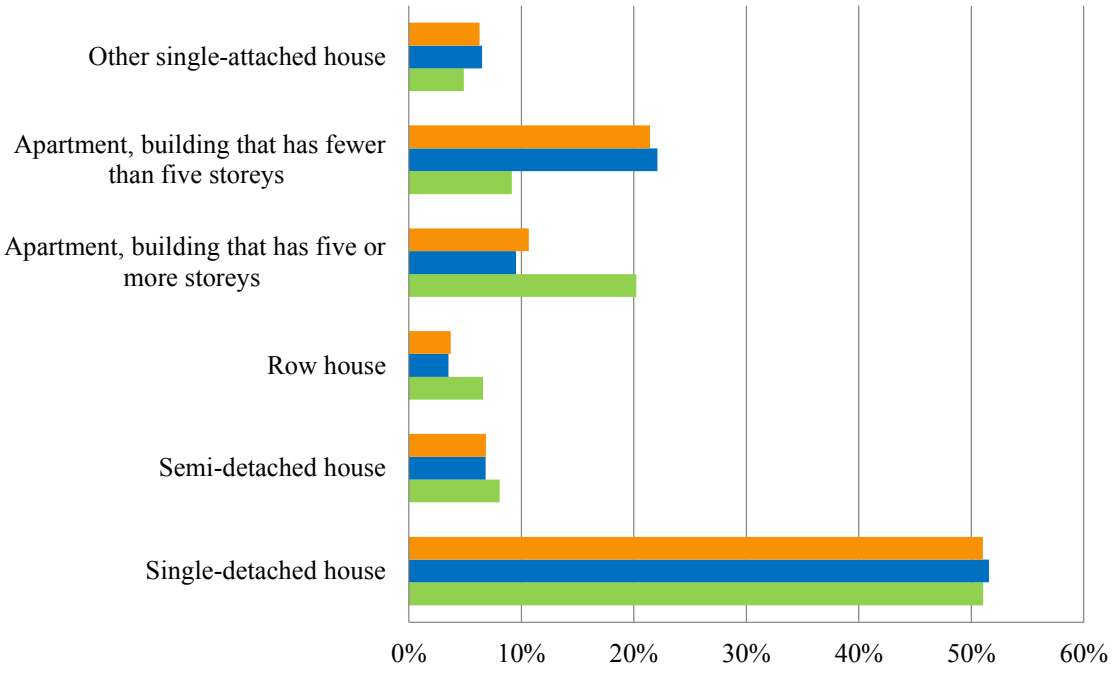


Figure 14: Household tenure validation

2.4.2.5 Dwelling Type

Most HMTS households occupy single-detached houses, similar to the percentages found in the 2006 and 2011 censuses. Figure 15 shows that the percentage of single-detached houses is very well represented in the sample, equal to the percentage found in the 2011 census. Furthermore, the percentages of row houses, semi-detached houses, and other single-attached houses are adequately represented in the sample, within 3% variability of the census. There is, however, a slight over-representation of apartments in a building with five or more storeys and a slight under-representation of apartments in a buildings fewer than five storeys.



	Single-detached house	Semi-detached house	Row house	Apartment, building that has five or more storeys	Apartment, building that has fewer than five storeys	Other single-attached house
2011 Census HRM	51.04%	6.84%	3.73%	10.66%	21.45%	6.29%
2006 Census HRM	51.57%	6.81%	3.51%	9.53%	22.09%	6.50%
HMTS	51.06%	8.09%	6.60%	20.21%	9.15%	4.89%

Figure 15: Dwelling type validation

2.5 Results of the HMTS

2.5.1 Travel Behaviour

2.5.1.1 Primary Mode

The highest percentage of residents (44%) travel primarily via the automobile (summation of auto drivers and auto passengers). Furthermore, a noteworthy percentage of residents walk (22%) and take transit (20%) as their primary mode as seen Figure 16.

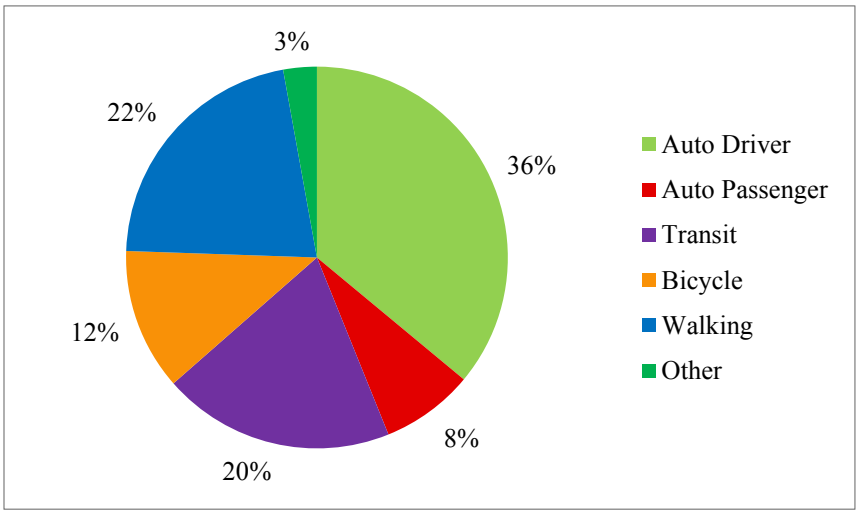


Figure 16: Primary mode

High-income households tend to have a higher percentage of automobile use whereas lower income households walk as their primary mode. Transit travel seems to be almost uniform for low to medium income households (below $100,000) but not for high-income households ($100,000 and above), where the percentage of respondents travelling primarily via transit decreases by 8% (see Figure 17). A higher percentage of medium and high income respondents bike as their primary commute mode when compared to low-income respondents; only 4% of low-income respondents (below $25,000) bike to work.

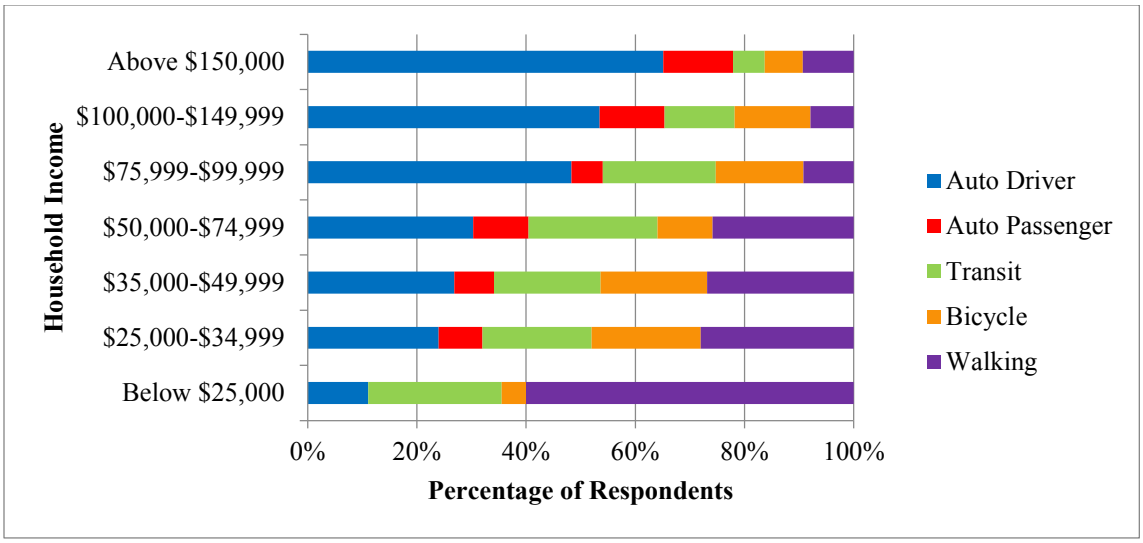


Figure 17: Primary mode by household income

As age increases, automobile travel tends to increase and walking tends to decrease. Figure 18 shows that younger residents primarily walk and take transit to work, accounting for 43% and 25% of individuals 15 to 24 years old respectively. In contrast, individuals 25 years and older predominantly travel via car. More than 70% of residents 45-54 years old, 55-64 years old, and 65 years and older travel via the automobile. A higher percentage of younger residents 15-24 years old (25%) primarily travel via transit when compared to older age cohorts. Transit is generally not used by seniors, 65 years and older (see Figure 18), which may be a reflection of the slight under-representation of seniors in the sample.

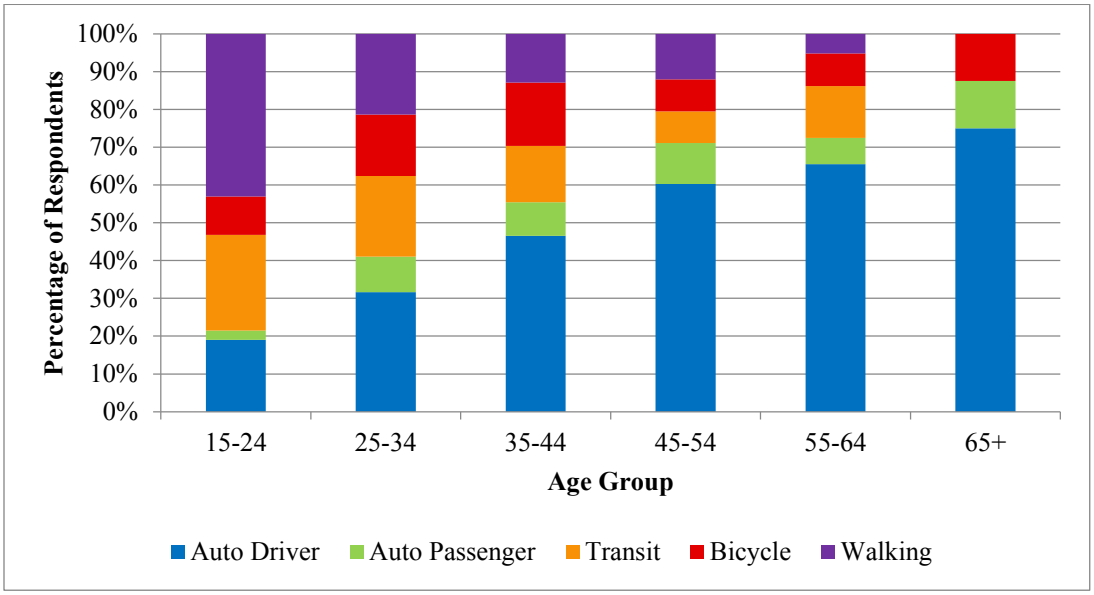


Figure 18: Primary mode by age

Residents that are less than 16 years old travel to school mainly as auto passengers, accounting for 36%. A similar percentage of residents less than 16 years old (31%) walk and a noteworthy percentage (24%) use public transit to travel to school (see Figure 19).

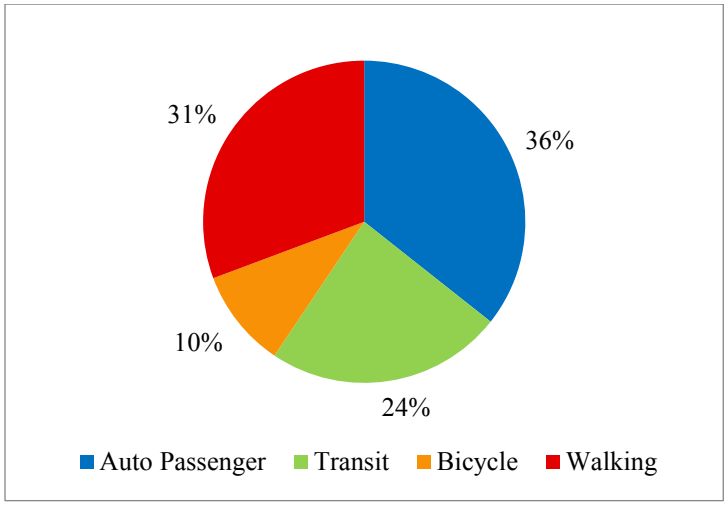


Figure 19: Primary mode to school for individuals less than 16 years old

Residents that are 16 years and older may have access to a driver's license and are legally allowed to drive. However, the majority of these residents walk to school, accounting for 40% of individuals less than 16 years old. A significant percentage (22%) of residents 16 years and older drive to school (see Figure 20). Similar percentages of residents 16 years and older take transit or bike to school, representing 16% and 15% respectively.

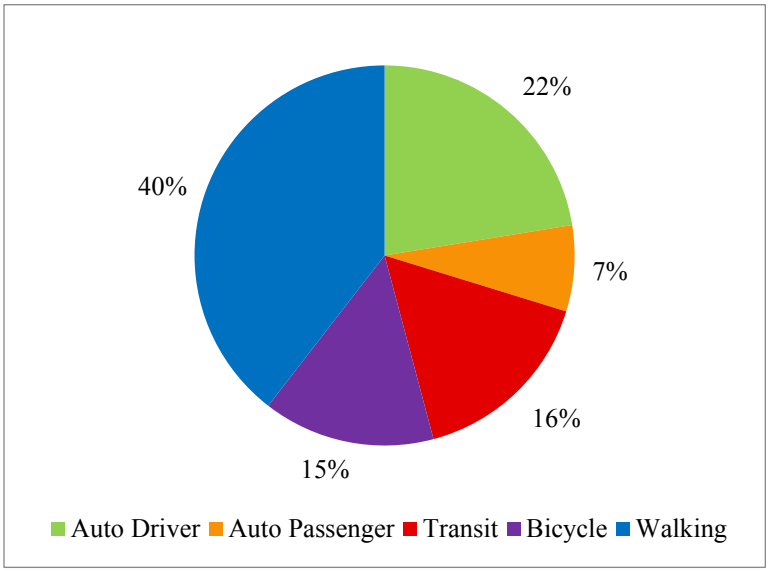


Figure 20: Primary mode to school for individuals 16 years and older

2.5.1.2 Primary Mode by Trip Purpose

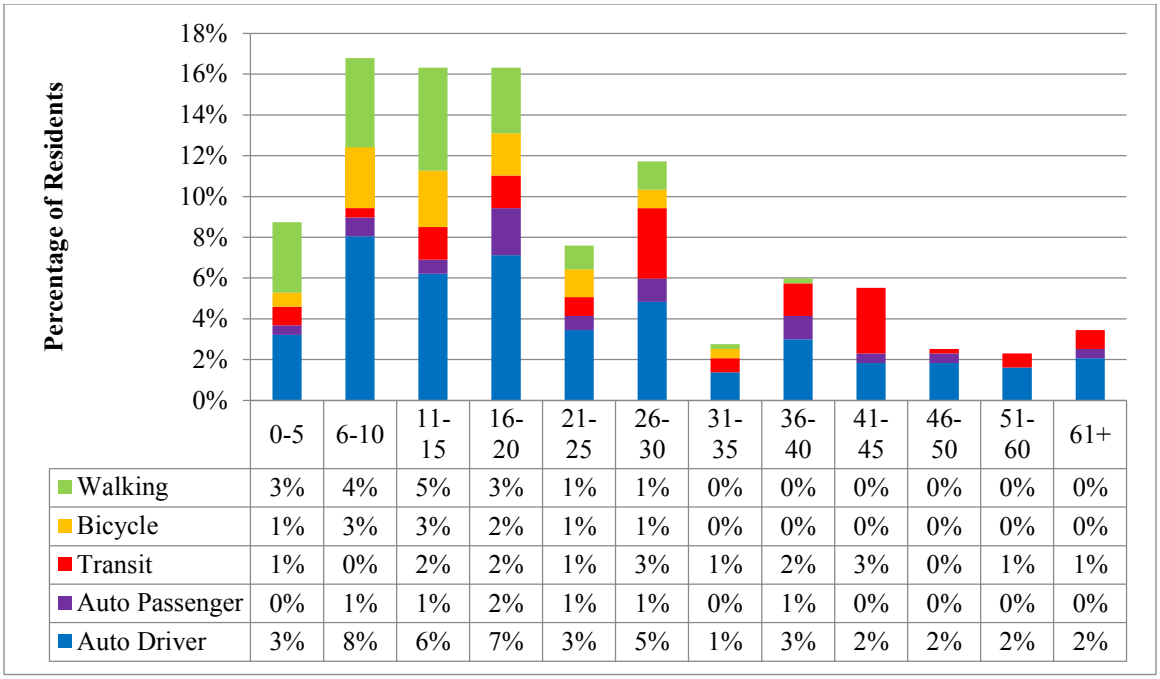
Most residents travel to work, food shopping, other shopping, and recreation trips via automobile. However, residents predominantly travel to school by walking (see Table 3). A very high percentage of residents travel for discretionary trip purposes (i.e. food shopping, other shopping, personal errands, and recreation trips) via the automobile, accounting for more than 60%. Therefore, alternatives to the automobile are generally not preferred for discretionary trips, in contrast to what was found for Oregon (Oregon Department of Transportation, 2002). A notable percentage of residents, however, walk for food shopping trips, accounting for 24%. Furthermore, 22% of individuals walk for personal errands and 20% walk for recreation trips.

Table 3: Primary mode by trip purpose

Primary Mode (Number of Residents)	Work Trips (483)	School Trips (309)	Food Shopping Trips (635)	Other Shopping Trips (649)	Personal Errand Trips (674)	Recreation Trips (712)
Auto Driver	43%	16%	47%	50%	44%	39%
Auto Passenger	9%	17%	19%	19%	16%	24%
Transit	17%	18%	5%	15%	9%	10%
Bicycle	12%	13%	4%	5%	9%	6%
Walking	19%	36%	24%	11%	22%	20%

2.5.1.3 Travel Time by Trip Purpose

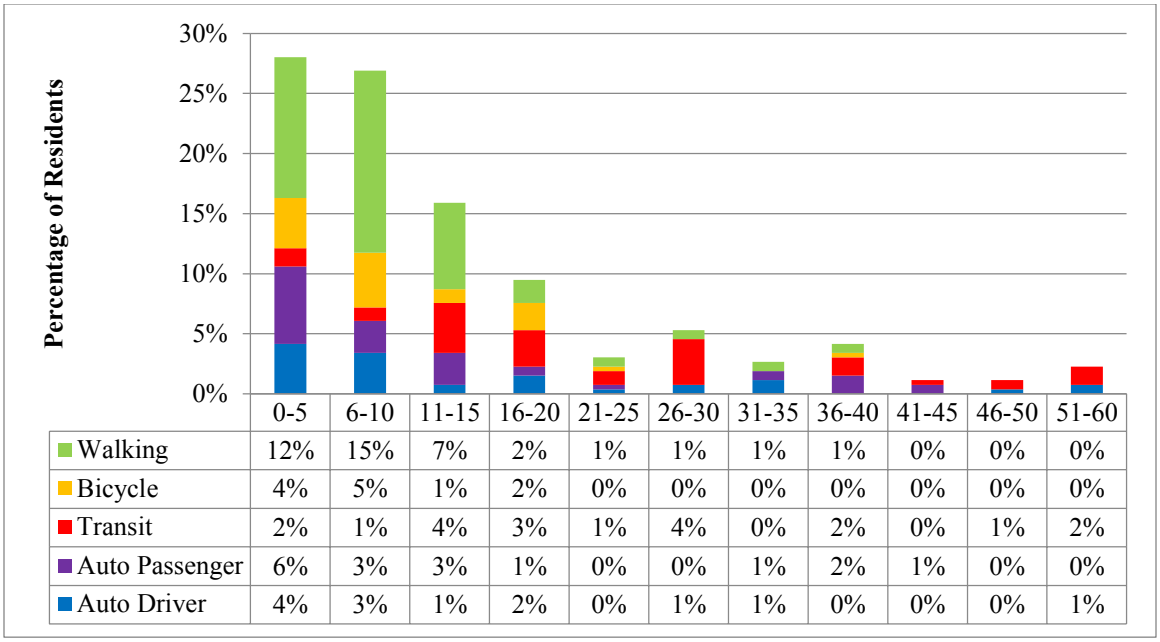
Almost 50% of work trips are within a 6-20 minute travel time as shown in Figure 21. Residents who travel more than 20 minutes for work trips primarily drive, but the second highest percentage of residents who travel more than 20 minutes to work use transit. Residents do not travel more than 20 minutes via active travel modes.



	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-60	61+
Walking	3%	4%	5%	3%	1%	1%	0%	0%	0%	0%	0%	0%
Bicycle	1%	3%	3%	2%	1%	1%	0%	0%	0%	0%	0%	0%
Transit	1%	0%	2%	2%	1%	3%	1%	2%	3%	0%	1%	1%
Auto Passenger	0%	1%	1%	2%	1%	1%	0%	1%	0%	0%	0%	0%
Auto Driver	3%	8%	6%	7%	3%	5%	1%	3%	2%	2%	2%	2%

Figure 21: Travel time to work (minutes) by travel mode

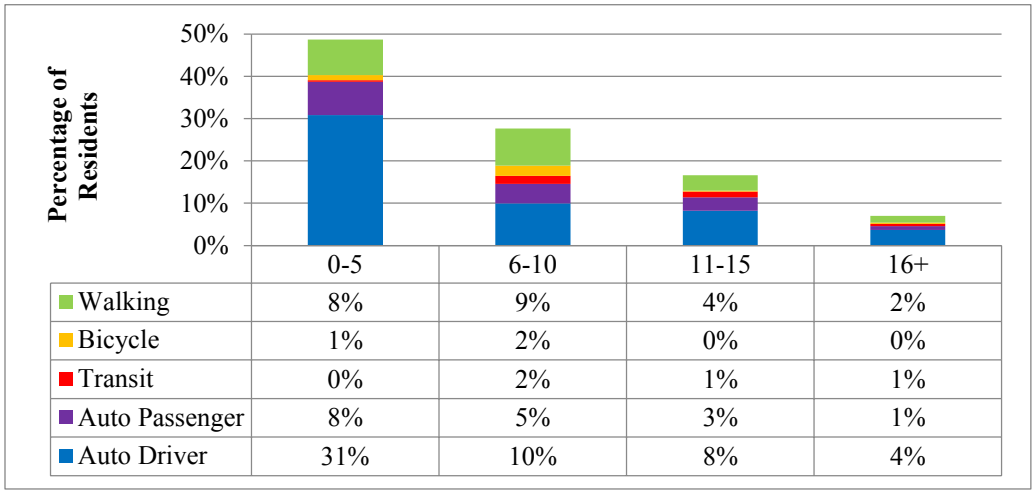
The majority of residents (55%) travel up to 10 minutes for school trips. Residents who travel for more than 20 minutes for school trips do not cycle to work. A higher percentage of residents who travel 20 minutes or less to school walk and cycle than residents who travel more than 20 minutes to school (see Figure 22).



	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-60
Walking	12%	15%	7%	2%	1%	1%	1%	1%	0%	0%	0%
Bicycle	4%	5%	1%	2%	0%	0%	0%	0%	0%	0%	0%
Transit	2%	1%	4%	3%	1%	4%	0%	2%	0%	1%	2%
Auto Passenger	6%	3%	3%	1%	0%	0%	1%	2%	1%	0%	0%
Auto Driver	4%	3%	1%	2%	0%	1%	1%	0%	0%	0%	1%

Figure 22: Travel time (minutes) for school trips by travel mode

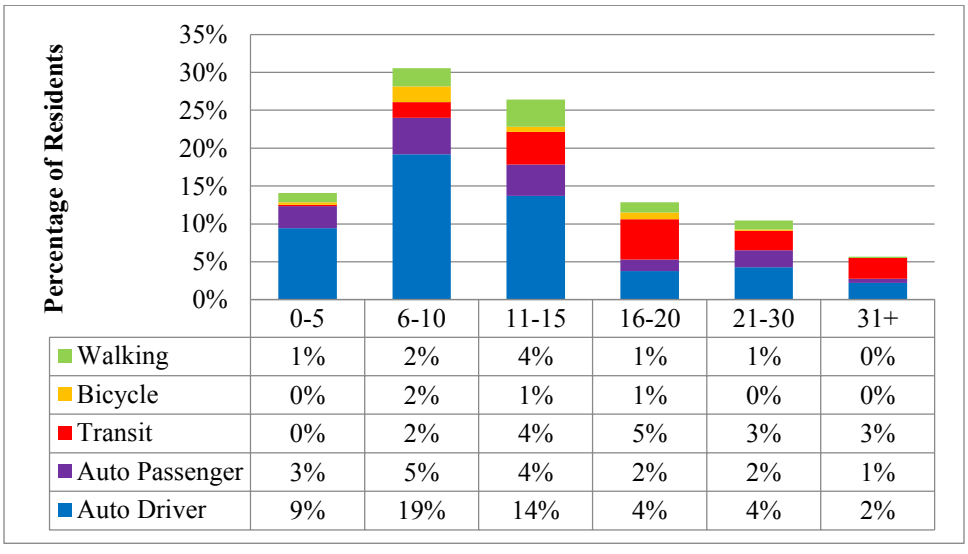
Residents typically travel 15 minutes or less for food shopping trips, accounting for 80% of residents. The majority of residents who travel within 5 minutes for food shopping trips travel via the automobile: 31% are auto drivers and 8 % are auto passengers as shown in Figure 23. The highest percentage of residents who walk for food shopping trips travel between 6-10 minutes.



	0-5	6-10	11-15	16+
Walking	8%	9%	4%	2%
Bicycle	1%	2%	0%	0%
Transit	0%	2%	1%	1%
Auto Passenger	8%	5%	3%	1%
Auto Driver	31%	10%	8%	4%

Figure 23: Travel time (minutes) for food shopping trips by travel mode

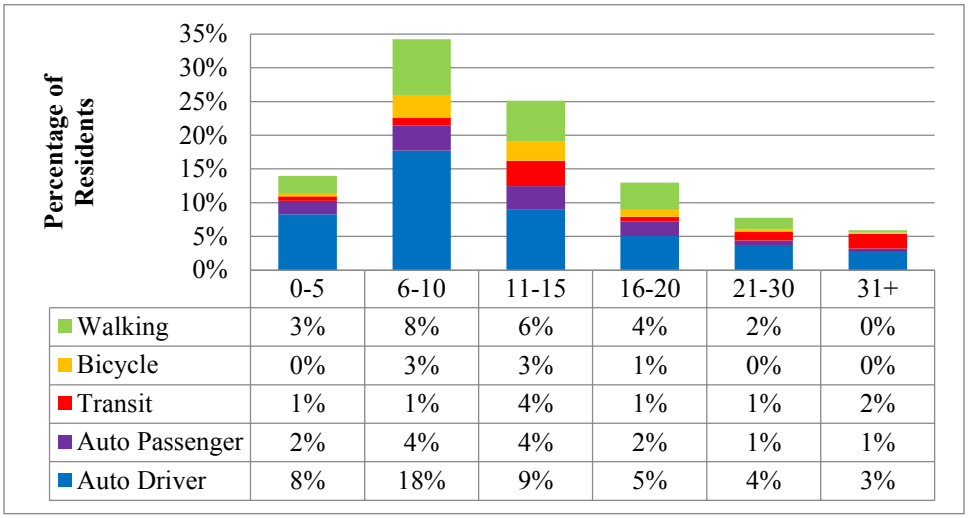
Figure 24 illustrates that the highest percentage of residents (30%) travel 6-10 minutes for general shopping trips. Interestingly, 24% of these residents travel via car and the remaining 6% of these residents travel via walking, cycling, or transit. A significant percentage (27%) of residents also travel 11-15 minutes for general shopping trips. Of those residents who take transit for general shopping trips, most travel 11 minutes or more to reach their destination.



	0-5	6-10	11-15	16-20	21-30	31+
Walking	1%	2%	4%	1%	1%	0%
Bicycle	0%	2%	1%	1%	0%	0%
Transit	0%	2%	4%	5%	3%	3%
Auto Passenger	3%	5%	4%	2%	2%	1%
Auto Driver	9%	19%	14%	4%	4%	2%

Figure 24: Travel time (minutes) for general shopping trips by travel mode

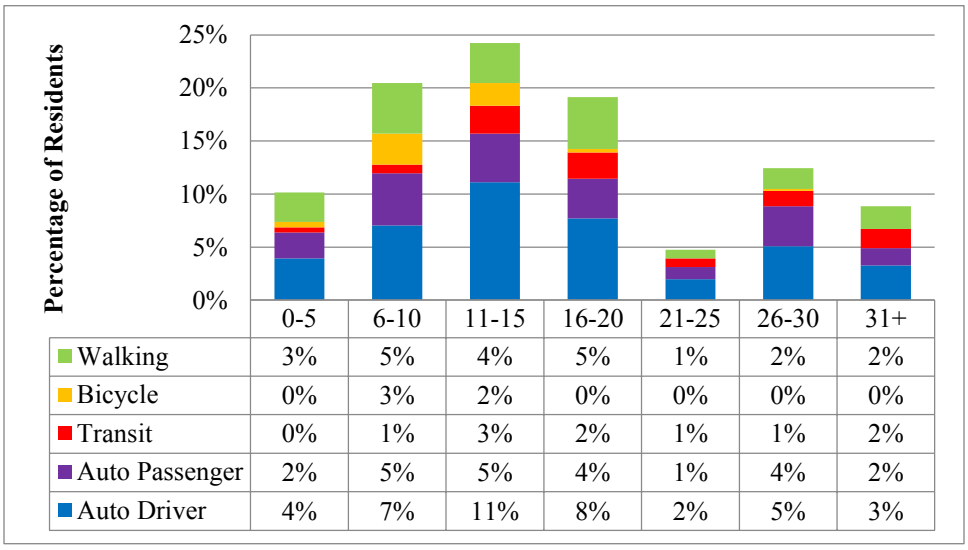
The highest percentage of residents (34%) travel 6-10 minutes for personal errand trips, as shown in Figure 25. Although the highest percentage of these residents drives for personal errand trips, a significant percentage walks accounting for 8% of residents. A noteworthy percentage of residents also travel 11-15 minutes for personal errands.



	0-5	6-10	11-15	16-20	21-30	31+
Walking	3%	8%	6%	4%	2%	0%
Bicycle	0%	3%	3%	1%	0%	0%
Transit	1%	1%	4%	1%	1%	2%
Auto Passenger	2%	4%	4%	2%	1%	1%
Auto Driver	8%	18%	9%	5%	4%	3%

Figure 25: Travel times (minutes) for personal errands by travel mode

Figure 26 shows that the highest percentage of residents (25%) travels between 11 and 15 minutes for recreation trip purposes. Residents that travel to recreation destinations via transit typically travel 11 minutes or more. Residents who travel 16 minutes or more for recreation trips do not cycle.



	0-5	6-10	11-15	16-20	21-25	26-30	31+
Walking	3%	5%	4%	5%	1%	2%	2%
Bicycle	0%	3%	2%	0%	0%	0%	0%
Transit	0%	1%	3%	2%	1%	1%	2%
Auto Passenger	2%	5%	5%	4%	1%	4%	2%
Auto Driver	4%	7%	11%	8%	2%	5%	3%

Figure 26: Travel time (minutes) for recreation trips by travel mode

2.5.1.4 Trip Rate

Figure 27 shows that the majority of residents conduct between five and fifteen round trips per week. The highest percentage of residents have a trip rate of seven or ten trips per week, accounting for 9.4% of residents. Approximately 5% of residents make 20 or more trips per week.

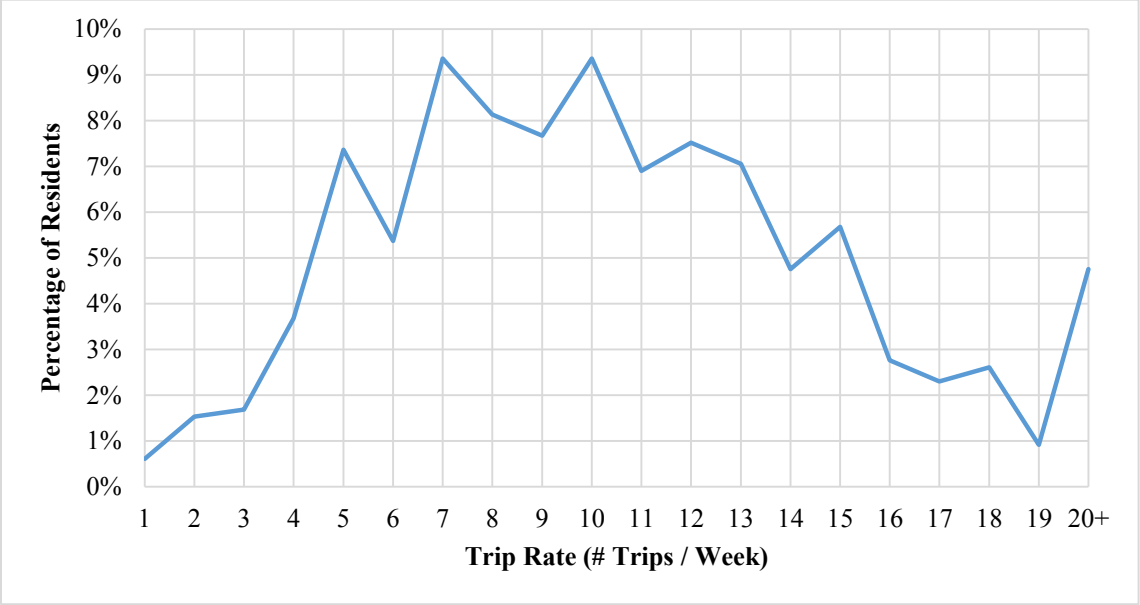


Figure 27: Trip rate (number of trips per week)

Overall, the majority of trips made per week are for discretionary purposes, accounting for 52%. As shown in Figure 28, the highest percentage of trips made per week are for work purposes, representing 28%, followed by recreation trips, representing 20%.

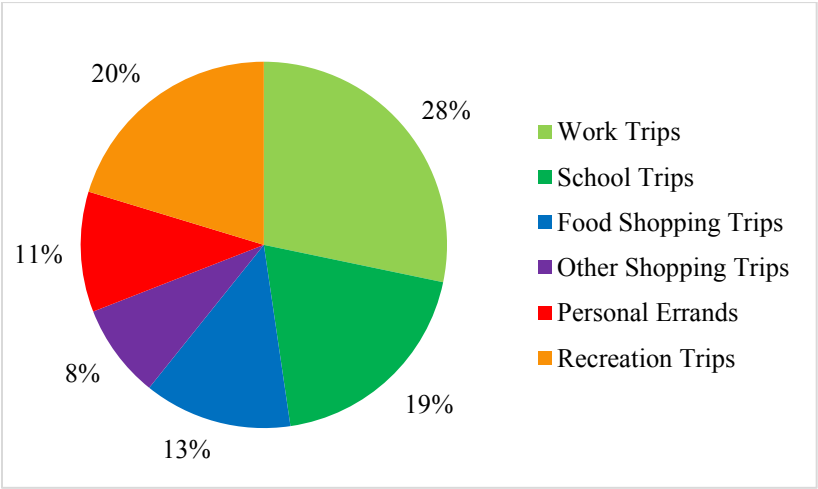


Figure 28: Share of trips per week by trip purpose

The majority of work and school trips are conducted four or five times per week. Food shopping, other shopping and personal errand trips are mainly generated once per week. Recreation trips are primarily generated two to three times per week (see Table 4).

Table 4: Trip rate by trip purpose

# of Round Trips (Weekly)	Work Trips	School Trips	Food Shopping Trips	Other Shopping Trips	Personal Errand Trips	Recreation Trips
0-1	7%	9%	49%	72%	65%	36%
2-3	12%	11%	43%	24%	31%	43%
4-5	68%	61%	7%	3%	3%	13%
6-7	9%	6%	0%	0%	1%	4%
More than 7	4%	12%	1%	1%	1%	4%

2.5.2 Mobility Tool Ownership

A substantial percentage of respondents own at least one household vehicle and bicycle, accounting for 79% and 73% respectively (see Figure 29). Furthermore, 25% of the sample own a monthly transit pass.

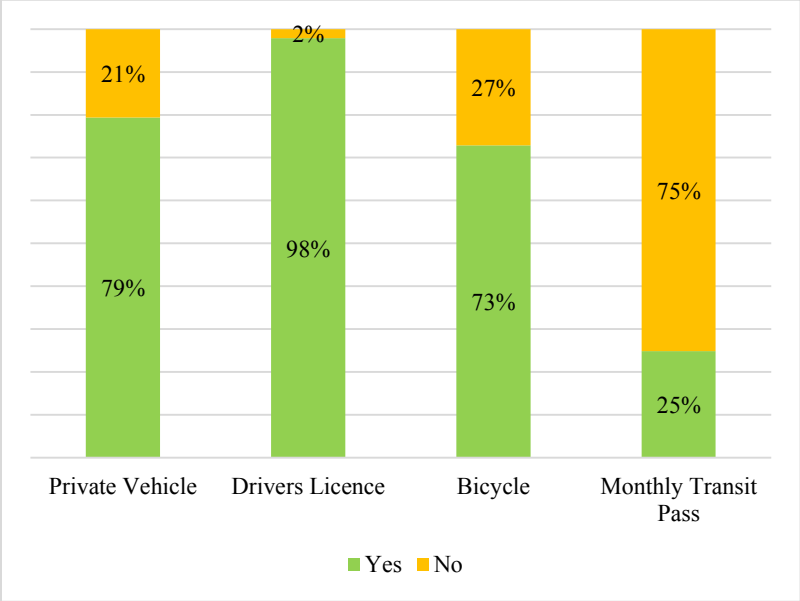


Figure 29: Mobility tool ownership

2.5.2.1 Vehicle Ownership

The majority of households own at least one car; the highest percentage of households (42%) own one vehicle. A noteworthy percentage of households (28%) own two cars (see Figure 30).

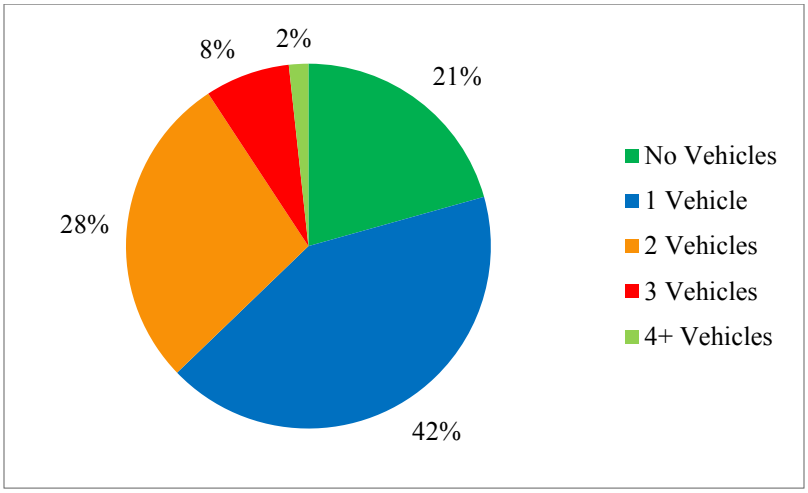


Figure 30: Vehicle ownership

In general, as annual household income increases, car ownership increases. Figure 31 illustrates that no car ownership ranges from 64% of households that receive an annual income below $25,000 to 3% for households that receive an annual income between $100,000 and $149,999. However, 21% of households that receive an annual income above $150,000 do not own a car.

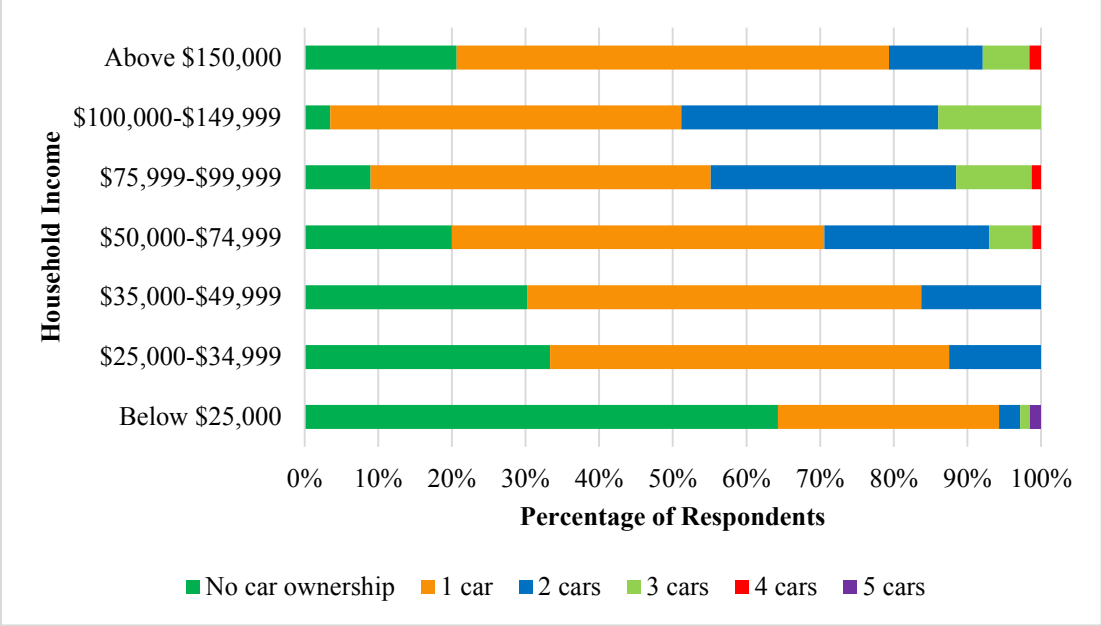


Figure 31: Annual household income vs. vehicle ownership

Overall, as household size increases, car ownership also increases. One-person households either own no cars or one car (see Figure 32). The highest percentage of two-person and three-person households (45%) own one car. The highest percentage of four-person and five person households own two cars, representing 42% and 37% respectively.

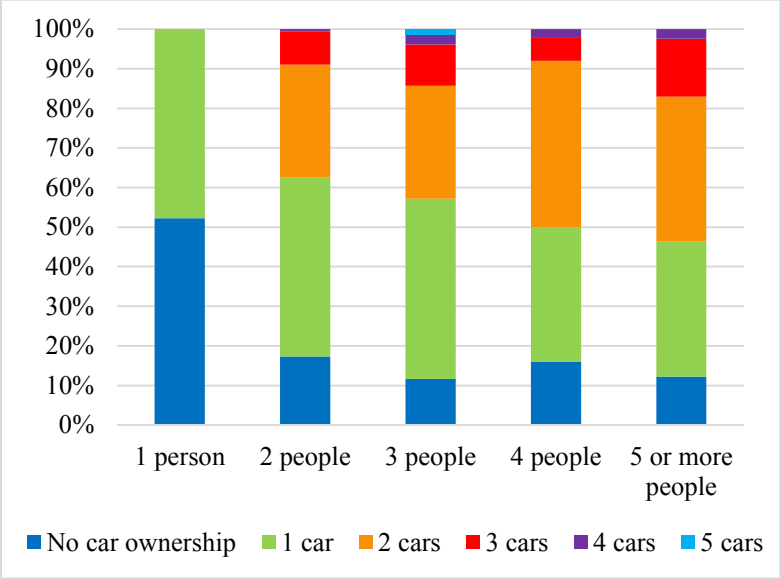


Figure 32: Vehicle ownership by household size

Furthermore, as the number of children in a household increases, car ownership also increases. Figure 33 shows that a significant percentage of households that do not have children (72%) have at least one car. All households with three or more children own at least one vehicle.

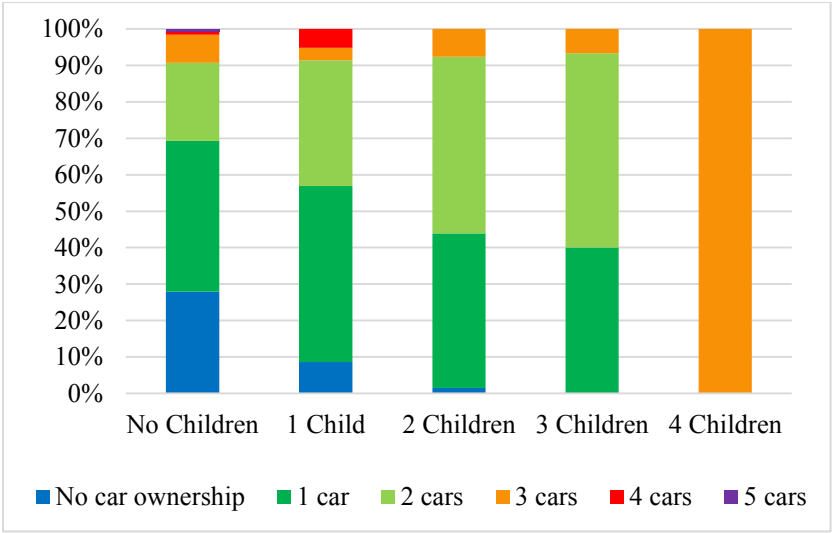


Figure 33: Vehicle ownership by number of children

The majority of household vehicles are purchased, as shown in Figure 34, accounting for 92% of all household vehicles.

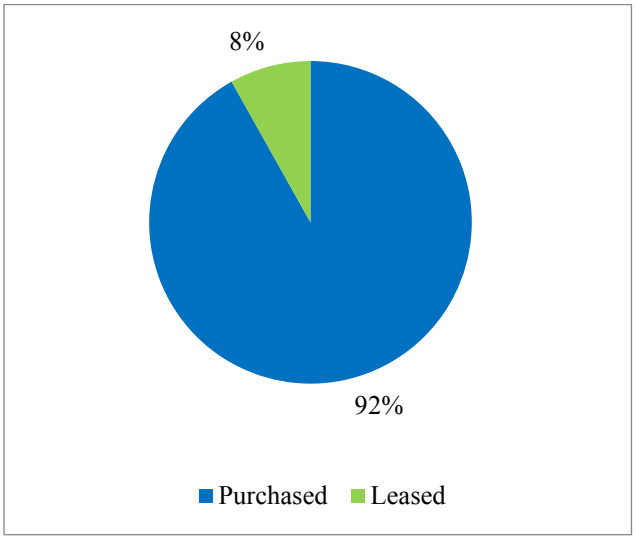


Figure 34: Purchased or leased vehicle

A higher percentage of purchased vehicles (54%) are previously used when purchased as shown in Figure 35.

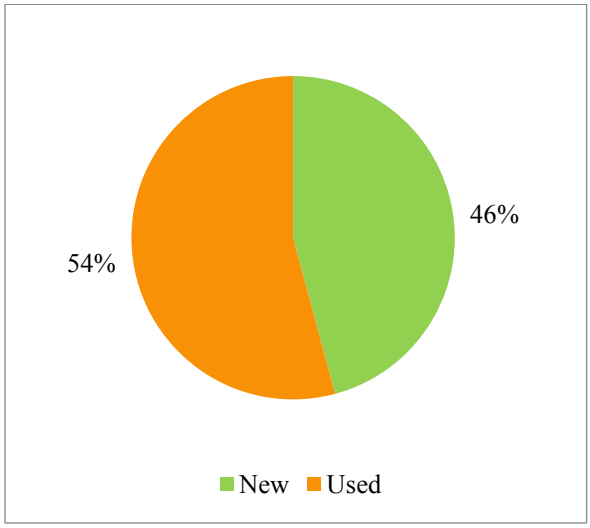


Figure 35: Vehicle purchasing condition

More than half of all purchased vehicles (52%) cost between $10,000 and $25,000. As shown in Figure 36, a noteworthy percentage cost over $25,000, accounting for 23% of all purchased vehicles. Furthermore, a considerable percentage of purchased vehicles (26%) cost below $10,000.

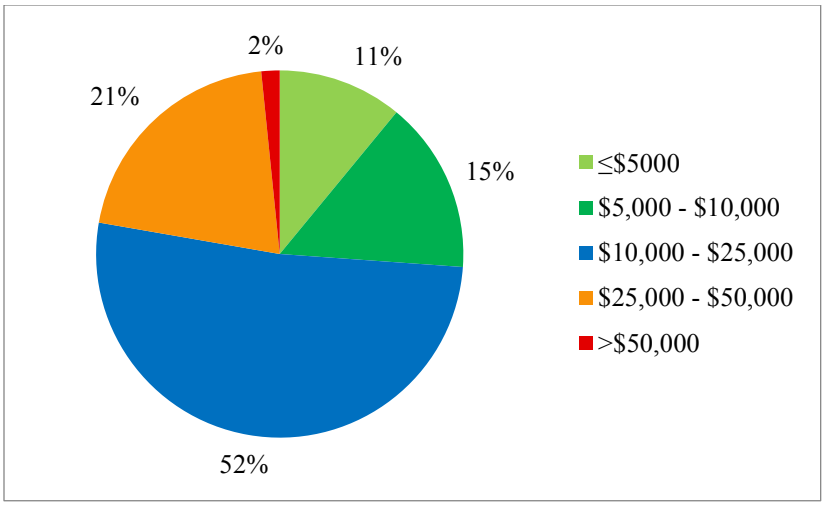


Figure 36: Cost of vehicle

2.5.2.2 Bicycle Ownership

In regards to bicycle ownership, 22% of households have one bicycle and 22% own two bicycles (see Figure 37). A significant percentage of households own three or more bicycles, accounting for 29% of households.

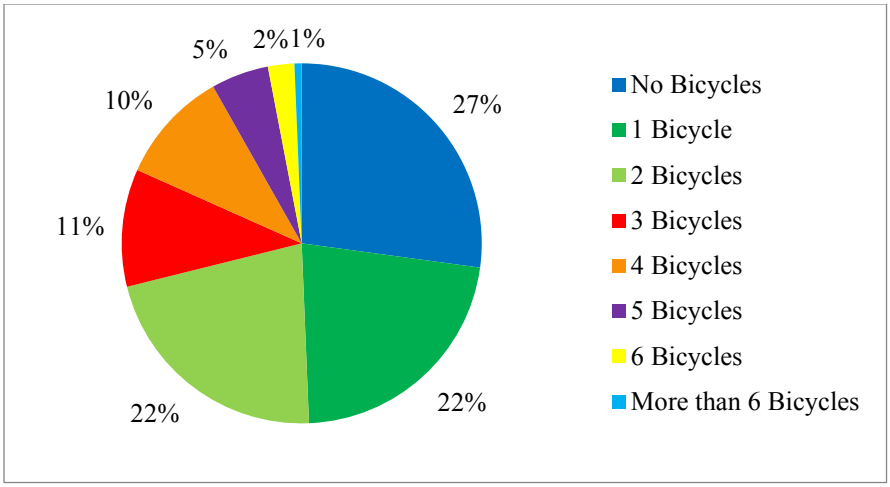


Figure 37: Bicycle ownership

Bicycle ownership generally increases as household income increases (see Figure 38). However, a significant percentage of low income households do not own any bicycles: 47% of households that have an annual income below $25,000 and 38% of households that have an annual income between $25,000 and $34,999. A higher percentage of households that receive an annual income below $100,000 own one bicycle than two, whereas a higher percentage of households that make $100,000 or more per year own two bicycles.

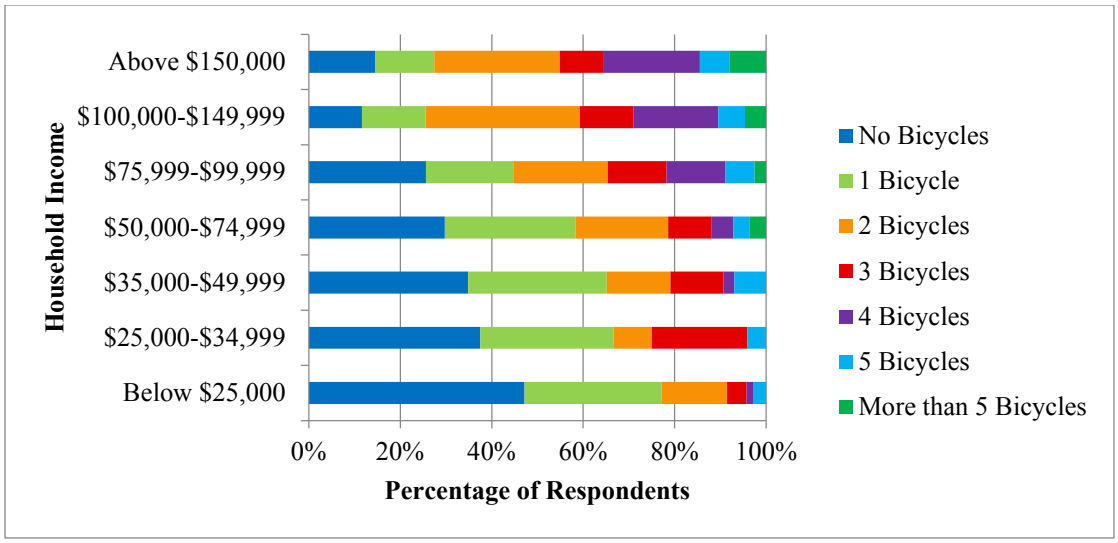


Figure 38: Bicycle ownership by household income

2.5.3 Spatial Analysis

As expected, respondents predominantly live within the Regional Centre, representing 50% of the sample, and 38% of respondents live in Suburban areas (see Figure 39). Respondents' current households are located in clusters mainly in the urban areas of Halifax and Dartmouth and surrounding suburban towns such as Woodlawn, Bedford, and Clayton Park.

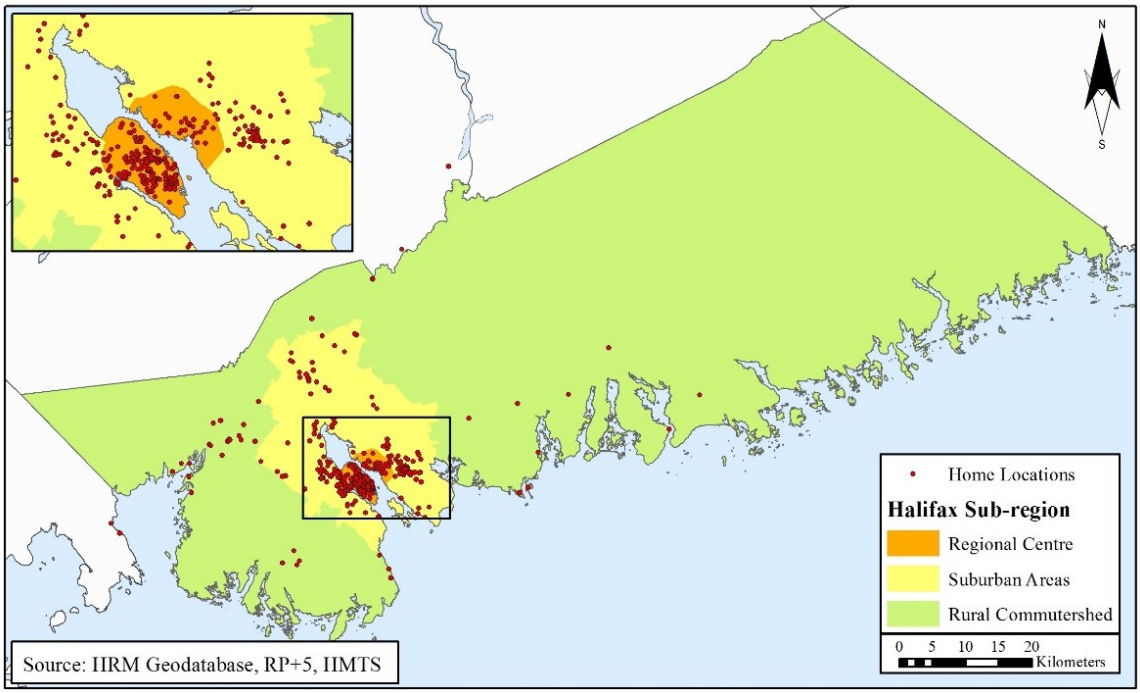


Figure 39: Household locations

The majority of respondents (71%) live within 500 metres of a bus stop, which is an estimated 7.5 minute walk (see Figure 40).

Figure 40: Distance from home to closest bus stop

Overall, primary commute mode varies by household location. The majority of individuals who live within the Regional Centre commute using more active transport modes; Figure 41 shows that 42% of individuals who live in urban areas walk and 23% cycle as their primary commute mode. A significant percentage (20%) of Regional Centre residents primarily take transit to work.

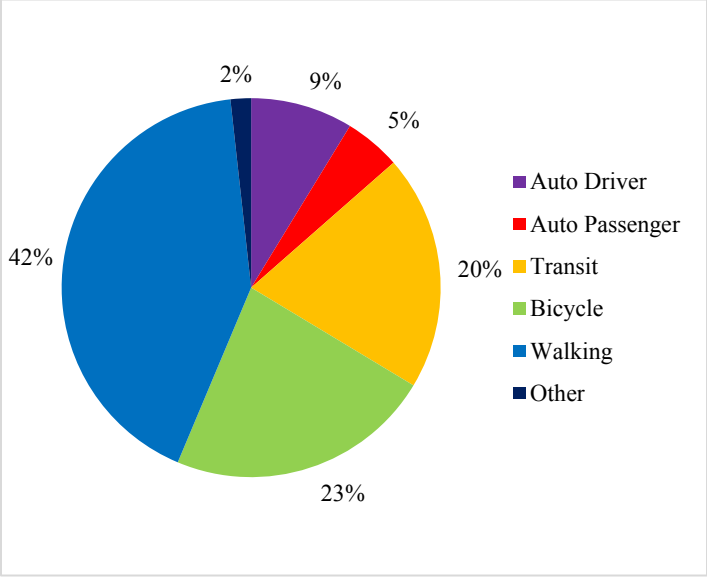


Figure 41: Primary mode of Regional Centre residents

In contrast, individuals who live in Suburban areas primarily commute via car as shown in Figure 42; about 61% of Suburban residents travel primarily as auto drivers and 9% as auto passengers. However, a noteworthy percentage (22%) of individuals that live in suburban areas use transit. Use of active transport modes as a primary commute mode is minimal for suburban residents as only 2% primarily cycle and only 1% primarily walk.

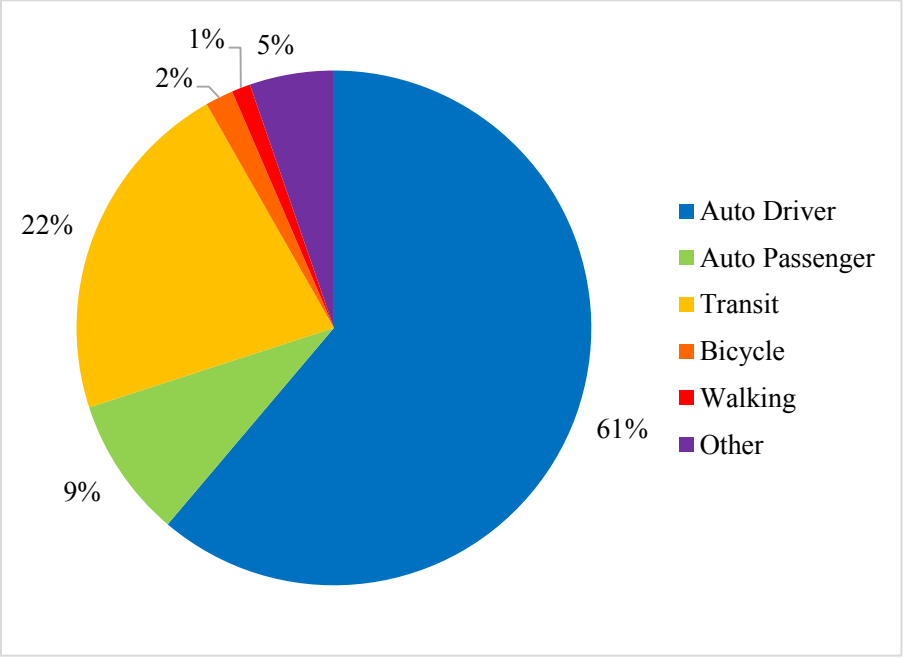


Figure 42: Primary mode of Suburban residents

Similar to residents of Suburban areas, residents of the Rural Commutershed travel primarily as auto drivers (68%) and auto passengers (23%). As shown in Figure 43, 10% of Rural Commutershed residents primarily commute via transit. Although transit is typically not available in the Rural Commutershed, there are a few community transit routes that connect Rural Commutershed areas including Tantallon, Herring Cove, Bear Cove, and Porters Lake to other community centres in the Regional Centre and Suburban areas. Active transportation modes are not used by residents of the Rural Commutershed.

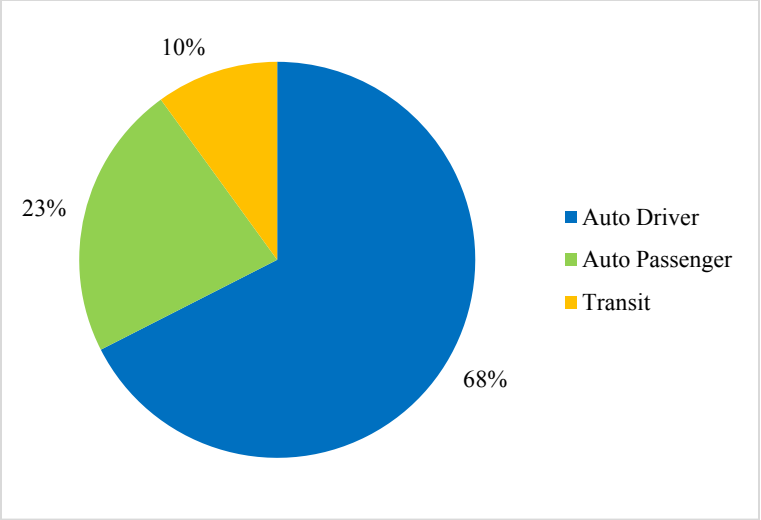


Figure 43: Primary mode of Rural Commutershed residents

The majority of respondents' work places are located in the Regional Centre of Halifax, in clusters toward the Halifax Central Business District (CBD) on Barrington Street, the Dartmouth waterfront, and toward Dalhousie University (see Figure 44). Some respondents also work in Burnside and Bedford.

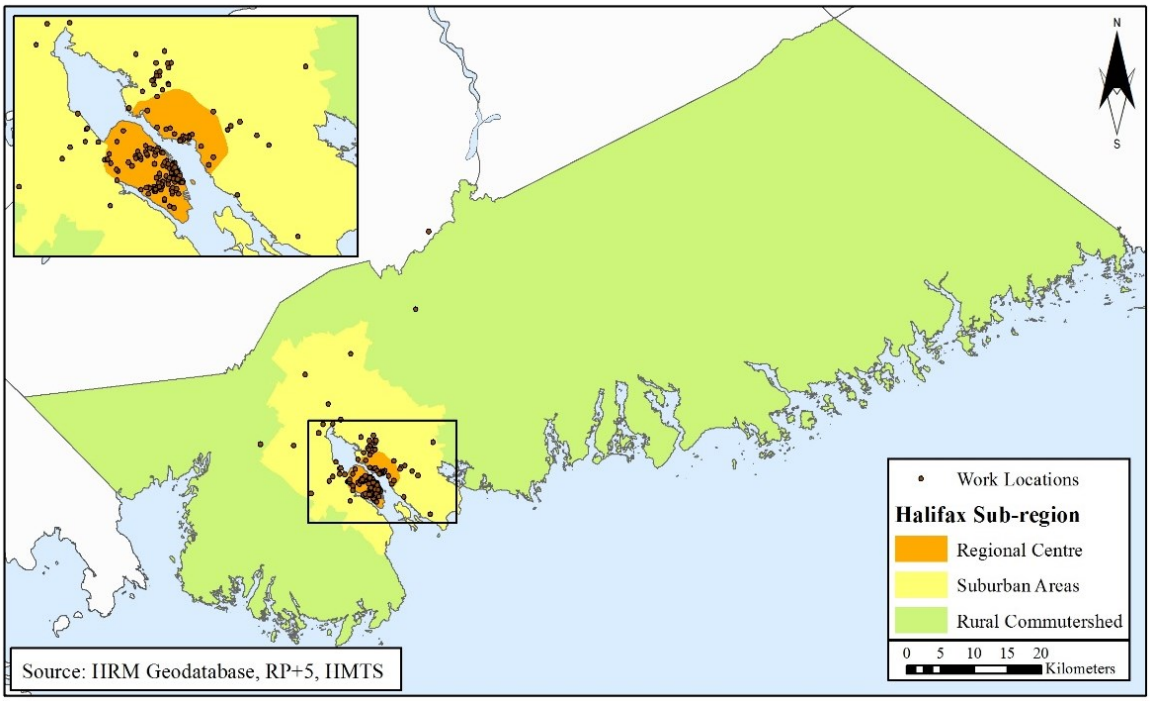


Figure 44: Work locations

The majority of respondents (69%) work between 2-15 kilometres from their home location (see Figure 45). The highest percentage of respondents (25%) work between two and five kilometres of their home location.

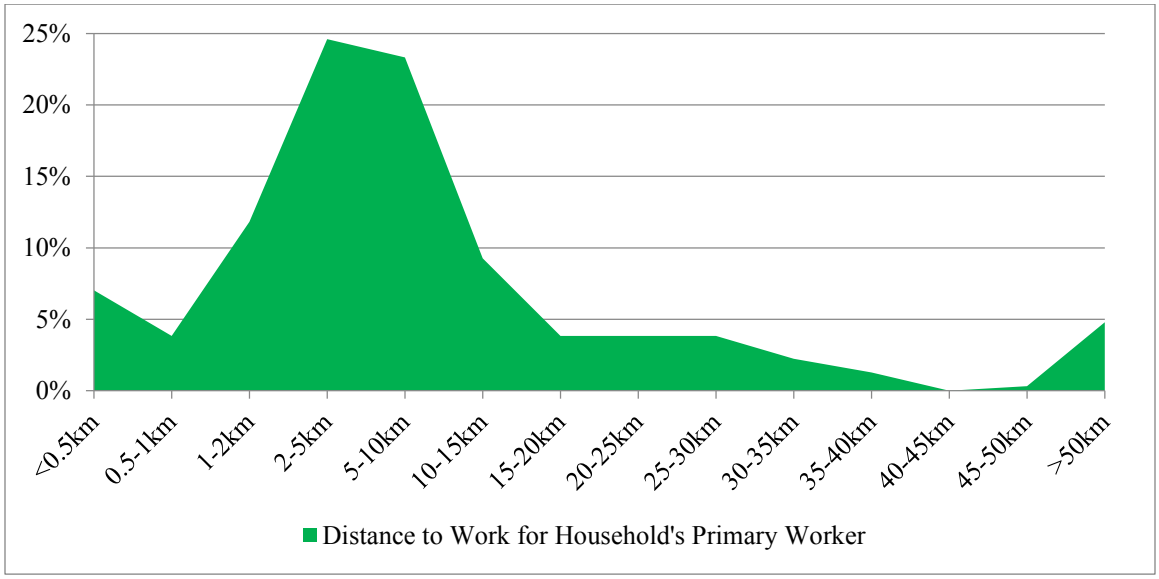


Figure 45: Home to work distances

Assuming that the first resident of each household is the primary worker, Figure 46 shows primary mode to work versus distance between home and the primary worker's work location. Figure 46 illustrates that active travel modes (biking and walking) are generally used more often to travel shorter distances to work. Home to work distances greater than 30km are typically travelled via car.

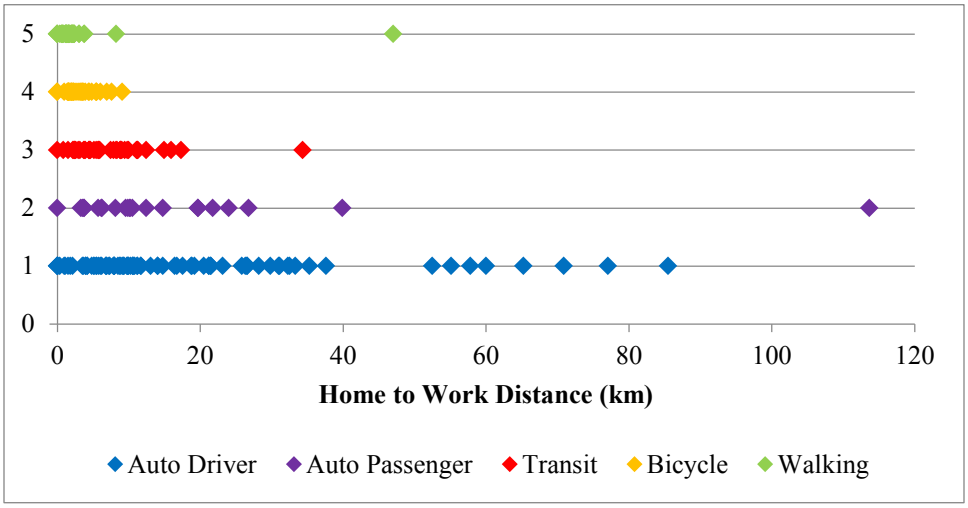


Figure 46: Primary mode to work versus home to work distance

2.5.4 Attitudinal Preferences

2.5.4.1 Attitudes toward Transit and Active Transport

Respondents typically support transit and active transportation. The majority of respondents enjoy riding a bicycle (73%) and prefer walking to driving (71%) whenever possible. Some 87% of respondents consider transit an essential service and 91% do not feel embarrassed taking public transit (see Figure 47). Furthermore, 72% of respondents agree that employers should subsidise monthly transit passes.

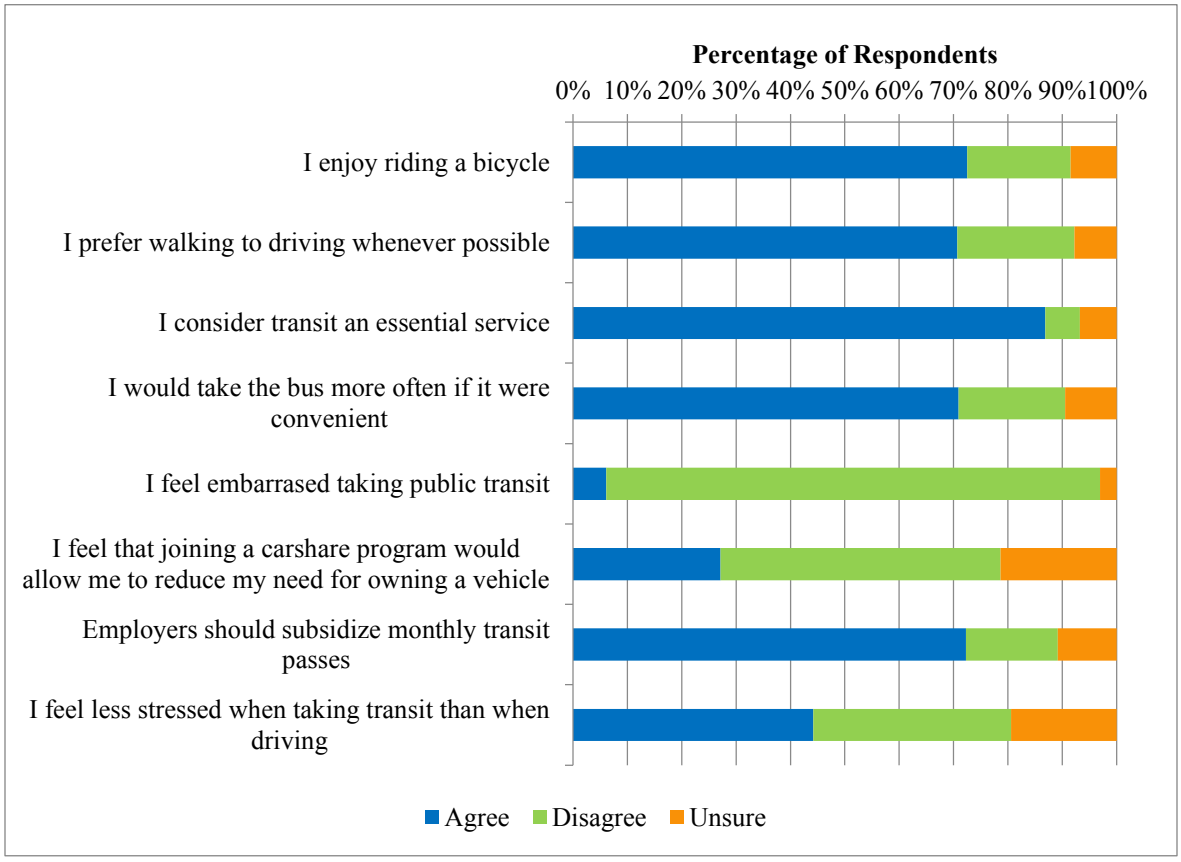


Figure 47: Attitudes toward active transport and public transit

Respondents who agree with the attitudinal statement, "I enjoy riding a bicycle" typically own a greater number of bicycles in their house compared to respondents who disagree with or are unsure about the statement. However, 36% of respondents who disagree with the statement own at least one bicycle. As shown in Figure 48, the highest percentage of respondents who agree with the statement (26%) own two bicycles.

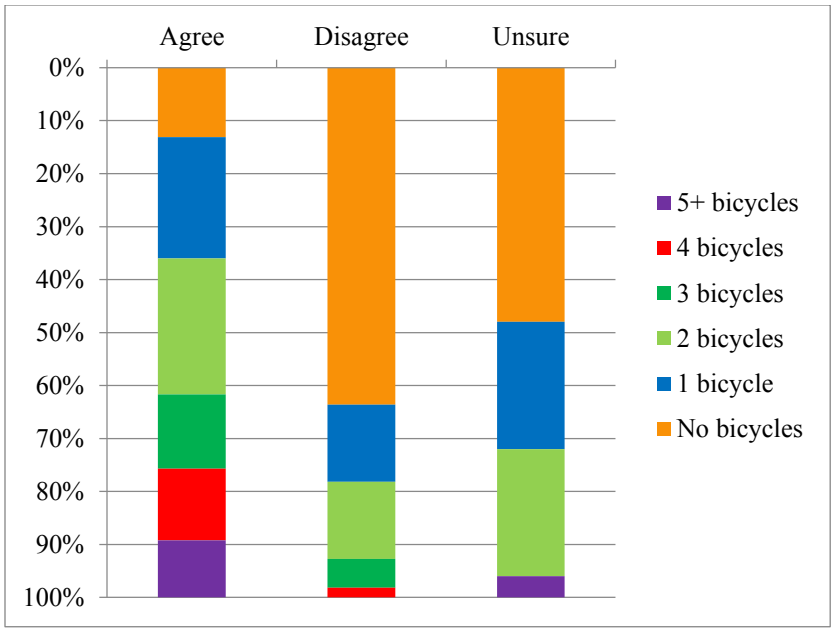


Figure 48: Bicycle ownership by response to "I enjoy riding a bicycle"

Although more than 70% of respondents prefer walking to driving whenever possible, auto driver is the primary mode for work and discretionary trips, representing 41% and 43% respectively of respondents who prefer walking to driving whenever possible. However, a noteworthy percentage of respondents who prefer walking to driving whenever possible primarily walk representing 22% of respondents for work trips, 41% for school trips, and 19% for discretionary trips (see Figure 49).

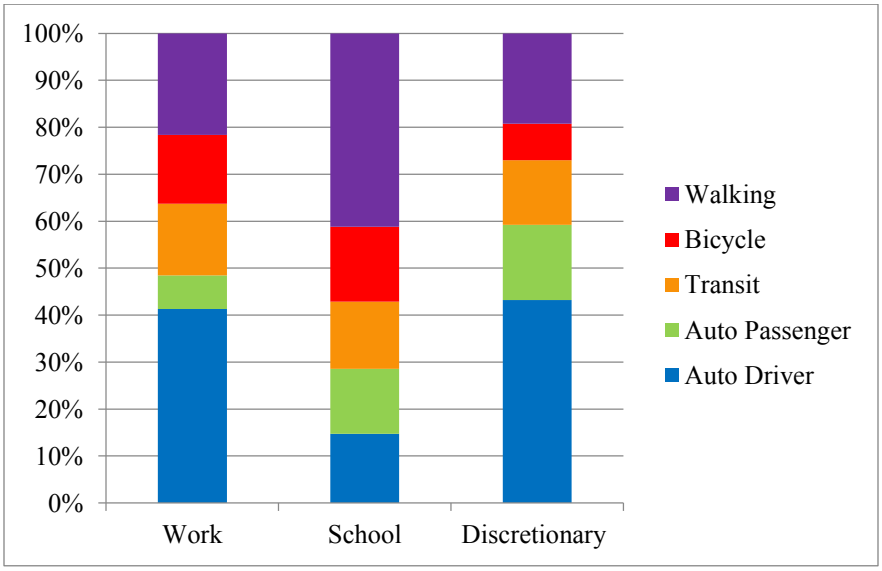


Figure 49: Primary mode of respondents who prefer walking to driving whenever possible

2.5.4.2 Attitudes toward Automobile Use

In regards to automobile use, 85% of respondents feel that driving provides them with a sense of freedom. However, only 40% of respondents take pride in owning a vehicle and 66% disagree that free parking and highway development are necessary (see Figure 50).

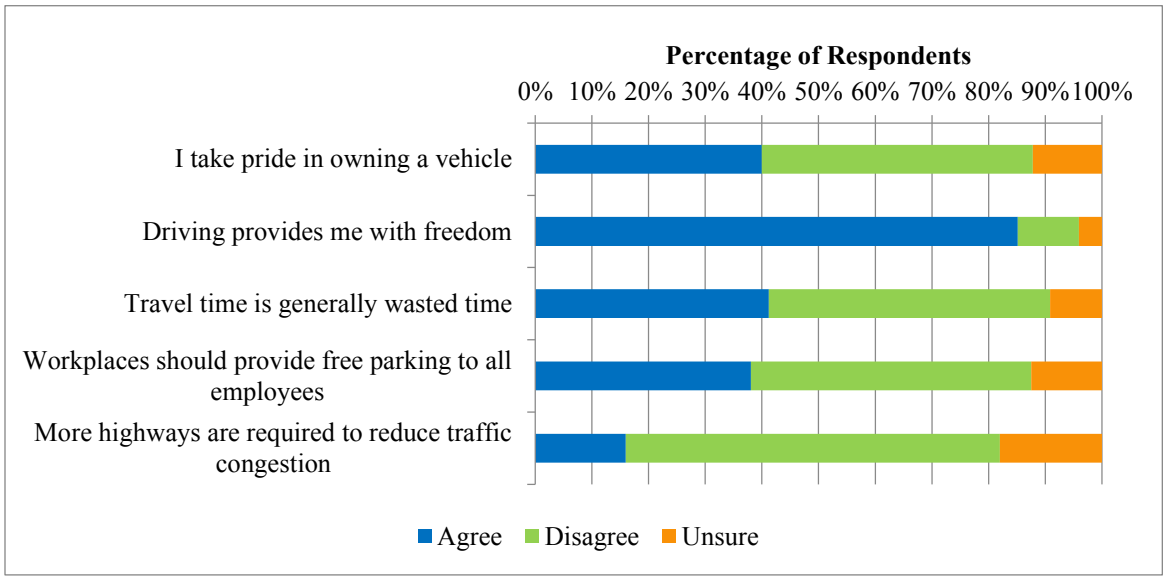


Figure 50: Attitudes toward auto transport

As shown in Figure 51, 93% of respondents who agree with the attitudinal statement, "I take pride in owning a vehicle" own at least one vehicle. The highest percentage of respondents who agree with the statement own one vehicle, accounting for 47%, followed by two vehicles, representing 39%. The highest percentage of respondents who disagree with the statement (41%) own one vehicle. Only 31% of respondents who disagree with the statement do not own a car.

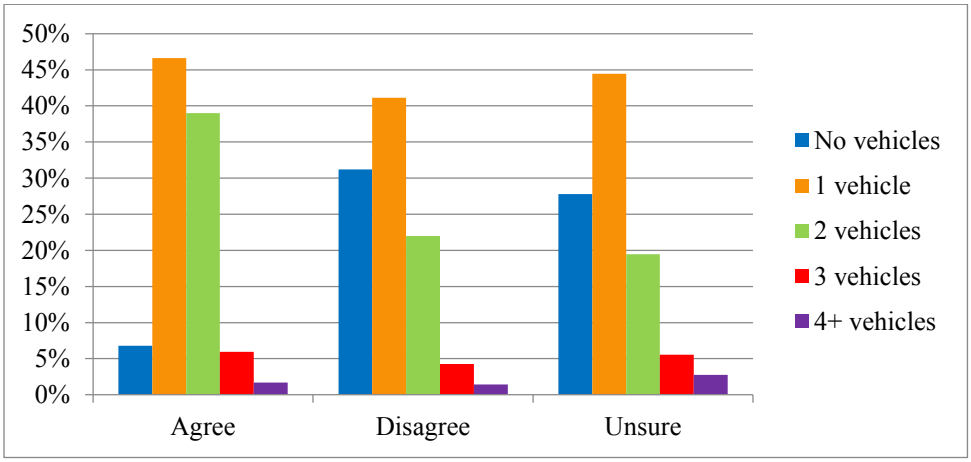


Figure 51: Vehicle ownership by response to "I take pride in owning a vehicle"

2.5.4.3 Attitudes toward Suburban Living

Although respondents generally agree that it is necessary to own a vehicle if they have a family (62%) and it is important that children have a backyard to play in (65%), only 25% of respondents agree that a suburban neighbourhood offers the best family life (see Figure 52).

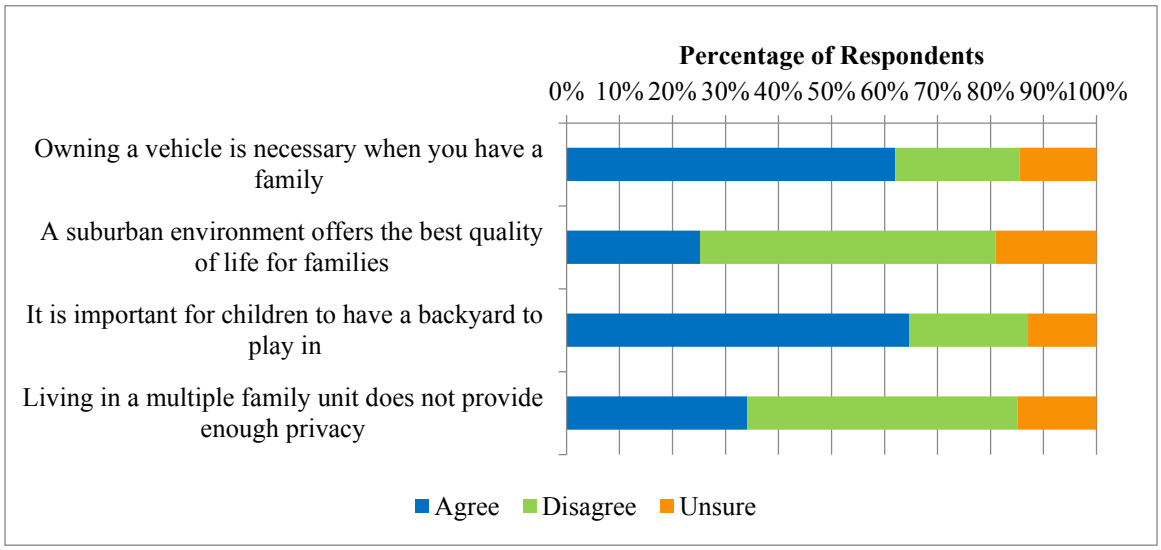


Figure 52: Attitudes toward suburban living

In regards to living in a multiple family unit, more than 70% of respondents who agree that living in a multiple family unit does not provide enough privacy live in single-detached houses. Furthermore, the highest percentage of respondents who disagree with this attitudinal statement (36%) also live in single-detached houses (see Figure 53).

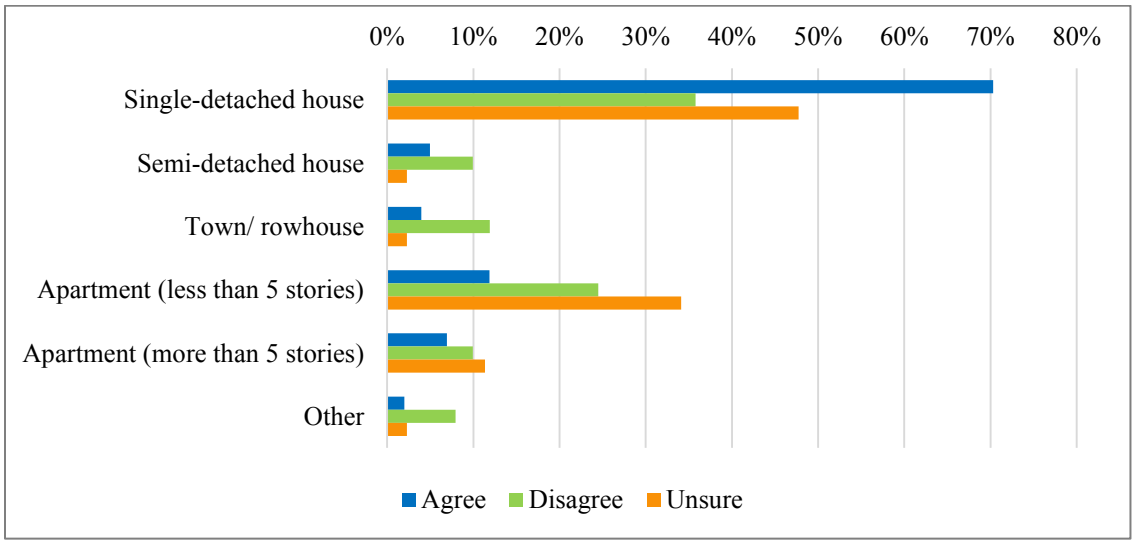


Figure 53: Dwelling type by response to "Living in a multiple family unit does not provide enough privacy"

2.5.4.4 Attitudes toward Density

The results suggest that the sample supports density because a high percentage of respondents (58%) agree that developing high-density neighbourhoods is good city planning. In addition, the majority of respondents (56%) love to live in the inner city (see Figure 54).

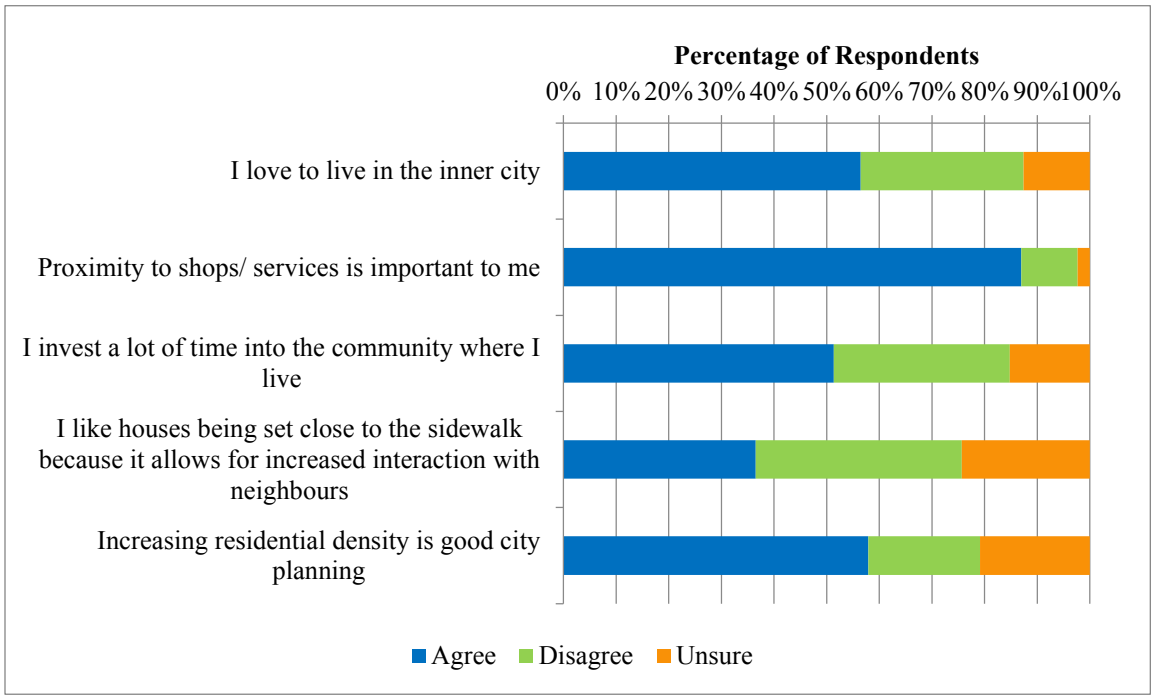


Figure 54: Attitudes toward density

Figure 55 shows that the majority of respondents who live in the Regional Centre love to live in the inner city, accounting for 77% of responses. In contrast, the highest percentage of respondents who do not like to live in the inner city (69%) live in Suburban areas.

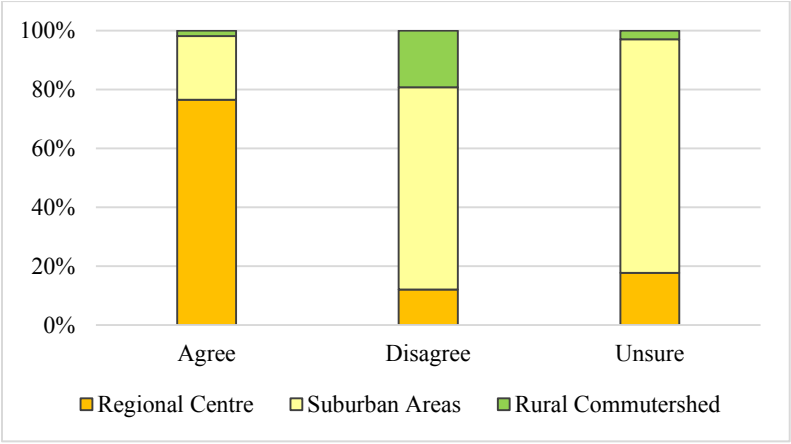


Figure 55: Response to "I love to live in the inner city" by household location

2.5.4.5 Attitudes toward Environment

In regards to environmental concerns, 46% of respondents agree that global warming is a major concern and limit their driving because of its impact on air quality. Moreover, respondents prefer rewards such as tax credits rather than implementing penalties to address issues regarding greenhouse gas emissions, representing 63% and 25% accordingly (see Figure 56).

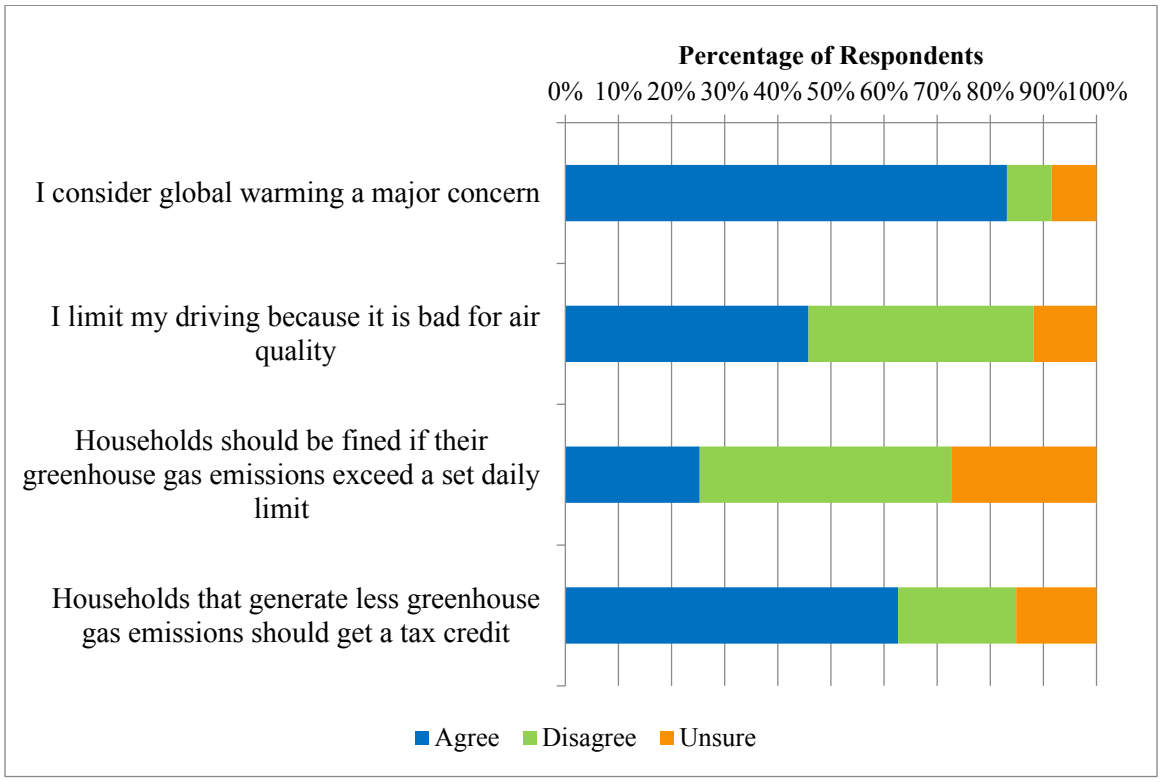


Figure 56: Attitudes toward environment

2.5.4.6 Attitudes toward Well-Being

Most respondents are satisfied with their commute behaviour (65%) and household location (93%). Generally, respondents enjoy taking good transit (64%) and walking as part of their daily exercise (79%), as shown in Figure 57.

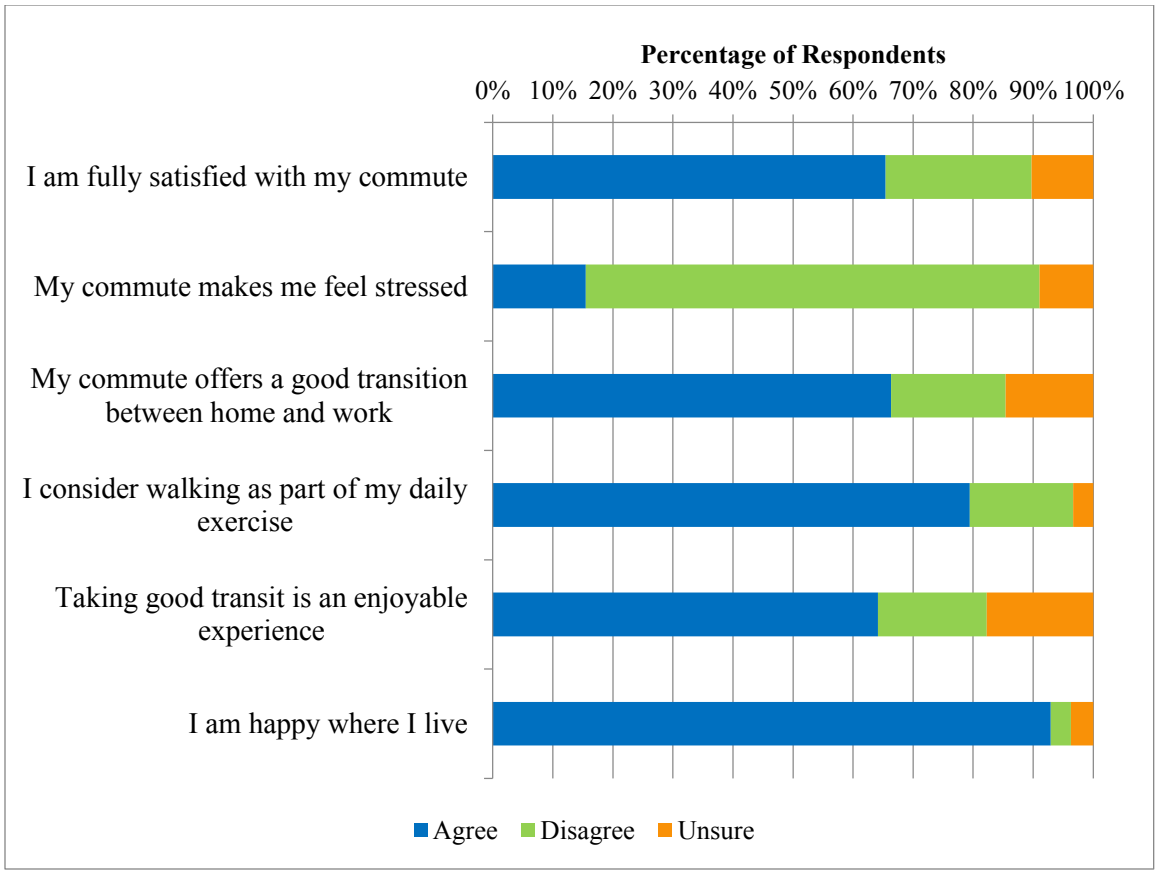


Figure 57: Attitudes toward well-being

The highest percentage of respondents who are fully satisfied with their commute travel primarily as auto drivers (31%), followed by walking (27%) and bicycling (19%). Respondents who are not fully satisfied with their commute primarily travel as auto drivers (37%) or by transit (34%). The majority of respondents who are unsure if they are fully satisfied with their commute travel primarily as auto drivers, representing 57% (see Figure 58).

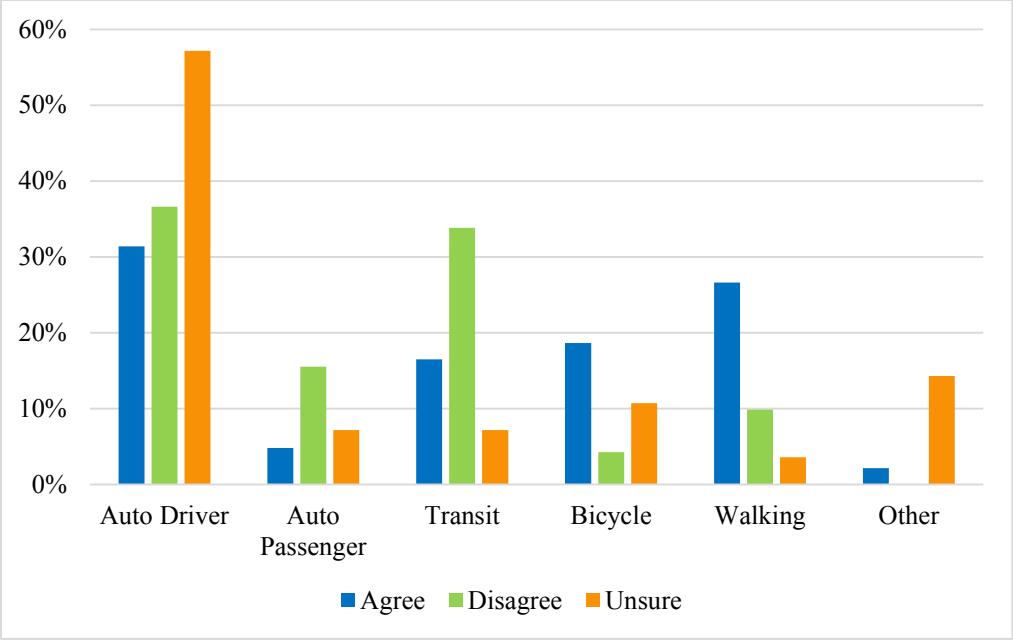


Figure 58: Response to "I am fully satisfied with my commute" by primary mode

2.5.4.7 Stated Preference toward Gas Price Spike

The highest percentage of respondents (33%) record that an increase in gas price of only $1.50/L would cause them to consider alternative modes to the automobile (see Figure 59). A significant percentage of respondents (22%) note that an increase in gas price of $3.00/L or more would cause them to consider alternative modes.

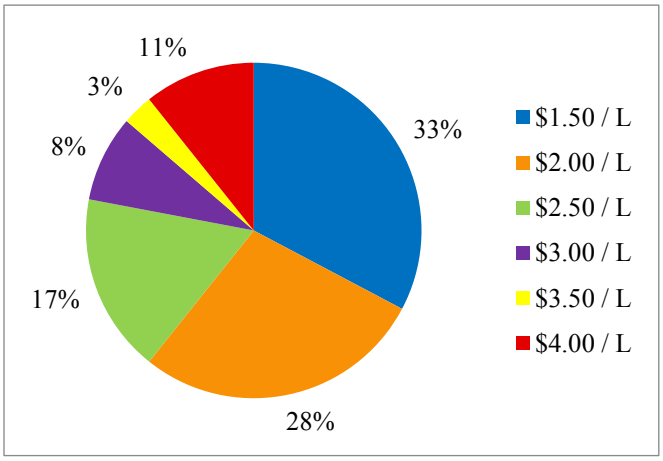


Figure 59: Price of gas which would cause alternate mode consideration

With regards to a 100% increase in gas price, respondents expect to carpool more often, use active transportation (i.e. walk or bike) more often, or use public transit more often in the short term. In the long-term, households expect to change their household location or make no change at all. The lowest percentage of respondents mentioned that they would most likely purchase a more fuel efficient vehicle in the long-term (See Figure 60). This data reveals that respondents do not anticipate switching to more fuel efficient modes in the long-term, even if fuel price increases significantly.

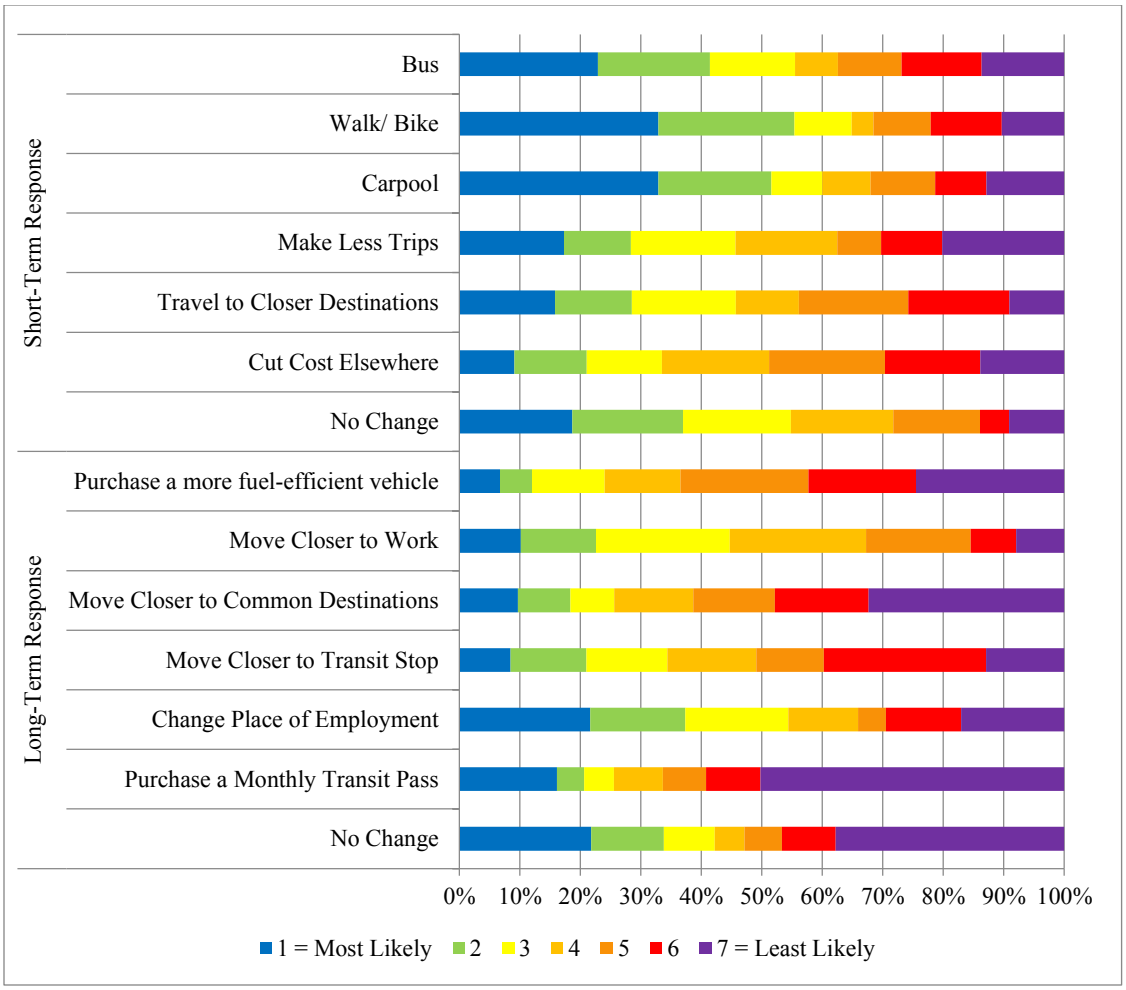


Figure 60: Perceived response to 100% increase in gas price

2.6 Summary and Discussion of Findings

The study found that younger respondents tend to travel more sustainably by using alternatives to the automobile such as walking, biking, and public transit. The 2011 TTS also identifies that younger respondents take transit more often (Data Management Group, 2011). Furthermore, lower income households typically travel more sustainably then higher income households. Higher income households generally own a greater number of vehicles and travel via car more often, similar to the results of the 2013 CARTAS (City of Calgary, 2013). Although higher income households also own a higher number of bicycles, biking is not the preferred travel mode.

The Regional Centre and Suburban areas of Halifax have a transit system and are more accessible to a variety of shops and service destinations. However, there is a very high percentage of auto ownership in these sub-regions. The majority of respondents live within 500m of a bus stop.

Nonetheless, most residents travel via the automobile, except for school trips where the predominant travel mode is walking possibly because students generally do not need to travel far to school in Halifax. Most students attend a school located in their home community (Halifax Regional School Board, 2014). Interestingly, individuals who live within the Regional Centre travel more sustainably, via car alternatives (walking, biking, and transit), and suburban and rural residents travel predominantly by car. Furthermore, respondents who live closer to their workplaces predominantly walk or cycle to work. These findings suggest that proximity or greater accessibility to work encourages more active travel behaviour.

The HMTS respondents are generally satisfied with their commute and happy with where they live. They show positive attitudes toward transit and active transportation. On the one hand, driving remains the preferred travel mode; a very high percentage of respondents agree that driving provides them with freedom. On the other hand, the majority of respondents agree that they would take the bus more often if it was convenient and of those who are not happy with their commute, a significant percentage commute via transit. These results suggest that the transit system could be improved to increase ridership.

Respondents display mixed views toward suburban living. Although a high percentage of respondents agree that it is necessary to own a vehicle when you have a family and it is important for children to have a backyard to play in, the majority of respondents are not concerned about privacy in multiple family units and disagree that suburban living provides the best quality of life. Regardless of privacy concerns in multiple family units, respondents generally prefer single-detached homes. These results advise that there are advantages of living in a single-detached home that are not explained in the survey. One possibility is that single-detached homes tend to have larger rooms than high-density apartment living. In addition, single-detached homes are a form of investment and economic achievement.

The HMTS respondents support density: a high percentage of respondents believe that increasing residential density is good city planning. In addition, a significantly high percentage of responses agree that proximity to shops and services is important. The attitudes toward suburban living and density suggest that respondents are open to the idea of mixed-use, high density living, but prefer single-unit housing. Respondents who love to live in the inner city live within the Regional Centre while those who do not love living in the inner city live in Suburban areas. Respondents who live in Suburban areas may prefer living away from the city because it is quieter and greener.

The majority of HMTS respondents agree that climate change is a major concern, but a much smaller percentage of respondents limit their driving in concerns for air quality. Although respondents express concern for the environment, they do not alter their travel behaviour to reduce environmental damage. Surprisingly, an increase in gas price may encourage respondents to shift their travel behaviour toward more sustainable and active travel modes. Although many respondents mention that a small increase in gas price will cause them to consider alternative travel modes, in the long term, they state that they will likely make no change to their current travel behaviour or change employment locations in response to a significant increase in gas price. Respondents are resistant to giving up the comfort and freedom they attain through having a car. They are willing to compensate in other ways if owning and maintaining a car becomes more expensive such as changing their household location. This suggests that the alternative, sustainable travel choices provided by the municipality are possibly not as attractive in terms of comfort and convenience as having a car.

The Household Mobility and Travel Survey (HMTS) offers a reasonably representative sample of Halifax. Most socio-economic stratums of the sample are within a 3% variability of the percentages found in the 2006 Census, 2011 Census, and 2011 NHS for Halifax. Therefore, the aggregate representation of travel behaviour in this analysis is considered representative of the travel behaviour of Halifax residents. There are, however, few limitations identified in the sample. For example, the travel behaviour of the elderly, 65 and older age group could not be further analysed as residents of this age were slightly underrepresented in the sample. Furthermore, there is a slight overrepresentation of high-income households. These discrepancies are considered insignificant to the overall travel behaviour analysis, but it is important to be aware of such limitations of the sample when conducting an exploratory analysis. The few limitations of the sample may occur because of the sample size and distribution of the survey, as well as the web-based nature of the survey. A larger sample will be useful for future studies. Future research can also explore the use of the HMTS data for travel behaviour modelling and test the relationships between travel behaviour and household location or attitudinal preferences, for example.

2.7 Conclusion

The exploratory analysis of HMTS responses reveals that Halifax residents favour sustainable travel and density but their travel behaviour does not reflect their attitudes. Overall, respondents are content with their existing, car-dependent travel behaviour, although they recognize that there

are alternative choices to the automobile. The majority of respondents live in single-detached houses and most people that do not like living in the inner city, live in suburban areas. People living in the Regional Centre tend to travel more sustainably, via walking and biking more often; in contrast, people living in Suburban areas and the Rural Commutershed heavily rely on car travel. A considerably high percentage of respondents state that they would utilise transit more often if it were convenient. These results suggest that transportation policy should be framed toward improving the transit system and active transportation options, specifically in the suburban region.

Chapter 3

Characterisation of Accessibility in Halifax

3.1 Introduction

Sustainable transportation planning includes creating diversified, connected communities that are more accessible to a variety of service destinations by sustainable travel modes including transit, walking, and biking (Kwan & Weber, 2008; Nova Scotia, 2013). Hansen (1949) defines accessibility as "the potential of opportunities for interaction... [and] a measure of the intensity of the possibility of interaction rather than just a measure of the ease of interaction" (p. 73). Examining the possibilities for interactions between points of origin and service destinations is important for monitoring and evaluating progress toward sustainable transportation and formulating policies in regional land-use and transportation planning (Achuthan, Titheridge, & Mackett, 2010; El-Geneigy & Levinson, 2007; Geurs & Ritsema van Eck, 2003; Geurs & van Wee, 2004; Gutiérrez, Condeço-Melhorado, & Martín, 2010; Hansen, 1959; Manaugh & El-Geneidy, 2012). Researchers and practitioners record that some areas are more accessible to amenities such as schools, healthcare, and shopping. Accessibility can positively influence travel behaviour: in areas of low accessibility to services, residents are less likely to use sustainable transport modes (Talen & Anselin, 1998; Tasic, Musunuru, & Porter, 2014). It is therefore important to investigate accessibility as a sustainable indicator to track progress toward sustainable transportation planning (Geurs & Ritsema van Eck, 2003; Geurs & van Wee, 2004; Manaugh & El-Geneidy, 2012; Zegras, 2006).

Transportation and land-use planning propose broadening the scope of accessibility measures to include a multi-modal, multi-destination analysis (Handy & Niemeier, 1996; Tasic et al., 2014); however, few accessibility frameworks in the literature achieve such a composite measure (Meng, Malczewski, & Boroushaki, 2011; Tasic et al., 2014; Yigitcanlar, Sipe, Evans, & Pitot, 2007). Additionally, earlier studies measure accessibility at a variety of scales, including census tracts (CTs) and neighbourhoods, some of which largely generalize the study area. Apparicio et al. (2008) and Kwan & Weber (2008) recommend measuring and analysing accessibility at a finer-grained disaggregate scale. Investigation concerning what distance thresholds define accessibility for different modes and types of service destinations is also limited. Previous studies define and rank accessibility differently, usually on an ad-hoc basis (Cervero, 2005).

This study contributes to the existing literature on composite multi-mode, multi-destination accessibility frameworks by developing a Composite Network-distance-based Accessibility Measurement (CNAM) at the parcel level for Halifax, Nova Scotia, Canada. This study utilises GIS techniques to develop a holistic, location-based approach to measure accessibility by considering access to multiple service destinations by active and automated transportation modes. Accessibility is therefore defined in this study as a measure of how proximate all service destinations are from a property parcel, in terms of driving, biking, and walking distances. Automated and active transportation networks are built in ArcGIS 10.1 using 2012 Road Logistics data from Desktop Mapping Technologies Incorporated (DMTI) Spatial. Furthermore, this study addresses aggregation concerns by measuring accessibility at a finer-grained disaggregate level, using Halifax parcels from the 2013 Nova Scotia Property Database and 50 types of Enhanced Points of Interest (EPOI) from DMTI Spatial. The EPOI are grouped into nine types of service destinations for analysis: food stores, general shopping, restaurants, personal services, health services, government services, schools, child day cares, and amusement and recreation destinations.

Additionally, this study offers a more context-specific definition of accessibility to different types of service destinations and modes, utilising a five-interval Likert scale, ranging from very poor accessibility to very high accessibility. It conducts a web-based, expert consultation survey, sent to planning, engineering, and health professionals, who select distances to define accessibility thresholds for each mode and destination type. The results of the survey are used to score accessibility to each type of service destination by all modes considered.

3.2 Literature Review

Researchers and practitioners acknowledge the need to shift existing travel behaviour from auto-dependent to more sustainable activity (e.g.,Goodwin, Cairns, Dargay, Hanly, Parkhurst, Stokes, & Vythoulkas, 2004). Spatial differences in accessibility contribute to the discussion on existing travel behaviour. For example, accessibility measures offer an evaluation of the spatial distribution of services to the spatial distribution of households, which inform planners and policy makers why individuals might prefer automobiles to more sustainable travel modes (El-Geneidy & Levinson, 2007; Talen & Anselin, 1998). Researchers suggest that accessibility to specific land uses has a significant positive effect on travel behaviour (e.g., ADONIS, 1998; Kockelman, 1996; Krizek, 2003). A study conducted in Europe notes that individuals are generally willing to

substitute short car trips for walking and cycling (ADONIS, 1998); therefore, greater accessibility may encourage active transportation.

Many municipalities adopt New Urbanism theory, which suggests that diversifying land uses and increasing accessibility between households, employment, services, and leisure activities may reduce travel distance and time, and consequently reduce auto dependency (Cervero & Duncan, 2006; Gärling & Fujii, 2009; Lawson, 1998; Maat, van Wee, & Stead, 2005; Næss, 2006). New Urbanism theory has strongly influenced planning in North America (Boarnet & Sarmiento, 1998; Grant, 2006). Conflicting empirical analyses on the application of New Urbanism theory, however, reflect that there is no definite conclusion to the effect of diversifying land uses on travel behaviour (Kockelman, 1996; Krizek, 2003; Maat et al., 2005; Boarnet & Sarmiento, 1998; Boarnet & Crane, 2001; Dieleman, Dijst, & Burghouwt, 2002). Nonetheless, local and regional governments propose neo-traditional, transit-oriented developments to reduce auto-dependency by "capitalizing on the relationship between land use and transportation planning" (Krizek, 2003, p.265). The Nova Scotia Sustainable Transportation Strategy (2013) and Halifax Regional Plan (2014) promote sustainable transportation through land use planning. It is therefore important to develop a composite accessibility measure to contribute to the understanding of the land use-transportation relationship in Halifax.

Accessibility measures are used extensively in econometric models to test the relationships between accessibility and mobility tool ownership (e.g., Fatmi, Habib, & Salloum, 2014), travel behaviour (e.g., Kockelman, 1996; Krizek, 2003; Foti & Waddell, 2014), residential location (e.g., Smart & Blumenburg, 2014), and social and economic relations (e.g., Tasic et al., 2014; Chen, Mei, & Liu, 2014). This study concentrates on developing the most appropriate composite accessibility measure at a finer-grained level that can be used in a future study to test land use-transportation relationships.

3.2.1 Measuring Accessibility

Different types of accessibility analysis and measures exist in transportation literature (Geurs & van Wee, 2004; Dalvi & Martin, 1976; Hass, 2009). Geurs and van Wee (2004) summarise the different approaches into four categories: infrastructure-based, location-based, person-based, and utility-based measures (Zegras, 2006; Handy & Niemeier, 1996). Geurs and van Wee (2004) also mention four interdependent components necessary for measuring accessibility: land-use, transportation, temporal, and individual components. Combining all four components is complex and rarely found in the literature (Geurs & van Wee, 2004; Vandenbulcke, Steenberghen, &

Thomas, 2009). Table 5 is an adaptation of Geurs and van Wee's (2004) perspectives and accessibility components and Hass's (2009) summary of trip-based accessibility measures. Most accessibility measures in the literature use a location-based approach, especially when using relatively large datasets. Furthermore, Table 5 shows that there is limited research on composite accessibility frameworks. Tasic et al. (2014) and Witten et al. (2003) use a location-based approach to measure accessibility to multiple destinations. The current study employs a location-based approach incorporating two of the four components necessary for measuring accessibility (transportation and land-use components), based on determining network distances for multiple modes and destinations.

Location-based measures (also known as connectivity measures) analyse relative distances, costs, or times between points of origin and destination (see Table 5). The CNAM employs a location-based approach due to its ease of interpretation by planners and policy makers (*5*) and broad use within the literature (e.g., Achuthan et al., 2010; El-Geneidy & Levinson, 2007; Clarke, Eyre, & Guy, 2002). Furthermore, location-based approaches measure the potential for land use-transport interactions, concurrent with the way this study defines accessibility. The CNAM incorporates both the cumulative opportunity and gravity potential approaches of measuring accessibility as it involves adding the scores of potential interactions between a place of origin and all service destinations. The scores are based on a destination's location within a predefined network-distance segment. This approach develops an innovative measure that incorporates all destinations and multiple modes. The current study focusses on characterising space in Halifax and hence, it better suits a GIS approach that estimates accessibility for all parcels in the Halifax region.

Researchers suggest that a GIS offers an effective means of developing and representing location-based accessibility measures (e.g., Clarke et al., 2002; El-Geneidy & Levinson, 2007; Gutiérrez et al., 2010; Kockelman, 1996; Lovett et al., 2002; Manaugh & El-Geneidy, 2012; Meng et al., 2011; Vandenbulcke et al., 2009; Yigitcanlar el al., 2008). Mapping accessibility assists planners and policy makers identify spatial differences and interpret accessibility measures. A GIS-base accessibility framework can consider either network (travel) or Euclidean (straight-line) distances. Although both methods are used in the literature, network distances are typically preferred because they offer the best estimation of opportunities by different travel modes. Some studies also deduce that Euclidean distances provide a false representation of distance, particularly when analysing less dense, rural areas (e.g., Apparicio et al., 2008; Carling, Han, &

Table 5: Summary of accessibility approaches and measures

Approaches to Measuring Accessibility		Examples of Accessibility Measures			
				Simple (One Mode / One Destinations) Accessibility Measures	**Composite (Multi-Mode / Multi-Destination Type) Accessibility Measures**
Infrastructure-based	Analyse the quality of service or performance of the transportation system.	Level of Congestion	Changes in congestion, characterized by changes in travel speed, trip times, and vehicular queuing.	Geurs & Ritsema van Eck, 2003 (*4*)	
		Travel speed	Changes in delays, characterized by average travel speed on the road network.	Geurs & Ritsema van Eck, 2003 (*4*)	
Location-based	Analyse the spatial distribution of places of origin and destination.	Contour Method Iso-chronic Measure Cumulative Opportunities Proximity Count Container Method	The number of opportunities reachable within a predefined time, distance, or cost, or the time, distance, or cost required to reach a fixed number of opportunities.	Talen & Anselin, 1998 (*11*); Cervero, 2005 (*17*)	Tasic, Musunuru, & Porter, 2014 (*10*); Witten, Exeter, & Field, 2003 (*45*)
		Gravity Potential	An index which involves summing the number of interactions between points of origin and destination.	Handy & Niemeier, 1997 (*13*); Talen & Anselin, 1998 (*11*)	
		Travel Cost	The average distance between a point of origin and all facility destinations.	Talen & Anselin, 1998 (*11*)	
		Minimum Distance	The distance between a point of origin and the nearest facility destination.	Talen & Anselin, 1998 (*11*); Haynes, Lovett, & Sünnenberg, 2003 (39)	
Person-based	Analyse accessibility at an individual level.	Space-time/ Activity-based Methods	The activities in which an individual can participate at a specified time.	Miller, 1999 (*40*)	Yigitcanlar, Sipe, Evans, & Pitot, 2007 (*15*)
Utility-based	Analyse the social and economic benefits that people derive from access to the spatially distributed activities.	Random Utility Theory Log-sum Doubly Constrained Entropy Model	Utility maximization (the utility of a choice relative to the utility of all choices), based on a person's socio-economic and household characteristics.	Handy & Niemeier, 1997 (*13*); Lawson, 1998 (24); Martínez C., 1995 (41)	

*Adapted from Geurs and van Wee, 2004 and Hass, 2009

Håkansson, 2010; Witten et al., 2003). Since this study encompasses measuring accessibility of the Halifax region by various modes, network distances are deemed most appropriate.

Accessibility studies rarely incorporate all available travel modes and destinations in their analyses (Tasic et al, 2014; Meng et al., 2011; Yigitcanlar et al., 2007). Networks generated for accessibility analyses are primarily for automotive transportation modes such as car and transit; less attention is given to active transportation modes such as walking and biking (Achuthan et al., 2010; Tasic et al., 2014). However, planners and researchers identify a need for such analyses (Handy & Niemeier, 1996; Tasic et al., 2014). The Land Use and Public Transport Accessibility Indexing (LUPTAI) Model measures the accessibility of five types of land use destinations using GIS analytical techniques, based on actual walking distances and public transport travel times (Yigitcanlar et al., 2007). The LUPTAI Model scales accessibility into five categories: no, poor, low, medium, or high accessibility. The current study implements a similar approach. A second study measures accessibility to six types of services, using multiple distance bands; Witten et al. (2003) define accessibility to a service destination as the distance whereby 50 per cent of the meshblocks (unit used by New Zealand for census enumeration) have access to at least one service. Other studies use ad-hoc demarcations to define accessibility; for example, Cervero (2005) defines accessibility to grocery stores as the number of convenience retail stores within quarter mile isochrones. This study assigns the accessibility scores based on planning and engineering experts' ranking of accessible walking, biking, and driving distances; additionally, it uses a wider range of service destinations and travel modes.

3.2.2 Effects of Scale

The geographical scale of the data used notably affects accessibility estimations (Apparicio et al., 2008; Kwan & Weber, 2008). The scale of accessibility measures refers to the extent of the analysis, as well as the areal units used in the analysis. Kwan and Weber (2008) identify two intra-urban scales (extents) in the literature: the local and regional scales. At the local scale, accessibility measures reveal the ability for community members to participate in convenience-based trips such as food shopping via alternative modes to the automobile (Kwan & Weber, 2008; Manaugh & El-Geneidy, 2012). At the regional scale, accessibility measures should reveal the extent to which people travel to work and larger shopping centres (Kwan & Weber, 2008). Previous accessibility measures generally focus on measuring accessibility at the regional level, rather than at the local level (Kockelman, 1996). The CNAM focuses on measuring accessibility at the local and regional scales.

It is crucial to select the most appropriate spatial unit for measuring and analysing accessibility to minimize the errors caused by aggregation (Apparicio et al., 2008). Aggregation errors occur when large areal units are used, which generalize the area and, consequently, generate less precise results. Studies conducted until the late 1990s typically use a wide range of zone-based data to measure accessibility (Kwan & Weber, 2008); zones were among CTs, neighbourhoods, transportation planning zones, and political subdivisions. Recent studies use smaller zones to measure accessibility. For example, Clarke et al. (2002) and El-Geneidy and Levinson (2007) estimate accessibility at residence zones (postal sectors and enumeration districts) and Transportation Analysis Zones (TAZ) respectively. Yigitcanlar et al. (2007) map their accessibility analysis as a raster dataset, using 50m by 50m grid cells in a GIS. When active travel modes are considered in the accessibility analysis, localised, finer-grained spatial units provide a better estimation of accessibility. For example, Apparicio et al. (2008) compared their accessibility measure by CTs, DAs, and blocks within CTs; their study found significant differences in the distance to the closest hospital by an average of 365m for CTs and 134m for DAs. The current research includes measuring accessibility by walking and biking and uses finer-grained disaggregated data. The CNAM estimates accessibility of a region at a local scale: to 50 types of EPOI in Nova Scotia from property parcels in Halifax.

3.3 Methodology

3.3.1 Data Preparation

This study uses Halifax parcel data from the 2013 Nova Scotia Property Database, street network data from the 2012 Road Logistics from DMTI Spatial, and service destinations from the 2012 Enhanced Points of Interest (EPOI) data from DMTI Spatial. The property data contains 168,420 parcels for mainland Halifax. An active transportation network was created using the Road Logistics dataset that excluded highways and ferry routes. An automobile network was created, also using the Road Logistics data, which excluded trails and ferry routes. This study measures accessibility to 50 types of EPOI across Nova Scotia based on the Standard Industrial Classification (SIC). Schools were further categorized by grade. The EPOI classifications selected for this study were based on the typical land-use activities found in urban areas as defined by the literature (e.g., Apparicio & Seguin, 2006).This study includes all discretionary activity destinations, health, and education services. All activities selected for this study are considered equally important to create a mixed-use, high-density, and connected community. The EPOIs cover all of Nova Scotia to address an accessibility analysis deficiency called the edge

effect, which involves over-representation of accessibility estimations when services outside the study area boundaries are not included in the analysis (Sadler, Gilliland, & Arku, 2011). As shown in Table 6, this study grouped the 50 types of EPOI into nine types of service destinations for analysis.

Table 6: Enhanced Points of Interest (EPOI) used in the study

Enhanced Points of Interest (EPOI)		
I Food Stores *(fs)*	V General Shopping Destinations *(gs)*	VII Schools *(edu)*
1 Grocery Stores	17 Department Stores	34 Adult Education
2 Meat and Fish Markets	18 Men's and Boys' Clothing and Furnishin	35 Early Childhood
3 Fruit and Vegetable Markets	19 Women's Clothing Stores	36 Elementary
4 Dairy Products Stores	20 Women's Accessory and Specialty Store	37 Junior High
5 Retail Bakeries	21 Children's and Infants' Wear Stores	38 High School
II Restaurants *(rest)*	22 Family Clothing Stores	39 University and College
6 Eating Places	23 Shoe Stores	40 Libraries
7 Drinking Places	24 Drug Stores and Proprietary Stores	VIII Government Services *(govt)*
III Personal Services *(pers)*	25 Liquor Stores	41 Police Protection
8 Beauty Shops	26 Used Merchandise Stores	42 Fire Protection
9 Barber Shops	27 Sporting Goods and Bicycle Shops	IX Recreation Destinations *(rec)*
10 National Commercial Banks	28 Book Stores	43 Motion Picture Theatres
IV Health Services *(hlth)*	29 Jewelry Stores	44 Video Tape Rental
11 Offices and Clinics of Physicians	30 Hobby Toy and Game Shops	45 Bowling Centres
12 Offices and Clinics of Dentists	31 Florists	46 Physical Fitness Facilities
13 Offices of Chiropractors	32 Tobacco Stores and Stands	47 Public Golf Courses
14 Offices of Optometrists	VI Child Day Cares *(dc)*	48 Museums and Art Galleries
15 General Medical and Surgical Hospitals	33 Child Day Cares	49 Botanical and Zoological Gardens
16 Home Health Care Services		50 Sporting and Recreational Camps

This study develops an origin-based (parcel-based) accessibility measure but uses a destination-based GIS approach: the accessibility scores were assigned to the places of origin, yet the GIS techniques were performed first on the points of destination. Using the Service Area Network Analyst GIS tool, this study produced eight walking network distance segments, eight biking network distance segments, and eight driving network distance segments (defined based on the current literature and the local context) for each type of EPOI. For example, the Halifax Regional School Board (2014) provides bus service for elementary students who live greater than 2,400m from school; this implies that walking more than 2,400 metres is considered too far to walk to school and alternative transportation is needed. Therefore, the maximum walking distance segment used was 2,400m. This study automated other GIS tools used, such as spatial joining to the Halifax parcels and field calculating for scoring, using the ArcGIS Model Builder. The distance segments were scored based on the results of an expert consultation survey.

Spatial differences in accessibility across the Halifax region were identified between three sub-regions -the Regional Centre, Suburban areas, and Rural Commutershed - based on the tax

designation boundaries and the regional centre boundary collected from the 2012 Halifax Geodatabase and the 2014 Regional Municipal Planning Strategy respectively.

3.3.2 Composite Network-Distance-Based Accessibility Measure (CNAM)

The CNAM, unlike other composite accessibility measures, offers a holistic, finer-grained accessibility estimation, incorporating a multi-destination and multi-mode accessibility framework. The CNAM estimates accessibility to 50 types of EPOI (categorised into 9 types of service destinations) by active and auto travel modes from property parcels for Halifax to different types of destinations. Moreover, the CNAM features a new method of defining accessibility thresholds, informed by transportation experts, which utilises a five interval Likert accessibility scale defined in terms of travel distances by different modes (i.e., walking, biking, and driving distances).

This study's accessibility framework involved generating distance segments for each EPOI and scoring them on a scale of 0 (very poor accessibility) to 5 (very high accessibility) based on the EPOI's type of service destination. The distance segments were then joined to the property parcels for Halifax. Since more than one distance segment from the same EPOI may intersect a parcel, the calculation used the maximum score of the distance segments from an EPOI. The maximum score represents the highest accessibility estimation for that parcel. For example, if two walking distance segments from a grocery store intersect parcel j and have scores of 5 and 4 respectively, the score used in the calculation for accessibility to that particular grocery store from parcel j would be 5. The following equation outlines how accessibility of a parcel to each type of service destinations (e.g., food stores) was calculated:

$$Access\ to\ type\ of\ service\ destinations\ from\ parcel\ j\ \left(A_{fs}(j)\ etc.\right) =$$

$$\sum_{n=1}^{N}\left[\sum_{k=1}^{K}\left(MS_W\ from\ EPOI_k\right) + \sum_{k=1}^{K}\left(MS_B\ from\ EPOI_k\right) + \sum_{k=1}^{K}\left(MS_D\ from\ EPOI_k\right)\right]_n$$

where:

N = number of types of EPOI within the type of service destination

$$\left(N_{A_{fs}} + N_{A_{rest}} + N_{A_{rest}} + N_{A_{pers}} + N_{A_{hlth}} + N_{A_{gs}} + N_{A_{dc}} + N_{A_{edu}} + N_{A_{govt}} + N_{A_{rec}} = 50\right)$$

K = number of EPOI from type of EPOI k that have distance segments that intersect parcel j

MS_W = Maximum score of walking distance segments that intersect parcel j

MS_B = Maximum score of biking distance segments that intersect parcel j

MS_D = Maximum score of driving distance segments that intersect parcel j

The CNAM sums the scores of EPOI distance segments for all modes and destination types that intersected each parcel. The following equation represents the composite accessibility measure:

$$CNAM(j) = A_{fs}(j) + A_{rest}(j) + A_{pers}(j) + A_{hlth}(j) + A_{gs}(j) + A_{dc}(j) + A_{edu}(j) + A_{govt}(j) + A_{rec}(j)$$

where:

$CNAM(j)$ = Accessibility from parcel j to all EPOI

$A_{fs}(j)$ = Accessibility to Food Stores from *j*

$A_{rest}(j)$ = Accessibility to Restaurants from *j*

$A_{pers}(j)$ = Accessibility to Personal Services from *j*

$A_{hlth}(j)$ = Accessibility to Health Services from *j*

$A_{gs}(j)$ = Accessibility to General Shopping Destinations from *j*

$A_{dc}(j)$ = Accessibility to Child Day Care Services from *j*

$A_{edu}(j)$ = Accessibility to Schools from *j*

$A_{govt}(j)$ = Accessibility to Government Services from *j*

$A_{rec}(j)$ = Accessibility to Amusement and Recreation Destinations from *j*

Finally, the CNAM values were standardised to compare accessibility scores using the same scale. The absolute accessibility scores were converted to a range of -1, representing very poor accessibility, and 1, representing very high accessibility. The following equation standardises the scores for each parcel:

$$CNAM_{US}(j) = \frac{2[CNAM(j) - CNAM_{MIN}(j)]}{CNAM_{MAX}(j) - CNAM_{MIN}(j)} - 1$$

where:

$CNAM_{US}(j)$ = Standardised composite accessibility score for parcel *j*

$CNAM_{MIN}(j)$ = Minimum $CNAM(j)$ for Halifax

$CNAM_{MAX}(j)$ = Maximum $CNAM(j)$ for Halifax

The finer-grained disaggregate (parcel level) accessibility scores were converted to aggregate level accessibility. For example, the Halifax parcels were spatially joined to their respective DAs and the average normalised score for each DA in Halifax was calculated to characterise accessibility at the DA level.

3.3.3 Expert Accessibility Survey

The estimation of the CNAM required distance bands to identify levels of accessibility for each destination type. This study conducted a web-based, expert consultation survey between July and August 2014. The survey asked transportation planning, engineering, and health professionals in Halifax to define a five-interval Likert accessibility scale for the nine types of service destinations (as defined in Table 6) in terms of travel distances. The accessibility intervals defined in the expert consultation survey included very high, high, moderate, low, and poor. The analysis incorporated a sixth accessibility interval, very poor, which included any distance greater than what was defined for poor accessibility.

The survey consisted of three sets of questions. Each question asked respondents to select a distance (between a point of origin and a type of service destination) they thought characterised the point on each accessibility interval of the Likert scale. For example, one question asked experts how they would define very high accessibility to food stores in terms of walking distances. In each question, the respondents chose from nine pre-defined distance ranges, which were similar to the distance segments generated for the EPOI. The sets of questions differed by the distance ranges that respondents could choose from. The first set of questions asked respondents to define accessibility to the types of service destinations in terms of walking distances. Walking distances ranged from 200m to greater than 2,400m. The second set of questions asked experts to define accessibility in terms of biking distances that ranged from 375m to greater than 9,000m. In the third set of questions, experts defined accessibility in terms of driving distances ranging from 2,500m to greater than 50,000m.

The distances respondents chose were coded from 0-9. The average response was calculated for all questions and was used to define the distance ranges that characterise each accessibility interval on the Likert scale. The distance segments generated in ArcGIS for the CNAM were assigned an accessibility score from 0-5 based on their distance range corresponding to the Likert scale. These scores were used in the calculations for the CNAM for Halifax.

3.4 Discussion of Findings

3.4.1 Expert Accessibility Survey

The results of the web-based, expert consultation survey, shown in Table 7, provide significant insight on how accessibility should be defined by type of service destination and travel mode, rather than using suggested travel distances from other studies (e.g., Cervero, 2005; Cervero,

Rood, & Appleyard, 1999; Ewing & Cervero, 2010). Of the experts contacted, 38 participated in the survey (a response rate of 49%). The results suggest that accessibility is defined differently for distinctive service destinations and travel modes. For example, as shown in Table 7, the walking, biking, and driving distances chosen to define high accessibility to food shopping destinations and child day cares are much shorter than those for high accessibility to health services. This finding shows that food shopping destinations and child day cares should be located in greater proximity than health services from household locations. The distance ranges chosen for accessibility to government services and recreation destinations are notably larger than distance ranges chosen for other types of destinations. Thus, the results suggest that government services and recreation destinations do not need to be as proximal to home locations.

Table 7 shows that high accessibility to the service destinations should be approximately within a 0.6 km walking distance, a 1.5 km biking distance, and a 10 km driving distance. The contacted professionals suggest that service destinations greater than 1.6km by walking, 3km by biking, and 15km away by driving represent low accessibility. Overall, the travel distances representing very poor accessibility are greater than 2.4km for walking, 6km for biking, and 30km for driving. Table 7 also shows that the accessibility scores assigned to biking distance segments are most consistent in comparison to all destination types. Conversely, accessibility scores assigned to walking distance segments are least consistent in comparison to all destination types. In other words, accessibility to the service destinations is defined similarly in terms of biking distance but not in terms of walking distance.

If an amenity or location is accessible by walking, it is expected to be more accessible by biking, and most accessible by driving. Surprisingly, this is not the case for some types of service destinations. Since the distance segments chosen for walking and biking are similar, there are some instances where accessibility scores by walking are higher than accessibility scores by biking by ±2. For example, Table 7 highlights that very high accessibility to recreation destinations is up to 0.8km by walking, but up to 0.75km by biking. As a result, EPOI located between 0.75km and 0.8km away from a parcel will have a higher walk score than bike score. Similarly, experts chose a larger walking distance range to define very high accessibility to food shopping destinations in comparison to accessibility by biking.

Table 7: Results of expert consultation survey - accessibility scale

Accessibility Rankings	Very High Accessibility (5)	High Accessibility (4)	Moderate Accessibility (3)	Low Accessibility (2)	Poor Accessibility (1)	Very Poor Accessibility (0)

Walking									
Distance Segments	0-0.2km	>0.2-0.4km	>0.4-0.6km	>0.6-0.8km	>0.8-1km	>1-1.2km	>1.2-1.6km	>1.6-2.4km	>2.4km
Food Store Destinations									
General Shopping Destinations									
Restaurants									
Personal Services									
Health Services									
Government Services									
Schools									
Child Day Cares									
Recreation Destinations									
Biking									
Distance Segments	0-0.375km	>0.375-0.75km	>0.75-1.5km	>1.5-3km	>3-4.5km	>4.5-6km	>6-7.5km	>7.5-9km	>9km
Food Store Destinations									
General Shopping Destinations									
Restaurants									
Personal Services									
Health Services									
Government Services									
Schools									
Child Day Cares									
Recreation Destinations									
Driving									
Distance Segments	0-2.5km	>2.5-5km	>5-10km	>10-15km	>15-20km	>20-30km	>30-40km	>40-50km	>50km
Food Store Destinations									
General Shopping Destinations									
Restaurants									
Personal Services									
Health Services									
Government Services									
Schools									
Child Day Cares									
Recreation Destinations									

3.4.2 Composite Network-distance-based Accessibility Measure (CNAM)

The CNAM for all Halifax parcels ranges between 0 and 33,862. Figure 61 illustrates that there are considerable spatial differences in accessibility throughout the Halifax region. In general, the highest CNAM values are along the Halifax Harbour and lowest CNAM estimations are in the peripheral areas of Halifax. Figure 61 also highlights that a large extent of Halifax parcels have relatively low composite accessibility scores, ranging from 0 to 3,386.

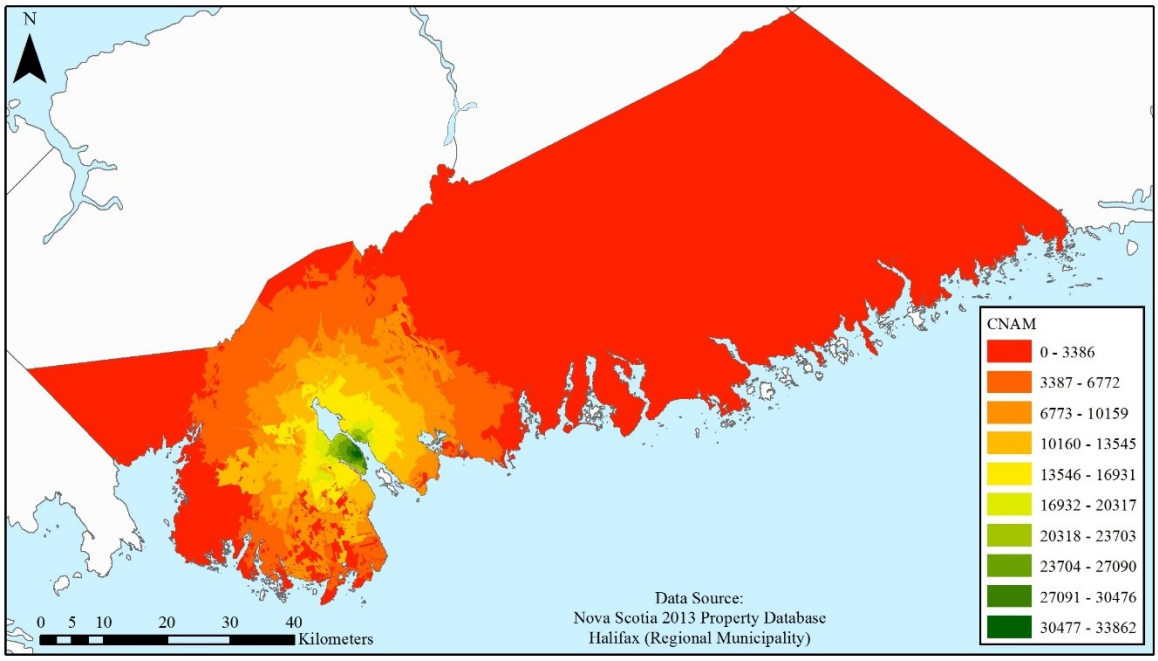


Figure 61: CNAM for Halifax, Nova Scotia

3.4.2.1 CNAM by Spatial Structure

The composite accessibility scores were analysed and compared by Halifax sub-region. Evidently, the highest accessibility scores are within the Regional Centre and the lowest scores are in the Rural Commutershed, as shown in Figure 62.

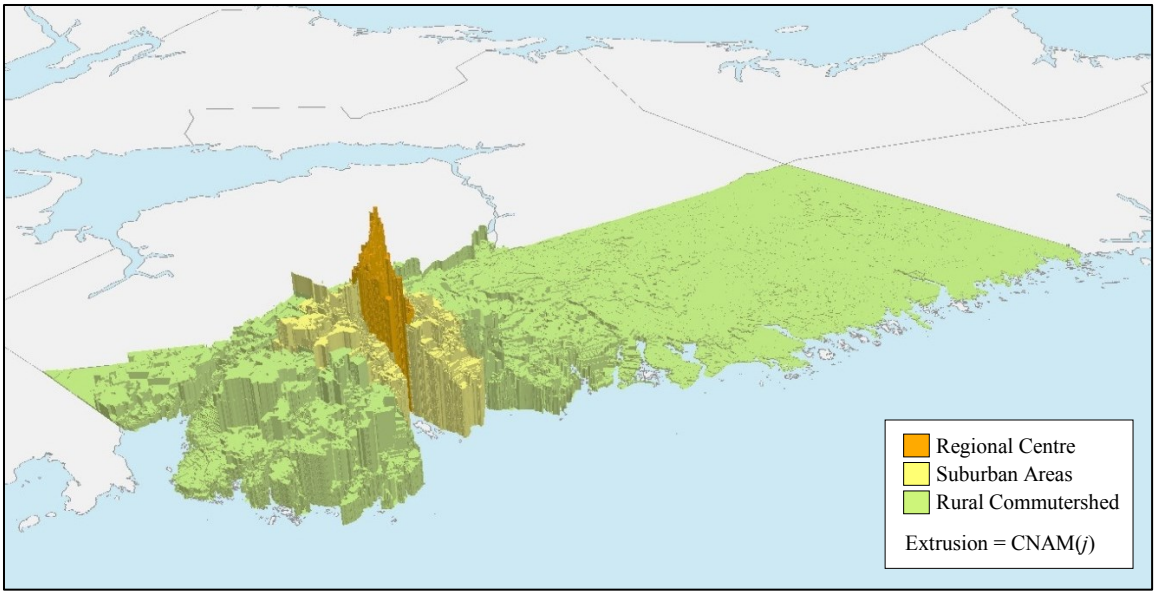


Figure 62: CNAM by Halifax sub-region

The distribution of composite accessibility scores was examined in relation to the point-to-point distance from the parcel centroid to the Central Business District (CBD), which is located within the Regional Centre. As expected, Figure 63 shows that as distance from the CBD increases, the CNAM generally decreases. The CNAM decreases significantly within 20km of the CBD. Parcels within the Regional Centre are considerably more accessible than the parcels in Suburban areas and the Rural Commutershed. The average CNAM for the Regional Centre is almost two times higher than that for Suburban areas, while the average CNAM for Suburban areas is approximately five times more than that of the Rural Commutershed. Additionally, Figure 63 illustrates that there is greatest variance in accessibility in the Regional Centre, with a standard deviation of 4,324, and least variance in accessibility in the Rural Commutershed. A standard deviation of 4,324 indicates that greatest spatial variation in accessibility to service destinations is found within the Regional Centre. Parcels in the Rural Commutershed have the lowest accessibility scores; however, the Rural Commutershed, overall, has the lowest standard deviation values, indicative of least spatial differences in accessibility.

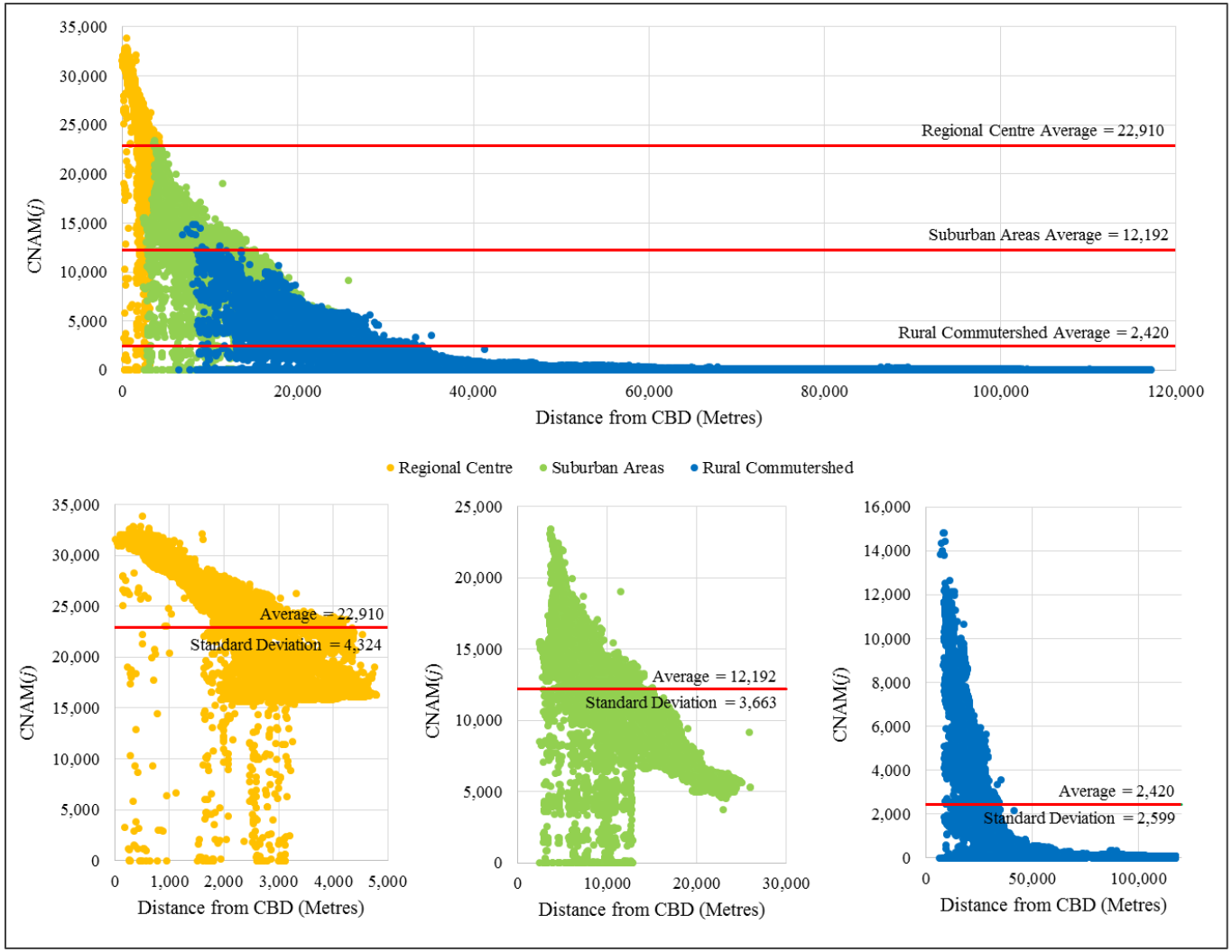


Figure 63: CNAM vs distance from Central Business District (CBD)

[63]

3.4.2.2 CNAM by Mode

The CNAM was also calculated by mode to identify differences in accessibility by travel mode. As expected, Table 8 shows that accessibility to all service destinations by car is substantially higher than accessibility by active transportation modes. The CNAM for driving estimations for all parcels in Halifax are approximately 10 times more than the CNAM for biking and 46 times more than the CNAM for walking. The accessibility scores to all destinations by walking and biking are significantly higher in the Regional Centre in comparison to Suburban areas and the Rural Commutershed. For example, the average CNAM for bike scores is 12 times higher in the Regional Centre than in Suburban areas. As shown in Table 8, the average CNAM by walking and biking are relatively poor for the Rural Commutershed. These findings suggest that a greater number of service destinations are located within the Regional Centre and fewest located in the Rural Commutershed.

3.4.2.3 Accessibility by Type of Service Destinations

The highest accessibility scores for Halifax are for health services and restaurants. Regarding accessibility to service destinations by Halifax sub-region, the Regional Centre is more accessible to all destination types than Suburban areas and the Rural Commutershed (see Table 8). The Regional Centre and Suburban areas are most accessible to health services, whereas the Rural Commutershed is most accessible to restaurants (see Table 8). Figure 64 illustrates that the highest accessibility scores are for health services in the Regional Centre and the lowest accessibility scores are for government services in the Rural Commutershed. Although Halifax is most accessible to health services, restaurants, and general shopping destinations, there are considerable differences in accessibility for these services by Halifax sub-region (see Table 8). For example, the average score for health services for the Regional Centre is two times higher than the average score for Suburban areas. Furthermore, the average score for accessibility to health services in Suburban areas is more than six times that of the Rural Commutershed. There are least spatial differences regarding accessibility to child day cares and recreation destinations in Halifax; average accessibility scores for the Regional Centre are about one and a half times the scores found for Suburban areas and scores calculated for Suburban areas are approximately four times higher than that of the Rural Commutershed. These findings indicate considerable spatial differences in Halifax, particularly between Suburban areas and the Rural Commutershed.

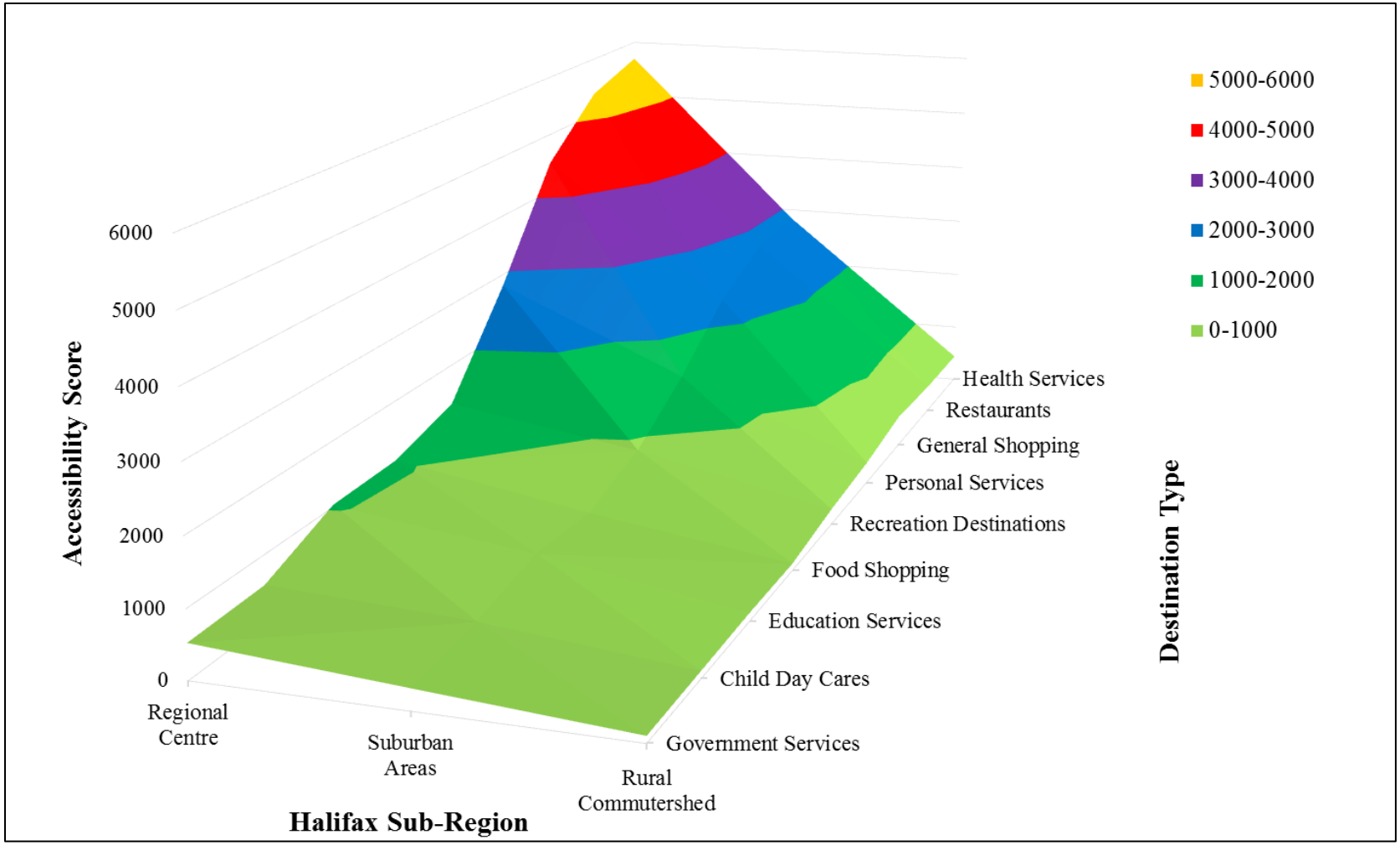


Figure 64: Accessibility scores by Halifax sub-region and destination type

Table 8: Summary of CNAM by Halifax sub-region

	Halifax			Regional Centre			Suburban Areas			Rural Commutershed		
	Avg.	**St. Dev.**	**Max.**	**Avg.**	**St. Dev.**	**Max.**	**Avg.**	**St. Dev.**	**Max.**	**Avg.**	**St. Dev.**	**Max.**
CNAM	10142.24	7722.37	33862	22909.61	4324.57	33862	12192.30	3663.03	23393	2420.03	2598.84	14793
$CNAM_{Walk}$	197.81	591.99	6817	1107.84	1176.03	6817	72.55	108.24	856	2.32	8.09	171
$CNAM_{Bike}$	861.31	1870.89	9106	4634.39	2401.96	9106	376.88	631.27	5158	5.16	12.82	196
$CNAM_{Auto}$	9083.13	6116.38	19014	17167.38	1598.86	18601	11742.87	3249.11	19014	2412.56	2596.02	14530
Child Day Cares	321.52	190.18	717	560.31	59.32	717	409.50	75.84	567	112.18	111.25	434
Restaurants	2287.35	1848.55	8206	5365.99	1012.29	8206	2767.18	897.02	5820	444.24	581.46	3579
Education Services	507.86	355.75	1334	1034.61	155.93	1334	640.90	163.52	1020	125.90	137.42	672
Food Shopping	458.31	356.84	1602	1055.87	226.16	1602	547.04	158.54	1112	106.33	126.14	645
Government Services	266.10	163.55	705	528.51	89.61	705	312.86	60.72	523	101.34	84.30	345
General Shopping	1957.65	1501.12	6816	4498.78	866.95	6816	2300.70	752.75	4614	505.66	490.52	2849
Health Services	2356.93	1969.32	8533	5693.36	1248.29	8533	2816.61	949.60	5920	438.39	578.60	3566
Personal Services	1266.99	940.74	4068	2811.56	518.63	4068	1510.78	480.20	2949	338.30	319.25	1821
Recreation Destinations	719.52	444.27	1939	1360.62	215.28	1939	886.73	172.86	1378	247.71	233.70	933

3.4.2.4 Accessibility by Type of EPOI

An investigation of accessibility to 50 types of EPOI offers an interesting, finer-grained comparison of service sub-categories (i.e., SIC codes from DMTI Spatial). Halifax is most accessible to health services when types of service destinations are compared; however, when types of EPOI are compared, Halifax is most accessible to eating places. The average score for accessibility to eating places for Halifax (2,121) is far greater than the average scores for other types of EPOI. Halifax is least accessible to child day cares and government services when types of service destinations are compared. Surprisingly, when accessibility to day cares is compared to other types of EPOI, the average scores are relatively high, in the top five types of EPOI. Accessibility to zoos and botanical gardens has the lowest accessibility scores, followed by adult education services, when types of EPOI are examined.

Regarding health services, Halifax is most accessible to offices and clinics of physicians and least accessible to home health care services. Accessibility scores to offices and clinics of physicians for all modes are considerably high, with an average score of 1,222, the second highest for Halifax. Accessibility scores to offices and clinics of dentists are also very high compared to all types of EPOI. Accessibility to general medical and surgical hospitals is surprisingly low, with an average score of 108 for Halifax.

The average accessibility scores to grocery stores (289) are highest of all other types of food stores. The average accessibility scores for the types of food stores are, overall, considerably low in comparison to other types of EPOI. This may reflect the experts' ranking of accessibility to food stores at a lower threshold. In other words, distances chosen were relatively low when compared to the distances chosen for other types of destinations. Of general shopping destinations, Halifax is most accessible to drug stores and propriety stores, with an average score of 298, and least accessible to tobacco stores. The average scores for types of general shopping destinations are similar to the average scores for other types of EPOI.

The average accessibility score to beauty shops is the third highest in comparison to all EPOI, with an average of 866 for Halifax. Accessibility to banks also has a relatively high score. Halifax is most accessible to physical fitness facilities, compared to all recreation destinations, and relatively high in comparison to other types of EPOI. Average scores to museums, art galleries, and video rental locations are also high, but the lowest accessibility scores for recreation destinations are for botanical and zoological gardens, followed by sporting and recreation camps.

Of all schools, the highest accessibility scores are for elementary schools and early childhood education services. The lowest scores are for accessibility to universities and colleges, followed by adult education services. Average accessibility scores for education services are generally lower than other types of EPOI.

Halifax parcels are more accessible to police protection services than fire protection services; however, there are less spatial differences in accessibility to fire protection services. Both types of destinations have average scores consistent with other types of EPOI.

A general trend exists involving accessibility between the Halifax sub-regions as the differences in accessibility scores between sub-regions were similar for all types of EPOI. The scores by type of EPOI for the Regional Centre are approximately two times more than the scores for Suburban areas and scores for Suburban areas are generally five times that of the Rural Commutershed. These values are consistent with the differences in the mean of the CNAM between the Regional Centre, Suburban areas, and the Rural Commutershed seen previously in Figure 63.

3.4.2.5 Accessibility by Service Destination and Travel Mode

When comparing types of service destination and travel modes, accessibility scores to all service destinations via the automobile are substantially higher than that for active transportation modes, similar to what is evident of the CNAM. Additionally, the average accessibility scores for active transportation modes are significantly higher for all types of destinations in the Regional Centre in comparison to Suburban areas and the Rural Commutershed. Average accessibility scores for active transportation modes in the Rural Commutershed are very poor, accounting for less than or equal to one for all destination types. This finding suggests that there may be more highways located in Suburban areas and the Rural Commutershed, which are not included in the active transportation network used in this study.

Scores for accessibility to the services destinations by biking are second highest, except for accessibility to a few service destinations, such as food shopping and recreation destinations, where the walking accessibility scores for some parcels are slightly higher than the bike scores. This is a result of how the experts ranked accessibility for these particular service destinations by biking and walking.

3.4.2.6 Unit-level Standardisation of CNAM

The accessibility scores were normalised to evaluate relative accessibility and characterise accessibility at a standardised scale. A standardised score of -1 represents relatively low accessibility and a standardised score of 1 represents relatively high accessibility. The

standardised scores provide a better understanding of how accessible the Halifax region is and thus allows for enhanced interpretation of accessibility at different scales. Since this study measures accessibility at the parcel level, the CNAM can be used to analyse accessibility at any spatial unit, if boundary files are available.

The distribution of standardised accessibility scores for Halifax parcels, shown in Figure 65, reveals that 75% of Halifax parcels have a relatively low accessibility, with a standardised CNAM below 0. The highest percentage of parcels (16%) has a standardised CNAM of -0.9, representing relatively poor accessibility. The highest percentage of parcels have a poor accessibility score (-0.9) for most destination types except for government services, recreation destination, and child day cares where the highest percentage of parcels have moderate accessibility scores. Figure 65 illustrates that 14% of parcels have a score of -0.1 for government services, 14% have a score of 0.1 for recreation destinations, and 13% have a score of 0.3 for child day cares (13%).

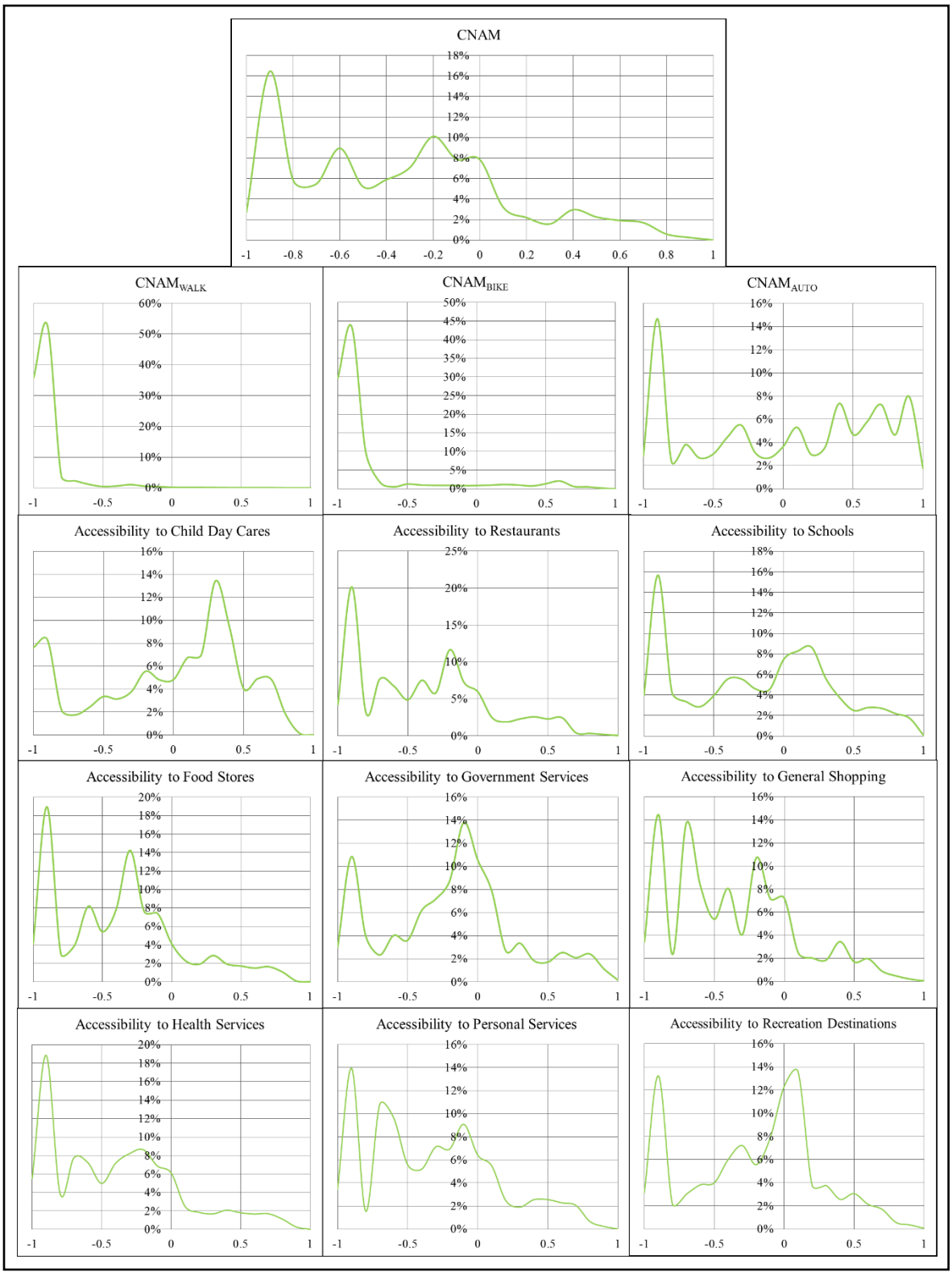


Figure 65: Distribution of normalised accessibility scores at parcel level

The parcel level standardised accessibility scores were used to presents a DA-level analysis in which the parcel level scores were joined to their respective DAs. This DA-level analysis is assumed representative of a neighbourhood-scale of accessibility. The average standardised scores of the parcels for each DA is represented in Figure 66. Most DA's in Halifax have relatively low accessibility scores. When compared to Figure 61, accessibility at the parcel level offers a finer-grained, more detailed representation of accessibility in comparison to using average scores at the DA level. The parcel-level accessibility data produced in this study, however, is scalable and can be converted to other aggregate units including postal codes, CTs and TAZs. The scalability of the accessibility measure presented in this research can be useful for future studies that focus on other spatial units of interest.

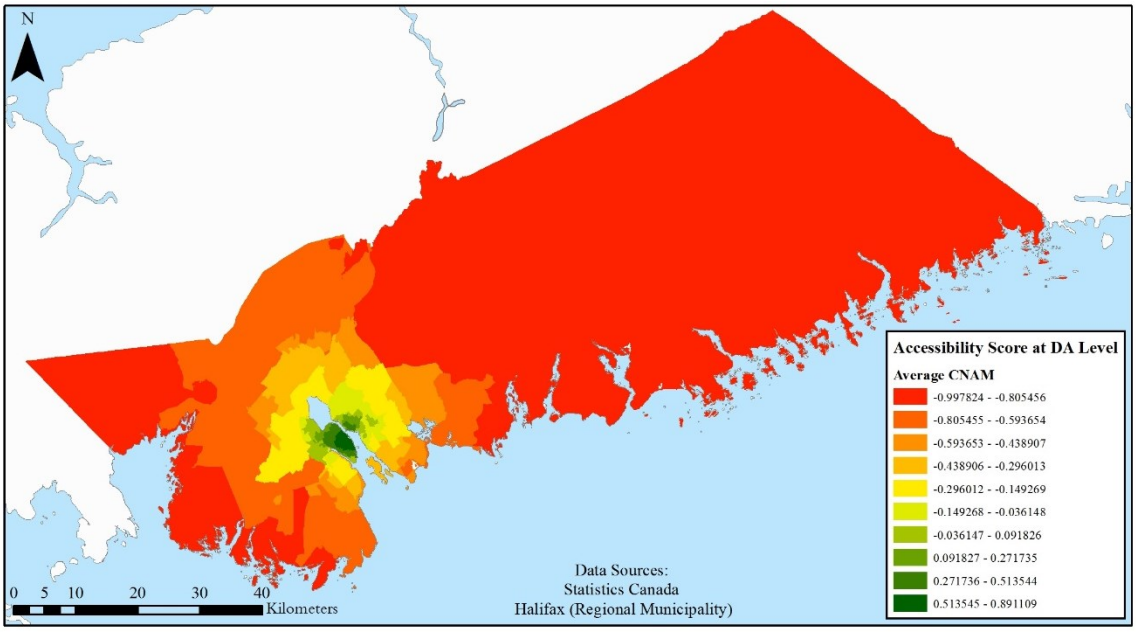


Figure 66: Accessibility at the DA level - average CNAM for DAs

The distribution of the standardised accessibility scores at DA level, shown in Figure 67, indicates that the majority of DAs in Halifax (54%) have a relatively low accessibility score to all destinations by all modes. Contrary to what is found at the parcel level shown in Figure 65, the highest percentage of DAs (11%) has a moderate standardised CNAM, about 0. Moreover, most DAs have a relatively poor accessibility score to all services by walking and biking; the highest percentage of DAs have a standardised CNAM of -0.9 for walking (76%) and biking (51%). Most DAs are relatively accessible to child day cares, schools, and recreation destinations, where the majority of DAs have standardised scores above 0.

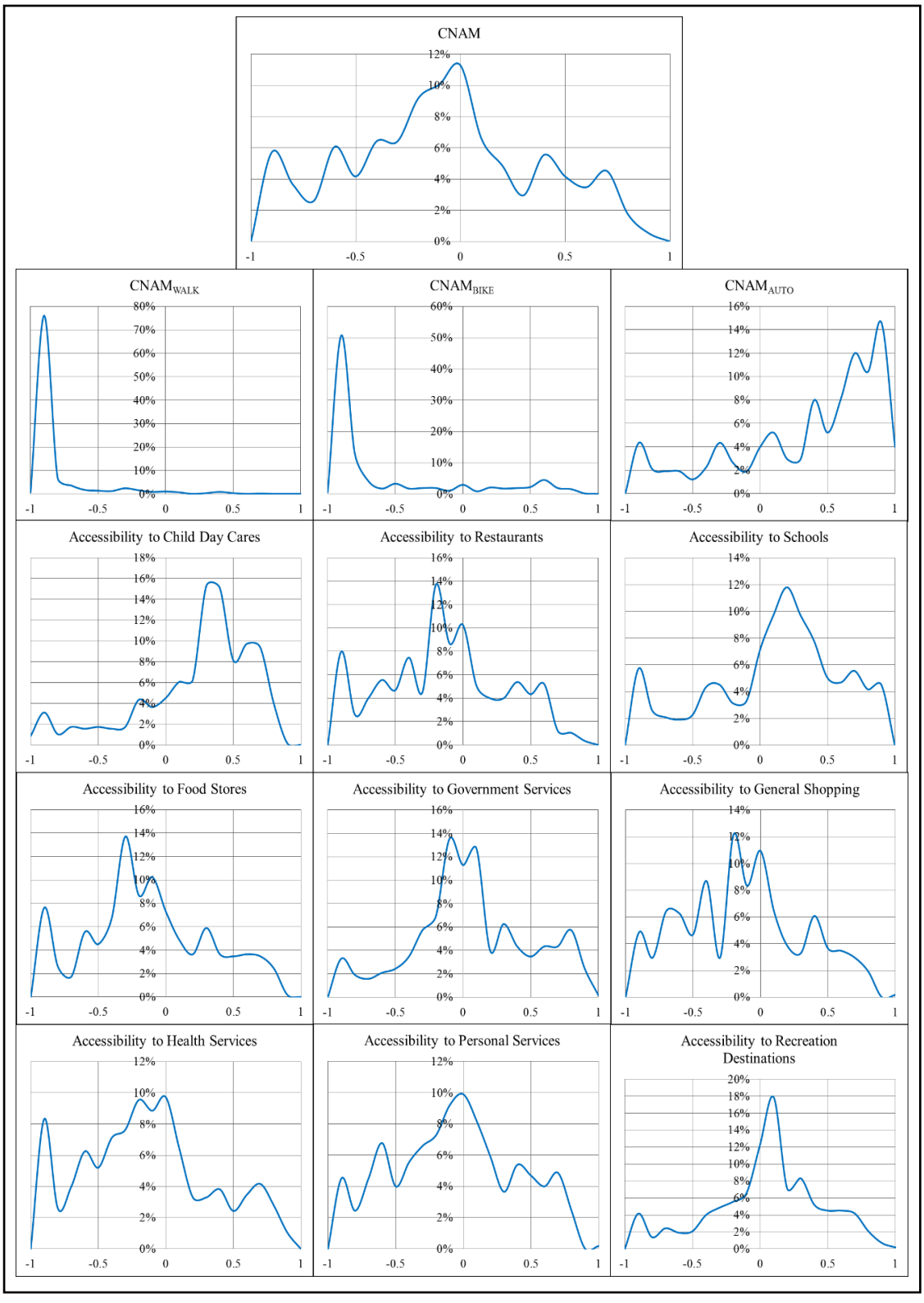


Figure 67: Distribution of normalised accessibility scores at DA level

3.4.3 Conclusion

The CNAM presented in this paper represents a comprehensive approach to measuring accessibility to multiple destinations by various travel modes at a finer-grained disaggregate level. The CNAM offers a unique comparative scale of accessibility, from very poor to very high, informed by planning, engineering, and public health experts. Experts defined high accessibility to food shopping destinations and child day cares using shorter distance ranges in comparison to accessibility to other destination types. Furthermore, experts defined high accessibility to government and recreation destinations using relatively large distances.

The results of the CNAM support the existing literature: accessibility to service destinations varies throughout a region. There is a significant decrease in the accessibility scores as distance from the CBD increases. The Regional Centre is most accessible to all destination types and by all modes. The Regional Centre is generally two times more accessible than Suburban areas, while Suburban areas are approximately five times more accessible than the Rural Commutershed. Accessibility by walking and biking is very poor for the Rural Commutershed. Halifax is most accessible to health services and restaurants and least accessible to government services. When comparing types of EPOI instead of types of service destinations, Halifax is most accessible to eating places.

The CNAM also provides a unique benefit: as demonstrated by a DA-level analysis, the data produced in this research is scalable and thus can be used for systems modelling. Approximately 54% of DAs have a relatively low accessibility score, with a standardised CNAM below 0, whereas 71% of parcels have a relatively low CNAM. The highest percentage of DAs has a moderate accessibility to all service destinations by all modes; however, the highest percentage of parcels has a very poor accessibility.

The results of this study are valuable for planning policy. People generally travel sustainably in areas that are more accessible. A higher percentage of people walk and cycle in the more accessible Regional Centre. Moreover, a higher percentage of people drive alone in the less accessible Suburban areas and Rural Commutershed. The high spatial variability within the Regional Centre suggests that greater attention is needed particularly for the Dartmouth side, where accessibility scores are considerably lower than the Halifax Peninsula. Future, high-density development can be concentrated in Dartmouth. Moreover, improvements in road connectivity and density, specifically for the active transportation network, which excludes highways, can be concentrated on the Dartmouth side of the Regional Centre and bordering Suburban areas.

There are few cases where the shortest active transport route in reality is via staircases and across parking lots, for example. However, these cases are not accounted for in the active transportation network. Additionally, one-way restrictions are not incorporated in the biking network. The accessibility scores assigned in this paper are suggested by experts, who might have similar perspectives of how accessibility should be defined. The perspectives of road users are not included but could be collected in a future study to get a broader perspective of how accessibility to service destinations should be defined by various modes. The accessibility scores were not weighted based on importance of a particular destination because such proved challenging due to biasness. However, the differences in how close the service destinations should be from a parcel were accounted for in this study. This study does not include accessibility by transit because transit estimations should incorporate a time variable as well as distance; this study defines accessibility using distance only. A future study can build on this study's accessibility framework to incorporate a schedule to examine accessibility to service destinations by public transit. The CNAM can also be applied to other counties in Nova Scotia to characterise accessibility in the Province and identify spatial differences by county as an indicator of sustainable transportation.

Chapter 4
Discussion

This study reveals that Halifax can be characterised in terms of travel behaviour and accessibility. The exploratory analysis of travel behaviour indicates that there is great dissonance in the current travel behaviour of Halifax residents and their attitudes toward sustainable transportation: they show positive attitudes toward transit and active transportation, yet residents travel predominantly via car. Residents of the Regional Centre, however, travel more sustainably (using car alternatives) than residents of Suburban areas and the Rural Commutershed. The accessibility analysis reveals that there are considerable differences in accessibility to key service destinations across the Halifax region. As expected, parcels in the Regional Centre are most accessible; however, there are greatest spatial differences in accessibility within the Regional Centre. The high accessibility scores and higher percentages of sustainable travel found for the Regional Centre suggest that greater accessibility may influence sustainable transportation in Halifax. The findings of this study provide significant information for future research and sustainable planning policy. This chapter provides a summary of the key findings and limitations of this study. Additionally, this chapter highlights the implications and contribution of this study for research and sustainable transportation planning policy.

4.1 Summary of Exploratory Analysis of Travel Behaviour

Halifax residents travel primarily via the automobile for all trip purposes, except for school trips where the primary mode is walking. The majority of trips per week are for work and recreation purposes. The HMTS households' primary workers travel, on average, 11 kilometres to work. Moreover, 79% of respondents own at least one vehicle and 73% own at least one bicycle. Surprisingly, 71% of respondents live within 500 metres of a bus stop; however, transit is not the preferred travel mode. More than 70% of respondents noted that they prefer walking to driving whenever possible and enjoy riding a bicycle. Furthermore, 87% of respondents consider transit an essential service. The results of the HMTS suggest that Halifax residents desire to be sustainable, as reflected in their attitudinal preferences; however, there is great dissonance in residents' travel behaviour. The HMTS respondents generally acknowledge climate change as a major concern and support active transportation, public transit, and density; nonetheless, Halifax residents are still auto dependent, an issue also found in other Canadian cities (e.g., Roorda et al., 2005; The City of Calgary, 2013a; The City of Calgary, 2013b; Trans Link, 2013). The HMTS results suggest that there are opportunities for improvement in the current transportation system

to encourage sustainable travel. For example, more than 70% of respondents would take transit more often if it were convenient. Hence, the current transit system could be enhanced to a more reliable and convenient level. The high percentages of respondents who own bicycles (73%), prefer walking instead of driving when possible (70%), and enjoy riding bicycles (73%) imply that there are also opportunities to improve linkages for pedestrians and cyclists in Halifax.

4.2 Summary of Accessibility Analysis

This study explores accessibility to 50 types of points of interest by driving, biking, and walking in Halifax. The accessibility scores assigned in this study are informed by planning, engineering, and public health experts who suggest that food shopping destinations and child day cares should be located closer to home locations than other service destinations; they also suggest that government services and recreation destinations do not need to be as proximate. There are considerable spatial differences in accessibility across the Halifax region. The Regional Centre is most accessible to all service destinations, but has the greatest spatial variability in accessibility when compared to Suburban areas and the Rural Commutershed. Within the Regional Centre, the accessibility scores estimated for parcels located in Dartmouth are considerably lower than those located in the Halifax Peninsula. As expected, the CNAM generally decreases as the distance from each parcel's centroid to the CBD increases. The CNAM decreases significantly within 20km of the CBD and gradually beyond 20km. The CNAM for driving is 10 times that for biking and 46 times more than the CNAM for walking. The biking and walking scores estimated for Suburban areas and the Rural Commutershed are significantly lower than the active transportation scores estimated for the Regional Centre.

When comparing accessibility scores by type of service destination and Halifax sub-region, the highest accessibility scores are for health services and restaurants in the Regional Centre and the lowest accessibility scores are for government services in the Rural Commutershed. Although Halifax is most accessible to health services, there are greatest spatial differences in accessibility to health services: accessibility to health services in the Regional Centre is 2 times that of Suburban areas and 13 times that of the Rural Commutershed. There are least spatial differences in accessibility to child day cares and recreation destinations. A finer-grained comparison of accessibility, at the EPOI level, reveals that Halifax is most accessible to eating places, followed by offices and clinics of physicians. Although Halifax is more accessible to police protection services than fire protective services, there are greater spatial differences in accessibility to police

protection services. Halifax is more accessible to elementary schools and early childhood education services than all other types of schools.

The accessibility analysis developed in this study offers a unique scalability feature: the parcel level accessibility scores calculated in this study can be converted to any spatial unit of interest. This study exemplifies this scalability feature through a DA level analysis, which offers finer-grained aggregate accessibility estimations at a neighbourhood level.

The findings of the accessibility analysis suggest that there are opportunities to improve the current land use and travel patterns toward sustainable transportation through improvements in active transportation linkages and diversifying and densifying service destinations, particularly in the Regional Centre where there are greatest spatial differences in accessibility.

4.3 Limitations and Implications for Future Research

The exploratory analysis of travel behaviour sometimes proved challenging. For example, there is a slight underrepresentation of the elderly (65+) age cohort in the sample. The travel behaviour of the elderly, therefore, could not be further analysed using the HMTS sample. The limitations of the sample are considered insignificant to the travel behaviour analysis of this study; however, a future study could assign weights to improve the data and compare the weighted results to the current accessibility analysis. The few demographic inconsistencies of the sample may occur due to the sample size, survey distribution, and the web-based nature of the survey. The sample comprises of only 475 survey responses and the survey was distributed using a stratified sampling approach, i.e., through major organizations and media coverage. The higher-income, working population of Halifax is well represented in the HMTS sample whereas the lower-income and elderly, retired population is slightly underrepresented. The distribution of the survey through major business organisations may account for the underrepresentation of retired residents and lower-income households. Furthermore, the web-based nature of the survey may influence survey responses as some studies found that the elderly and lower-income households are less likely to participate in web-based surveys (e.g., Fricker & Schonlau, 2002; Solomon, 2001). Future studies that attempt to analyse travel behaviour information for Halifax that is not collected in existing surveys could consider improving survey distribution to include a greater percentage of elderly, retired residents and lower-income households.

The exploratory analysis of travel behaviour suggests that the quality of transit in Halifax could be explored further to identify opportunities to increase ridership and shift travel behaviour toward more sustainable activity. However, the accessibility analysis in this study does not

include accessibility by transit because it uses distance thresholds to define accessibility. Analyses of accessibility by transit should incorporate a time/schedule variable, in addition to distance, because transit is not always available to Halifax residents. In contrast, residents do not need to consider a schedule to travel to service destinations via walking, biking, and driving. A future study could incorporate the bus schedule, which could offer an effective and accurate measure of accessibility by transit.

There is also a limitation of the active transportation network used in this study's accessibility estimation. There are some instances where the closest route to a service destination may be across a parking lot or via a staircase; these routes are not included in the active transportation network used in this study. A future study could enhance the active transportation network by mapping and including these routes in the analysis. Furthermore, a one-way restriction was not used to produce the biking distance segments.

The accessibility scores assigned in this study are based on experts' opinions of accessible travel distances to derive more reliable accessibility thresholds. Therefore, the differences in how proximate each type of service destination should be was accounted for in this study. There is also a question of how important each type of EPOI is; however, the accessibility data in this study was not weighted by importance of EPOI because such weighting proved challenging. When calculating the composite score, including all destinations and modes, a weight could impose a high level of subjectivity to the data. A future study could extend the consultation survey by including road user perspectives to define the accessibility thresholds. Furthermore, a future study could consider weighting this study's accessibility data by level of importance for all types of EPOIs, possibly by employing a survey to rank importance of the 50 types of EPOI.

4.4 Contribution to Research

The CNAM developed in this study offers significant contribution to the existing literature on composite accessibility estimations. Previous composite accessibility estimations generally consider fewer service destinations and modes, whereas this study measures accessibility for a wide range of service destinations and modes (using 50 types of EPOI) and automated and active travel modes. The accessibility thresholds defined in this study are based on expert opinions of accessible travel distances whereas accessibility is typically defined using ad-hoc demarcations in the existing literature. Furthermore, accessibility in this study is measured at a finer grained disaggregate level, using the smallest spatial unit in contrast to previous studies that typically use larger spatial units. The unit-level standardisation and analysis by DA presented in this study

demonstrates the scalability of the CNAM. This study's accessibility framework thus shows a unique scalability feature, which can be used to generate aggregate measures of accessibility at any spatial unit of interest. This characteristic of the CNAM contributes to further studies that aim to model accessibility data at various scales. The findings of this study could also be used in modelling to test the relationships between accessibility and travel behaviour in Halifax. Another interesting extension of the study would be to identify spatial differences in accessibility across the Province.

4.5 Implications for Policy

The literature suggests that individuals will use sustainable transportation modes more often for shorter trips. Creating more "connected communities" can assist in the shift toward using more sustainable transport modes. Most Halifax residents are not travelling sustainably, but their attitudes reflect a desire to be more sustainable. Interestingly, residents of the Regional Centre, which is most accessible to all service destinations by all travel modes, travel more sustainably than residents of Suburban areas and the Rural Commutershed, which are less accessible. Creating more "connected communities" that offer shorter travel distances for more sustainable travel requires greater accessibility to service destinations. As found in this study, Figure 68 illustrates that a higher composite accessibility score is associated with a higher number of opportunities/ activities, a mix or variety of service destinations, greater proximity to multiple activities, and greater density of service destinations. This study suggests that densifying and diversifying land use activities and transportation linkages in more populated areas such as the Regional Centre and Suburban areas can assist in creating more "connected communities".

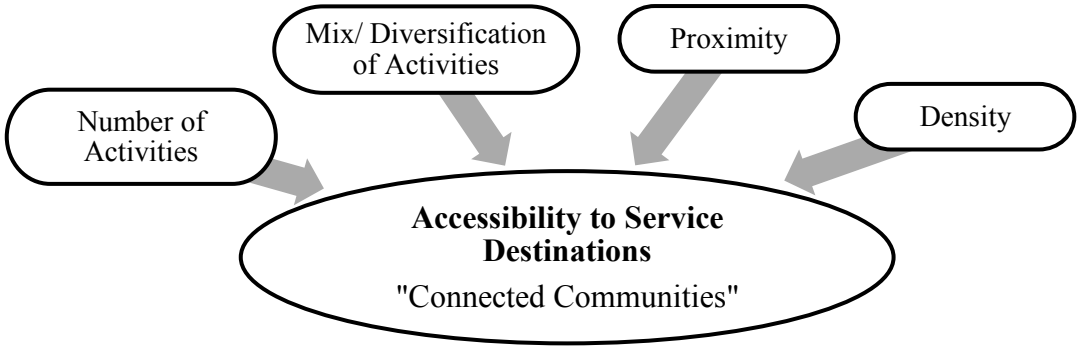


Figure 68: Creating more accessible and "connected communities" in Halifax

Existing planning policy documents such as the 2013 Sustainable Transportation Strategy and the 2014 Regional Plan promote sustainable transportation through public awareness, enhancing the

transit system, and creating mixed-use, denser neighbourhoods. These planning initiatives encourage residents to reduce distance travelled via the automobile and travel more efficiently by increasing connectivity and accessibility to work locations and essential service destinations (Nova Scotia, 2013). The findings of this study can be used to reinforce the principles proposed in the existing policy documents shown in Table 9 and to guide policy for the Regional Centre Plan (expected completion in 2015). Table 9 shows some of the planning initiatives proposed for Halifax growth centres in the Regional Centre, Suburban areas, and the Rural Commutershed, taken from the 2014 Halifax Regional Plan.

Table 9: Excerpt of future characteristics of growth centres (Halifax, 2014, pg. 45-48)

	Regional Centre	Suburban Areas	Rural Commutershed
Transit and Active Transport	▪ Connecting point for transit routes to other centres ▪ Pedestrian oriented terminals with limited park and ride ▪ Frequent local transit ▪ Enhanced pedestrian linkages ▪ Access to active transportation routes ▪ Short interconnected blocks for ease of walkability	▪ Transit to connect to other centres and Regional Centre ▪ Pedestrian oriented transit stops ▪ Enhanced pedestrian linkages ▪ Access to active transportation routes ▪ Short interconnected blocks for ease of walkability	▪ Park and ride with trail linkages, express bus service to Regional Centre ▪ Enhanced pedestrian linkages ▪ Access to active transportation routes ▪ Short block connectivity for pedestrians ▪ In areas with no transit, potential for cost-shared community-based transit in some locations
Land Uses and Design	▪ Mix of high density residential, commercial, institutional and recreation uses ▪ Adjacent to established residential neighbourhoods, low to medium density residential uses ▪ Existing retail plazas and shopping centres ▪ Encourage infill or redevelopment of large parking lots into traditional blocks with street walls and step-backs	▪ Mix of medium to high density residential, commercial, institutional and recreation uses ▪ In established residential neighbourhoods, low to medium density residential uses	▪ Low to medium density residential, (convenience) commercial, institutional and recreation uses ▪ Town or village scale ▪ Redevelopment of retail plazas in traditional blocks with street-walls encouraged

The 2014 Regional Plan proposes to concentrate the majority of new development within the Regional Centre and Suburban areas. There are particular areas within the Regional Centre, identified in this study, that are considerably less accessible to all types of service destinations than other areas of the Regional Centre. The Regional Centre has the greatest accessibility scores, but also has greatest spatial differences in accessibility; accessibility scores for Dartmouth are notably lower than the estimations for the Halifax Peninsula. The variations in accessibility scores by type of destination and EPOI indicate that the distribution of the destinations play an integral role in the accessibility score rather than only considering the number of destinations. For example, the number of grocery stores ranked 4th of all types of EPOI, yet the average accessibility score for grocery stores ranked 7th in comparison to all types of EPOI. Furthermore, the significant spatial differences in accessibility within the Regional Centre show that the distribution of the service destinations is disparate: a higher number of destinations are clustered on the Halifax side and fewer destinations are located farther apart on the Dartmouth side of the Regional Centre. Therefore, this study suggests that increased density and diversification of service destinations should be focused particularly on the Dartmouth side of the Regional Centre and in Suburban areas, close to the Regional Centre.

As highlighted in Table 9, the Regional Plan proposes a mix of high-density institutional, commercial, and recreational land uses for the Regional Centre. This study reveals that the Halifax Peninsula has the highest density and mix of service destinations; the Dartmouth side of the Regional Centre has a much lower density and mix of service destinations. Furthermore, the Regional Centre is more accessible to certain types of service destinations: it is most accessible to institutional land uses compared to commercial and recreational activities. Concerning institutional land uses, the Regional Centre is more accessible to health services than education services. The Dartmouth side of the Regional Centre is less accessible to health services and schools than the Halifax Peninsula. The accessibility scores to child day cares within in the Regional Centre are relatively high. Halifax residents travel to school primarily via walking, which indicates that, although schools received a lower accessibility score, they may be distributed adequately across Halifax or students possibly live closer to school intentionally to reduce travel cost. Greater attention is needed for the distribution of adult education, high schools, and junior high schools within the Regional Centre. Regarding commercial land uses, Dartmouth is less accessible to general shopping destinations and food stores than the Halifax Peninsula. Accessibility to beauty shops and drug stores had very high accessibility scores compared to other types of commercial activities. Specialty food stores such as dairy products

stores and fruit and vegetable markets are not as accessible within the Regional Centre. Furthermore, men's, family, and children's clothing stores in addition to hobby and game stores are not as accessible in the Regional Centre. Greater attention is needed for the distribution of recreation activities in the Regional Centre. Overall, recreation destinations had relatively lower accessibility scores than other types of EPOI. This finding indicates that recreation destinations are not as dense within the Regional Centre. Botanical and zoological gardens, bowling centres, and motion picture theatres are least accessible within the Regional Centre when compared to other types of recreation destinations.

The 2014 Regional Plan also proposes new design standards to improve connections between growth centres and the Regional Centre to increase transit ridership and active transportation. A very high percentage of HMTS respondents agree that they would take transit more often if it were convenient. Another study records that Halifax respondents suggest that improving transit can enhance the quality of life for Halifax residents (Kouzovnikov & Leahey, 2012). Implementing new routes, increasing bus frequency and reliability, and creating a friendly, comfortable experience can all contribute to improving the existing transit system that will encourage an increase in ridership and a decrease in auto-dependence. Furthermore, the road network in Dartmouth is less dense than the Halifax Peninsula road network. The Dartmouth side has more highways, which were not included in the active transportation network in this study. Therefore, the Dartmouth side of the Regional Centre, in particular, needs greater attention regarding active transportation and transit linkages.

The implications of this study comply with the planning initiatives proposed in the Nova Scotia Sustainable Transportation Planning Strategy (2013) and the Regional Plan (2014), as shown in Table 9. The Regional Centre is denser, more compact, and has a greater mix of land uses when compared to Suburban areas and the Rural Commutershed. This suggests that active travellers favour denser, mixed-use development. The Regional Plan proposes to increase mixed-use, high and medium density development and create more "connected communities" in the Regional Centre and Suburban areas. This study illustrates that the Halifax Peninsula is significantly more accessible than other areas in the Halifax region. Greater attention is needed for the Dartmouth side of the Regional Centre and Suburban areas.

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Appendix 1: HMTS Database Codes

Appendix 1.1: Household Information

Field	Description
respid	Respondent ID
add_cur	Current home address
city_cur	Current home city
	1 Halifax
	2 Dartmouth
	3 Bedford
	4 Other
post_cur	Current home postal code
year_cur	Year moved into current address
month_cur	Month moved into current address
rchange	Primary reason for residential location change
	1 To be closer to work
	2 Change in household size
	3 Formation of a new household
	4 Closer to transit
	5 Closer to good schools
	6 Closer to shopping, entertainment, etc.
	7 Desirable neighbourhood
	8 Characteristics of the house/apartment
	9 Other
dweltyp	Type of dwelling that best describes current home
	1 Single-detached house
	2 Semi-detached house
	3 Town/rowhouse
	4 Apartment (less than 5 stories)
	5 Apartment (more than 5 stories)
	6 Other
tenure	Do you Rent or Own this current home?
	1 Rent
	2 Own
room	Number of rooms in current home
bed	Number of bedrooms in current home
value_cur	Approximate purchase price of the current home
rent	Approximate monthly rent of current home
ppl	Number of people in the current household

Field	Description
child	Number of children in the current household
cars	Number of private vehicles in the current household
dl	Number of people holding drivers licenses in the current household
bike	Number of bicycles in the current household
tpass	Do you purchase a monthly transit pass?
	0 No
	1 Yes
h2tsd	Approximate distance from current home to nearest transit stop
pmode	Primary mode of transportation used to commute to work from current home
	1 Auto Driver
	2 Auto Passenger
	3 Transit
	4 Bicycle
	5 Walking
	6 Other
hinc	Approximate annual gross household income of current home
	1 Below $25,000
	2 $25,000 - $34,999
	3 $35,000 - $49,999
	4 $50,000 - $74,999
	5 $75,000 - $99,999
	6 $100,000 - $149,999
	7 Above $150,000
add_pre	Previous home address
city_pre	Previous home city
	1 Halifax
	2 Dartmouth
	3 Bedford
	4 Other
post_pre	Previous home postal code
year_pre	Year moved into previous address
month_pre	Month moved into previous address
prchange	Primary reason for residential location change
	1 To be closer to work
	2 Change in household size
	3 Formation of a new household
	4 Closer to transit
	5 Closer to good schools

Field	Description
	6 Closer to shopping, entertainment, etc.
	7 Desirable neighbourhood
	8 Characteristics of the house/apartment
	9 Other
pdweltyp	Type of dwelling that best describes previous home
	1 Single-detached house
	2 Semi-detached house
	3 Town/rowhouse
	4 Apartment (less than 5 stories)
	5 Apartment (more than 5 stories)
	6 Other
ptenure	Did you rent or own your previous home?
	1 Rent
	2 Own
p_room	Number of rooms in previous home
p_bed	Number of bedrooms in previous home
p_value	Approximate purchase price of previous home
p_sale	Approximate selling price of previous home
p_rent	Approximate monthly rent of previous home
P_ppl	Number of people in the previous household
p_child	Number of children in the previous household
p_cars	Number of private vehicles in the previous household
p_dl	Number of people holding drivers licenses in the previous household
p_bike	Number of bicycles in the previous household
p_tpass	Did you purchase a monthly transit pass when you lived in your previous home?
	0 No
	1 Yes
p_h2tsd	Approximate distance from previous home to nearest transit stop
p_pmode	Primary mode of transportation used to commute to work from previous home
	1 Auto Driver
	2 Auto Passenger
	3 Transit
	4 Bicycle
	5 Walking
	6 Other
p_hinc	Approximate annual gross household income of previous home
	1 Below $25,000
	2 $25,000 - $34,999

Field	Description
	3 $35,000 - $49,999
	4 $50,000 - $74,999
	5 $75,000 - $99,999
	6 $100,000 - $149,999
	7 Above $150,000
add_for	Past home address
city_for	Past home city
	1 Halifax
	2 Dartmouth
	3 Bedford
	4 Other
post_for	Past home postal code
year_for	Year moved into past address
month_for	Month moved into past address
frchange	Primary reason for residential location change
	1 To be closer to work
	2 Change in household size
	3 Formation of a new household
	4 Closer to transit
	5 Closer to good schools
	6 Closer to shopping, entertainment, etc.
	7 Desirable neighbourhood
	8 Characteristics of the house/apartment
	9 Other
fdweltyp	Type of dwelling that best describes past home
	1 Single-detached house
	2 Semi-detached house
	3 Town/rowhouse
	4 Apartment (less than 5 stories)
	5 Apartment (more than 5 stories)
	6 Other
ftenure	Did you rent or own your past home?
	1 Rent
	2 Own
f_rooom	Number of rooms in past home
f_bed	Number of bedrooms in past home
f_value	Approximate purchase price of the home
f_sale	Approximate selling price of the past home
f_rent	Approximate monthly rent of past home

Field	Description
f_ppl	Number of people in the past household
f_child	Number of children in the past household
f_cars	Number of private vehicles in the past household
f_dl	Number of people holding drivers licenses in the past household
f_bike	Number of bicycles in the past household
f_tpass	Did you purchase a monthly transit pass when you lived in your previous home?
	0 No
	1 Yes
f_h2tsd	Approximate distance from past home to nearest transit stop
f_pmode	Primary mode of transportation used to commute to work from past home
	1 Auto Driver
	2 Auto Passenger
	3 Transit
	4 Bicycle
	5 Walking
	6 Other
f_hinc	Approximate annual gross household income of past home
	1 Below $25,000
	2 $25,000 - $34,999
	3 $35,000 - $49,999
	4 $50,000 - $74,999
	5 $75,000 - $99,999
	6 $100,000 - $149,999
	7 Above $150,000

Appendix 1.2: Primary Worker

Field	Description
respid	Respondent ID
p_age	Age of primary worker
p_sex	Gender of primary worker
	1 Female
	2 Male
p_edu	Primary worker's highest level of education
	1 High school
	2 Community college/trade school
	3 University – Bachelor degree

Field	Description
	4 University – Masters degree or higher
	5 Other
pcj	Primary worker current job
ppj	Primary worker previous job
pfj	Primary worker past job
For each job (i.e. current, previous, and past), the following were asked:	
_comy	Job start date year
_comm	Job start date month
_endy	Job end date year
_endm	Job end date month
_typ	Job type
	1 Full-time
	2 Part-time
_add	Job address
_city	Job City
_post	Job postal code
_h2wd	Home to work distance

Appendix 1.3: Secondary Worker

Field	Description
respid	Respondent ID
s_age	Age of secondary worker
s_sex	Gender of secondary worker
	1 Female
	2 Male
s_edu	Secondary worker's highest level of education
	1 High school
	2 Community college/trade school
	3 University – Bachelor degree
	4 University – Masters degree or higher
	5 Other
scj	Secondary worker current job
spj	Secondary worker previous job
sfj	Secondary worker past job
For each job (i.e. current, previous, and past), the following were asked:	
_comy	Job start date year
_comm	Job start date month

Field	Description
_endy	Job end date year
_endm	Job end date month
_typ	Job type
	1 Full-time
	2 Part-time
_add	Job address
_city	Job City
_post	Job postal code
_h2wd	Home to work distance

Appendix 1.4: House and Employment Size Change

Field	Description
respid	Respondent ID
hc1	First Most Recent Household Size Change
hc2	Second Most Recent Household Size Change
hc3	Third Most Recent Household Size Change
hc4	Fourth Most Recent Household Size Change
hc5	Fifth Most Recent Household Size Change
For each Household Size Change, the following was asked:	
_r	Reason for Household Size Change
	1 Birth/adoption
	2 Death
	3 Member(s) moved out
	4 New member(s) moved in
	5 Other
_year	Year Household Size Change Occurred
_tot	Total Household Size after the Change
ec1	First Most Recent Household Employment Change
ec2	Second Most Recent Household Employment Change
ec3	Third Most Recent Household Employment Change
ec4	Fourth Most Recent Household Employment Change
ec5	Fifth Most Recent Household Employment Change
For each Household Employment Change, the following was asked:	
_r	Reason for Household Employment Change
	1 Addition of new job
	2 Loss of employment
	3 Retirement
	4 Withdrawal from labour force

Field	Description
	5 Returning to school
	6 Other
_year	Year Household Employment Change Occurred
_tot	Total Household Employment after the Change

Appendix 1.5: Daily Trip Information

Field	Description
respid	Respondent ID
r1	Resident 1
r2	Resident 2
r3	Resident 3
r4	Resident 4
r5	Resident 5
For each resident, the following were asked:	
m_age	Age of Resident
m_work	Primary Travel Mode for Work Trips
m_sch	Primary Travel Mode for School Trips
m_fd	Primary Travel Mode for Food Shopping Trips
m_shp	Primary Travel Mode for Other Shopping Trips
m_err	Primary Travel Mode for Personal Errands
m_rec	Primary Travel Mode for Social and Recreational Trips
	Value Labels for Primary Mode
	1 Auto Driver
	2 Auto Passenger
	3 Transit
	4 Bicycle
	5 Walking
	6 Not Applicable
t_work	Typical One-Way Travel Time (mins) for Work Trips, using aforementioned primary mode
t_sch	Typical One-Way Travel Time (mins) for School Trips, using aforementioned primary mode
t_fd	Typical One-Way Travel Time (mins) for Food Shopping Trips, using aforementioned primary mode
t_shp	Typical One-Way Travel Time (mins) for Other Shopping Trips, using aforementioned primary mode
t_err	Typical One-Way Travel Time (mins) for Personal Errands, using aforementioned primary mode
t_rec	Typical One-Way Travel Time (mins) for Social and Recreational Trips, using aforementioned primary mode

Field	Description
r_work	Number of Round Trips Generated for Work Trip Purposes over the last 7 days
r_sch	Number of Round Trips Generated for School Trip Purposes over the last 7 days
r_fd	Number of Round Trips Generated for Food Shopping Trip Purposes over the last 7 days
r_shp	Number of Round Trips Generated for Other Shopping Trip Purposes over the last 7 days
r_err	Number of Round Trips Generated for Personal Errand Trip Purposes over the last 7 days
r_rec	Number of Round Trips Generated for Social and Recreational Trip Purposes over the last 7 days
a_bike	Uses bicycle to access public transit
a_walk	Walks to access public transit
a_pr	Uses park & ride to access public transit
a_car	Uses a drop off by car to access public transit
	Value Labels for Public Transit Access
	0 No
	1 Yes

Appendix 1.6: Vehicle Information

Field	Description
respid	Respondent ID
cv1	First current vehicle
cv2	Second current vehicle
cv3	Third current vehicle
cv4	Fourth current vehicle
_make	Vehicle Manufacturer
_type	Vehicle Model
_year	Year vehicle was manufactured
_nu	New or Used Vehicle
	1 New
	2 Used
_own	Purchased or Leased Vehicle
	1 Purchased
	2 Leased
_py	Year of vehicle purchase
_cost	Vehicle Purchase Price (incl. HST)
pv1	First previous vehicle

Field	Description
pv2	Second previous vehicle
pv3	Third previous vehicle
pv4	Fourth previous vehicle
_make	Vehicle Manufacturer
_type	Vehicle Model
_year	Year vehicle was manufactured
_nu	New or Used Vehicle
	1 New
	2 Used
_py	Year of vehicle purchase
_cost	Vehicle Purchase Price (incl. HST)
_dy	Year of vehicle disposal
_disp	Method of vehicle disposal
	1 Sold
	2 Lease Expired
	3 Traded
	4 Expired
gas_alt	Price of gas which would cause alternate mode consideration
	1 $1.50 / L
	2 $2.00 / L
	3 $2.50 / L
	4 $3.00 / L
	5 $3.50 / L
	6 $4.00 / L
st_bus	Short Term – Ride the Bus more often
st_act	Short Term – Walk or Bike more often
st_carpl	Short Term – Carpool more often
st_revkt	Short Term – Make fewer trips
st_dest	Short Term – Choose closer destinations
st_cuts	Short Term – Cut spending elsewhere
st_nochg	Short Term – Make no Change
lt_fueff	Long Term – Purchase a more fuel efficient vehicle
lt_clwrk	Long Term – Move closer to work
lt_cldt	Long Term – Move closer to common destinations
lt_cltrn	Long Term – Move closer to transit stops
lt_chemp	Long Term – Change place of employment
lt_trpas	Long Term – Purchase a monthly transit pass
lt_nochg	Long Term – Make no change
fu_vehic	Future vehicle purchase given rise in fuel costs

Field	Description	
	1	Regular gasoline vehicle
	2	Diesel powered vehicle
	3	Hybrid electric vehicle (HEV) (i.e. Toyota Prius)
	4	Plug-in hybrid electric vehicle (PHEV) (i.e. Chevrolet Volt)
	5	Plug-in electric vehicle (PEV) (i.e. Nissan Leaf)

Appendix 1.7: Lifestyle Choice Preferences

Field	Description
respid	Respondent ID
enjybike	I enjoy riding a bicycle
wlk2drv	I prefer walking to driving whenever possible
trnsessl	I consider transit an essential service
bus_conv	I would take the bus more often if it were convenient
embrtns	I feel embarrassed taking public transit
carshare	I feel that joining a carshare program would allow me to reduce my need for owning a vehicle
pridecar	I take pride in owning a car
drivfree	Driving provides me with freedom
trlwaste	Travel time is generally wasted time
emppark	Workplaces should provide free parking to all employees
emptrnsp	Employers should subsidize monthly transit passes
trns_drv	I feel less stressed when taking transit than when driving
morehwys	More highways are required to reduce traffic congestion
inner	I love to live in the inner city
vehfamrq	Owning a vehicle is necessary when you have a family
sububrfm	A suburban environment offers the best quality of life for families
childyrd	It is important for children to have a backyard to play in
goodcomm	I am fully satisfied with my commute
strscomm	My commute makes me feel stressed
trancomm	My commute offers a good transition between home and work
walk_ex	I consider walking as part of my daily exercise
transenjy	Taking good transit is an enjoyable experience
happyrlc	I am happy with where I live
globwarm	I consider global warming a major concern
driv_air	I limit my driving because its bad for air quality
hhldfine	Households should be fined if their greenhouse gas emissions exceed a set daily limit

Field	Description
hhldtaxc	Households that generate less greenhouse gas emissions should get a tax credit
proxshop	Proximity to shops/services is important to me
apt_priv	Living in a multiple family unit does not provide enough privacy
invest_tm	I invest a lot of time into the community where I live
hs_swalk	I like houses being set close to the sidewalk because it allows for increased interaction with neighbours
res_den	Increasing residential density is good city planning
Value Labels for all fields	
	1 Agree
	2 Disagree
	3 Unsure

Appendix 1.8: Wave

Field	Description
RespID	Respondent ID
Wave	Completed survey collected in Wave 1 or Wave 2
	1 Wave 1
	2 Wave 2

Appendix 1.9: Home to Work Distance

Field	Description
RespID	Respondent ID
CurrWork_dist	Distance from current home to current workplace

Appendix 1.10: Closest Bus Stop

Field	Description
RespID	Respondent ID
Busstop_Loc	Bus Stop Location
Busstop_dist	Distance from current home to closest Bus Stop

Appendix 2: EPOI Classification

SIC CODE	DESCRIPTION	TOTAL PTS.
53	**General Merchandise Stores**	**229**
5311	Department Stores	229
54	**Food Stores**	**1040**
5411	Grocery Stores	719
5421	Meat and Fish Markets	95
5431	Fruit and Vegetable Markets	71
5451	Dairy Products Stores	22
5461	Retail Bakeries	133
56	**Apparel and Accessory Stores**	**406**
5611	Men's and Boys' Clothing and Furnishings	29
5621	Women's Clothing Stores	136
5632	Women's Accessory and Specialty Stores	69
5641	Children's and Infants' Wear Stores	47
5651	Family Clothing Stores	48
5661	Shoe Stores	77
58	**Eating and Drinking Places**	**2220**
5812	Eating Places	2063
5813	Drinking Places	157
59	**Miscellaneous Retail**	**1270**
5912	Drug Stores and Proprietary Stores	285
5921	Liquor Stores	126
5932	Used Merchandise Stores	293
5941	Sporting Goods and Bicycle Shops	159
5942	Book Stores	80
5944	Jewelry Stores	107
5945	Hobby Toy and Game Shops	87
5992	Florists	107
5993	Tobacco Stores and Stands	26
60	**Depository Institutions**	**318**
6021	National Commercial Banks	318
70	**Hotels, Rooming Houses, Camps and Other Lodging Places**	**33**
7032	Sporting and Recreational Camps	33
72	**Personal Services**	**1109**
7231	Beauty Shops	997
7241	Barber Shops	112
78	**Motion Pictures**	**147**
7832-33	Motion Picture Theatres	25
7841	Video Tape Rental	122
79	**Amusement and Recreation Services**	**460**
7933	Bowling Centres	30
7991	Physical Fitness Facilities	285
7992	Public Golf Courses	145
80	**Health Services**	**2142**
8011	Offices and Clinics of Physicians	1097

SIC CODE	DESCRIPTION	TOTAL PTS.
8021	Offices and Clinics of Dentists	542
8041	Offices of Chiropractors	132
8042	Offices of Optometrists	117
8062	General Medical and Surgical Hospitals	168
8082	Home Health Care Services	86
82	**Educational Services**	**948**
By Level	Adult Education	14
	Early Childhood	278
	Elementary	311
	Junior High	160
	High School	67
	University and College	22
8231	Libraries	96
83	**Social Services**	**242**
8351	Child Day Care Services	242
84	**Museums, Art Galleries, and Botanical and Zoological Gardens**	**260**
8412	Museums and Art Galleries	358
8422	Botanical and Zoological Gardens	2
92	**Justice, Public Order, and Safety**	**247**
9221	Police Protection	145
9224	Fire Protection	129

Appendix 3: Distance Segments Produced using Service Area Tool in ArcMap

Walking Distance Segments*	Biking Distance Segments**	Driving Distance Segments***	Scores
200m	375m	2500m	8
400m	750m	5000m	7
600m	1500m	10000m	6
800m	3000m	15000m	5
1000m	4500m	20000m	4
1200m	6000m	30000m	3
1600m	7500m	40000m	2
2400m	9000m	50000m	1
>2400m	>9000m	>50000m	0

*These distance thresholds are offered for selection in the **first** set of questions from the expert consultation survey.
** These distance thresholds are offered for selection in the **second** set of questions from the expert consultation survey.
*** These distance thresholds are offered for selection in the **third** set of questions from the expert consultation survey.

Appendix 4: Expert Consultation Survey – Accessibility to Services

Dear Survey Respondent:

Graduate researchers at Dalhousie University's Transportation Collaboratory (DalTRAC) are conducting an expert consultation survey as part of their Masters of Planning Studies research. The main purpose of this research is to characterize travel behaviour and accessibility in Nova Scotia. The information collected will provide insight in measuring accessibility in Nova Scotia, which will assist planners and policy makers better understand transportation and land use needs in Nova Scotia.

Survey Instructions:

This survey will take approximately 20 minutes to complete. In this study, accessibility is determined by the travel distance between any point of origin to a service destination in Nova Scotia, by a particular travel mode. This survey consists of three questions that ask you to select walking, biking, and driving distances (between any point of origin and a particular service destination) that you think characterizes a point of origin as having a very high accessibility, high accessibility, moderate accessibility, low accessibility, or poor accessibility rank.

The quality of this survey depends highly on the number of respondents. It is, therefore, extremely important that we receive a response from each person contacted. However, you may withdraw from participating at any point of the survey. Individual responses are confidential and will be used to produce statistical summaries by DalTRAC researchers only. This survey does not collect any personal information and is entirely anonymous.

Thank you for your participation in this survey.

Sincerely,
Stephanie Salloum
Masters in Planning Studies (Candidate)
Dalhousie University
School of Planning
st318884@dal.ca

1. **In your expert opinion, how would you characterize a point of origin as having Very High Accessibility, High Accessibility, Moderate Accessibility, Low Accessibility, and Poor Accessibility, based on <u>walking distance</u> between the point of origin and the following service destinations?**

   For example, if you think a point of origin with Very High Accessibility to Food Shopping by walking should be approximately 200m from a grocery store, you should select 200m for Very High Accessibility to Food Shopping. If you think a point of origin with Moderate Accessibility to Food Shopping by walking should be approximately 1200m from a grocery store, you should select 1200m for Moderate Accessibility to Food Shopping.

   You should select a distance for each rank of accessibility for all service destinations. The following questions only differ by travel mode.

	Very High Accessibility	High Accessibility	Moderate Accessibility	Low Accessibility	Poor Accessibility
Food Store Destinations	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾
General Shopping Destinations	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾
Government Services (e.g. Protective Services)	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾
Personal Services (e.g. Bank, Hair Salon)	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾
Amusement and Recreation Destinations (e.g. Park, Cinema, Zoo)	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾
Eating and Drinking Places (e.g. Restaurant, Cafe, Bar)	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾
Health Services (e.g. Family Physician)	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾
Schools	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾
Child Day Cares	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾	Walking Distance ▾

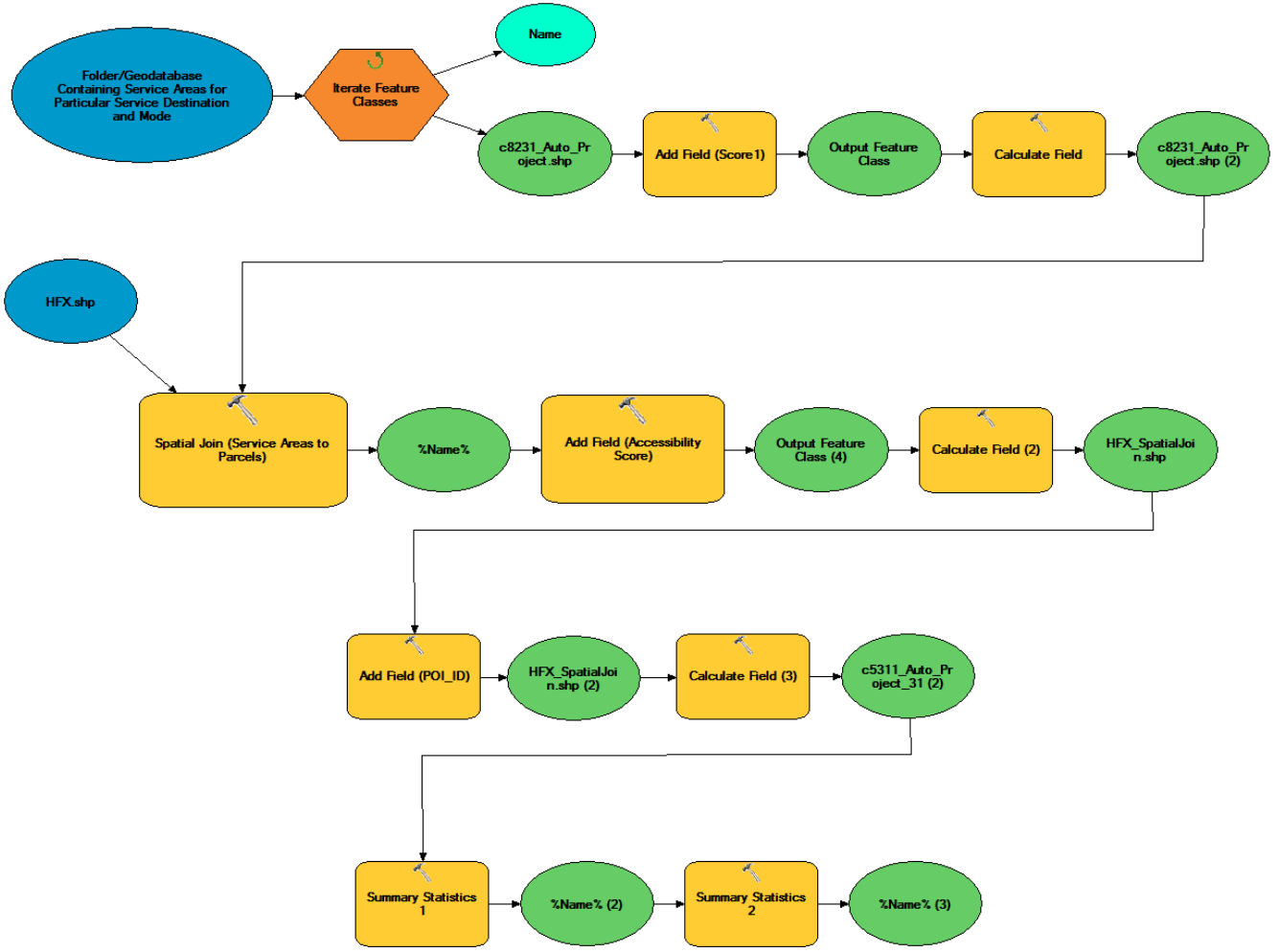
2. In your expert opinion, how would you characterize a point of origin as having Very High Accessibility, High Accessibility, Moderate Accessibility, Low Accessibility, and Poor Accessibility, based on <u>biking distance</u> between the point of origin and the following service destinations?

	Very High Accessibility	High Accessibility	Moderate Accessibility	Low Accessibility	Poor Accessibility
Food Store Destinations	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾
General Shopping Destinations	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾
Government Services (e.g. Protective Services)	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾
Personal Services (e.g. Bank, Hair Salon)	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾
Amusement and Recreation Destinations (e.g. Park, Cinema, Zoo)	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾
Eating and Drinking Places (e.g. Restaurant, Cafe, Bar)	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾
Health Services (e.g. Family Physician)	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾
Schools	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾
Child Day Cares	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾	Biking Distance ▾

3. **In your expert opinion, how would you characterize a point of origin as having Very High Accessibility, High Accessibility, Moderate Accessibility, Low Accessibility, and Poor Accessibility, based on <u>driving distance</u> between the point of origin and the following service destinations?**

	Very High Accessibility	High Accessibility	Moderate Accessibility	Low Accessibility	Poor Accessibility
Food Store Destinations	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾
General Shopping Destinations	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾
Government Services (e.g. Protective Services)	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾
Personal Services (e.g. Bank, Hair Salon)	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾
Amusement and Recreation Destinations (e.g. Park, Cinema, Zoo)	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾
Eating and Drinking Places (e.g. Restaurant, Cafe, Bar)	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾
Health Services (e.g. Family Physician)	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾
Schools	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾
Child Day Cares	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾
Automobile Service Stations	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾	Driving Distance ▾

Appendix 5: CNAM GIS Model



Appendix 6: Accessibility by Type of Service Destination and Travel Mode

Halifax Sub-Region		Halifax			Regional Centre			Suburban Areas			Rural Commutershed		
Destination Type	**Mode**	**Average**	**St. Dev**	**Maximum**	**Average**	**St. Dev**	**Maximum**	**Average**	**St. Dev**	**Maximum**	**Average**	**St. Dev**	**Maximum**
Child Day Cares	Driving	306.43	173.86	520	490.53	39.13	520	399.56	68.98	500	111.93	110.96	434
	Biking	12.58	22.97	124	58.57	26.27	124	8.17	10.32	60	0.18	0.79	11
	Walking	2.52	5.84	78	11.21	10.62	78	1.77	2.86	19	0.07	0.55	10
Restaurants	Driving	2055.22	1488.51	5820	4078.47	422.00	4462	2677.27	810.08	5820	442.81	580.94	3561
	Biking	204.64	459.72	2287	1130.85	604.22	2287	80.68	143.15	1230	1.08	3.31	39
	Walking	27.48	104.20	1636	156.67	231.53	1636	9.24	17.82	146	0.34	1.90	37
Schools	Driving	452.88	291.20	907	813.61	77.78	907	594.79	131.88	823	124.85	136.82	659
	Biking	43.77	70.69	312	175.80	79.91	312	36.84	40.84	191	0.72	2.26	29
	Walking	11.21	20.58	156	45.20	32.69	156	9.27	10.40	64	0.33	1.48	30
Food Shopping	Driving	409.82	279.46	918	797.64	90.80	918	525.13	131.96	918	105.89	126.06	635
	Biking	36.62	79.12	411	192.97	100.60	411	17.22	33.38	220	0.28	1.22	15
	Walking	11.87	32.10	313	65.26	58.13	313	4.69	9.58	89	0.17	1.04	18
Government Services	Driving	241.39	128.78	428	393.42	32.86	428	303.05	51.22	401	100.72	84.15	345
	Biking	19.76	41.47	188	105.50	46.99	188	8.67	16.07	109	0.41	1.24	15
	Walking	4.95	15.02	121	29.60	28.43	121	1.14	2.54	21	0.21	1.04	15
General Shopping	Driving	1748.38	1170.31	3615	3311.96	316.06	3615	2227.38	682.65	3446	504.55	490.22	2839
	Biking	167.97	378.25	1880	942.44	476.77	1880	62.04	115.53	1021	0.73	2.51	38
	Walking	41.29	130.97	1482	244.38	260.46	1482	11.27	18.28	163	0.38	1.70	33
Health Services	Driving	2075.94	1512.92	5179	4107.65	404.38	4425	2715.55	846.56	5179	437.21	577.99	3566
	Biking	220.81	506.20	2416	1233.05	676.89	2416	83.45	161.21	1406	0.79	2.79	60
	Walking	60.18	193.25	1840	352.65	389.50	1840	17.61	31.64	259	0.39	2.03	60
Personal Services	Driving	1133.41	740.55	2388	2114.79	192.17	2285	1445.60	414.52	2388	337.62	319.20	1821
	Biking	106.85	225.93	1066	554.82	289.07	1066	52.99	90.07	663	0.43	1.79	25
	Walking	26.73	74.08	819	141.94	142.27	819	12.20	21.79	168	0.24	1.32	25
Recreation Destinations	Driving	659.65	369.60	1123	1059.30	84.14	1123	854.53	148.77	1084	246.98	233.30	933
	Biking	48.29	95.40	467	240.38	114.15	467	26.83	39.05	271	0.53	1.93	32
	Walking	11.57	35.55	387	60.93	74.47	387	5.37	7.96	54	0.20	1.16	34

Appendix 7: Summary Statistics of Accessibility Scores by Type of EPOI

Halifax Sub-region		Halifax			Regional Centre			Suburban Areas			Rural Commutershed		
Destination Type	EPOI Type	Average	St. Dev	Max	Average	St. Dev	Max	Average	St. Dev	Max	Average	St. Dev	Max
Health Services	Offices and Clinics of Physicians	1222.11	1044.95	4552	3023.43	688.16	4552	1442.88	503.31	3111	222.15	296.72	1856
	Offices and Clinics of Dentists	656.17	530.40	2274	1530.77	317.97	2274	797.75	253.53	1641	125.67	163.40	979
	Offices of Chiropractors	155.34	121.39	471	340.81	69.39	471	194.69	62.62	377	30.64	40.48	232
	Offices of Optometrists	132.41	109.14	518	316.17	64.96	518	158.48	53.84	312	25.76	33.76	207
	General Medical and Surgical Hospitals	107.74	100.47	508	286.33	85.42	508	122.02	47.53	292	18.55	25.13	169
	Home Health Care Services	83.16	68.48	287	195.85	39.54	287	100.78	35.27	210	15.62	21.18	123
Schools	Libraries	53.44	46.21	240	139.37	34.59	240	59.24	17.62	118	11.94	14.50	72
	Adult Education	0.12	0.46	5	0.00	0.00	0	0.11	0.35	2	0.18	0.63	5
	Elementary Schools	146.43	98.08	332	276.47	33.41	332	189.74	49.21	298	38.46	40.09	203
	Early Childhood Education	135.71	91.70	314	257.24	32.63	314	176.13	45.74	268	34.85	37.79	192
	High Schools	69.05	48.96	197	143.20	25.76	197	86.36	21.81	142	17.15	18.39	93
	Junior High Schools	86.81	60.90	216	172.92	25.98	216	111.72	28.16	174	20.23	23.44	114
	Universities and Colleges	16.29	15.73	73	45.43	14.80	73	17.60	6.15	44	3.09	4.55	23
Food Stores	Grocery Stores	288.59	197.03	750	562.93	65.28	646	368.58	95.21	750	75.65	89.19	451
	Meat and Fish Markets	29.23	21.86	106	63.36	11.66	106	36.11	10.48	70	6.76	8.22	42
	Fruit and Vegetable Markets	19.23	13.09	54	36.52	5.38	54	25.02	6.08	47	4.82	5.81	27
	Dairy Products Stores	6.71	4.70	35	10.04	1.19	15	9.44	3.43	35	1.82	2.37	15
	Retail Bakeries	77.70	63.84	337	190.12	45.90	337	90.24	25.14	178	16.93	21.64	108
General Shopping	Department Stores	154.99	114.36	519	342.91	59.65	519	184.48	58.83	345	42.22	40.23	223
	Men's and Boys' Clothing and Furnishings	45.53	36.37	165	108.33	20.43	165	52.92	18.92	115	11.07	11.21	63
	Women's Clothing Stores	185.04	143.07	668	427.22	81.13	668	217.60	72.54	456	46.83	46.85	274
	Women's Accessory and Specialty Stores	89.01	69.17	334	207.62	39.97	334	104.08	34.09	197	22.47	22.38	127
	Children's and Infants' Wear Stores	63.99	49.14	207	147.72	23.58	207	75.50	24.80	154	15.88	15.72	84
	Family Clothing Stores	58.52	47.15	212	139.80	26.94	212	67.84	25.21	158	14.23	14.34	85
	Shoe Stores	92.37	74.36	356	222.12	43.01	356	106.75	37.91	232	22.33	22.64	134

Halifax Sub-region		Halifax			Regional Centre			Suburban Areas			Rural Commutershed		
Destination Type	**EPOI Type**	**Average**	**St. Dev**	**Max**	**Average**	**St. Dev**	**Max**	**Average**	**St. Dev**	**Max**	**Average**	**St. Dev**	**Max**
	Drug Stores and Proprietary Stores	297.61	229.49	926	643.82	166.19	926	363.85	129.80	715	74.28	80.35	449
	Liquor Stores	104.06	79.42	392	239.45	53.56	392	120.66	39.11	244	28.91	25.91	150
	Used Merchandise Stores	238.17	179.23	769	546.20	103.08	769	278.08	83.68	520	64.34	60.85	329
	Sporting Goods and Bicycle Shops	181.09	133.12	568	395.59	70.79	568	217.74	68.75	398	48.48	47.18	278
	Book Stores	85.16	67.53	313	201.59	40.59	313	98.54	34.85	198	21.70	21.74	129
	Jewelry Stores	158.00	134.52	695	398.85	97.45	695	177.39	66.50	417	37.53	38.34	231
	Hobby Toy and Game Shops	50.64	36.49	154	111.10	19.38	154	58.87	19.71	116	15.99	14.46	74
	Florists	119.01	93.08	426	282.16	59.32	426	137.04	43.89	280	31.02	28.84	172
	Tobacco Stores and Stands	34.45	28.03	162	84.29	22.24	162	39.35	11.21	81	8.37	8.44	48
Child Day Cares	**Child Day Cares**	321.52	190.18	717	560.31	59.32	717	409.50	75.84	567	112.18	111.25	434
Personal Services	**National Commercial Banks**	270.13	206.04	929	616.36	120.80	929	318.70	103.74	671	69.90	66.34	387
	Beauty Shops	866.61	636.97	2689	1896.55	340.83	2689	1038.69	333.06	1991	234.89	221.34	1254
	Barber Shops	130.25	98.53	453	298.65	59.02	453	153.39	44.54	288	33.50	31.81	180
Recreation Destinations	**Sporting and Recreational Camps**	13.22	8.30	50	26.86	6.69	50	14.96	3.56	27	5.54	3.96	18
	Motion Picture Theatres	27.14	16.32	72	46.35	5.23	61	34.98	7.25	72	9.30	9.78	41
	Video Tape Rental	154.88	93.07	326	270.84	33.37	326	198.36	38.69	296	52.22	51.89	200
	Bowling Centres	19.31	11.74	47	33.02	3.64	43	25.13	5.19	47	6.28	6.63	30
	Physical Fitness Facilities	285.31	178.24	814	544.64	93.05	814	350.91	68.55	549	97.13	93.33	368
	Public Golf Courses	49.25	26.26	100	81.69	7.83	100	60.97	11.41	93	21.11	16.78	80
	Museums and Art Galleries	170.42	114.85	567	357.22	75.71	567	201.42	43.00	354	56.13	53.59	226
	Botanical and Zoological Gardens	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Government Services	**Police Protection**	163.03	115.42	529	361.10	82.60	529	186.47	42.70	362	54.19	53.62	210
	Fire Protection	103.07	51.57	218	167.42	17.46	218	126.40	20.72	180	47.15	32.11	145
Restaurants	**Eating Places**	2121.18	1706.26	7464	4952.69	925.09	7464	2569.99	830.36	5614	416.21	541.21	3328
	Drinking Places	166.17	143.35	742	413.30	91.69	742	197.19	68.36	408	28.03	40.62	251