Infrastructure Canada

RESEARCH SHOWCASE CATALOGUE

Research & Innovation Symposium

Exploring Innovations in Housing and Public infrastructure

2024

Event website
Online & In-person
Place du Portage Phase IV,
140 Promenade du
Portage, Gatineau, QC

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Open Data for Infrastructure Decision-making & Community Engagement

*The Research and Knowledge Initiative (RKI) is a national merit-based contributions funding program from Infrastructure Canada that funds projects focused on key Government of Canada research and data priorities related to housing, infrastructure and communities.

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CLIMATE RESILIENCE

Protecting Nova Scotia's People and Infrastructure through Improved Climate Data for Flood Mapping

Robust flood line mapping is necessary to inform decisions regarding public infrastructure investments and to support climate resilience. This project will build on Nova Scotia's mapping of flood lines by including locally specific data and using climate forecasting to support climate resilience across sectors affected by flooding. The project duration is February 2023 – March 2025.

The primary goal of the project is to identify historical and potential future flooding mechanisms relevant to the diverse watersheds and river systems across Nova Scotia. To accomplish this, we are conducting high resolution climate modeling that will be used to characterize spatial variability in projected extreme precipitation events caused by climate change.

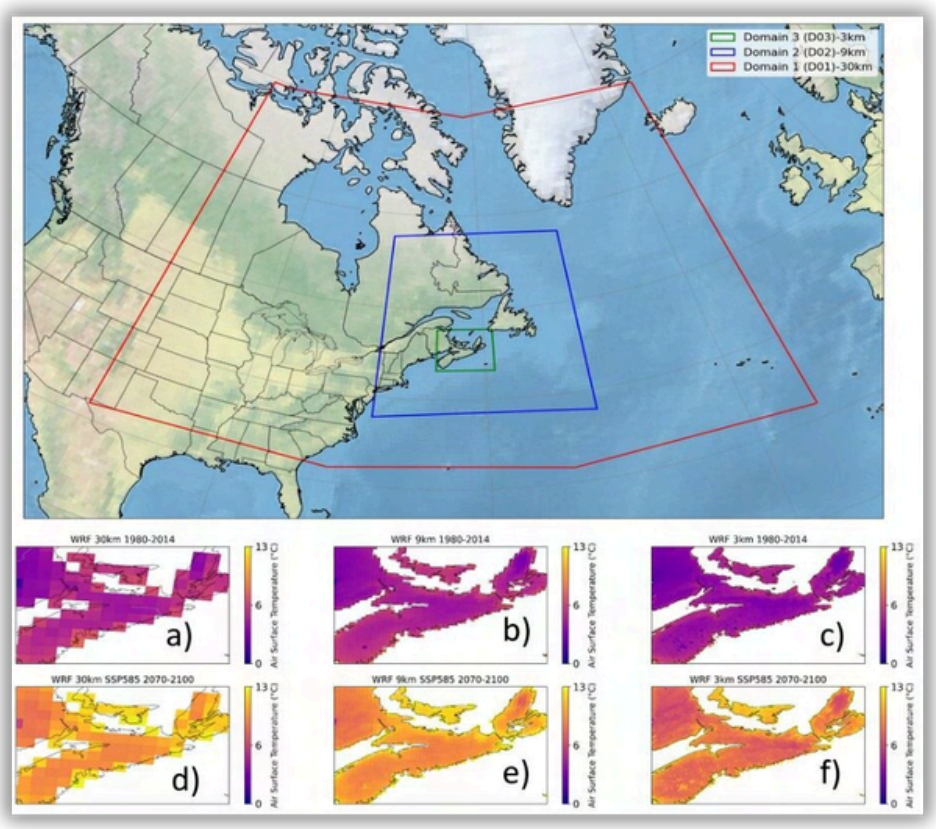

Fig. 1. Top panel: WRF downscaling domain for Atlantic Canada. Bottom panel: Surface air temperature spatial variability at different resolutions. Figures (a), (b) and (c) show WRF historical simulations while (d), (e) and (f) show long-term projections (2070-2100) under the SSP585

The model results will be used to develop recommendations for future design storms that should be used in flood line mapping. Field monitoring, data mining and process-based modeling is also helping us understand the likelihood of encountering different climate and watershed conditions that exacerbate flooding, such as extreme rainfall events occurring on frozen soils, under present and future climate scenarios throughout Nova Scotia's subregions.

Collectively, information garnered from these studies will be used to update the Nova Scotia Municipal Flood Line Mapping Technical Guidelines. In partnership with municipalities and local engineering consulting firms, we will then test and evaluate the revised guidelines on several river systems in the Province. Finally, public communications will be developed to reduce uncertainty and foster knowledge of issues related to public infrastructure and climate threats.

Meet the Research Project Team

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Strategic Evacuation Planning and Infrastructure: Wildfire, Transportation, and Human Behaviour

We are employing a multidisciplinary approach that connects wildfire, human behaviour, and transportation modeling to understand infrastructure needs in supporting emergency travel. We are applying our approach in five different communities in western Canada: Whitecourt and Canmore in Alberta; and Quesnel, Salmon Arm, and Nelson in British Columbia.

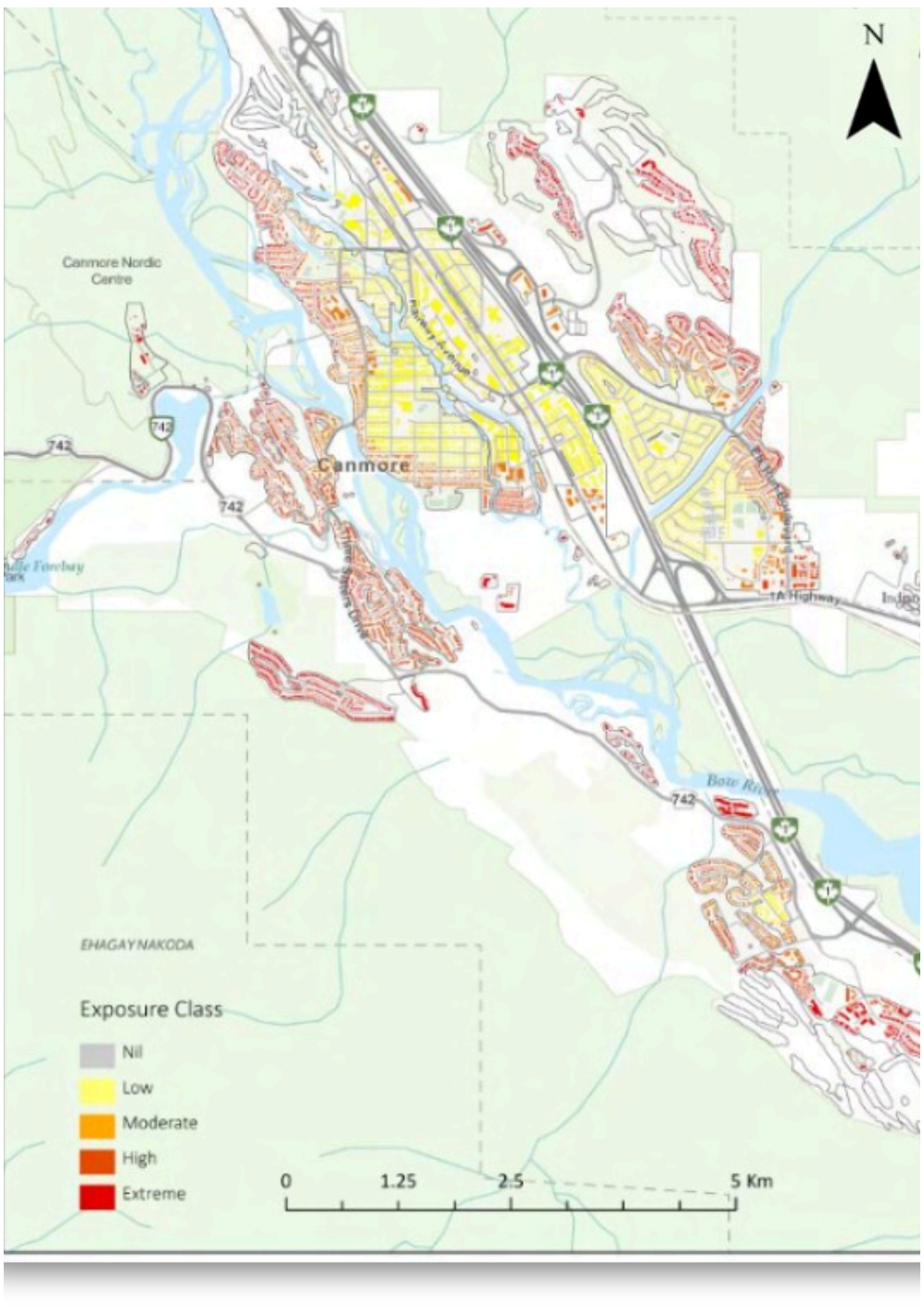

Fig. 1 An example of one of the community wildfire exposure assessments completed for Canmore, Alberta.

Our project methodology involves three core components that are being integrated together. Researchers at the Wildfire Analytics lab led by Dr. Jen Beverly have completed assessments of wildland fire exposure and directional vulnerability to wildfire in each of the five study communities and their surrounding landscapes. Focus meetings with representatives from each community have been used to review wildfire assessment results and identify possible wildfire emergency scenarios. Researchers at the RESUME GROUP led by Dr. Stephen Wong have completed community surveys to understand the potential decisions of residents during evacuations. Researchers at the Multimodal Mobility Systems Lab led by Dr. Amy Kim are integrating behavioural survey results as well as biophysical wildfire assessments into a transportation evacuation simulation modeling exercise for each of the communities.

Fig. 2. A group photo of the project team (from left to right): Jen Beverly (Associate Professor, UA), Veronica Wambura (MSc Student, UA), Ehsan Hassanzadeh (Phd Student, UBC), Nima Karimi (Postdoctoral Researcher, UA), Stephen Wong (Assistant Professor, UA), Amy Kim (Associate Professor, UA), Syeda Narmeen Zehra, (MSc Student, UA).

Together, we are assessing infrastructure exposure to wildfire, identifying how people will use the infrastructure in wildfire evacuations, and highlighting community resilience needs. Results can be leveraged by researchers and practitioners across Canada to inform evacuation and infrastructure planning. The project kicked off in September 2022 and will wrap-up in March 2025.

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Developing New Climate Hazard Data and Knowledge Mobilization Tools on Coastal Infrastructure for Professionals and Communities in Prince Edward Island

This project, led by the Province of Prince Edward Island (PEI), aims to develop new data and tools to improve understanding and awareness of climate hazards on Prince Edward Island. The project will result in updated coastal change (erosion) data, an improved understanding of coastal infrastructure vulnerability and efficacy to a changing climate, and social vulnerability mapping for flood risk on PEI.

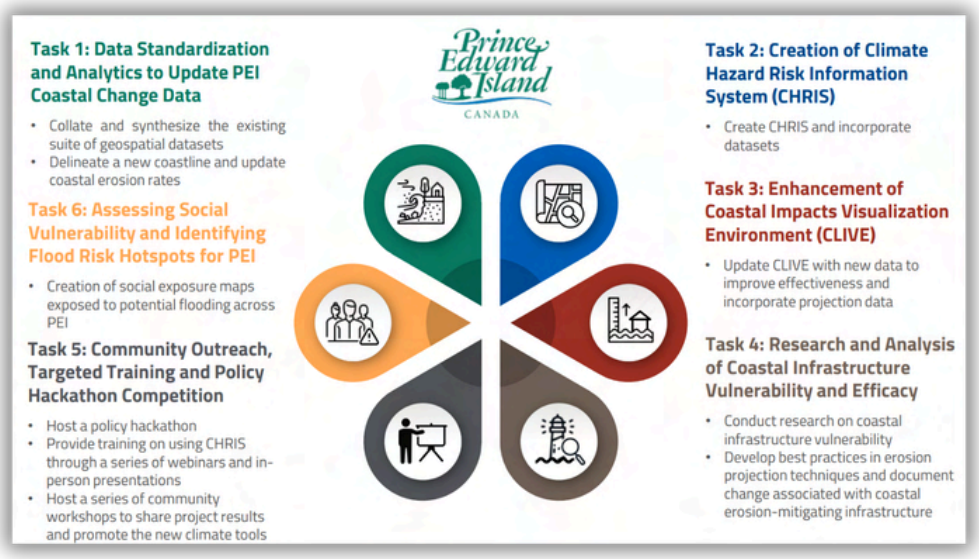

Fig. 1. Research & Knowledge Initiative tasks overview

The project involves key dissemination tools, including the interactive web mapping portal known as CHRIS (Climate Hazard & Risk Information System), which provides PEI-wide flood hazard mapping and coastal erosion data, an immersive tool to visualize sea level rise in at-risk areas known as CLIVE (CoastaL Impact Visualization Environment) allowing users to "fly" around PEI and toggle different sea level rise scenarios, and community outreach, targeted trainings, and a policy hackathon competition surrounding the theme of climate adaptation.

The project was initiated in June 2022 and is forecasted to be complete by September 2024.

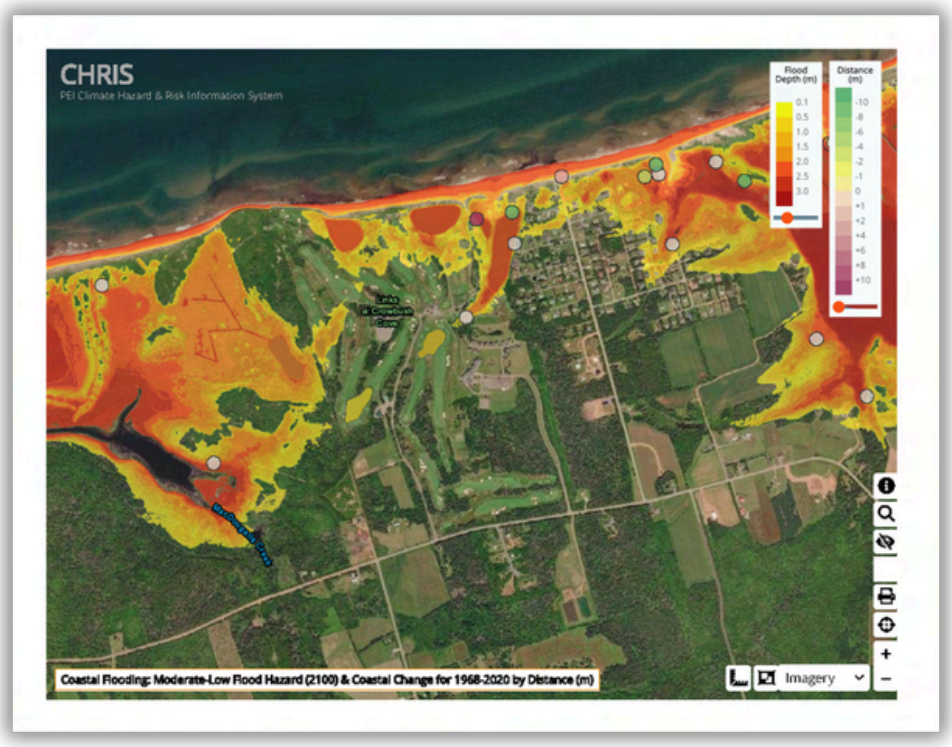

Fig. 2. Screenshot of the Climate Hazard & Risk Information System (CHRIS)

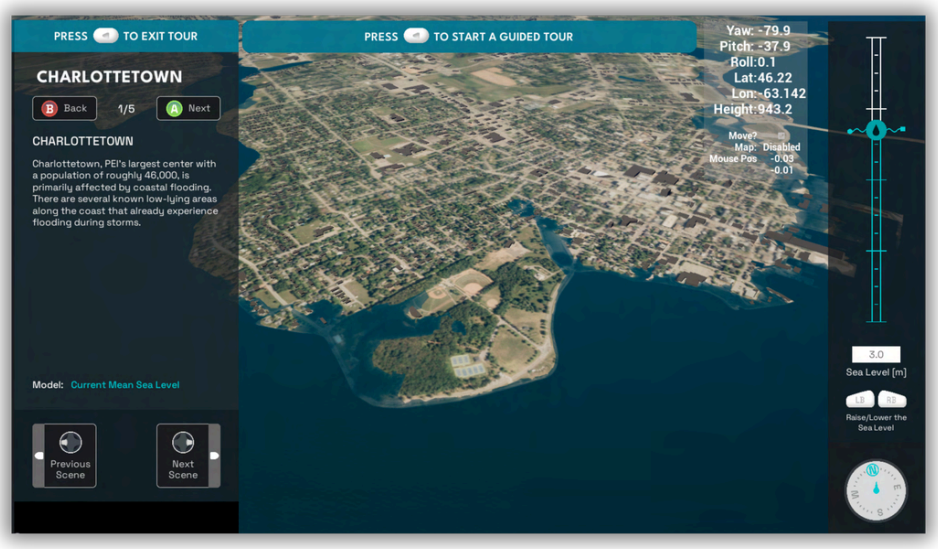

Fig. 3. Screenshot of the CoastaL Impact Visualization Environment (ClIVE)

For more information on CHRIS visit PEI's dedicated website here.

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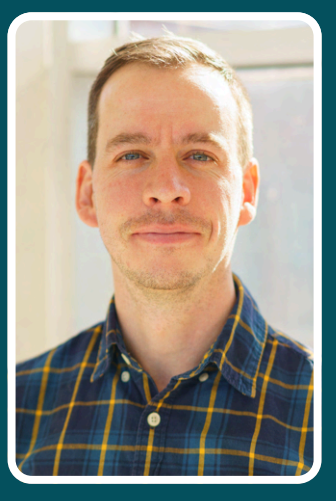

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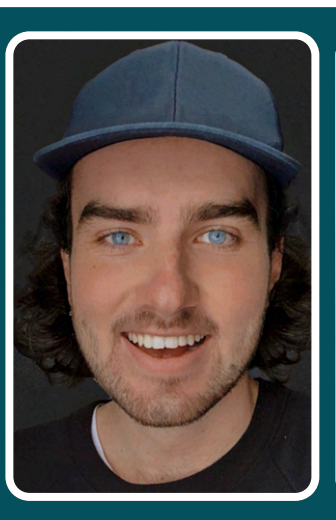

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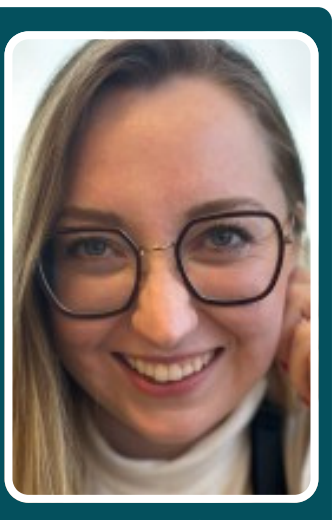

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Supporting Climate Risk Mitigation for Municipalities with Nature-Based and Natural Infrastructure

New Brunswick Environmental Network
Réseau environnemental du Nouveau Brunswick

The "Supporting climate risk mitigation for municipalities with nature-based and natural infrastructure" project was designed to help build the capacity of municipalities in New Brunswick to implement nature-based climate solutions in their efforts to adapt to and mitigate the impacts of climate change.

In this project, we conducted engagement sessions with municipal staff and elected officials, as well as local NGOs to understand what barriers they faced in the implementation of nature-based solutions. We also polled residents of NB to understand the public perception and opinion of nature-based approaches and current actions to adapt to climate change. The engagement sessions and polling presented a positive outlook for the implementation of nature-based solutions in NB, however, municipalities and NGOs found that there was a lack of information and resources on the costs and monetary benefits of nature-based solutions.

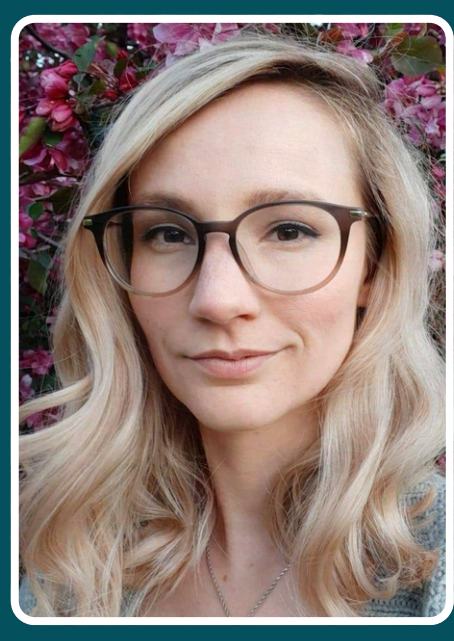
Learn more about the **New Brunswick Environmental Network's work** on their website and **access their benefit-cost analysis tool.**

The major research product of this project was the development of a benefit-cost analysis tool for nature-based climate solutions that provides users with cost and monetary value estimates for the construction, operation, and administration of living shoreline and naturalized stormwater retention pond approaches. In addition to the development of the tool, we provided multiple in-person and online training sessions on completing benefit-cost analyses for municipalities and NGOs. This project took place from June 2022 - March, 2024.

Through the training sessions, one-on-one guidance and mentoring, and presentations to councils, conferences, and professional organizations, this project promoted the implementation of nature-based climate solutions in NB. The tool was well received and viewed by municipalities and NGOs as critical to developing the case for nature-based solutions in their communities. Many groups and practitioners explained that they faced challenges in finding cost estimates and monetary valuations for benefits for nature-based climate solutions and that this benefit-cost analysis tool will play a critical role in filling that gap.

Although this tool was initially developed for New Brunswick, we have built relationships and partnerships with other communities and organizations across all four Atlantic Canada provinces, and hope to expand the tool to the other provinces in the near future. We also intend to expand the scope of the tool to incorporate nature-based solutions to impacts of climate change beyond flooding. This project was successful in furthering the discussion on and implementation of nature-based solutions in NB, and we, at the NBEN, intend to continue to support communities in building their capacity to adapt to and mitigate climate change.

Meet the Research Project Team



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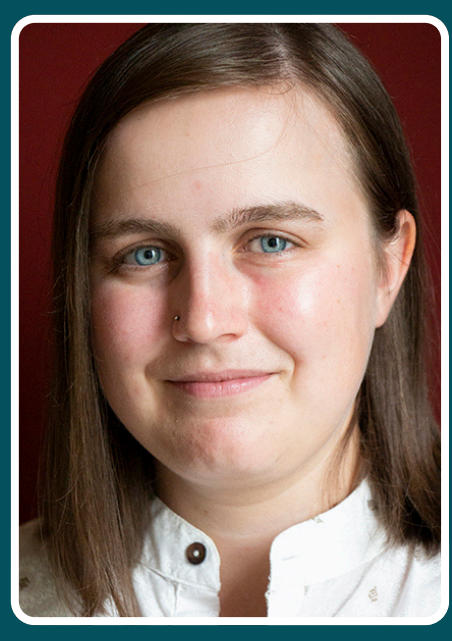

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Nunamiutuqaq (Building from the Land)

PITQUHIRNIKKUT ILIHAUTINIQ
KITIKMEOT HERITAGE SOCIETY

The Kitikmeot Heritage Society is overseeing construction of an energy-efficient cultural campus in the Nunavut community of Cambridge Bay. When sharing the building's energy monitoring program with our community, multiple homeowners and builders expressed interest in having their own buildings monitored for performance and efficiency. We saw an opportunity to begin developing a valuable, and much needed database of building practices in the Arctic.

Through funding from Infrastructure Canada's Research and Knowledge Initiative, and in partnership with SAIT Green Building Technologies Access Centre (GBTAC), Cambridge Bay's Aurora Energy Solutions, and multiple community members, our project is monitoring and analyzing multiple quantitative and qualitative building performance indicators - such as indoor air quality, energy and water usage - in six residential Cambridge Bay buildings representing a range of conventional and advanced building methods. The goal of this research is to better understand the impacts of different construction, typologies and building choices in the Arctic, including building envelope; mechanical, electrical energy use and renewable energy systems; ventilation; and water use. It additionally considers the impact of extreme climate conditions in the Arctic and occupant habits in response to these changing conditions.

We are in the process of gathering a full year (March 2024-March 2025) of monitoring data to help us contrast and compare the various ways that people are actively building in the Arctic, and how each of these strategies performs, in order to make recommendations for developing more long-term and sustainable infrastructure for the Canadian Arctic.

Learn more about the Kitikmeot Heritage Society's community monitoring work **here**.

The first part of this project documented the challenges faced by building owners and dwellers, and catalogued the main issues with building performance in our community, such as high heating demand and humidity levels, issues with molding and underperforming HRV systems, to name a few. Based on this preliminary research and community engagement, our team defined metrics and parameters of building performance, researched appropriate monitoring strategies, and designed the monitoring plan.

Fig. 1. Temperature/humidity sensor on boiler and water heater exhaust stack

Various sensors were then installed in participant buildings, and our team is reviewing and analysing the data monthly to capture all four seasons of building operations. This will include research of the data points including: circuit level monitoring of electrical consumption; hot and cold water consumption, water usage characteristics and profiles; thermal transfer and moisture travel through wall assembly; HRV performance; and relative humidity in the house, venting and sewage stacks.

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The First Nations Infrastructure: Climate, Culture, and Community-based Decision-Making

The First Nations Infrastructure: Climate, Culture, and Community-based Decision-making project is an exciting partnership that brings together diverse partners and supporters to advance climate risk assessment and adaptation planning by, with, and for First Nations communities in Canada. The project is being co-led by the Pacific Institute for Climate Solutions (PICS) and Prairie Climate Centre (PCC) in partnership with the Ontario First Nations Technical Services Corporation (OFNTSC), the University of Manitoba Faculty of Architecture, and Hereditary Heiltsuk Chief Frank Brown.

Our vision is to collaboratively develop a community-level decision support tool that allows First Nations to learn from each other and to meaningfully evaluate climate risks for their built, natural, and cultural infrastructures. Community and practitioner engagements, combined with climate change data and regional climate risks, are informing the overall design of the Infrastructure risk tool within the Climate Atlas.

Fig. 1. Northwest Angle 33 Ice Road

Fig. 2. Prairie Climate Centre Team

This decision support tool will be built as a new feature within the Climate Atlas, and will link First Nations video-based stories, climate data, analysis and interpretation from the project with applied risk assessment functionality. The tool will be accompanied by plain-language reports and will allow users to download information for use in their own activities. There will also be resources that focus on relationship building and its importance in creating resilient infrastructure and provide insight into challenges and opportunities First Nations communities face in addressing the impacts of climate change.

The activities of this project began in fall of 2022 and will be completed March of 2025.

Fig. 3. Pacific Climate Centre, Pacific Institute for Climate Solutions, and Ontario First Nations Technical Services Corporation host a session at Adaptation Futures on October 4, 2023.

Keep an eye out for project updates on the **Climate Atlas website**.

Meet the Research Organizations

PICS
PACIFIC INSTITUTE FOR CLIMATE SOLUTIONS

WEBSITE

Prairie Climate Centre
From Risk to Resilience

WEBSITE

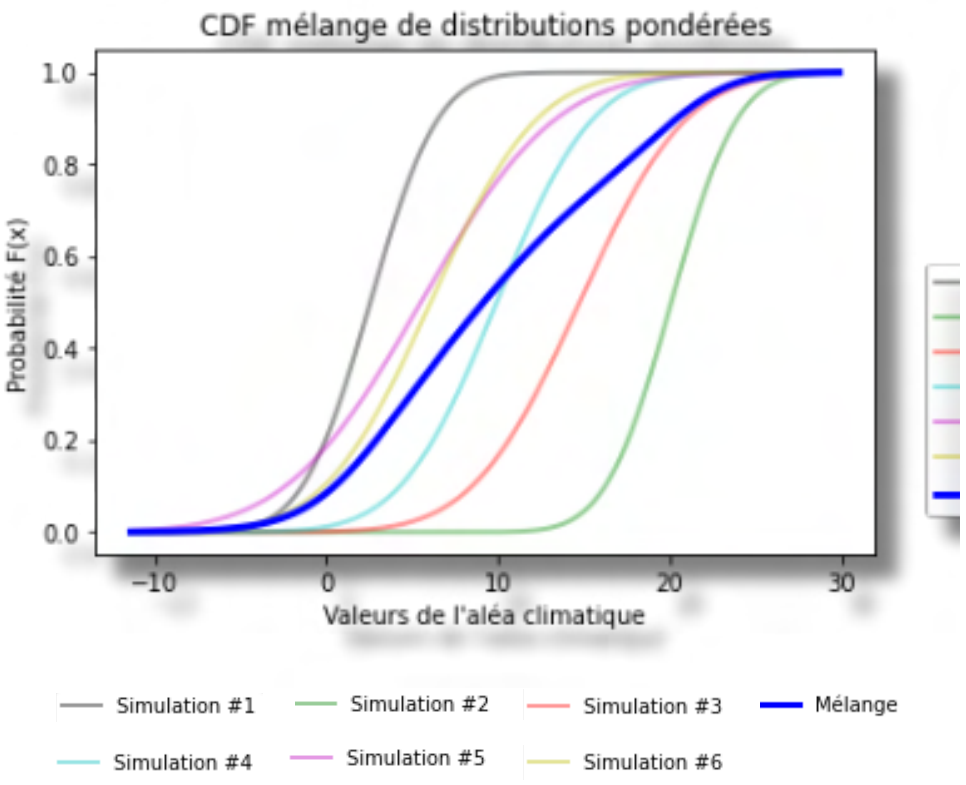
Tools to help Analyze Climate-Related Risks to Infrastructure

Ouranos

Adapting infrastructures to climate change often requires quantifying the risks associated with hazards such as extreme precipitation or heat waves. Existing guides and methodological approaches (ISO 31000; CVIIP Protocol) leave it to practitioners to carry out the climatic analyses required for their implementation. However, estimating the likely evolution of a climate hazard in the future requires advanced expertise in climate science and access to large datasets, which few organizations have.

The aim of the project is to develop tools for estimating the probability of occurrence of various infrastructure-relevant hazards influenced by climate change. The project includes the development of calculation services and a prototype to make them available online. It will also provide data sheets and examples of their application for professionals working on risk analyses. Users will be able to choose from a dozen indicators, including temperature, precipitation and sea-level hazards, and customize historical and future periods and return periods via the prototype.

To achieve these objectives, the computational services will use climate simulation data participating in CMIP6 whose bias has been adjusted to the adjusted and homogenized Canadian Climate Data stations. In order to provide users with a single future occurrence per hazard, climate uncertainty will be treated using a mixture of distributions that weight simulations according to their resemblance to observed distributions, their equilibrium climate sensitivity, and the likelihood of climate scenarios assessed from integrated probabilistic assessment model (IAM) simulations.



The project's development is overseen by an advisory committee made up of a dozen professionals working in different sectors, guaranteeing the relevance and validity of the choices made by the project team. Four workshops are scheduled for autumn 2024 to obtain feedback from potential users of the prototype.

Learn more on [Ouranos' website](#).

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TRANSIT & MOBILITY

Measuring access to opportunities through regional public transit in Quebec

POLYTECHNIQUE MONTRÉAL
UNIVERSITÉ D'INGÉNIERIE
UTACQ Union des transports adaptés et collectifs du Québec

In Quebec, regional mass transit services are essential to ensure accessibility to opportunities (shops, public services, healthcare, post-secondary education, jobs) in regions where travel distances are great and there are few alternatives to the car available. However, few data are available to measure the impact of the services put in place, either because they do not exist, or because their format does not allow for analysis.

The "Measuring access to opportunities through regional public transport in Quebec" project aims to measure the impact of regional transport services through accessibility indicators, and to answer the following research questions:

1. Given the variety of services offered, is it possible to measure access to opportunities through regional public transit?
2. To what extent do regional public transit services make it possible to reach main services and opportunities?
3. Would a concrete measure of accessibility to opportunities facilitate the planning of public transit services in the region?

In three administrative regions of Quebec, data on public transit services will be collected from organizations' websites and interviews with their managers. This data will then be transformed into GTFS (General Transit Feed Service) and used, in conjunction with open data on opportunities, to calculate accessibility indicators using rStudio's r5r library. The accessibility indicators will then be published in the form of an interactive map and presented to the public transport organizations involved in the project. This process will be carried out between January 2023 and March 2025.

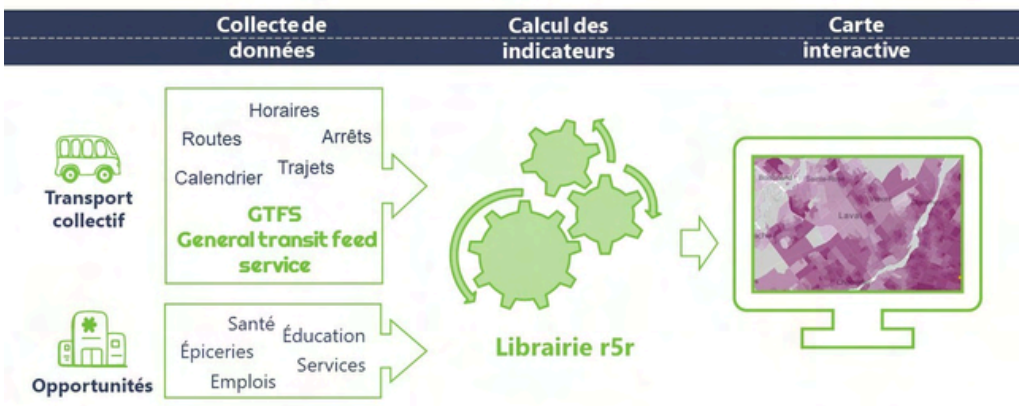

Fig. 1. Proposed methodology.

To date, data collection shows a great diversity in the types of public transit services offered, posing a challenge for the creation of GTFS that are designed to properly describe the services to be linked to the public transit network.

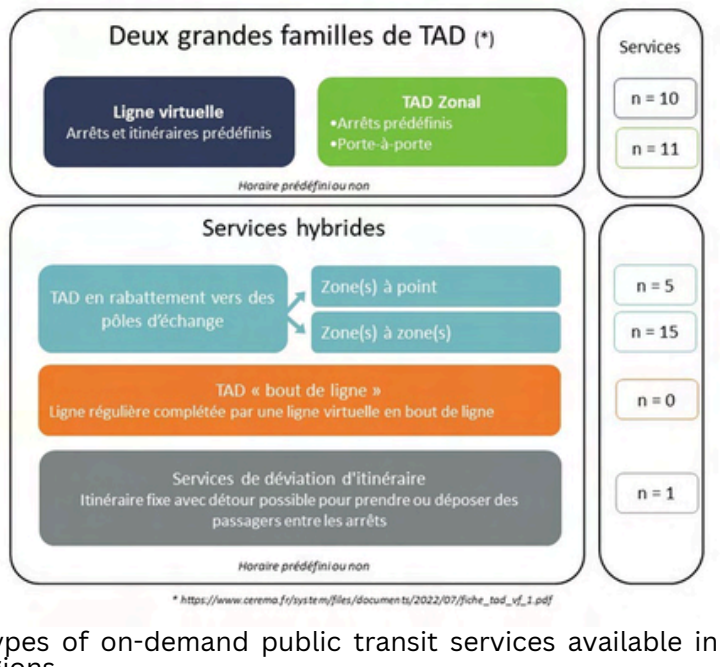

Fig. 2. Types of on-demand public transit services available in the three study regions.

Preliminary calculations of accessibility indicators in certain parts of the study area show that accessibility to food stores varies according to the public transit service offered, confirming the positive impact of public transit on accessibility and the value of this measure in planning future services.

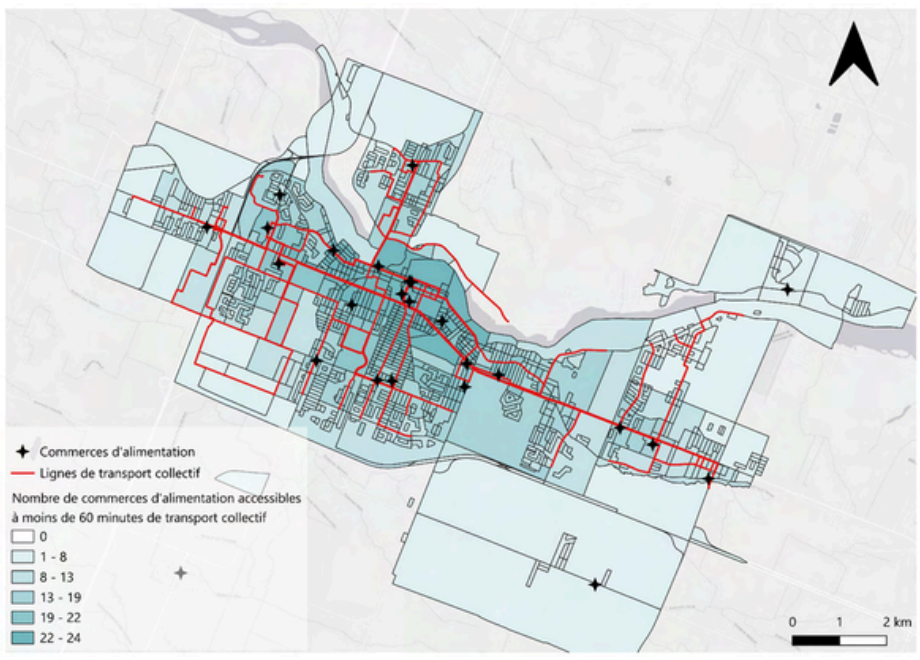

Fig. 3. Public transit access to food stores in Drummondville

The calculation of indicators for the entire study area will enable us to produce a comprehensive map, as well as tools for popularizing the concepts associated with accessibility, which will be presented to organizations responsible for service planning.

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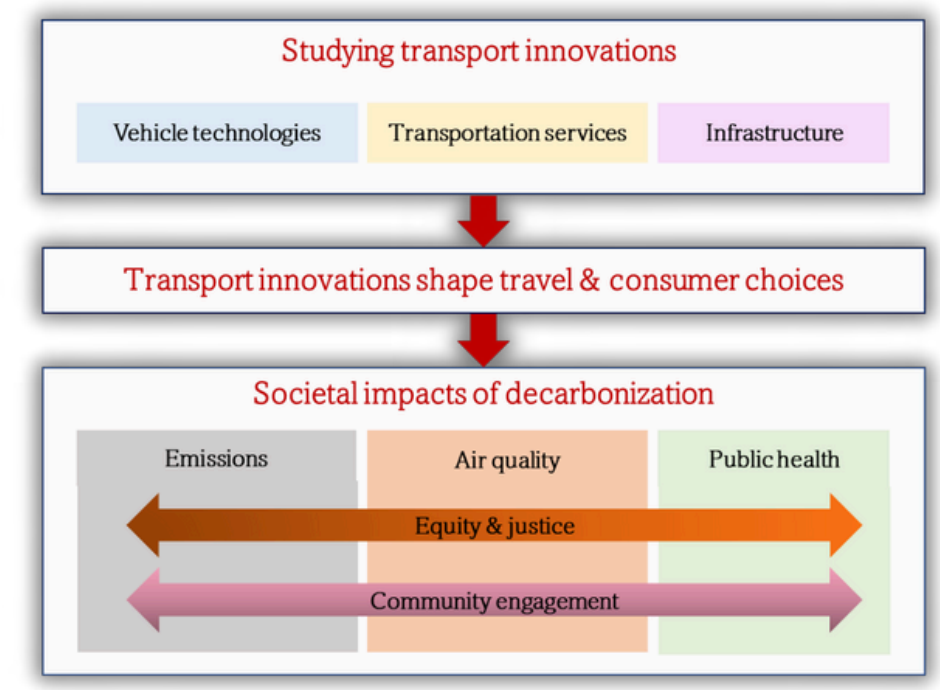
The Road to Net Zero

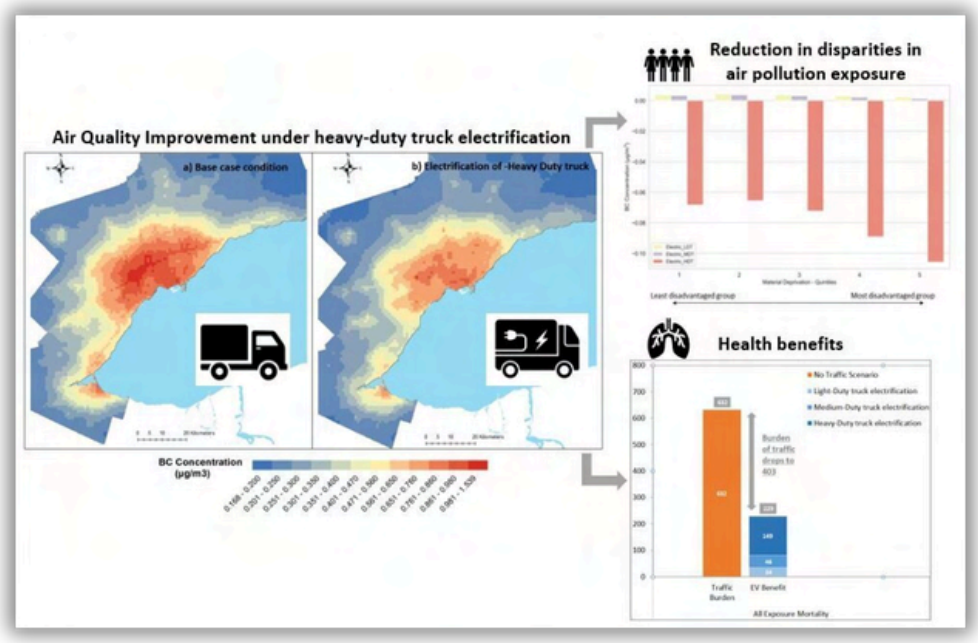
UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

POSITIVE ZERO TRANSPORT FUTURES

Mobility Network

Due to socioeconomic shifts and the need to achieve deep cuts in greenhouse gas (GHG) emissions, Canada will experience an unprecedented transformation in its transportation infrastructure. The implications of such changes on the movement of people and goods are not well-characterized, hindering the ability to direct them towards maximum climate benefits while minimizing societal costs. Using the Greater Toronto and Hamilton Area as a testbed, this project addresses knowledge gaps in the quantification of emissions associated with individual mobility choices, with particular emphasis on the transport infrastructure investments that can achieve the highest shifts in travel behaviour, reduce GHG emissions, while improving air quality, public health, and equity.

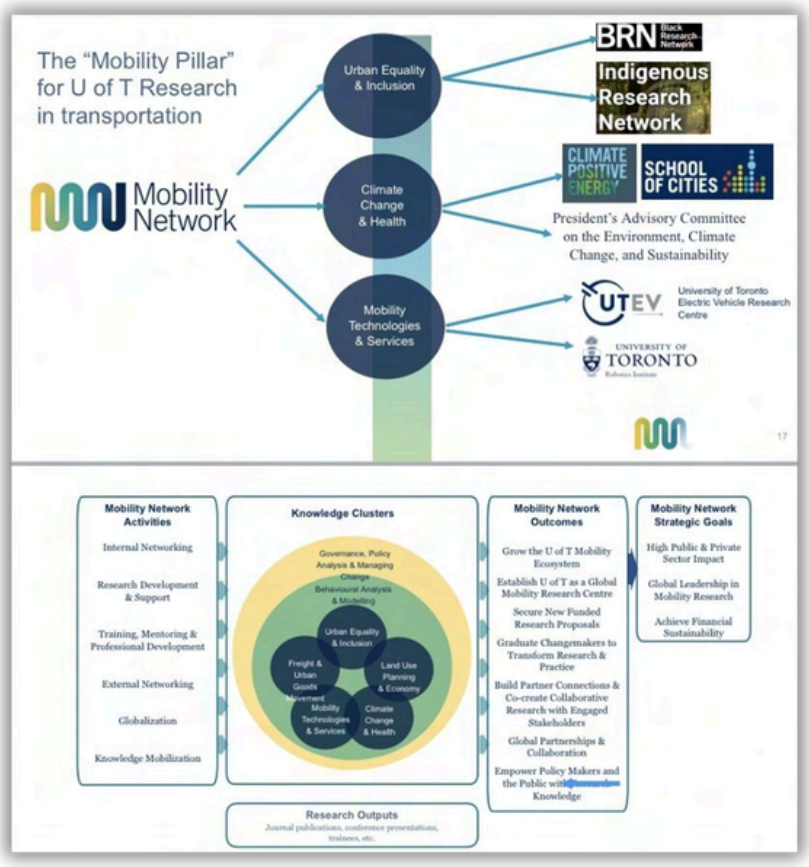




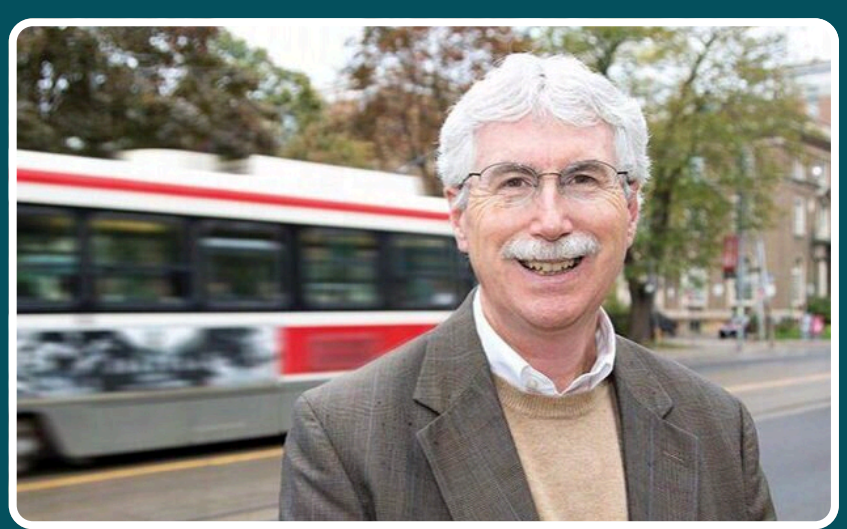
The project — known as The Road to Net Zero — is led out of Positive Zero Transport Futures, a cluster within the University of Toronto's Mobility Network. The team is developing generalizable long-term modelling with local intervention studies, leveraging participatory data collection methods and community engagement, to obtain place-based perspectives that enable broader learning.

Learn more about the road to net-zero on the [Positive Zero Transport Futures website](#).

By combining computer modelling with participatory data collection and community engagement, the team is quantifying how the design of public transit initiatives, active transport infrastructure, and innovative uses of infrastructure for personal vehicles (roads and parking) can contribute to a decarbonized and healthy transportation system.



Meet the Research Project Team



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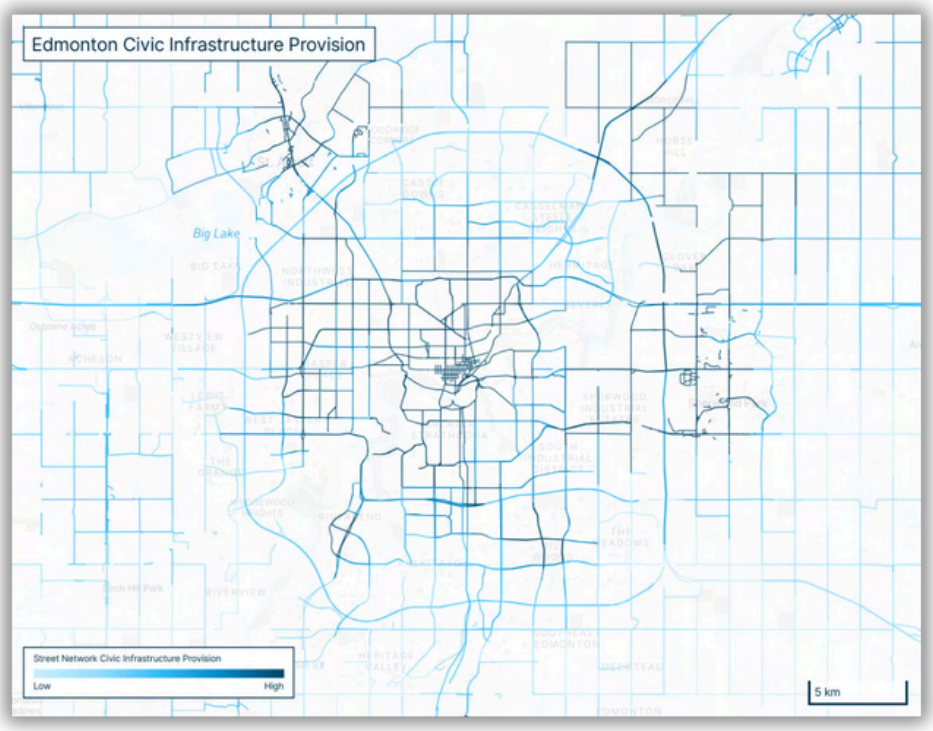
OPEN DATA FOR INFRASTRUCTURE DECISION-MAKING & COMMUNITY ENGAGEMENT

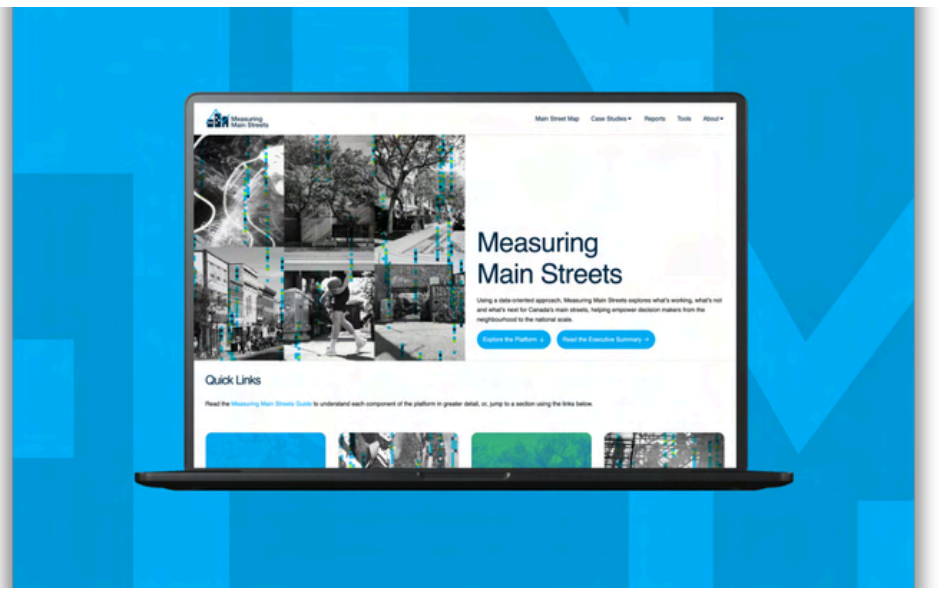
Measuring Main Streets

The Measuring Main Streets Platform (MMSP) provides data and analysis on the role of civic infrastructure in creating and maintaining vibrant main streets in Canadian communities. The MMSP is the first research tool that uses main streets as the primary unit of analysis.



The Canadian Urban Institute used the platform to analyze the resiliency of main streets in three cities: Montreal, Toronto, and Edmonton through the stages of the COVID pandemic. GPS data from cell phones were used to track visitor levels to 60 main streets (and 15 regional shopping centres for comparison) from 2019 to 2022. This work was supplemented with observational research for 10 case study main streets in each of the three urban regions. We found that main streets that primarily serve a local population tended to experience a lower drop in visitor numbers at the onset of the pandemic and/or recovered more quickly. Conversely, main streets in the downtowns of the three cities were generally hit the hardest and have not fully recovered. The presence of greenspace was the key type of civic infrastructure that supported higher levels of resiliency through the pandemic.

It identifies and maps every main street in Canada and supplies data on the businesses and civic infrastructure present as well as a demographic profile of the neighbourhood each main street serves. We also analyzed the equitable distribution of civic infrastructure across the three urban regions. Our research shows that civic infrastructure deficits are most acute in recently built suburban neighbourhoods that tend to have higher levels of immigrant populations. Many of these housing developments are planned without main streets and have a low capacity to adapt. Conversely, civic infrastructure surpluses are found in many well-established neighbourhoods that have experienced population decline. These places tend to have traditional main streets that present significant opportunities for infill housing which could improve the efficiency of existing infrastructure.



The Measuring Main Street project began in June of 2022 and will formally launch in June 2024. It is comprised of four primary components, an interactive map of all main streets in Canada, thematic and regional research briefs, detailed main street case studies, and a set of data and visualization tools. The Measuring Main Streets Platform will be publicly available and serve as a hub of main street research going forward.

View the platform at **www.measuringmainstreets.ca**.

Meet the Research Project Team

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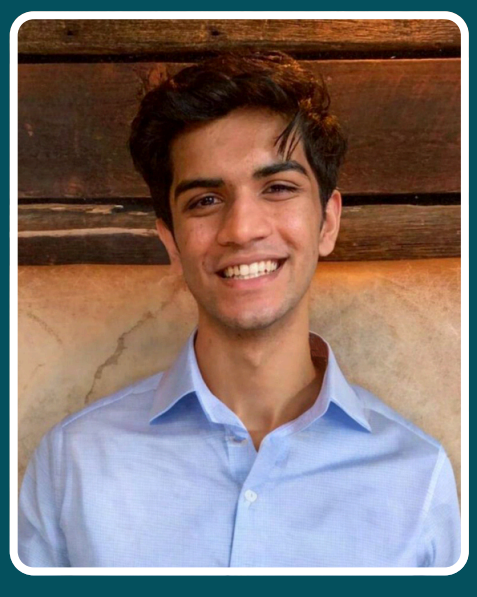

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Bridgewater Energy Security Study (or BridgES Study)

Energy poverty occurs when households are unable to access or afford enough energy services at home to meet their needs and maintain a healthy indoor environment. The prevalence of energy poverty is 19% across Canada, and over 30% in Atlantic Canada. However, very little Canadian research has examined energy poverty in the country, its impacts on health, or the effectiveness of intervention strategies.

Over the past years, Bridgewater, a small town in Nova Scotia, has been tackling energy poverty head-on. The municipality won the Infrastructure Canada's Smart Cities Challenge to implement Energize Bridgewater, a community-wide program aiming to reduce energy poverty in the community through home energy efficiency improvements, coordinated access and support services for households in energy poverty, improvements to the local public transportation system, and community outreach.

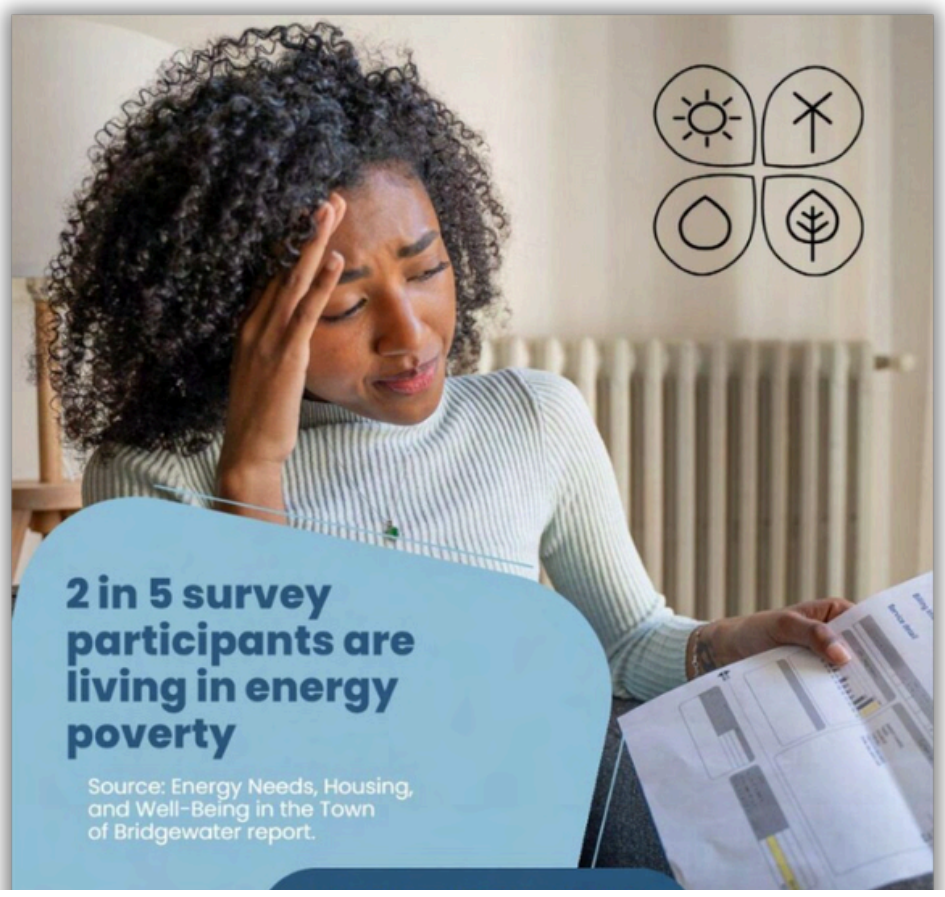

Fig. 1. Infographic developed by Energize Bridgewater

The objective of this research project, called BridgES for Bridgewater Energy Security, is to assess the well-being impacts of Energize Bridgewater at the household and community levels. Through BridgES, we hope to answer the following questions: (1) What is the extent of energy poverty in Bridgewater? (2) What are the impacts of participating in Energize Bridgewater? And (3) what is the potential for Energize Bridgewater to be implemented in other communities? We used an integrated knowledge translation approach to collaborate with the municipality through each step of the research process. A mixed-method approach was employed for data collection and analysis. We distributed a survey to a sample of the population (n=516; 13% of households) and conducted in-depth interviews with households facing energy poverty (n=39). The BridgES project began in the spring of 2021, receiving funding from INFC in 2022, and will be completed in the spring of 2025.

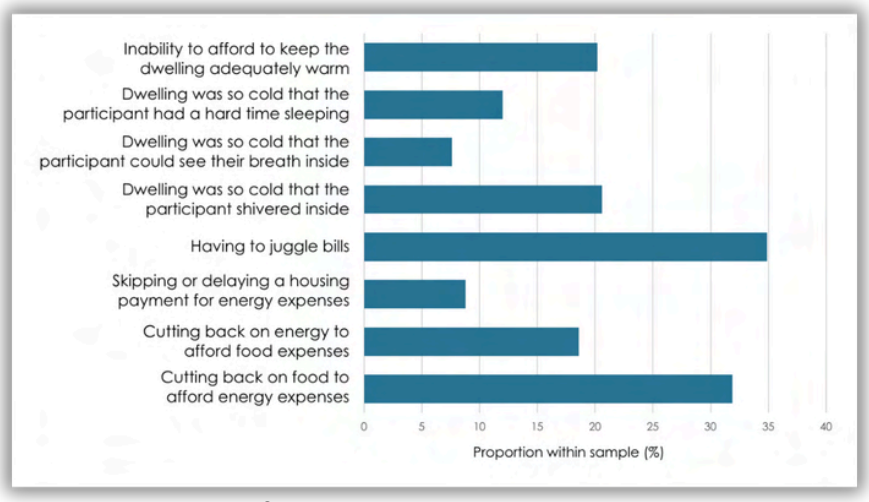

Fig. 2. Proportion (%) of participants in Bridgewater reporting experiences energy poverty, thermal discomfort, and financial difficulties

Findings from the BridgES project reveal that 38% of participating households in Bridgewater are in energy poverty. Women, those with lower education levels, and people living in housing in poorer conditions are more at risk of being in energy poverty. To cope with energy poverty, households described using social and financial trade-offs, with over one in three households reporting having to choose between energy and food expenses to manage finances. Energy poverty was found to be associated with poorer general and mental health, higher levels of stress, and lower social support. To date, findings from this project have been disseminated through scientific articles (two currently under review), national and international conference presentations, a master's thesis, and summary reports presented back to the municipality.

Fig. 3. Research team photo

Learn more about Dr. Riva's work on energy and health here.

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Development of an Online Platform for Municipal Infrastructure Data Sharing and Collaborative Deterioration Modelling

Toronto Metropolitan University

Many municipalities in Canada are collecting more reliable condition and performance data for developing their infrastructure asset management plans; however, there lacks an effective data-sharing mechanism that would allow different municipalities to borrow information to develop more reliable infrastructure deterioration models. The project aims to develop an online platform for infrastructure performance data sharing and collaborative deterioration modelling for Canadian municipalities. Bridges, pavements and sewers are the focus of the project.

We meant to develop a nation-wide platform that would help particularly small municipalities and remote communities that do not have the resources to collect asset condition and performance data.

Asset condition and performance data from different geographical regions can form a meaningful statistical population, from which the deterioration trends with different asset attributes can be inferred.

The project started in September 2022, and is expected to complete in March 2025. A prototype of the platform is expected to be established by the end of June 2024. The dashboard will use statistical learning methods and Bayesian updating.

To date, we have found that fairly consistent condition assessment protocols are used across Canada for bridges and sewers, whereas pavement condition assessment methods are very different.

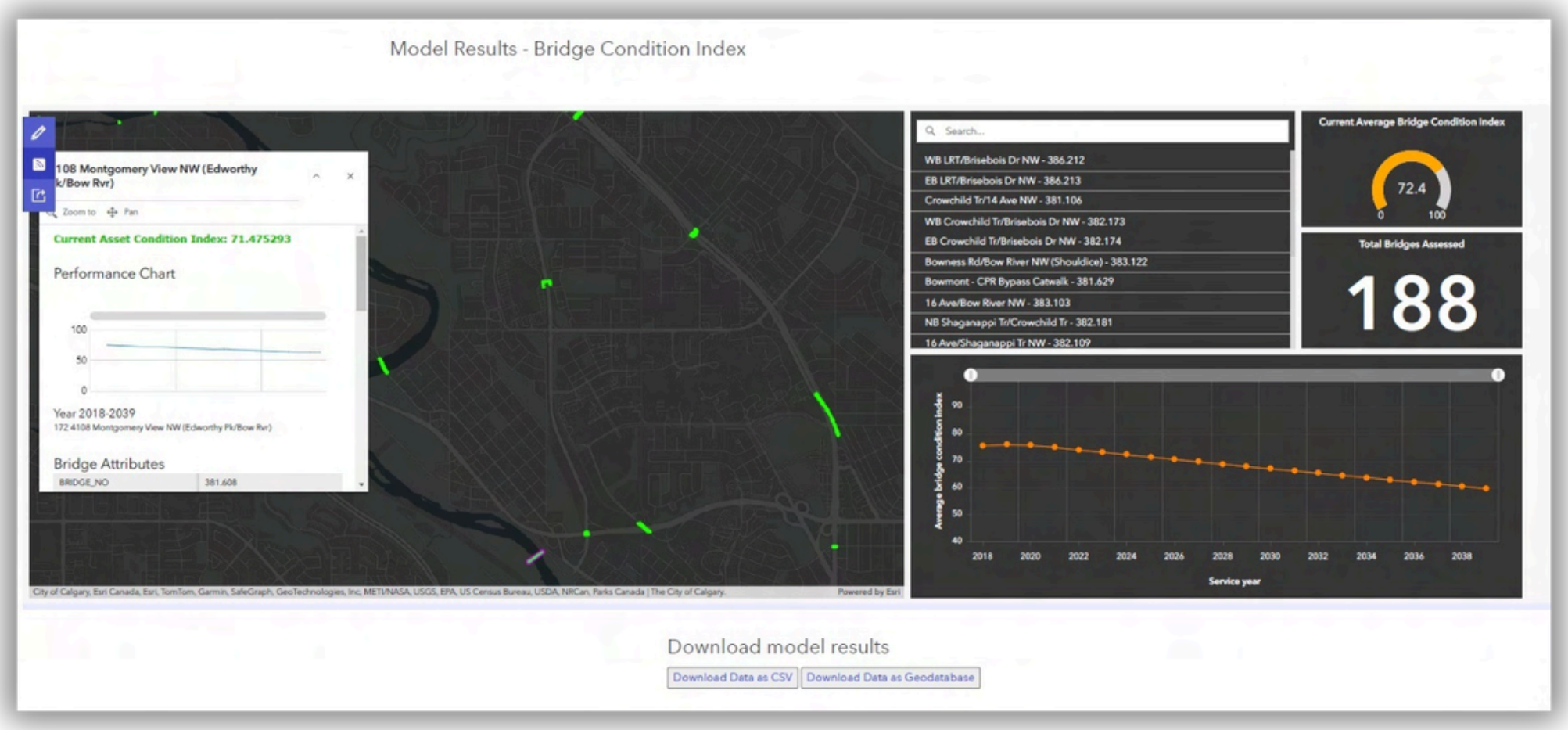
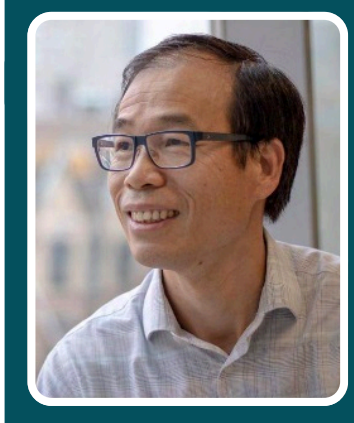


Fig. 1. Screenshot of the prototype dashboard

Meet the Research Project Team



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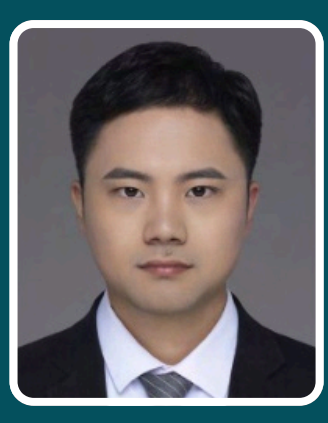

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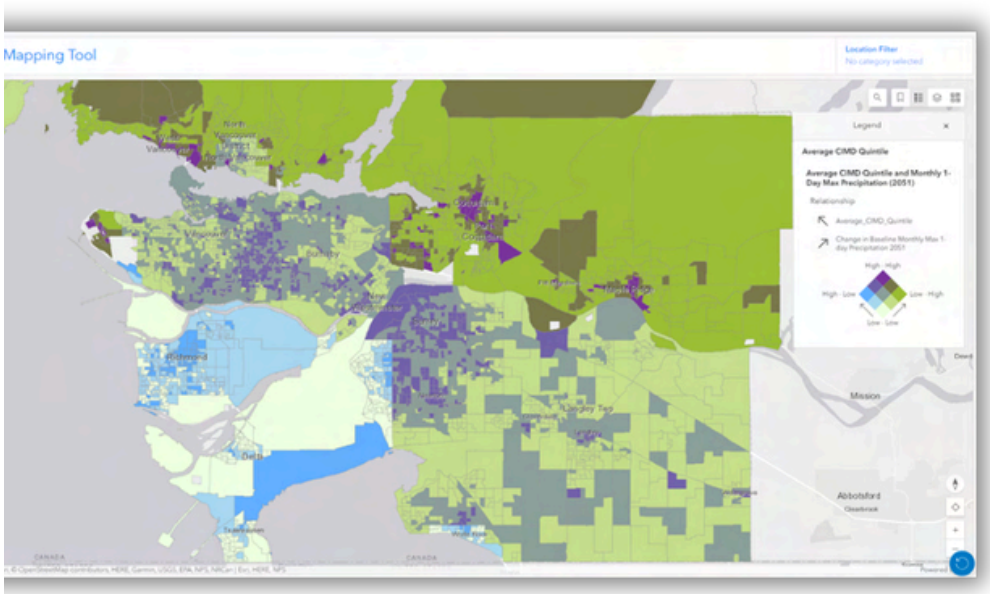
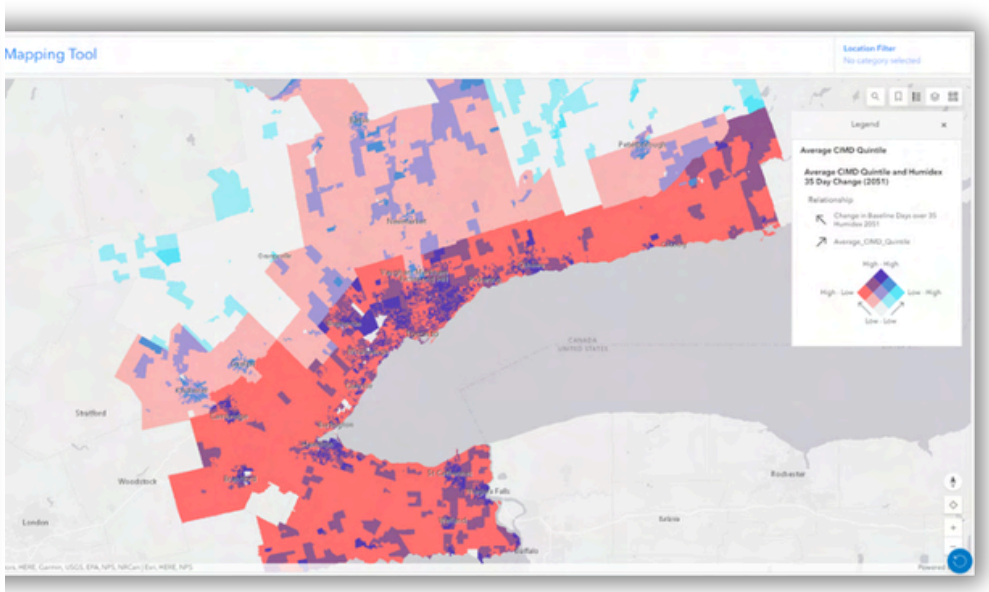
INFRASTRUCTURE CANADA PROJECTS

Climate Equity Mapping Tool

The Climate Equity Mapping Tool would allow users to identify areas in Canada where the population is more vulnerable to hazards related to climate change.

The tool is currently available for internal use only, however if you have interest in this product, please contact the lead researcher.





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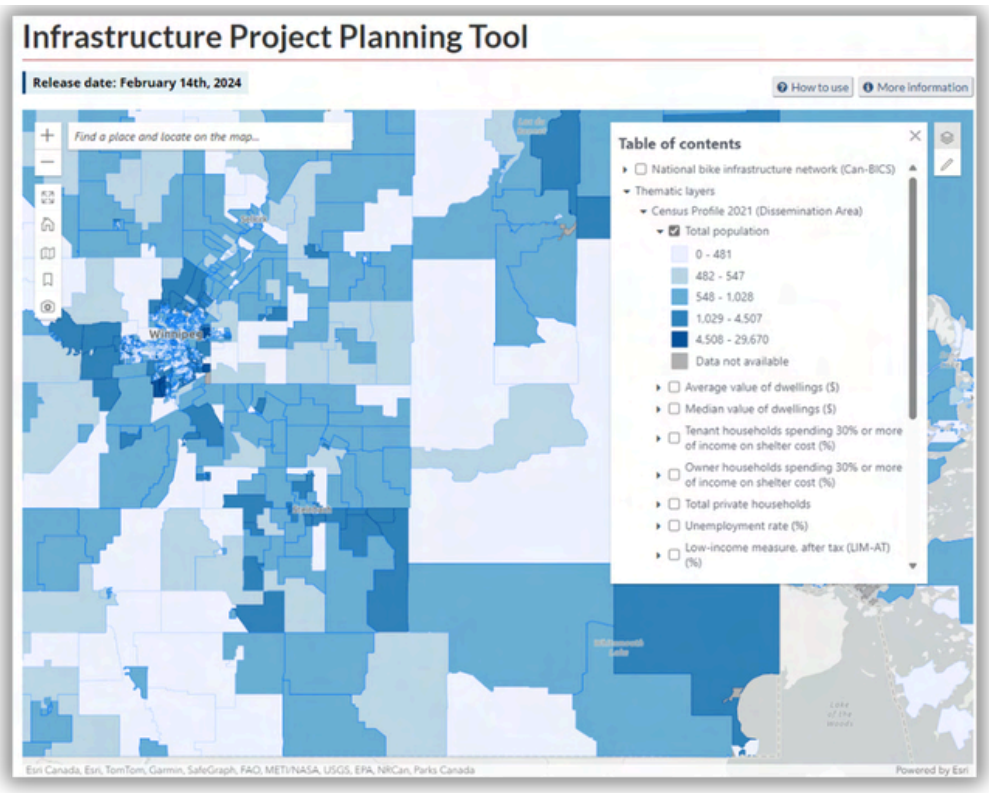
Infrastructure Project Planning Tool

The Infrastructure Project Planning Tool is a decision-making support tool for early phases of infrastructure projects. It combines several socio-economic datasets from Statistics Canada to support decision-making for users. It allows users to search these datasets by area of interest, to export data, and to uses them in the context of infrastructure projects.

Access the infrastructure project planning tool **here**.



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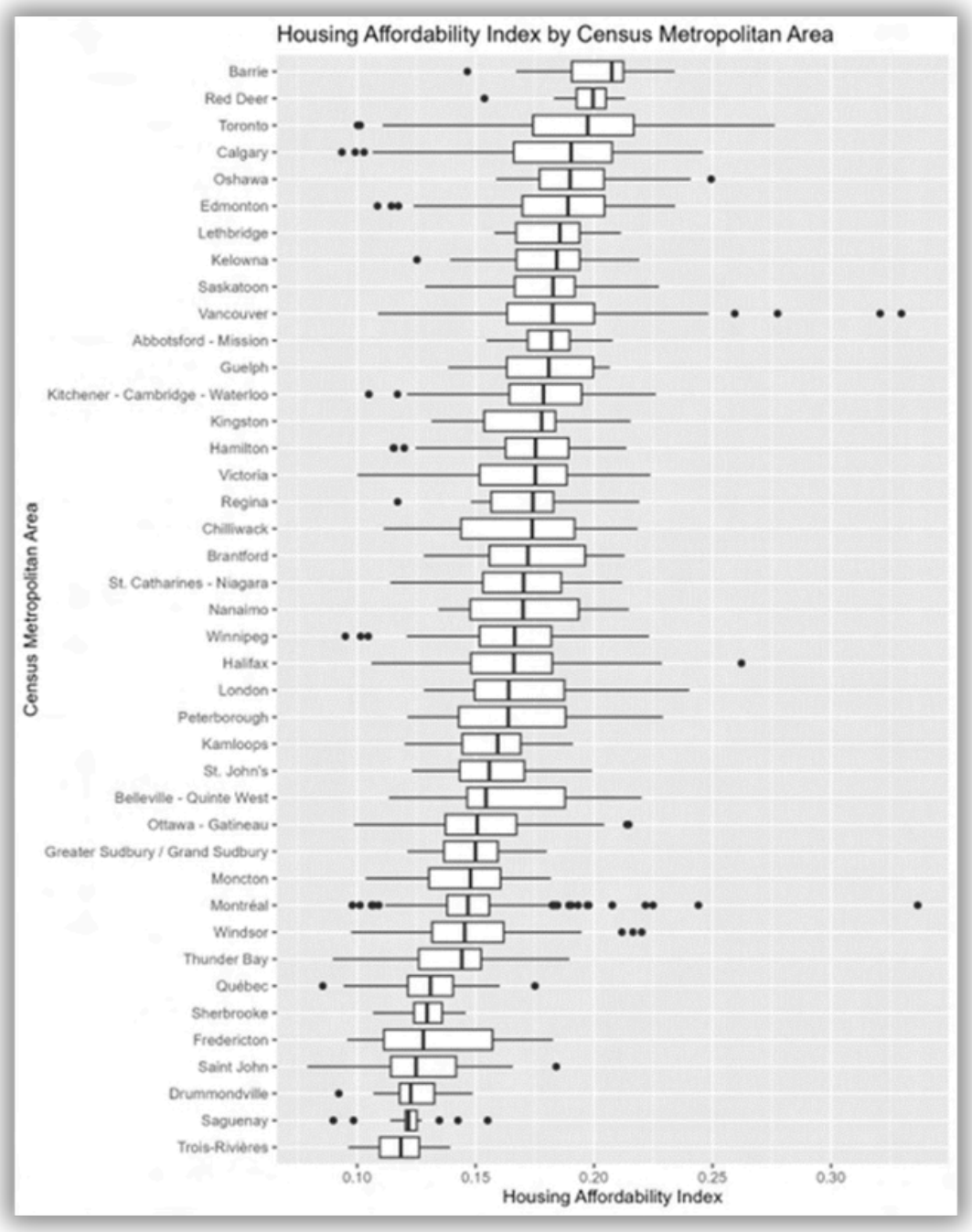
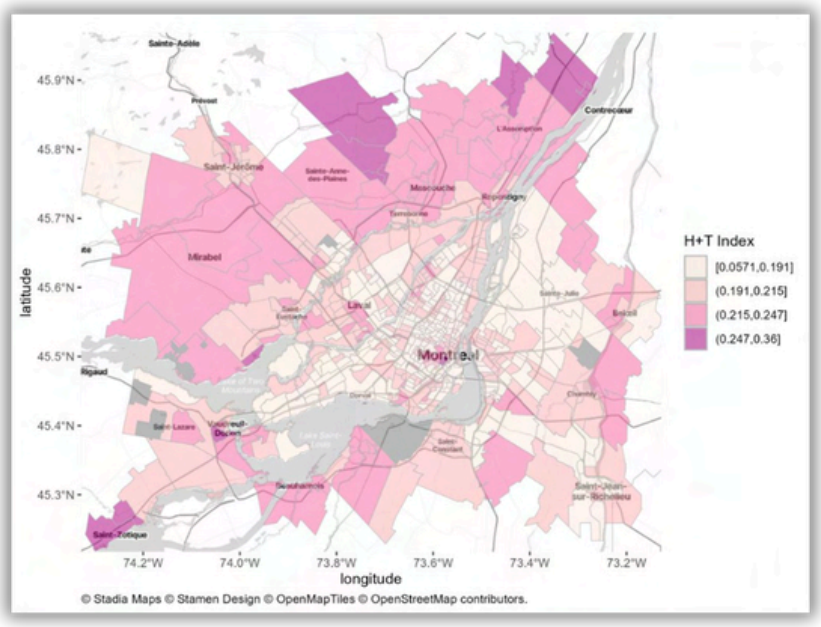
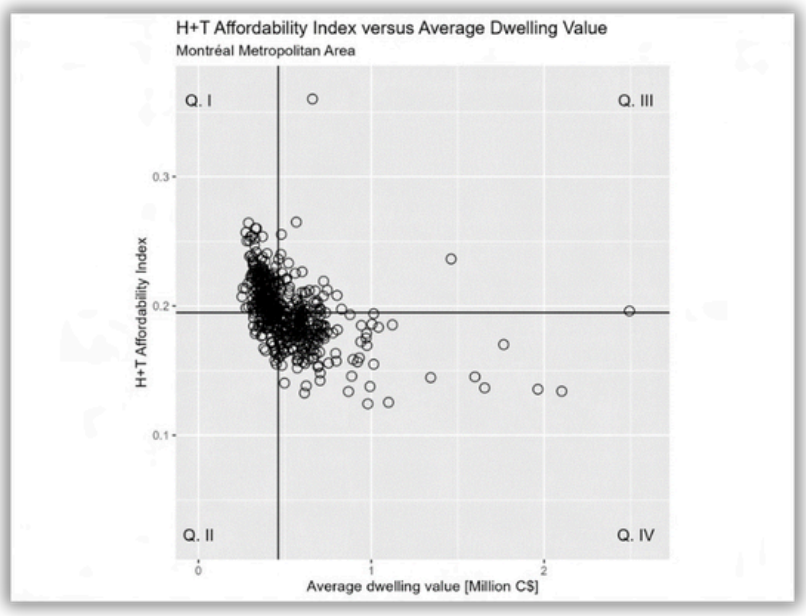
Housing and Transportation Affordability Index

A measure of affordability that accounts only for one element of the equation (housing or transportation) is likely to provide only a partial picture of affordability for households. The Housing and Transportation Affordability Index is a national index of affordability for housing and transportation available at the aggregate dissemination area level.

The tool is currently available for internal use only, however if you have interest in this product, please contact the lead researcher.







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Environmental Equity Index

The Environmental Equity Index is an index that takes into consideration positive and negative externalities of infrastructure and the environment to produce a measure of the equitable access of populations to the natural environment and infrastructure. This product is currently in development.

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National Transportation Survey

The National Transportation Survey will collect data on mobility patterns and behaviors of Canadians. The objective is to develop comprehensive data on mode share, kilometers travelled and behaviors about mobility decisions. This product is currently in development.

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Open Database of Infrastructure

The Open Database of Infrastructure (ODI) is a collection of open data containing the types and locations of a selection of infrastructure across Canada, and is made available under the Open Government License - Canada.

The categories covered in the ODI include bridges, tunnels, solid waste, pedestrian and cycling paths, public transit stops, potable water, storm water, and wastewater.

The ODI brings together data primarily originating from municipal, provincial, and federal open data portals. This database aims to enhance access to a harmonized collection of business data across Canada and is a component of the Linkable Open Data Environment (LODE).

Access the open database of infrastructure **here**.

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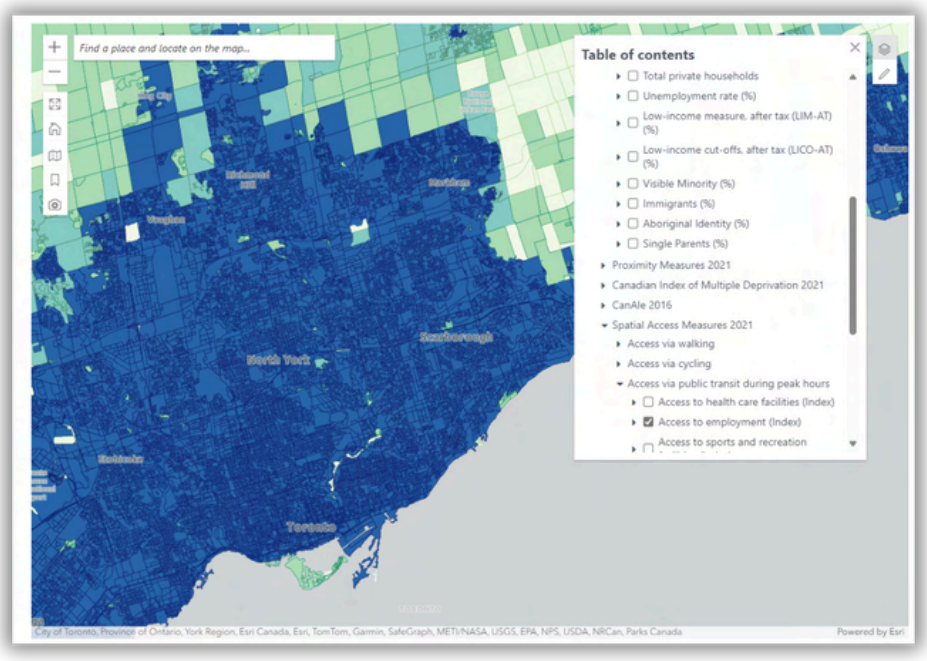
Spatial Access Measures

The Spatial Access Measures are a set of indicators that quantify the ease of reaching destinations of varying levels of attractiveness from an origin dissemination block (DB). DBs are the smallest census geography, about the size of a block in urban areas and considerably larger in less urban areas. There are seven destination amenity categories within the measures. For each amenity, there are four variants based on the transportation mode: access via public transit during peak hours, access via public transit during off-peak hours, access via cycling and access via walking.



View the spatial access measures **here**.

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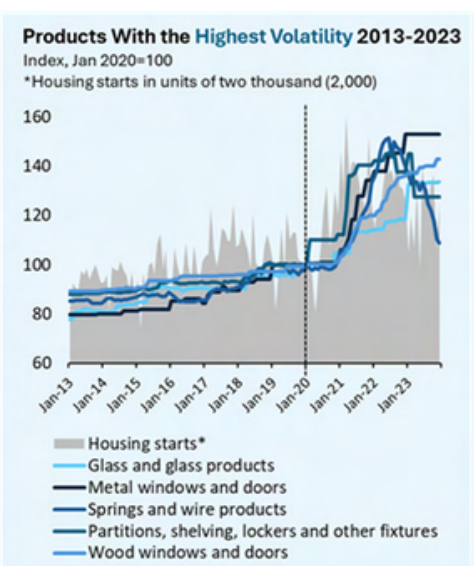
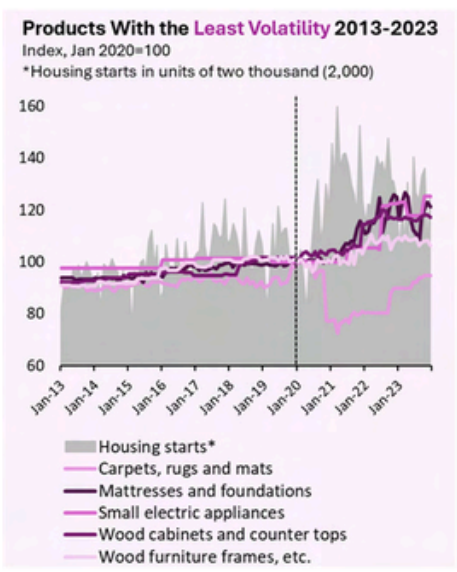
Canadian Residential Housing Supply Chain

The research project delves into the supply chains necessary for constructing detached homes, apartments, and prefabricated/modular homes. It reviews the current state of Canada's housing supply chain nationwide, including material composition requirements for building example homes, the impact of building codes on material selection, and the direct supply chain costs associated with delays.

The purpose is to determine the extent to which supply chain delays affect housing starts and to identify the greatest bottlenecks in the residential construction supply chain. Methods included using a model to calculate fluctuating construction costs for different structures by assessing the price volatility of residential construction products. This involved comparing the standard deviation of the most volatile products to actual lead times to identify any correlations. Additionally, a model was constructed to display the relative importance and reliance on various commodities or products in residential construction across different regions in Canada.

The project lasted from November 2023 to May 2024.





	Products	Standard deviation (2013-2023)
Highest Volatility	Metal windows and doors	24.6
	Partitions, shelving, lockers and other fixtures	19.3
	Springs and wire products	19.2
	Wood windows and doors	16.1
	Glass and glass products	15.3
	Hardware	14.2
	Blinds, shades, and curtain fixtures	13.2
	Household furniture	12.7
	Ceramic tile, and other structural and architectural ceramic products	11.4
	Electric lamps, lighting fixtures, and parts	10.2
	Major appliances	9.2
Least Volatility	Mattresses and foundations	9.0
	Wood cabinets and counter tops	8.4
	Small electric appliances	7.6
	Carpets, rugs and mats	5.8
	Wood furniture frames, n.e.c.	5.6

Source: Statistics Canada

Fig. 1. Calculating the standard deviation of residential construction product prices highlights which products have experienced the greatest price volatility.

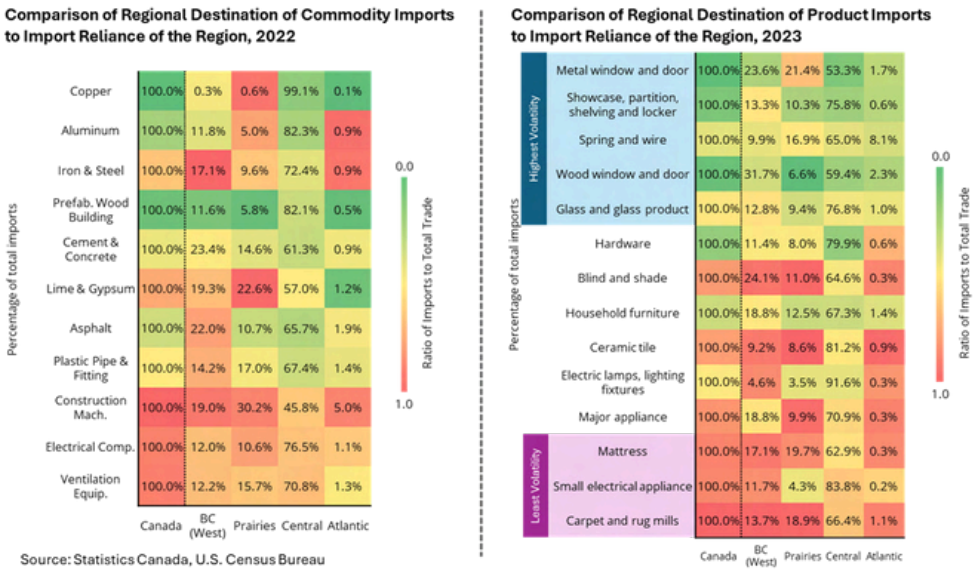


Fig. 2. Matrix displaying the percentage of each commodity/product's destination relative to total imports into Canada

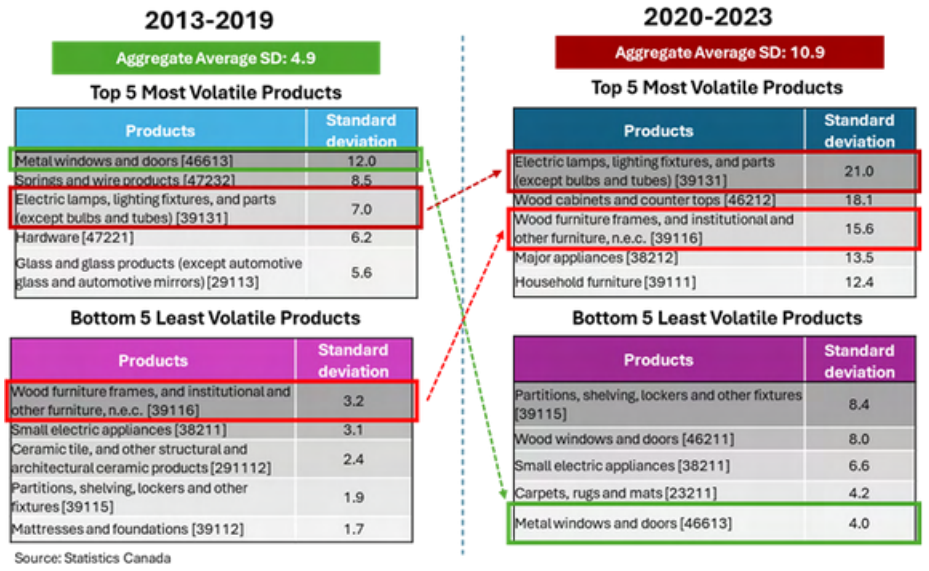


Fig. 3. Tables Comparing the standard deviation of the top five most and least volatile products pre-COVID (2013-2019) and post-COVID (2020-2023)

The central findings of the project revealed that products with the highest price volatility and longest lead times also had the greatest domestic production. This indicates that delivery delays for these products are due to demand issues rather than supply constraints. Cities that have longest delays from issuing development and building permits add 8% to 14% to construction costs annually.

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Exploring the Impacts of Climate Change on Infrastructure

As extreme weather events continue to intensify in Canada and pose substantial risk to our infrastructure, this work explores the impact climate change will have on the service life and operating and maintenance (O&M) costs of infrastructure assets.

The condition of infrastructure assets degrades over time. However, climate hazards can increase the pace of asset deterioration. Building off of the methodology developed by the Financial Accountability Office of Ontario (FAO), we utilized climate-cost elasticities to estimate the impact of extreme heat and extreme rainfall on the useful service life and O&M costs of infrastructure assets. Climate-cost elasticities estimate the response of infrastructure costs to key climate indicators, i.e., for every 1% change in a climate indicator, there is an x% change in infrastructure costs. Subject-matter experts were consulted by the FAO to estimate these elasticities by asset class, and to determine the most relevant climate indicators to serve as a proxy for each climate hazard.

The FAO's analysis is focused on Ontario, whereas we wanted to conduct a national assessment. We collected historical and projected climate data from Canada's 10 largest municipalities, and took a weighted average based on population. It is important to note that weighting climate projections based on population does not reflect how Canada's climate will change as a whole. Instead, it emphasizes regions with higher populations, and therefore, more infrastructure. Thus, this analysis is not appropriate for place-based decision making, and instead serves as a starting point in investigating high-level deterioration trends for Canada's infrastructure.

	Roads		Potable Water Facilities		Public Buildings		Water Pipes
	Service Life	Annual O&M Spending	Service Life	Annual O&M Spending	Service Life	Annual O&M Spending	Annual O&M Spending
Baseline (1971-2000)	31	1.5% ($13.4B)	67	1.5% ($627M)	49	1.5% ($1.8B)	1.0% ($2.1B)
2021-2050	28	2.0% ($17.9B)	64	1.8% ($752M)	47	1.8% ($2.1B)	2.5% ($5.2B)
2051-2080	25	2.6% ($23.2B)	62	2.0% (836M)	45	2.0% ($2.4B)	3.8% ($7.9B)
2071-2100	22	3.3% ($29.5B)	59	2.2% ($920M)	43	2.2% ($2.6B)	5.1% ($10.5B)

Fig. 1. Summary of results, high-emissions scenario. The national assessment used weighted average of climate data from Canada's ten largest cities

With the projected climate data and the climate-cost elasticities, estimates of assets useful service lives and annual O&M expenses were obtained under various climate scenarios and time period. Overall, when future climate conditions are considered, assets will require replacement earlier and require additional O&M spending compared to the baseline climate scenario. These results emphasize the importance of adaptation and integration of climate considerations in infrastructure decision making.

Future work will focus on a more region-specific analysis to consider the unique climate conditions that are expected across Canada to help inform local decision making.

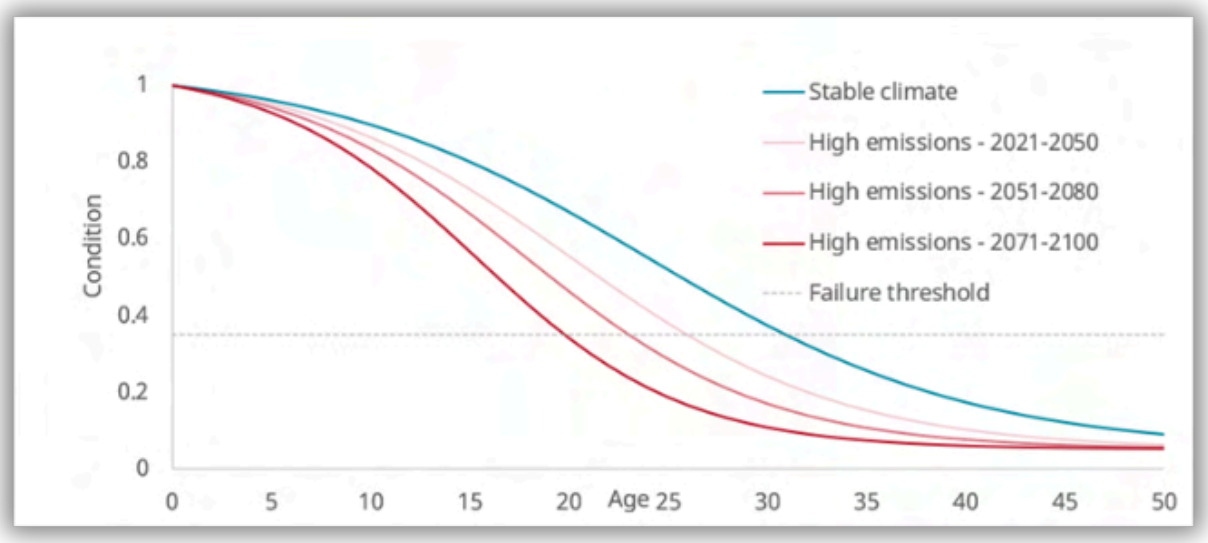

Fig. 2. Asset Deterioration Curves for Portable Water Facilities
Source: FAO, WSP, ECCC, INFC calculations

Extreme heat and extreme rainfall could cause an additional **$16 billion annually** in O&M costs by the end of the century.

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Estimating the Environmental and Social Benefits of Public Transit

This research project aims to quantify the social, environmental, and economic benefits of public transit development and investment. The study's primary goal is to position transit investment as an essential component of urban development by demonstrating its wide-ranging advantages, including greenhouse gas (GHG) reductions, cost savings, and improved urban density. The research employs two main analytical approaches: a binary approach, which evaluates the benefits by comparing scenarios with and without transit, and a marginal approach, which examines year-over-year changes in commuter behavior and total commuter growth. Through these methods, the study aims to provide a comprehensive valuation of transit development's positive outcomes.

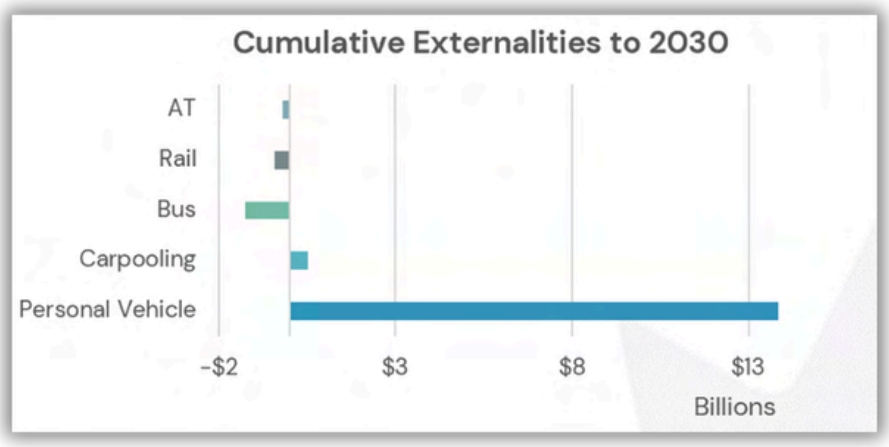

Fig. 1. Benefits of meeting United Nations Sustainable Development Goals target

Key findings indicate that transit investment yields significant dividends. For instance, reducing reliance on personal vehicles through increased transit use can substantially lower household travel costs, decrease travel times, and reduce GHG emissions. The study estimates that societal costs for annual personal vehicle travel are about $9,600 compared to approximately $1,700 for public transit, highlighting a 5.8 times lower cost for transit users. The research also reviews similar studies from various regions, such as Toronto, Vancouver, and Quebec City, which reinforce the findings of this project. These studies demonstrate the economic benefits of transit investment, including contributions to GDP, reduced travel time, and lower environmental and public health costs due to decreased vehicle usage.

	Personal Vehicle	PT
2011 Per Capita	$9,489	$1,581
2016 Per Capita	$9,649	$1,662
Change	+$160	+$81
Change %	+1.68%	+5.14%

Fig. 2. Per capita results

This research also suggests a framework for further examination of the interplay between transit systems and housing development. The study suggests that transit-oriented development can lead to increased housing density, enhancing urban livability and accessibility while potentially lowering housing costs. For example, the development of the Ottawa LRT and the ION Rapid Transit system in Kitchener-Waterloo has been associated with increased residential density near transit stations, suggesting significant benefits in terms of accessibility and reduced commute times.

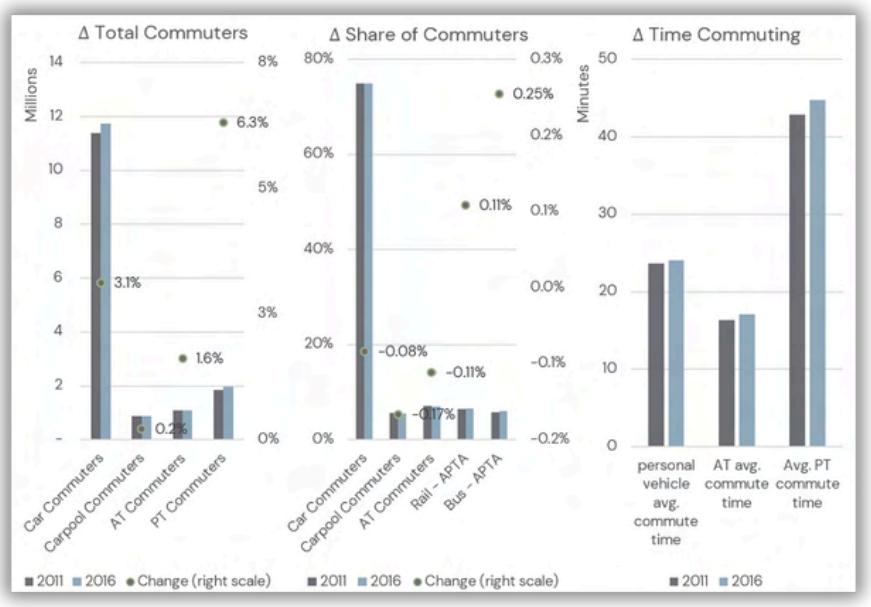

Fig. 3. Mode shift inputs

Future projections using population growth estimates from Statistics Canada indicate that continued transit investment could further amplify these benefits. The study highlights the value of transit-oriented urban planning. In conclusion, this research underscores the indispensable role of public transit in fostering sustainable urban development, reducing environmental impacts, and delivering economic benefits. The findings support the need for ongoing transit investment to achieve broader social and environmental objectives.

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Water and Wastewater Cost Estimation For Housing Need

Canada's housing affordability crisis requires significant investment in new housing units. The Canada Mortgage and Housing Corporation (CMHC) has identified a need for 3.45 million additional units to achieve affordability. However, this growth will strain existing water and wastewater infrastructure.

The Economic Analysis and Modelling team at Infrastructure Canada undertook a preliminary analysis to estimate the costs associated with expanding water and wastewater infrastructure to support these new housing units.

We leveraged existing data on water and wastewater provision costs, asset replacement values, and the rural/urban distribution of infrastructure assets. Notably, the analysis considered rural households connected to municipal wastewater systems. Provincial results were derived based on initial assumptions, acknowledging that local community capacity variations exist and may not be fully captured in these estimates.

		Potable water		Wastewater		Total	
		Rural	Urban	Rural	Urban	Rural	Urban
ON-QC-BC	Per unit cost	$37,723	$2,915	$63,504	$4,337	$101,227	$7,252
AB-SK-MB-NS-NL	Per unit cost	$60,778	$5,842	$88,381	$6,203	$149,159	$12,045

Fig. 1. Water and wastewater per unit cost - Urban vs Rural

The cost of providing water and wastewater services varies significantly depending on population density. In urban areas, the average cost per unit for potable water is around $3,000, and wastewater costs on average $4,000. However, these figures jump dramatically in rural areas, where the cost per unit can be up to 12 times higher.

This disparity aligns with research conducted by various studies, including one by the City of Halifax. Their findings demonstrate a clear link between density and infrastructure cost-efficiency. The City of Halifax study specifically revealed that the annual cost of providing water infrastructure per household is nearly ten times higher in rural areas and five times higher in suburban areas compared to urban areas. Furthermore, our estimates for urban infrastructure costs closely match the figures provided by municipalities themselves when considering the cost of water and wastewater services for new housing projects in these cities. This convergence strengthens the validity of our findings and underscores the economic benefits of density for water and wastewater infrastructure.

The analysis provides valuable insights for policymakers and stakeholders as they consider the infrastructure investments required to achieve Canada's housing targets while ensuring sustainable water and wastewater services.

Further research will explore the specific capacity differences among local communities to refine cost estimates.

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PROJECTS SUPPORTED BY THE CANADA INFRASTRUCTURE BANK

A Jump-Start: Providing Infrastructure for More Housing

Canadian Urban Institute | Institut Urbain du Canada

This research paper explores the connection between more housing supply and the need to invest in infrastructure that enables housing developments including water, wastewater, district energy, and public transit. The paper also quantifies investment required and undertakes a comparative analysis of how different Canadian and global jurisdictions (i.e., North America, Europe, and Asia) finance this type of infrastructure.

The project relied on desktop research and stakeholder interviews to answer the questions:

- What actions will governments at all levels need to take to ensure infrastructure's availability keeps pace with a significant increase in new housing starts?
- Given the fiscal constraints facing all governments – and particularly municipal governments – are there innovations in municipal funding and financing and/or ways to enlist more private investment in the construction of public infrastructure?
- What role could financial institutions play in facilitating those efforts?

The project began in February 2024 and concluded in June 2024. The report proposes four new approaches to investing the billions of dollars needed to build supporting infrastructure —such as, water lines, sewers, and storm drains — to advance millions of homes across the country. Among the findings, the research looks at a variety of ways to finance housing-enabling infrastructure, such as leveraging private capital to invest in public infrastructure.

The report demonstrates there are a variety of new financing supports, such as leveraging private capital, that can help municipalities to build the infrastructure needed for housing ahead of population growth.

Financing tools	Characteristics
Financing vehicles recommended for use in Canada	Financing options that achieve this Paper's four objectives: (1) financing infrastructure over its useful life; (2) all beneficiaries contribute, over time; (3) sharing municipal risk; and, (4) facilitating small municipality project financing.
Municipal Services Corporations (MSCs)	Arm's length municipal corporations and utilities; if some cases, they can be non-recourse borrowers; energy-service corporations (ESCOs) are a variant
Development Corporations	Arm's length municipal or statutory corporations, with both borrowing and development-control powers; can be non-recourse (off-balance sheet) borrowers
Tax-increment Financing (TIF)	Redevelopment adds value and generates additional taxes; additional taxes fund infrastructure and debt-service
TIFs for TOD	TOD development adds value and generates additional taxes, used to fund transit and other infrastructure or debt-service
Land Value Capture (LVC)	New development is required to contribute to capital cost of higher-order transit or other infrastructure – beyond mere TIF
Benefitting Area LVC	Defined-area pays additional levy or rates for capital cost of higher-order transit or other infrastructure – beyond mere TIF
"Development rights" / access to infrastructure	Site-specific sale of development rights, zoning, density, access to infrastructure

Read the report here.

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A Microgrid Playbook: Conditions and Opportunities for Investment

The Conference Board of Canada

What are the community, investment and environmental conditions needed to make microgrids a game changer in energizing Canada and reducing emissions? This question was answered in the context of understanding what conditions exist and need to exist, to build out microgrids in Canada in northern and remote communities to achieve their potential. The conditions formed a playbook for any organization looking to fund microgrid infrastructure.

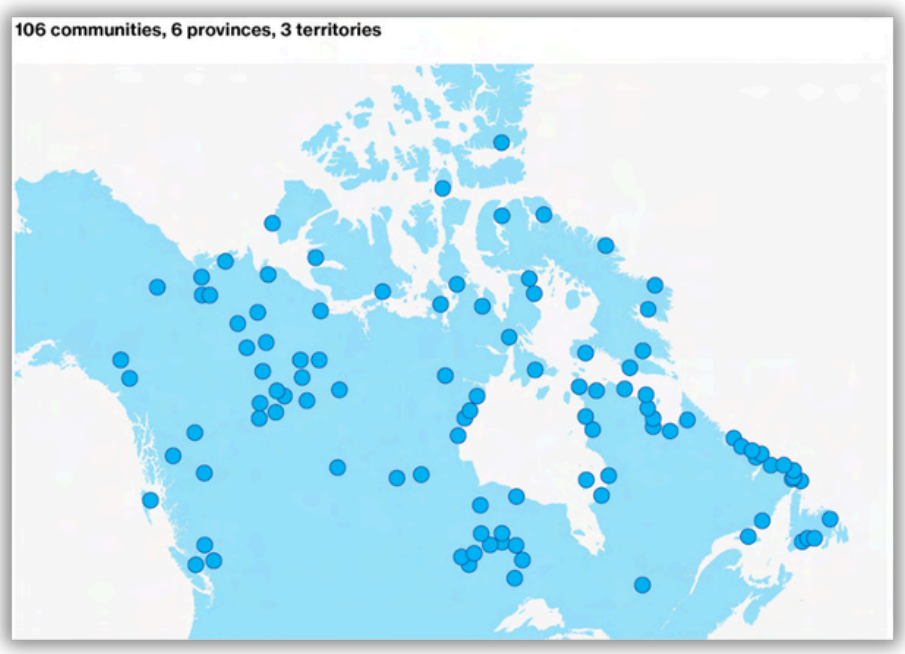
Through desktop research, modeling and analysis, the project achieved five main objectives to:

- Quantify the total community potential for microgrid development
- Quantify infrastructure investment required
- Quantify the total economic impacts of community-based microgrid solutions
- Assess the public and private investments tools
- Quantify emission reductions from microgrid scenarios

The project began in June 2020 and concluded in April 2021.

The challenges of building and providing clean power in rural and remote locations can be daunting. They include lack of capacity, limits of economic scale and difficulty in securing access, among others. As a result, many off-grid communities rely on diesel generation, bringing emissions with it, the risk of spills and air quality impacts. Microgrids that rely on solar, or wind power could be part of the solution.

This paper sets out a playbook that identifies positive outcomes that could be achieved with microgrid solutions, including a reduction in the use of diesel, greenhouse gas emission reductions and new employment. Microgrids are also an opportunity to provide for community-led energy in Indigenous communities. The Canada Infrastructure Bank (CIB) has identified clean power as a priority sector for investment and was pleased to support and provide input to this work.



Read the report here.

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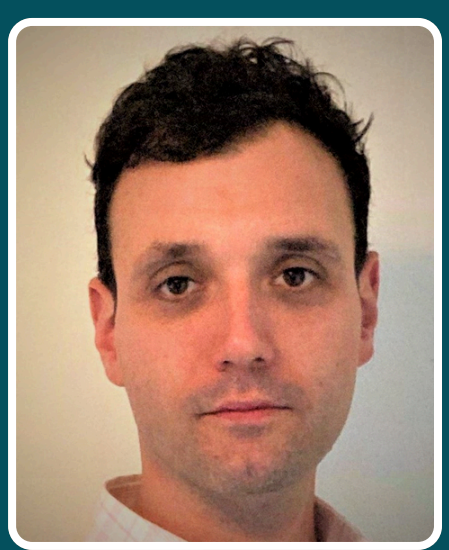

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Green Retrofit Economy Study

CAGBC Canada Green Building Council

DELPHI GROUP

The goal of this research was to go deeper on previous studies and initial foundational work conducted over the past few years to explore supply-related enabling success factors for low-carbon and green building retrofit sector growth in Canada. Enabling factors – such as the necessary workforce capacity, access to a robust supply chain of affordable low-carbon construction related products, technologies, and materials – are critical to ensure financing and investment in aggressive retrofit programs is successful.

The project relied on desktop research, analysis and evaluation. It began in August 2021 and concluded in June 2022.

In 2020, buildings accounted for 87.8 million mega tonnes of greenhouse gas emissions in Canada. Building owners across Canada are looking to make investments to advance deep retrofits that can generate long term emission reductions and operational savings, and CIB is investing $2B in large-scale building retrofits as a way to catalyze this work. The CIB Initiative is designed to support an overarching vision that there is, by 2030, a well-functioning marketplace for decarbonizing and modernizing existing commercial buildings in Canada that has sufficient capacity to help meet Canada's climate targets. Achieving this vision depends on progress in several other key areas, including sufficient workforce and industry capacity and supportive government policies that drive demand for retrofits. Research by the Delphi Group and the Canada Green Building Council identifies how Canada can scale up retrofits for large buildings, including industrial, commercial, and large residential buildings by examining the workforce capacity to ensure that workers with the right skills are available to support retrofit projects and that supply chains have capacity to deliver affordable low-carbon construction-related products, technologies, and materials.

Read the report **here**.

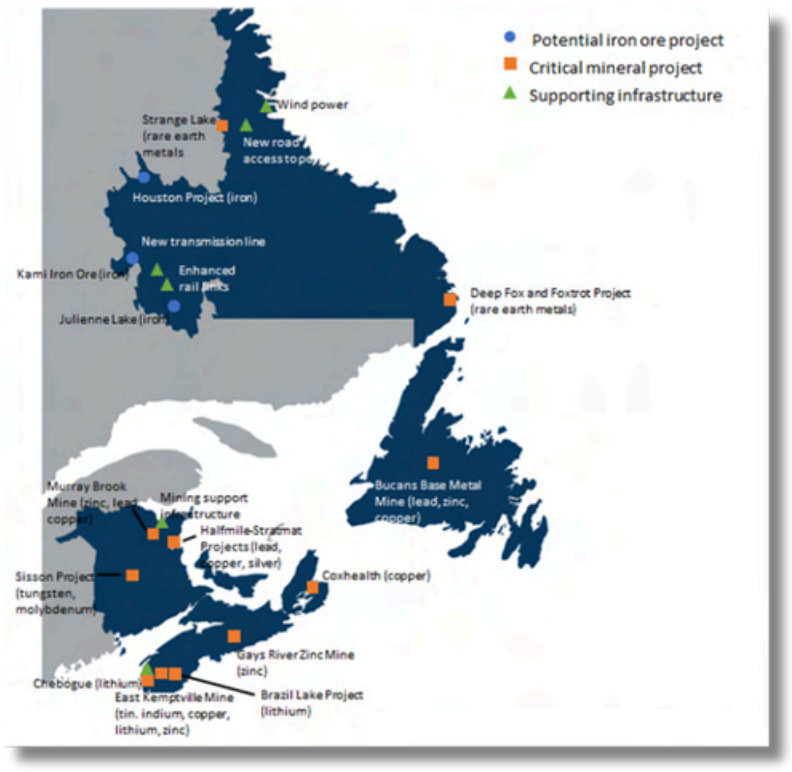
Investment Opportunities for Transformational Change in Atlantic Canada's Economy

Atlantic Economic Council

This report identifies opportunities for investment in three key sectors in Atlantic Canada which could accelerate growth in the region's economy – hydrogen and clean fuels, critical minerals, and trade and transportation. Among the findings, the report points to a critical role for CIB to advance major infrastructure projects through blended finance partnerships.

The report relied on in-depth desktop research, case studies and interviews with stakeholders. The project began in August 2023 and concluded in February 2024.

The paper found that the region is positioned to capitalize upon an advantageous trade location, a growing population, and critical minerals across the region. The report also emphasized the role the CIB can play to help get projects off the ground. The report included an appendix of potential investable projects.



Read the report **here**.

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Land Value Capture Study – Paying for Transit-Oriented Communities

Infrastructure Institute

Land value capture (LVC) recognizes that transit leads to increased value for landowners in the vicinity and leverages value uplift for reinvestment in the community. LVC leverages fees, charges, and levies on landowners to reinvest for community benefit. Among the findings, the study outlines how CIB could play a key role in sharing risk and leveraging private capital to expand LVC.

Infrastructure Levies

A tax or levy on landowners who stand to gain financially from a government investment in infrastructure. Infrastructure levies can either be geographically restricted to property owners within close proximity to an infrastructure investment, or they can be more generally applied to all landowners in a city.

Development Charges (DC)

This is an infrastructure cost-recovery mechanism, also known as Development Cost Charges and Development Cost Levies. DCs are fees collected from developers at the time of permit approvals to help pay for the cost of infrastructure required to provide municipal services tied to new developments, such as roads, transit, water and sewer infrastructure. It is commonly associated with the concept of growth-pays-for-growth.

Density Bonuses

Also described as "incentive zoning", the benefits from this LVC mechanism are realized when developers provide certain desired features, design elements, or amenities in the locality in exchange for valuable increased density. Examples of these include affordable housing, sidewalk upgrades and heritage preservation.

Tax Increment Financing (TIF)

Developed in the U.S. and common in North America, TIF is commonly designed as a policy approach to revitalize depressed areas. This is essentially a manipulation of property taxes, where a TIF district is established for which bonds are issued to pay for specified infrastructure. With this mechanism, local governments borrow against expected future property tax revenues to fund infrastructure projects. Within the designated TIF district, increases in total property tax revenues, above an agreed baseline, are used to pay for the bonds allocated towards public investment. Importantly, in TIF arrangements it is typically the municipal government rather than private sector project proponents that borrow against future tax revenues.

Land Acquisition, Investment and Disposition

This broadly refers to active involvement in land and urban development processes through purchase or ownership of a large portfolio of land sale/lease, joint development, land readjustment, and/or through partnerships that take direct advantage of land value growth as a result of rezoning, market growth and/or new infrastructure.

Land Sale/Lease: Land value uplift is captured when land or its development rights, whose values have increased due to public investment, is sold to developers in return for an up-front payment, leasehold charge, or annual land rent payments through the term of the lease.

Joint Development: This refers to development projects, such as new transit station facilities and adjacent private properties, typically involving transit agencies and developers. The latter usually contributes with land or money to construction of the station, as their property values will increase due to the transit investment.

Land Readjustment: Here, landowners pool their land and contribute a portion of their land for sale to raise funds and partially defray public infrastructure development costs.

The research explored LVC in North America, Asia and Europe, and relied on desktop research and modeling to answer the research questions:

- What is the range of LVC mechanisms?
- How do they work and who are the main actors involved?
- What does the domestic and international experience say about the pros and cons of various land value capture approaches?
- What is the Canadian legislative landscape to permit or inhibit LVC tools nationwide?

The study began in January 2022 and concluded in April 2023. It found that:

- Land value capture remains underutilized in Canada to finance transit infrastructure through market-driven approaches.
- Public institutions could accelerate integrated infrastructure, which is at the core of complete communities, by investing up front in the capital costs of transit stations and associated infrastructure at key locations and be partially repaid over time through private development revenues.
- Collaboration among transit agencies, municipalities, developers and public investors like CIB will be critical to making the most of this financing tool.

Development Setting	Transit Investment Need	Transit Investment Cost	Amount of Development needed at $10 LVC/sq.ft.	Amount of Development needed at $48 LVC/sq.ft.
Large brownfield site	Fund new above ground station on existing rail line	$100 million	10 million	2.08 million
Large brownfield site	Fund new under-ground station on existing rail line	$250 million	25 million	5.2 million
Rapid transit corridor with 20 stations	Fund $500 million of new rapid transit line cost through LVC	$500 million	50 million	10.4 million
Existing publicly-owned rail yard with development overbuild potential	Fund $750 million steel deck to enable development on publicly owned land	$750 million	75 million	15.62 million

Read the report here.

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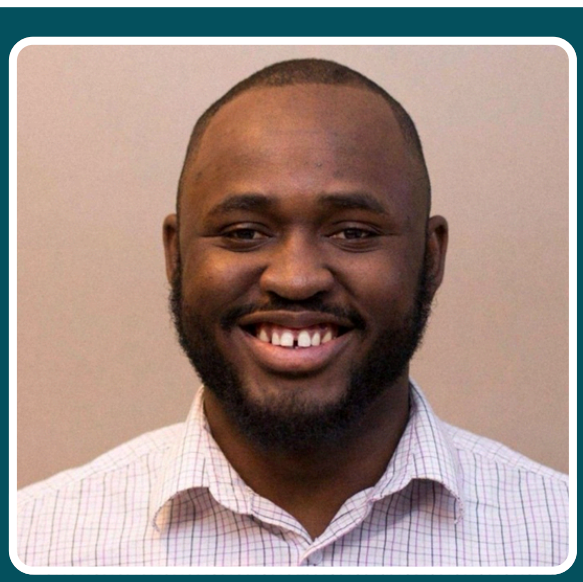

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Non-Traditional Modes of Transportation Report

This research report outlines effective strategies for infrastructure investments in five non-traditional transportation systems – such as aerial transit, micromobility like bikes or e-bikes, ferries, on-demand transit and autonomous shuttles – in Canada. Through international and domestic case studies and industry trends, the report's key findings highlight non-traditional transportation systems that can play a critical role in providing transit options for users and enhancing the reach and performance of transit networks. Case studies include North America, South America, Asia, and Europe.

The report relied on in-depth desktop research, case studies and interviews with stakeholders to analyze the viability of each of the five non-traditional modes of transportation solution in Canada. The project began in April 2023 and concluded in March 2024.

Light rail transit, bus rapid transit, and subways may not always be economically viable due to ridership/demand limitations. There are a variety of projects in the public transit sector that can fill an important niche in non-traditional modes of public transit. However, these smaller and non-traditional projects are not always viewed as "infrastructure." The report highlights the use cases for 5 non-traditional modes (i.e., aerial transit, ferries, micro-mobility, autonomous vehicles, and on-demand transit) including details on models, financing, integration with larger transit networks, role for private sector. The report also identifies success factors and challenges and educates and informs key stakeholders on how non-traditional transit modes can be helpful in building transit systems and growing ridership.

Read the report here.

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