Digital Twins for Urban Decarbonization Strategies @ Next-Generation Cities Institute

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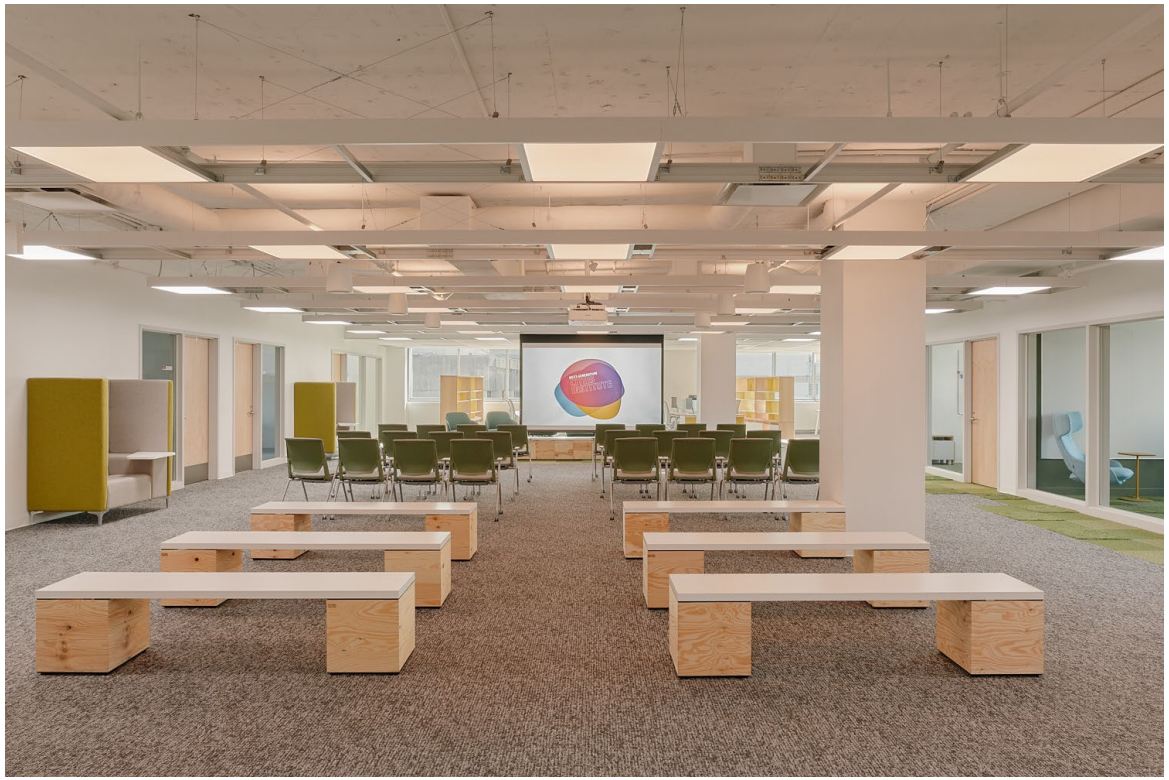
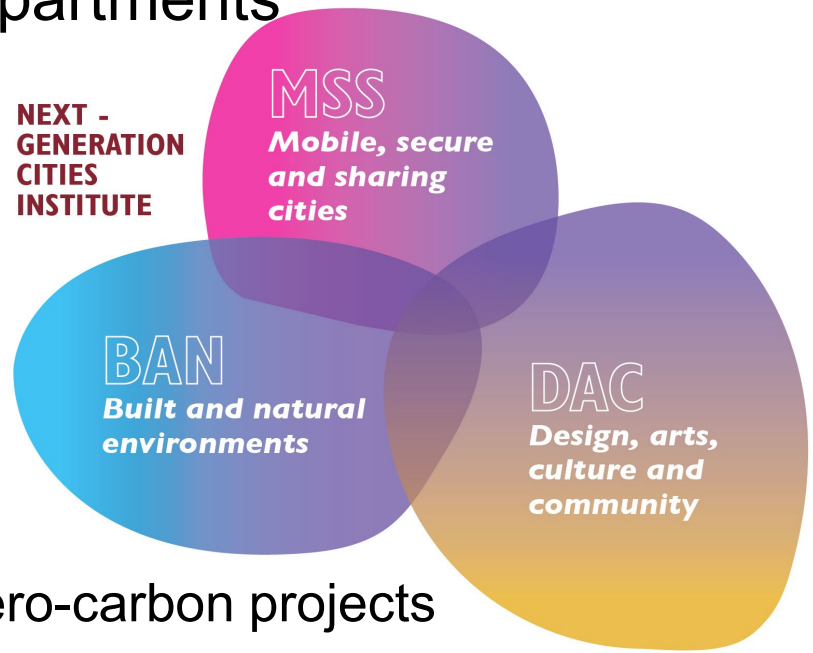
Agenda

- Introduction NGCI
- TOOLS*4*CITIES
- Prototyping use cases for impact
- Science applied to urban challenges
- Future developments and trends
- Scalable solutions to mitigate climate change



The Next-Generation Cities Institute

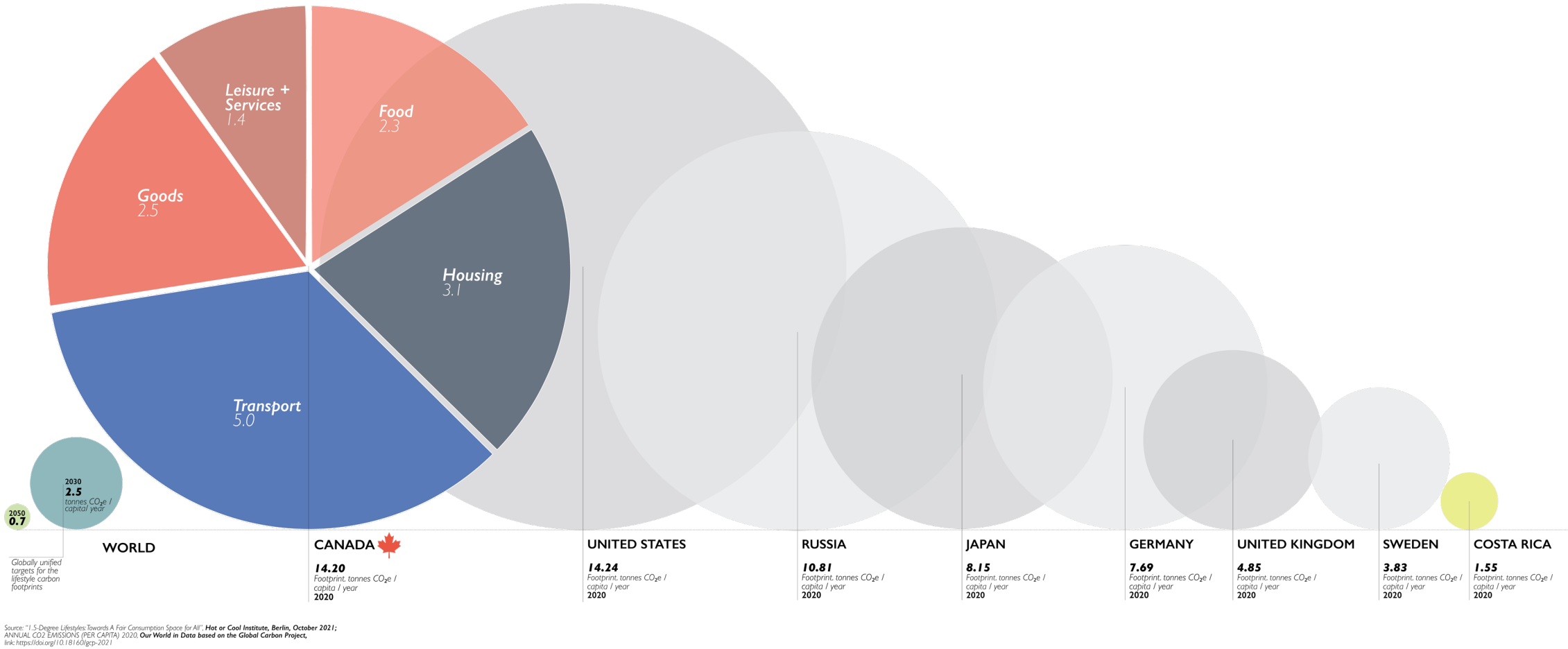
- Interdisciplinary Institute - Cross-faculties, cross-departments
- 3 Research Clusters
- 200 Researchers & 14 Associated Centres



Flagship projects

- Urban Simulation platform TOOLS *4* CITIES
- Campus Living Lab @ CONCORDIA
- Private and social sector accelerators to realize trailblazing zero-carbon projects
- International Collaborations with Ben Gurion University, City University New York, Amsterdam Metropolitan Solutions Institute, ..
- Developing an Inter-University Hub for Montréal and beyond

Global CO_2 and Greenhouse Gas Emissions



Source: "1.5-Degree Lifestyles: Towards A Fair Consumption Space for All", **Hot or Cool Institute, Berlin, October 2021;** ANNUAL CO2 EMISSIONS (PER CAPITA) 2020, **Our World in Data based on the Global Carbon Project,** link: https://doi.org/10.18160/gcp-2021

NEXT-GENERATION CITIES INSTITUTE

TOOLS*4*CITIES

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TOOLS*4*CITIES

- Enabling Decision-Makers with Science
- Visualization & Realtime Interaction
- Engaging (Serious Gaming)
- Reflection and Education
- Demystifying Complexity
- Different Stakeholder Problems – Different Tools

TOOLS 4CITIES

CITYlayers
CITYplayer
BUILDINGretrofitter

TOOLS*4*CITIES
CITYLayers

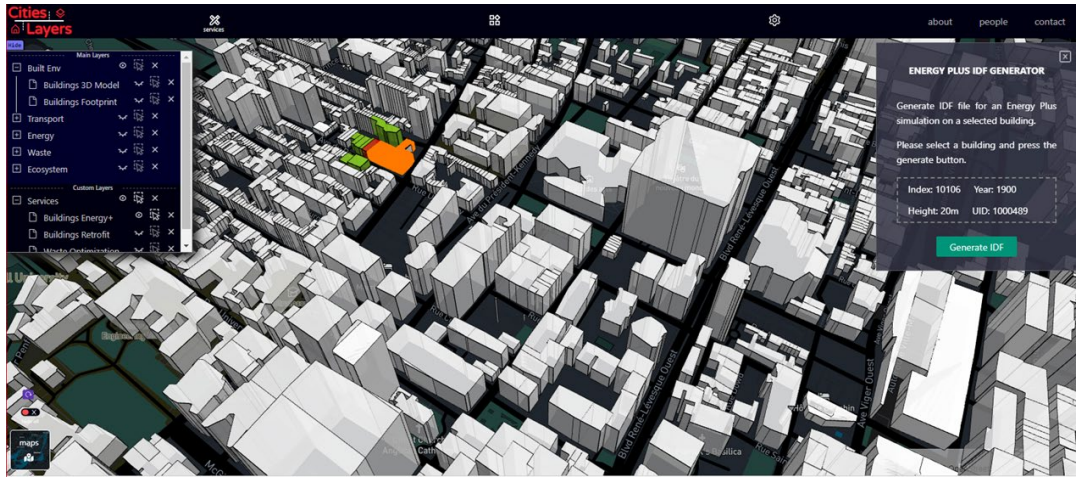
TOOLS CITYlayers
4CITIES

Please see recording for video

The science behind TOOLS*4*CITIES

- **Digital Twins –** allowing creating of user-centred decarbonization strategies by simulating scenarios for urban densification, building retrofit and sustainable mobility solutions
- **Urban Data Models** to structure information needed for modeling and to integrate real time data
- **Co-Creation processes** to allow informed decision-making based on sustainability and livability indicators

Automated processes for energy and carbon emission accounting



Strategies and scenarios for urban electrification

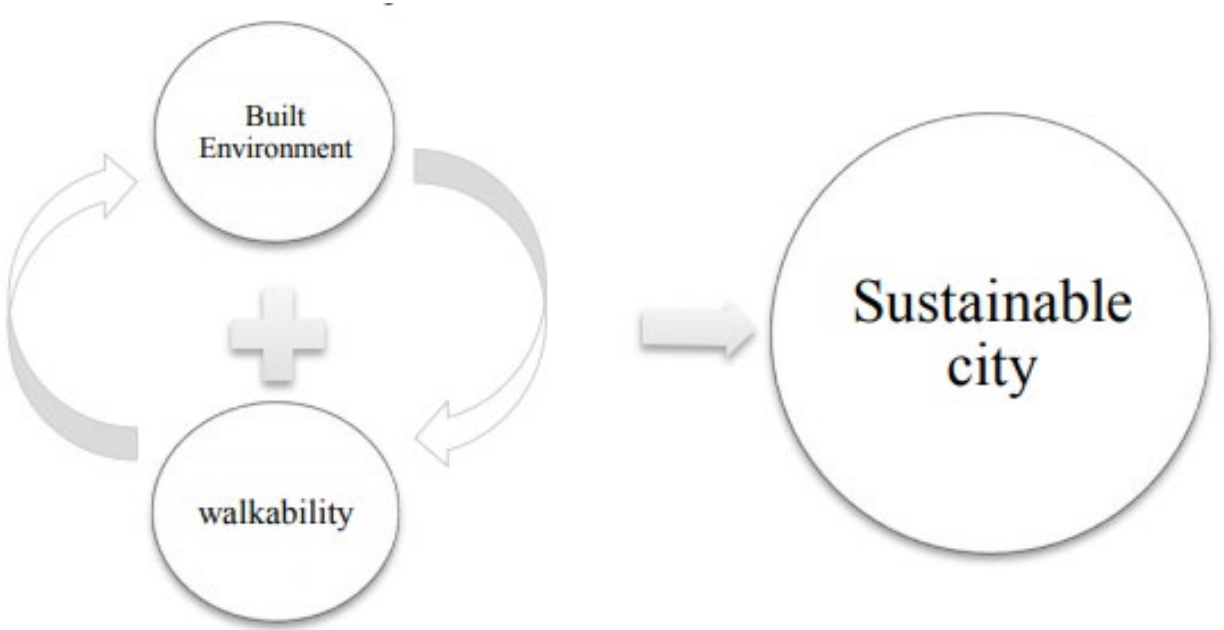
- Built a digital twin of the city
- Make it easy to estimate cost and savings for retrofit and electrification strategies
- Act as a convenor of interested parties to push ambitious zero-emission projects in the city
- Build interactive and engaging interfaces to allow multiple stakeholder discussions on new projects

Further dimensions of an “ecological city”

minimization of car traffic,

emphasis on walking, cycling and public transport,

a compact urban form and a people-centered city center



https://www.who.int/activities/investing-in-physical-activity

Connectivity, Access to amenities and public transport , Active transportation and health:

1- Improve mental health (Melis et al. 2015) such as reduced self-reported depressive (Berke *et al*. 2007) and stress
2- reduced incidence of hypertension (Chiu et al. 2016) and diabetes (Paquet et al. 2014) From (Ige-Elegbede et al. 2020)
3- lower risk of disability (Freedman et al. 2008) From (Ige-Elegbede et al. 2020)
4- increase physical activity and fitness from (McCormack et al. 2020) (Michael et al. 2006, Richardsen et al. 2016) (Ige-Elegbede et al. 2020) and lower BMI; Lovasi et al. (2012) From (Wang and Yang 2019)
5- Reduced auto-related injuries–Reducing the number of auto trips reduces the chances of auto-related injury (Properties & Mucosa, 2015).

Potential impact of green space and public open space on health

1- increased physical activity (Picavet *et al*. 2016; Sugiyama *et al*. 2010)

2- reduction of mortality (Villeneuve *et al*. 2012, Mueller *et al*. 2016)

3- Reduction the risk factors for cardiovascular diseases (Paquet *et al*. 2014, Tamosiunas *et al*. 2014).

4- lower risk of asthma (Andrusaityte *et al*. 2016)

5- improve mental health (Annerstedt *et al*. 2012)

6- reduction of the prevalence of cardiovascular diseases (Tamosiunas *et al*. 2014) From (Ige-Elegbede et al. 2020)

7- lower BMI; Lovasi et al. (2012) from (Wang and Yang 2019)

On sunny days, New York's Bryant Park is full morning to night with office workers, tourists and local residents. Shutterstock

Urban density, walkability, greening and urban heat

Neighbourhoods with higher proportions of concrete and higher dense infrastructure, despite being more walkable, exacerbate urban heat. (O'Brien, Ross, and Strachan 2019)

Simultaneous planning solutions to mitigate urban heat and promote walkability:

1- **Using advanced cooling materials** to change albedo and reduce heat associated with walkway surfaces **(e.g.** white cool coatings of pavement and cool coloured materials with near-infrared reflective pigments). (Santamouris et al. 2011)

2- **More On-street tree canopies** : Trees are aesthetically pleasing and increase people's walking rates and offer the additional benefit of lowering surrounding temperatures. (O'Brien, Ross, and Strachan 2019)

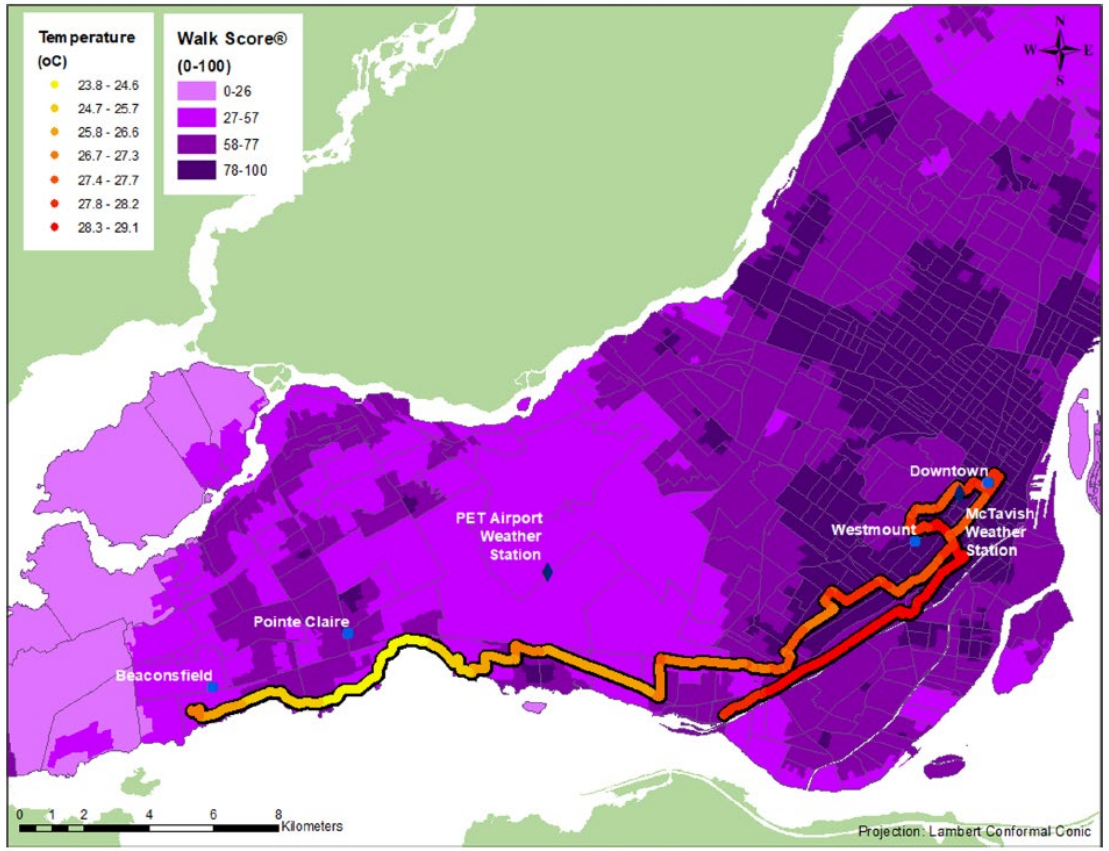
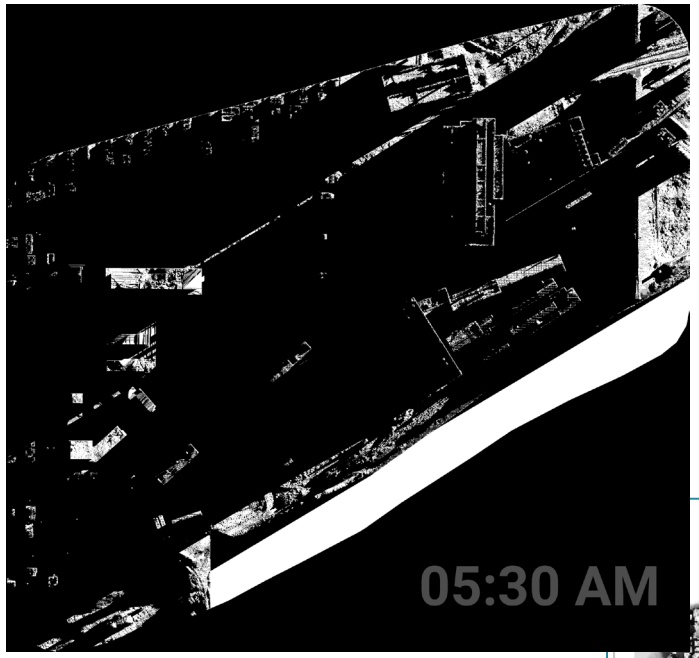
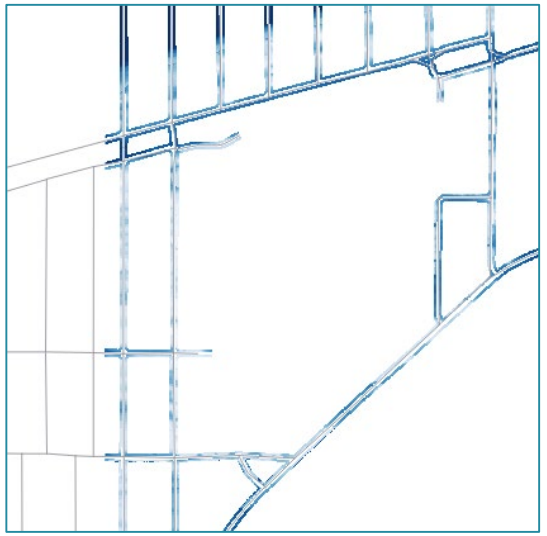


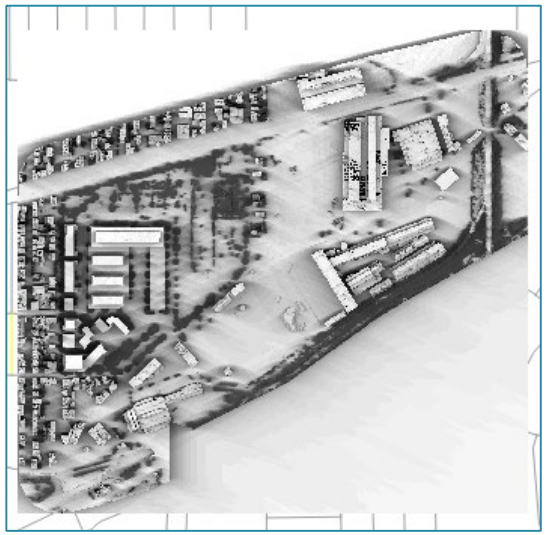
Fig. 1 Detrended average air temperatures recorded by instrumented car and Walk Score® (aggregated by census Dissemination Area) for Montréal, QC, Canada, during a Heat Event on July 13, 2016 (11:30–14:30 EDT). Some neighbourhood descriptors and the weather stations are provided for orientation (downtown, Westmount, Pointe Claire, Beaconsfield, PET weather station and McTavish weather station)

FUTURE SCENARIO

Pedestrian comfort/Shadow

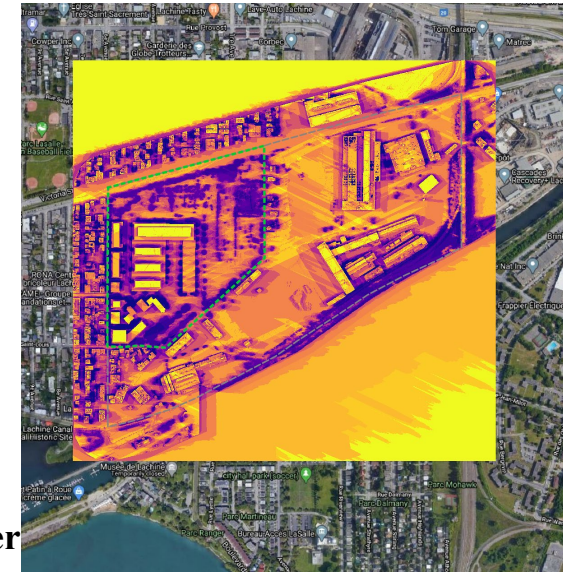




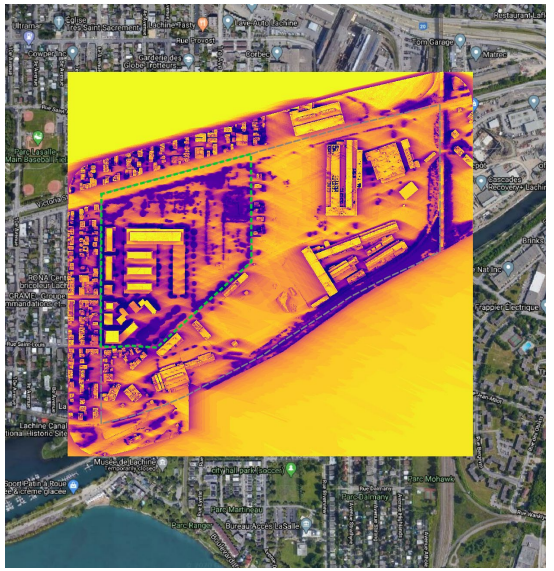


Current

Future

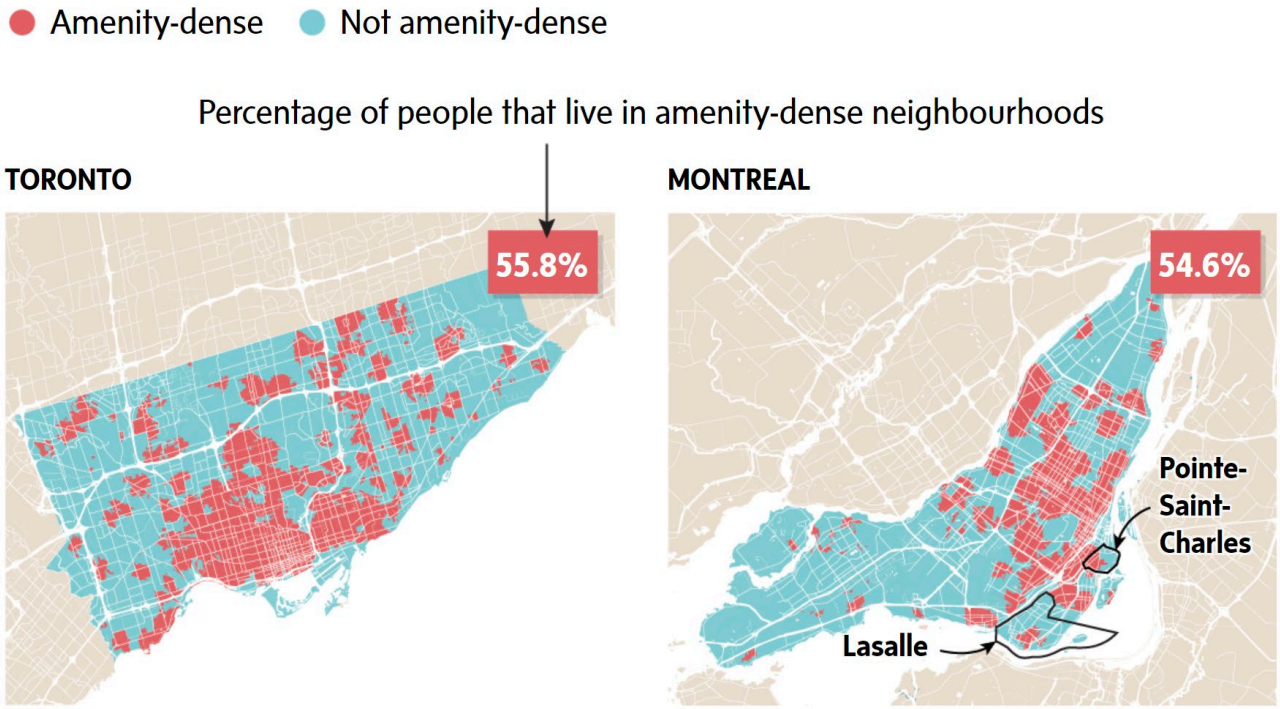


Winter

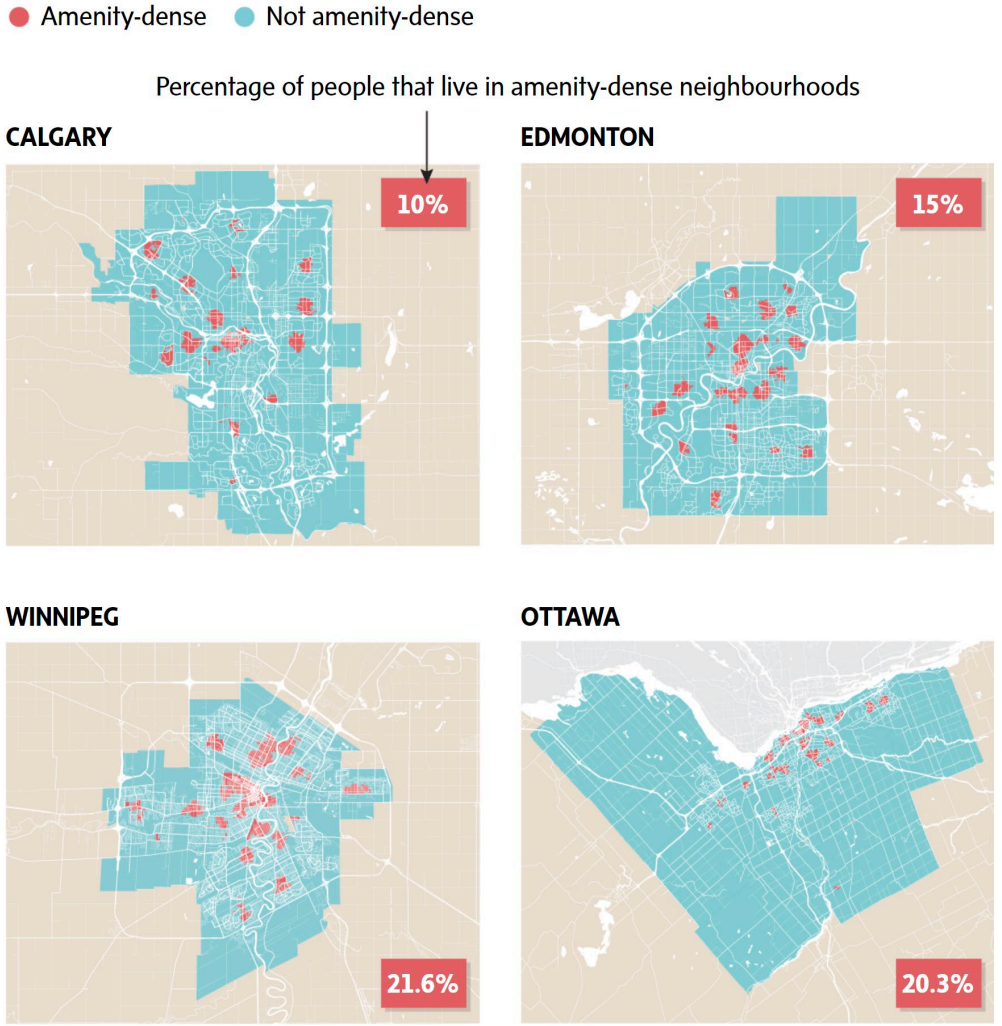


Summer

Urban and sub-urban cities

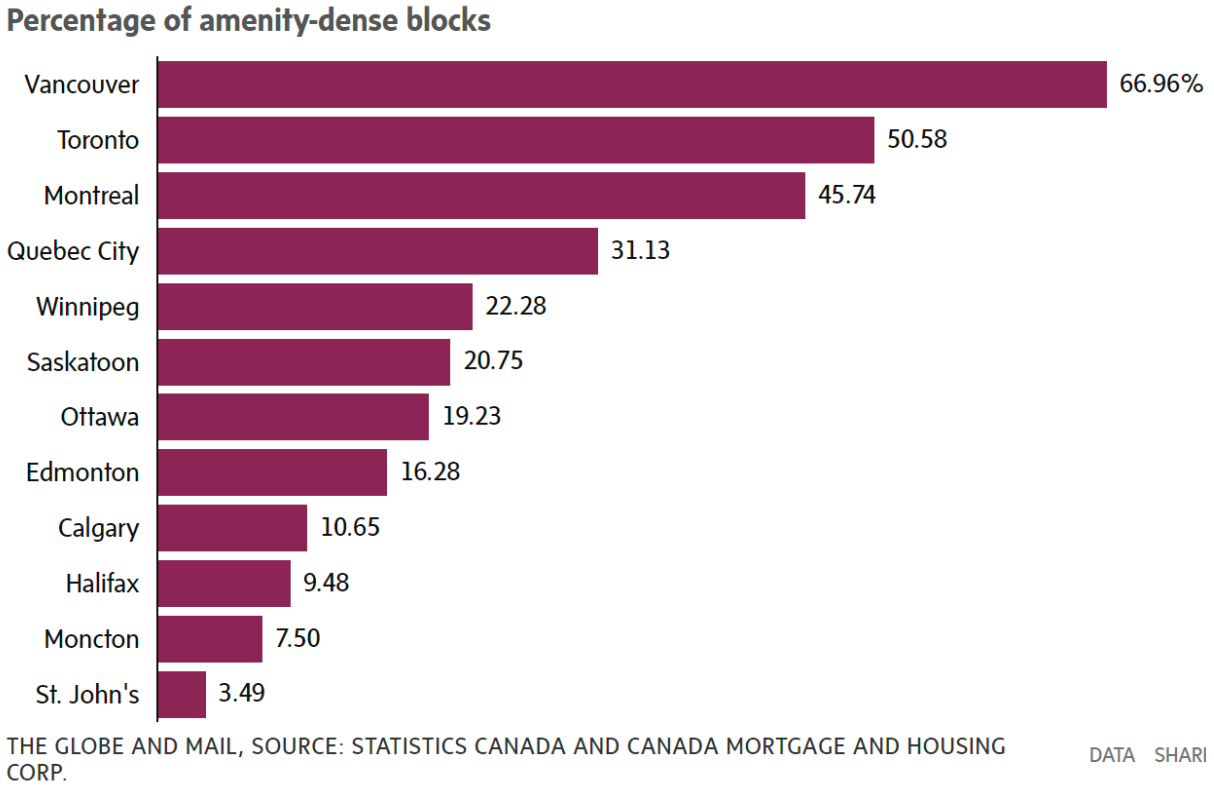


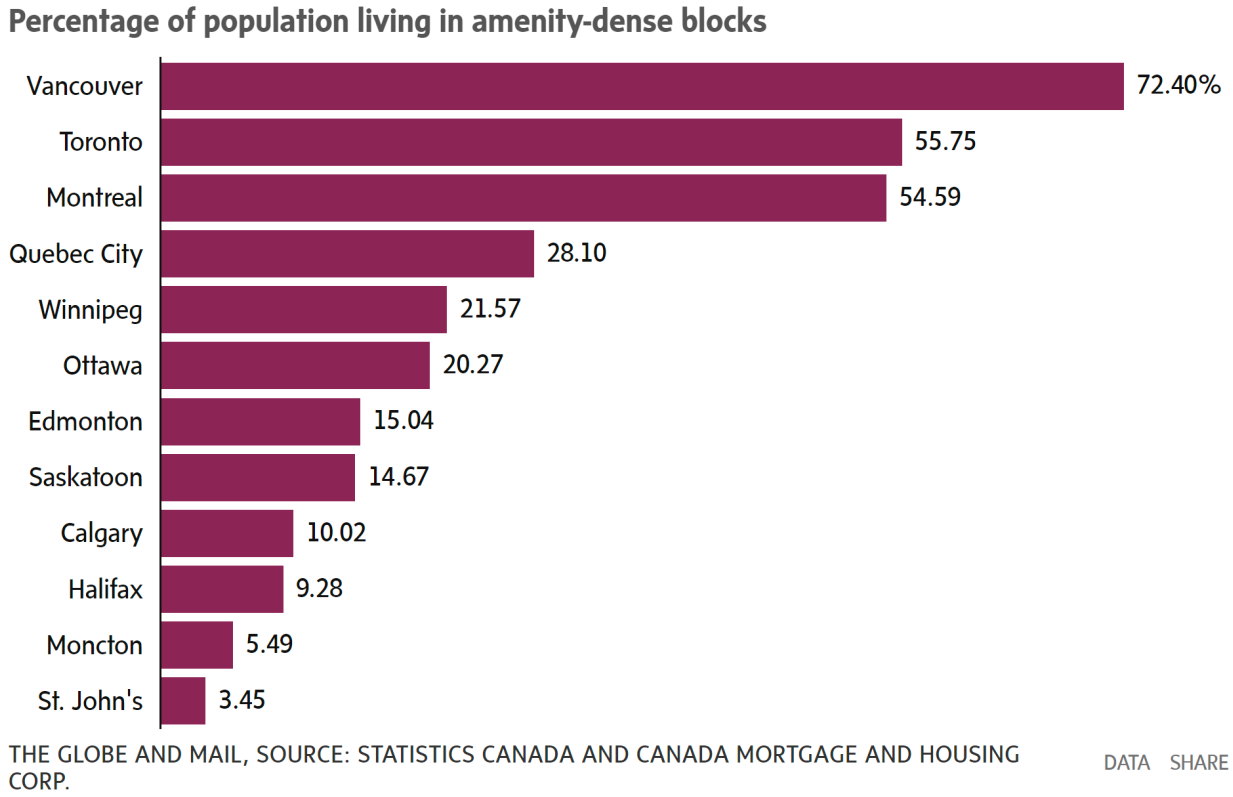
THE GLOBE AND MAIL, SOURCE: STATISTICS CANADA; CANADA MORTGAGE AND HOUSING CORP.



THE GLOBE AND MAIL, SOURCE: STATISTICS CANADA; CANADA MORTGAGE AND HOUSING CORP.

Current situation in Canada





ALEX BOZIKOVIC, JOE CASTALDO AND DANIELLE THE GLOBE AND MAIL

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Environmental Benefits of TOD

- **Greenhouse Gas (GHG) Reduction**

https://www.nytimes.com/guides/year-of-living-better/how-to-reduce-your-carbon-footprint

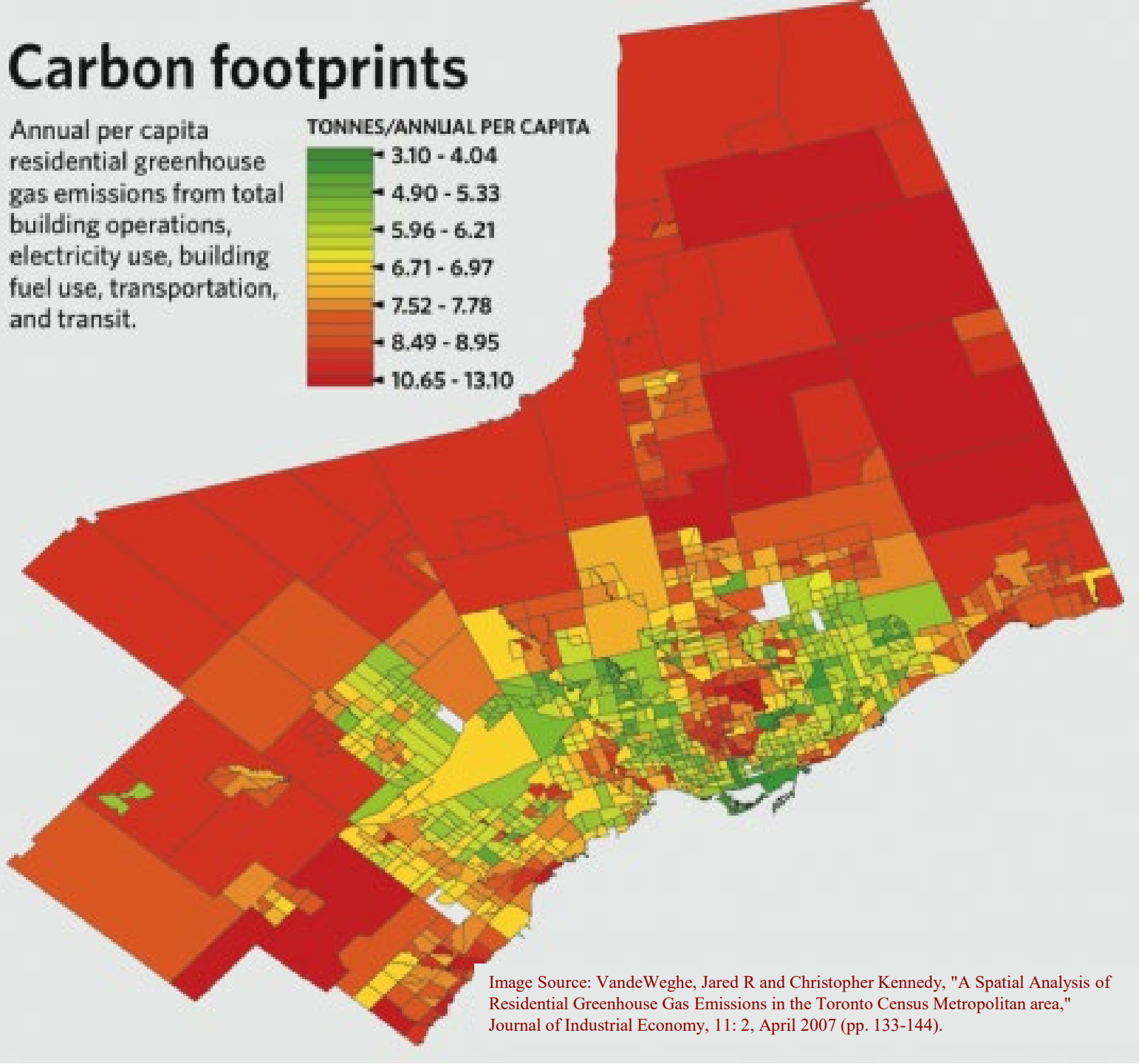


Image Source: VandeWeghe, Jared R and Christopher Kennedy, "A Spatial Analysis of Residential Greenhouse Gas Emissions in the Toronto Census Metropolitan area," Journal of Industrial Economy, 11: 2, April 2007 (pp. 133-144).

Potential of food production by community gardens

Parks in Montreal

Community Gardens in Montreal

	Number	Surface area (m^2)
Community Gardens	178	311,185
Parks	2218	66,679,700

Investigating CG land usage, food production and economic aspects of community gardens

- Utilizing the system dynamics modeling approach

- Assumption: Assigning 20% of Montreal's parks areas to community gardens

•Population Statistics of Montreal

- Total Population: 1,762,949
- Low-Income Individuals (Income below $30,000 per year): 559,045 individuals

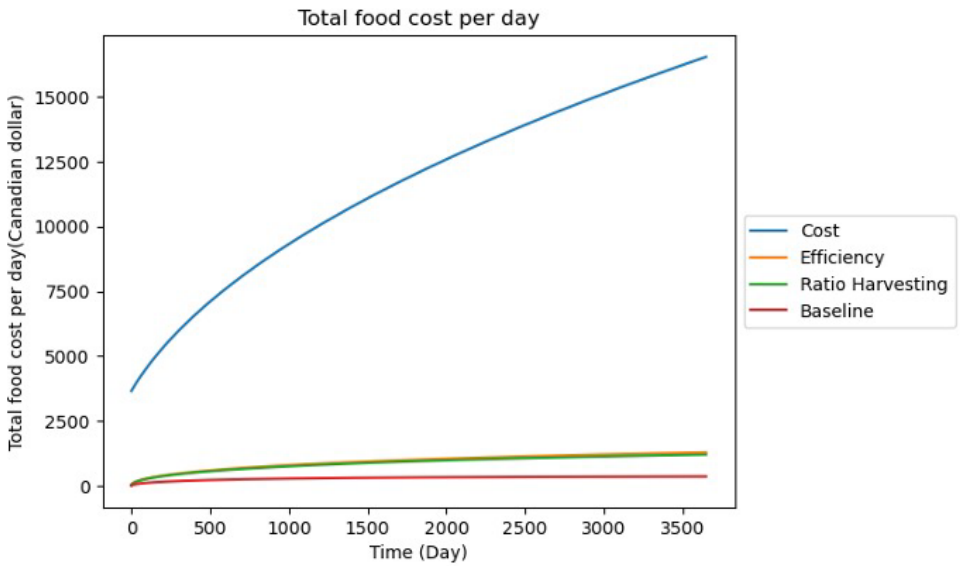
•Food Requirements for the low-income residents in Montreal

- Vegetables: 167,713.5 kg
- Legumes: 27,952.25 kg
- Fruits: 111,809 kg

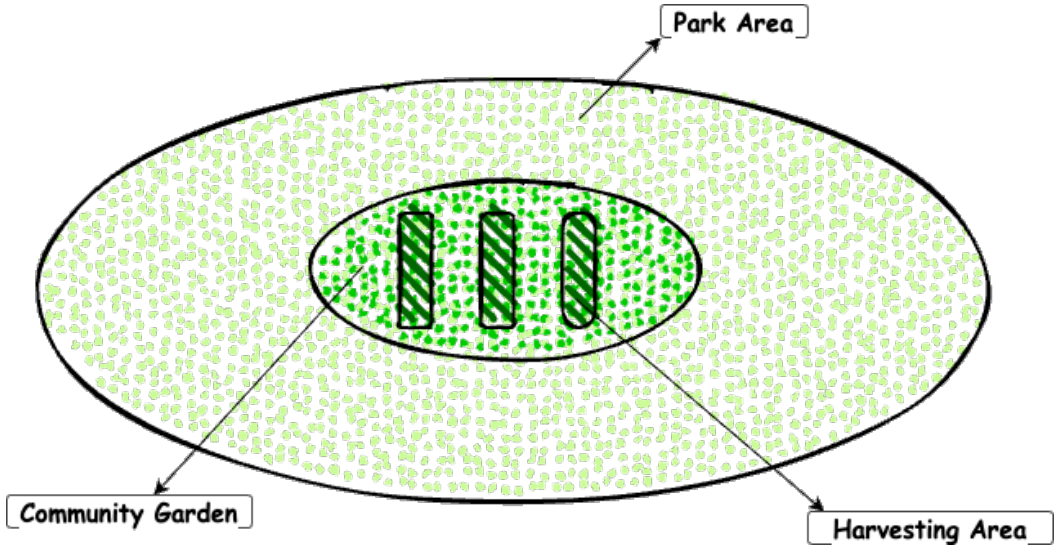
•Daily Food Requirements (EAT-LANCET)

- Vegetables: 300g
- Legumes (dry beans, lentils, peas): 50g
- Fruit: 200g

Daily food costs of community gardens



Scenario	The food cost (CAD) (t=0)	The food cost (CAD) (t=3650)
Baseline	8.67	365.8
Ratio Harvesting	39.43	1,210.86
Efficiency	43.38	1,292.76
Cost	3662.78	16,528.1



•Resulting Food Production in Efficiency Scenario

- Vegetables: 18,416.1 kg (10.98% of demand)
- Legumes: 454.37 kg (1.62% of demand)
- Fruits: 3.89 kg (0.003% of demand)

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