Toronto's Heat Vulnerability Maps: A Planning Tool for Hot Weather Response and Climate Change Adaptation

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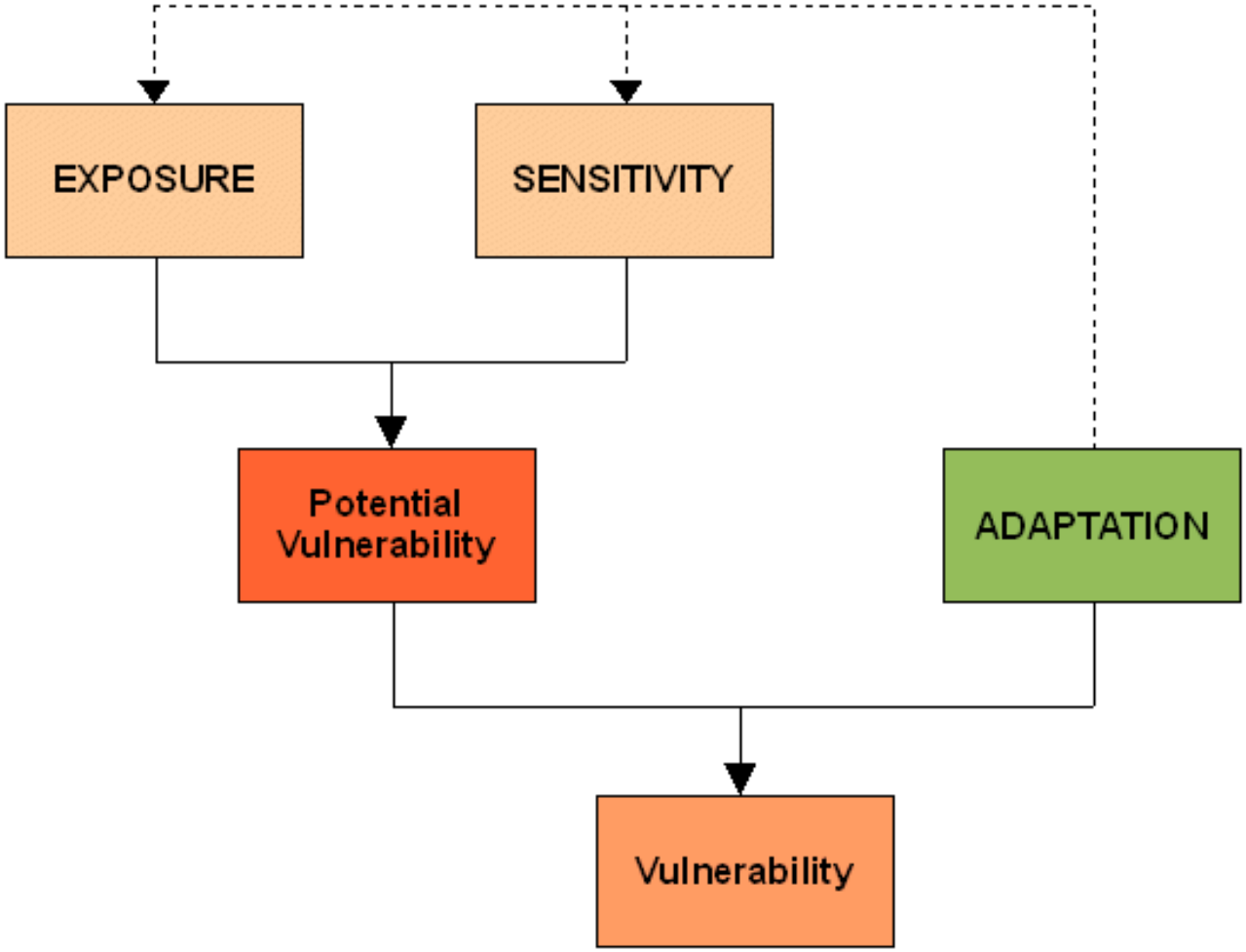
A Challenge…

- **Where** in Toronto are people most vulnerable to heat?

- Knowing where vulnerable people are helps to support
  - Hot weather response, both in terms of pre-season planning and delivery of services on hot days
  - Longer-term climate change adaptation planning

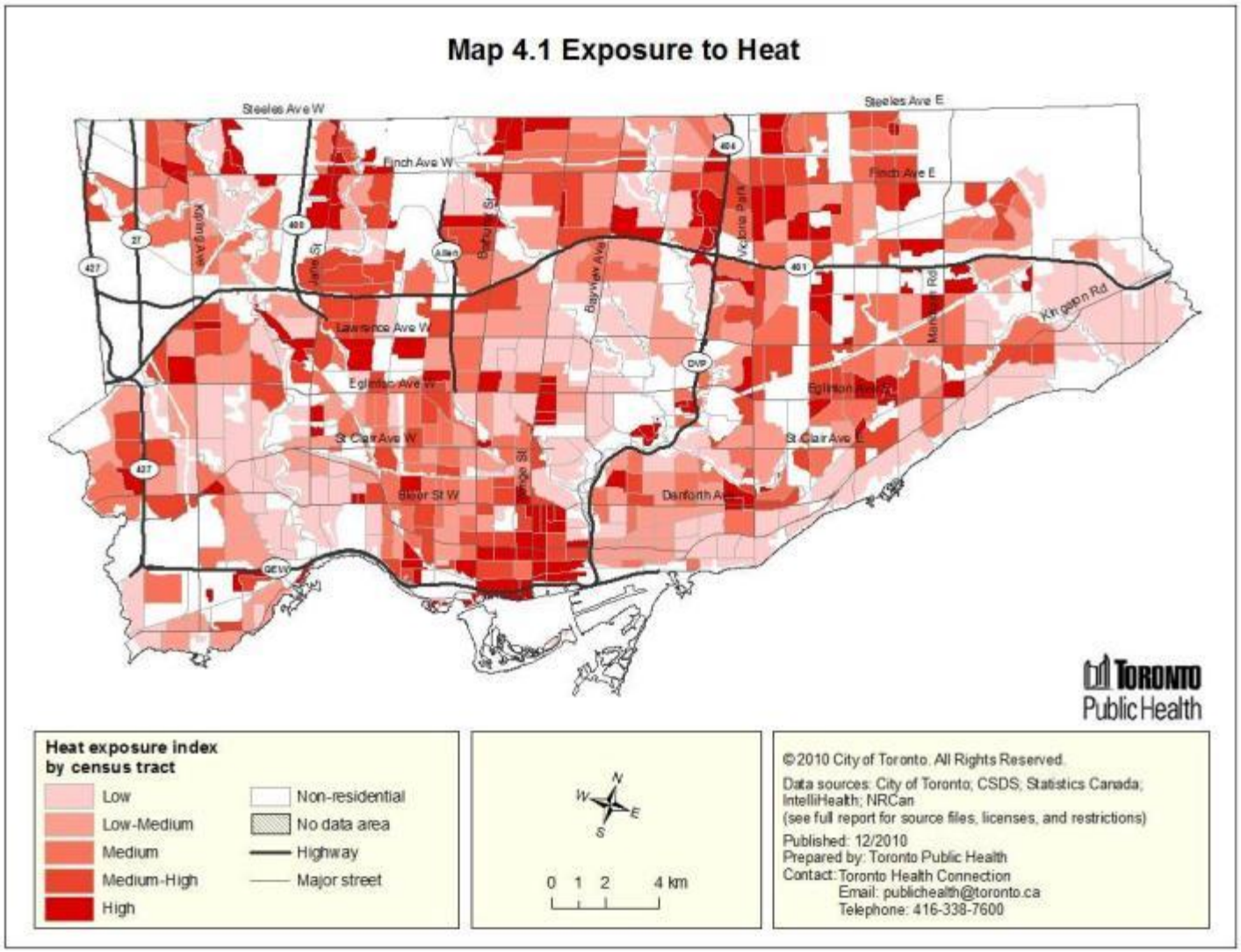
- ..led to ***Spatially Explicit Heat Vulnerability Assessment Project***
  - Phase I: Development of Methodology (2008/09)
  - Phase II: Consultation and Implementation (2010/11)

Conceptual Model for Heat Vulnerability



Rinner, et al. (2010) *The Role of Maps in Neighborhood-level Heat Vulnerability Assessment for the City of Toronto.* Cartography and Geographic Information Science (37)1: 31-44

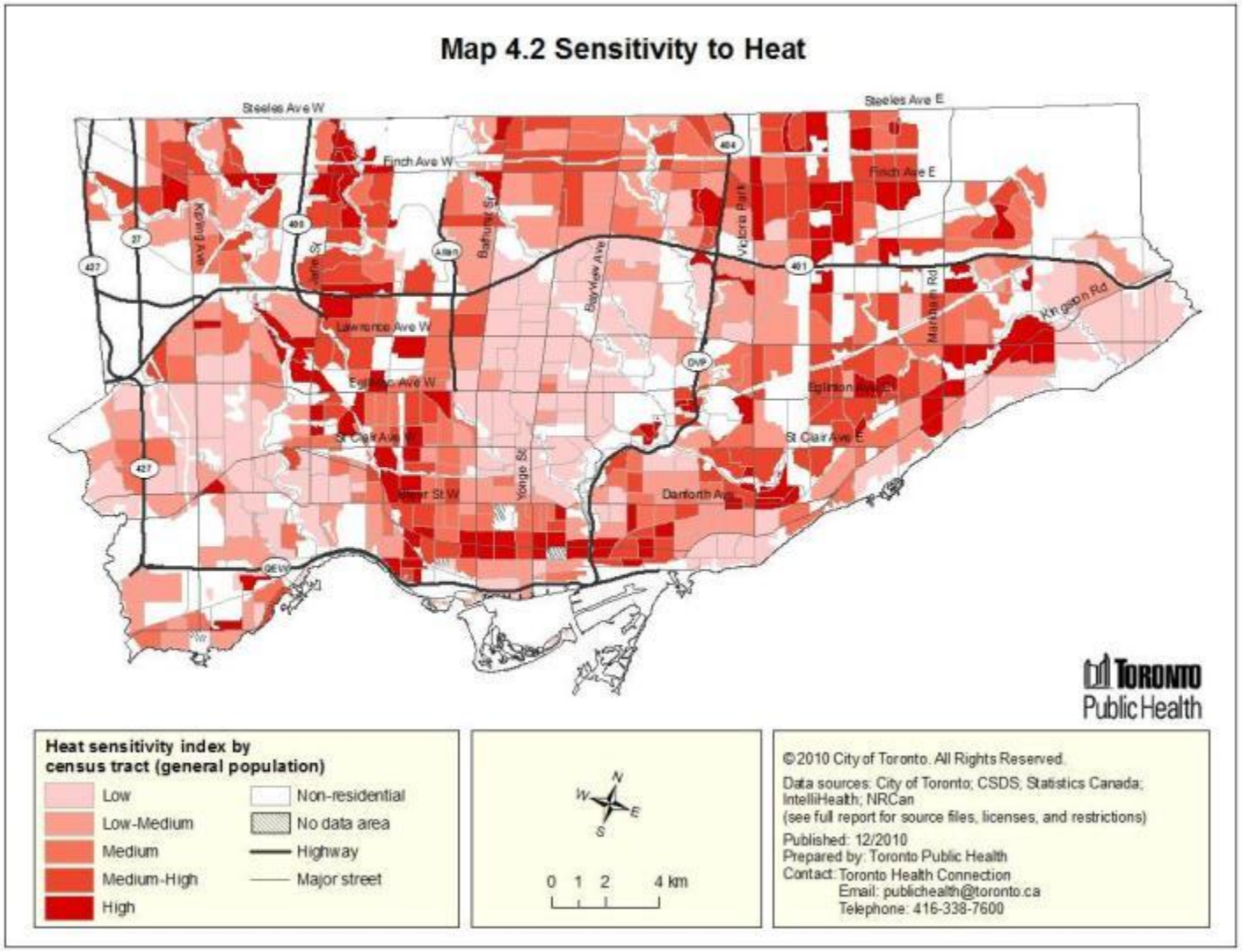
Selecting Indicators and Creating Maps: Exposure



Exposure Index - includes information about

- Surface Temperature
- Proximity to Green Space
- Tree Shading
- High-Rise Buildings
- Rented Dwellings in Older High-Rises
- Population density

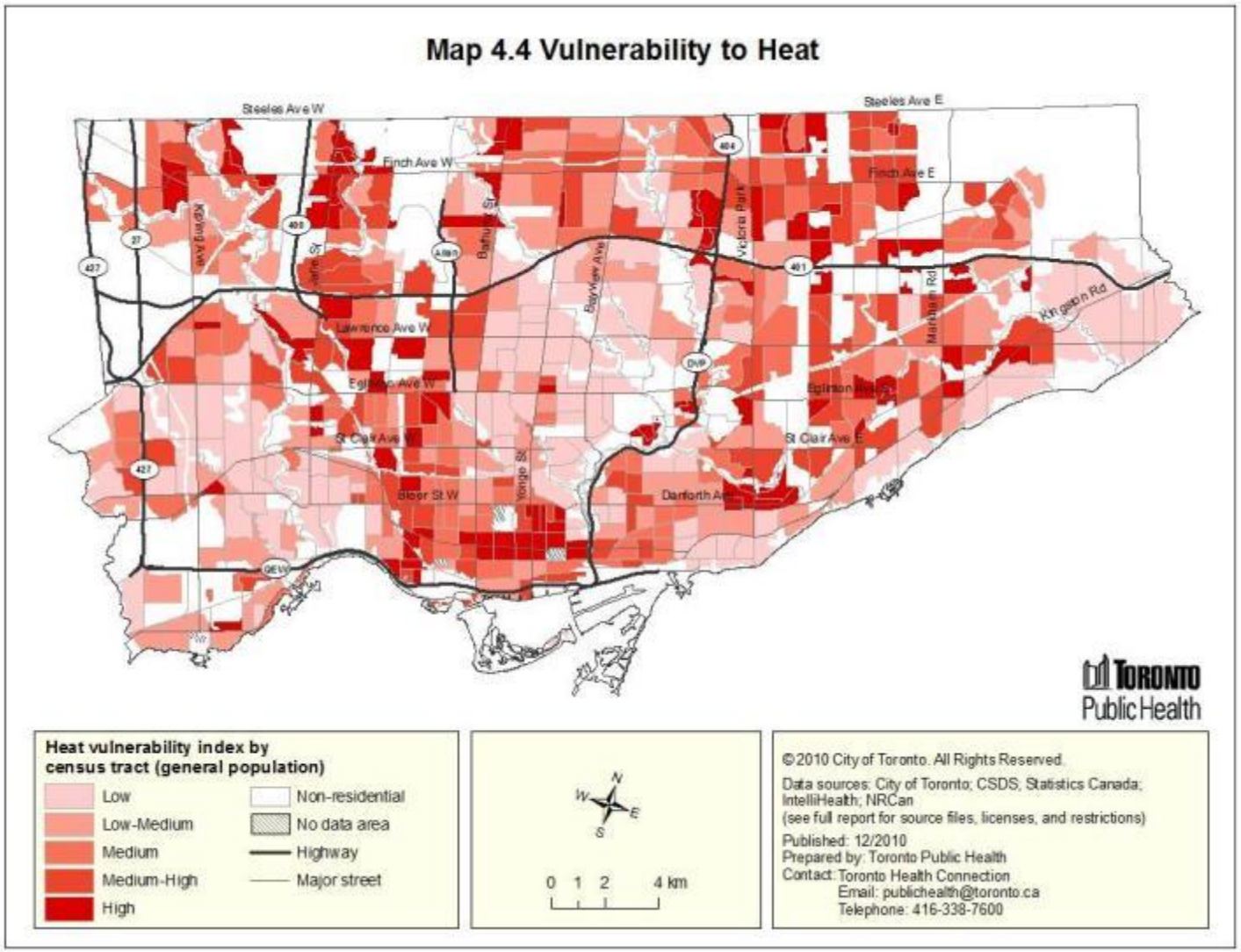
Selecting Indicators and Creating Maps: Sensitivity



Sensitivity Index - includes information about

- Low-Income Persons
- Low-Income Among Young Children
- Housing Costs of Renter Households
- Housing Costs of Low-Income Renters
- English Language Knowledge
- Recent Immigrants
- No High School Certificate Among Adults
- Racialized Groups
- Disability Among Adults
- Seniors sensitivity

Selecting Indicators and Creating Maps: Vulnerability



Vulnerability Index - includes information about

- Exposure
- Sensitivity

Stakeholder Information Needs

- Feedback from hot weather response committee members
  - E.g. requests for additional vulnerability indicators and reference layers; concern about stigmatization of neighbourhoods
- Feedback from workshop participants
  - Possible operational and strategic map uses beyond public health mandates
  - Key features and most popular maps
  - Additional data and cartographic improvements
- Post-season feedback

Stakeholder Input – Benefits of Maps

In what ways do you think the maps might be used by your organization or others?

"To inform the development of a future heat alert program (geographically, priority areas and priority groups)"

"To guide public health comments re: future development applications"

"To assist EMS services to better plan for heat emergencies during extreme heat events"

"In the development of a future heat registry program"

"As a tool for advocacy to influence policy decisions relating to urban landscapes and […] in future tree planting and shade improvements"

"To be used by […] stakeholders that work with vulnerable populations to help inform program planning and outreach"

Stakeholder Input - Suggestions

Suggestions from stakeholders:

"The ability to create our own maps would be very useful to our organization. These maps would be used as a planning tool in the development of a comprehensive heat alert response program. In particular, the ability to generate our own maps would allow us to develop programming specific to the needs of our communities and available resources"

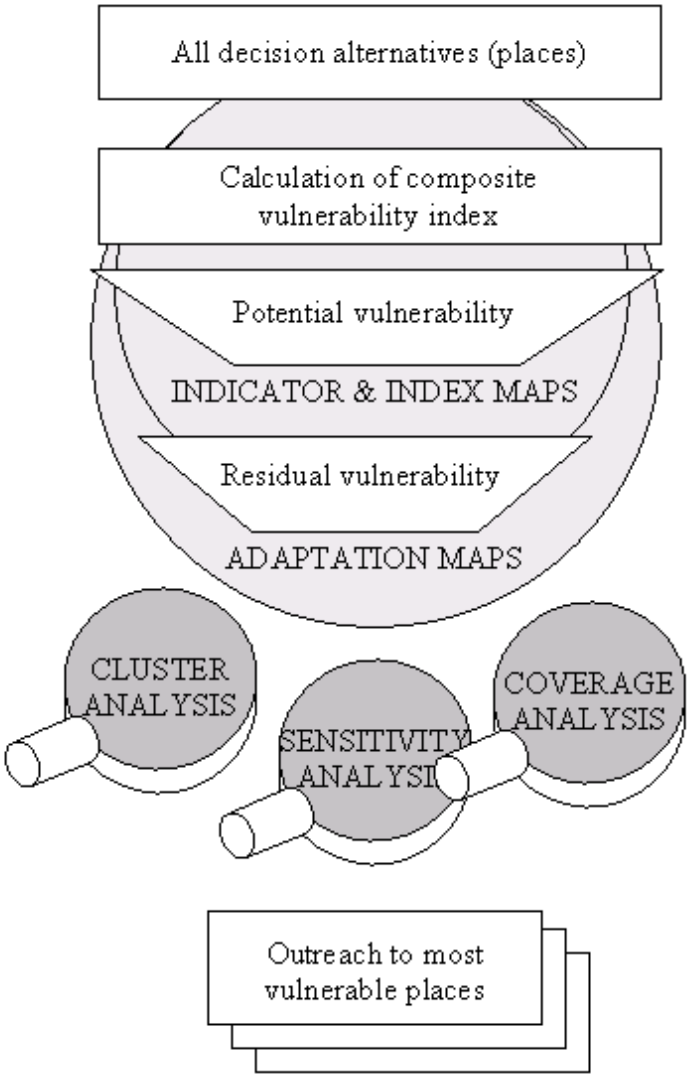
"Staff in our organization would require training in map interpretation [to] ensure proper interpretation and accurate dissemination of map information"

"Assess and better understand implications for making maps available to public (e.g. possible negative consequences for stigmatization if identified as living in heat vulnerability area)"

"Consider adding a future case scenario mapping option (this could help track interventions)"

Research Avenues

- Vulnerability index composition and weighting
  - Complexity of the indices and data reduction
- Role of maps in planning and decision-making
  - Indicator and index maps
  - Adaptation maps
  - Cluster maps
  - Coverage maps



Index Composition and Weighting

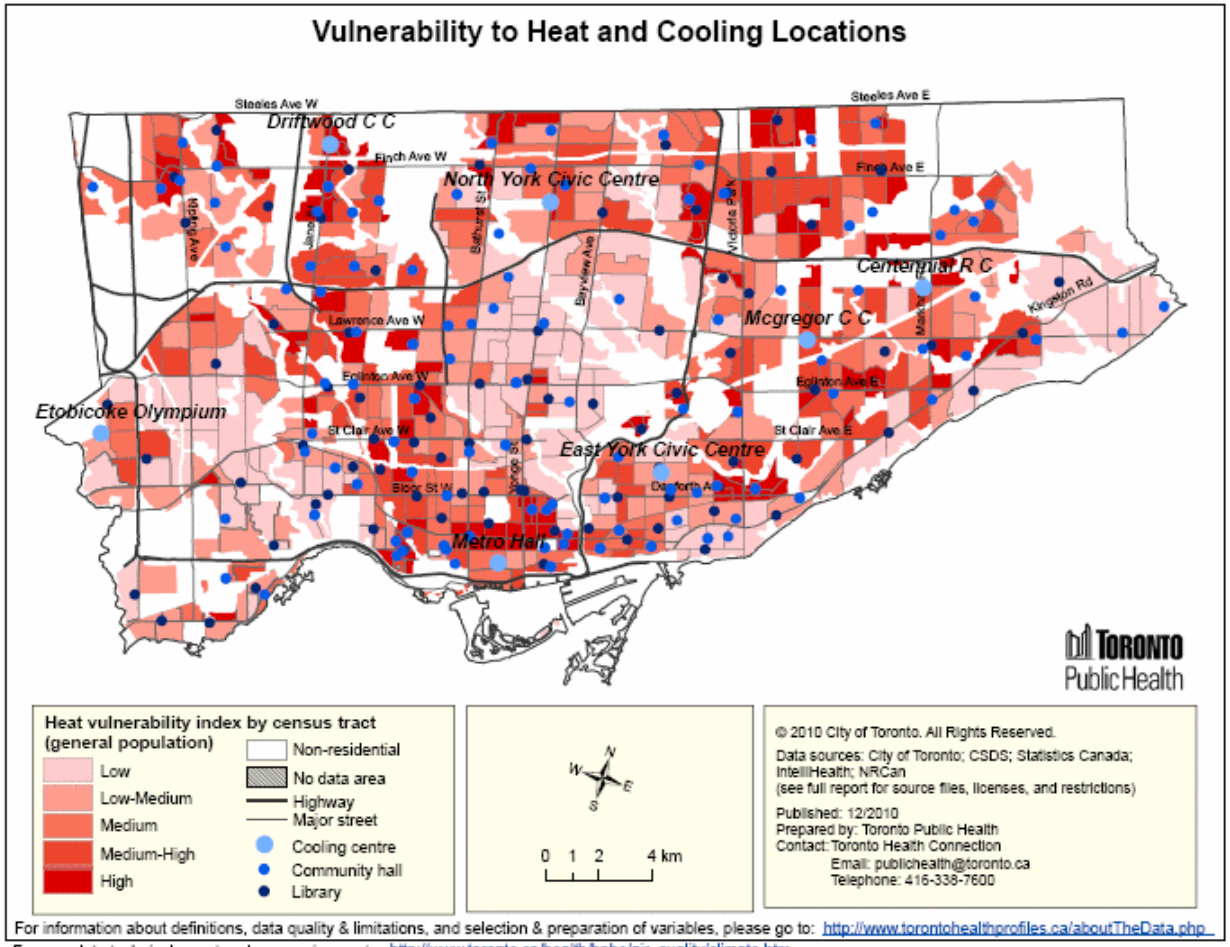
40%	**Exposure index**	30%	Surface temperature		
		10%	Access to green space		
		10%	Tree canopy shading		
		17.5%	Dwellings in high-rises (five or more storeys)		
		17.5%	Rented dwellings in older high-rises (built before 1986)		
		15%	Population density		
60%	**Sensitivity (general population) index**	25%	Low-income persons (2005, after tax LICO)		
		5%	Low-income among children (age 0-5)		
		5%	Renter households spending >= 50% on housing		
		5%	Low-income renters spending >= 50% of income on housing		
		10%	Persons not speaking English		
		5%	Recent immigrants (2001-2006)		
		5%	No high school certificate among adults (age 25+)		
		5%	Racialized groups		
		10%	Disability among persons age 25-64		
		5%	Emergency visits 2004-08 for circulatory disease (age-standardized rate)		
		5%	Emergency visits 2004-08 for respiratory disease (age-standardized rate)		
		15%	**Seniors sensitivity index**	10%	Frail seniors (age 75+ with a disability) among total population in private households
				10%	Low income (2005, after tax LICO) and living alone among seniors (age 65+)
				20%	Low income among seniors
				10%	Low income among seniors living alone
				5%	Senior families paying >= 30% on housing
				5%	Unattached seniors paying >= 30% on housing
				10%	Seniors not speaking English
				5%	Recent immigrants (1996-2006) among seniors
				5%	No high school certificate among seniors
				5%	Seniors in racialized groups
				5%	Unattached seniors with disability
				5%	Disability among persons age 65-74
				5%	Emergency visits 2004/05 among persons age 65-74

Alternative Indices

- Six weighted variables from original set of 30 variables
- Ten equally weighted variables from the literature
- Seven principal components based on the original 30 variables
  - Similar spatial patterns, but differences in outcomes for local neighbourhoods
  - Statistical correlation ≠ spatial association

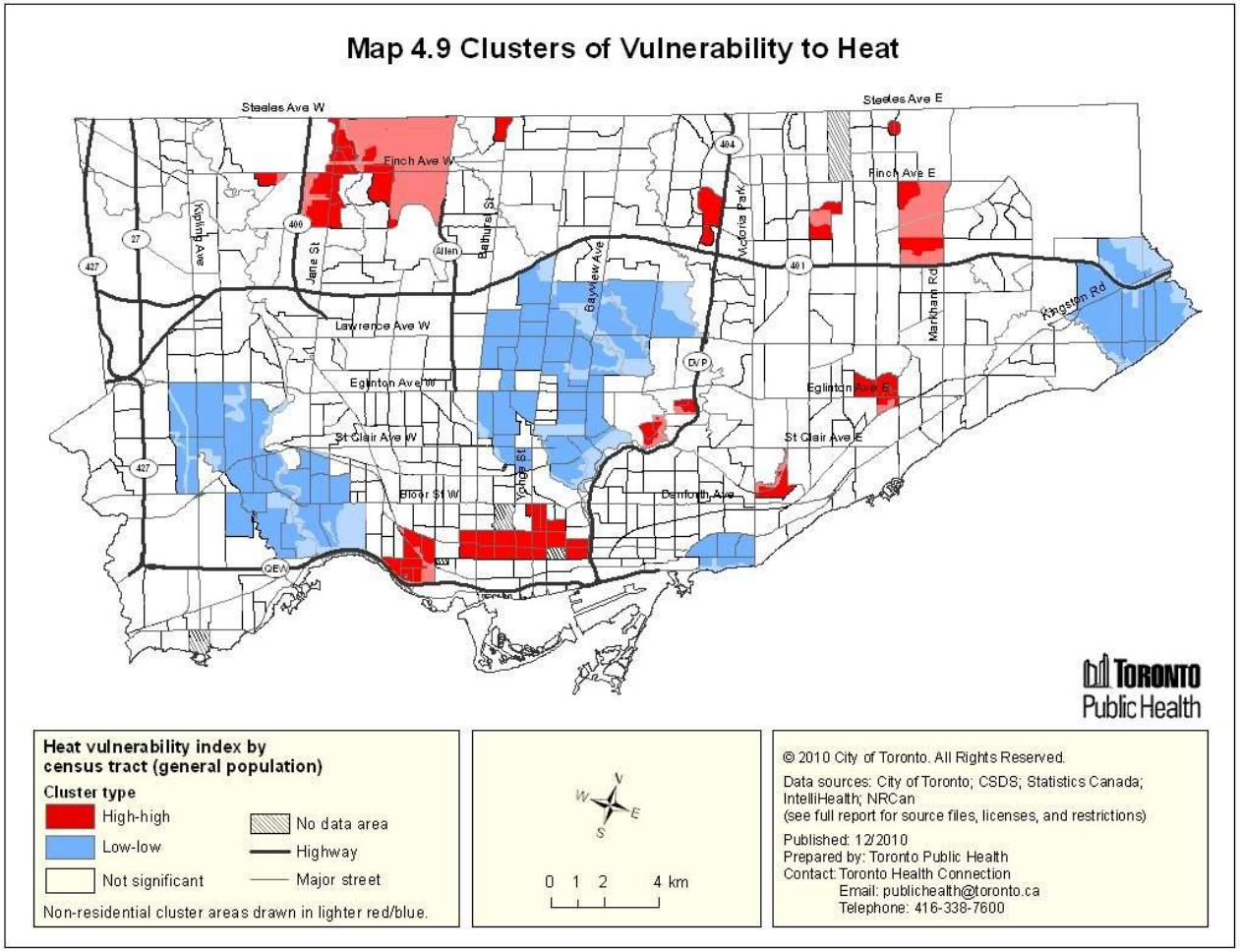
Cartographic Overlays of Adaptation and Context Information

- Data format incompatible with area-based information in GIS map layers



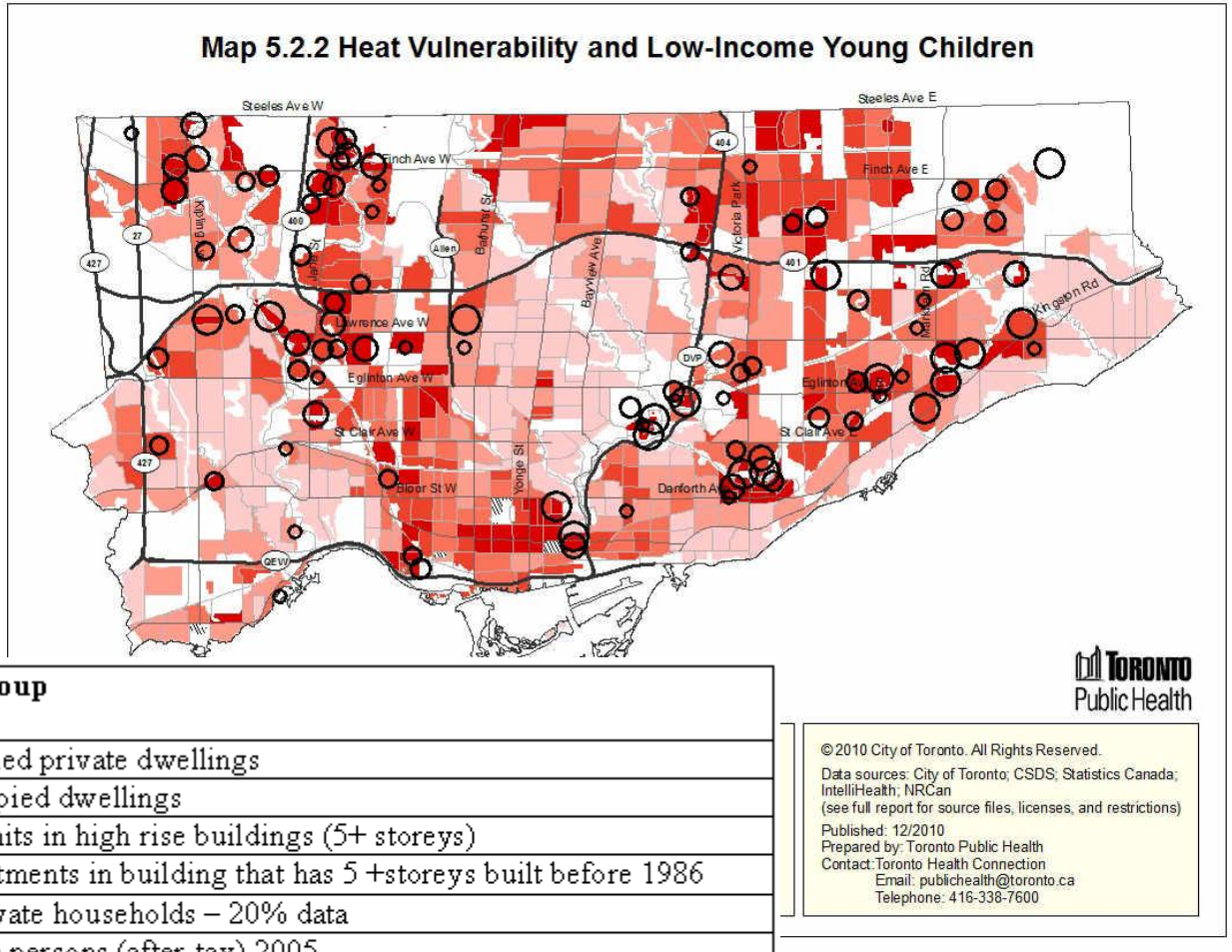
Cluster Analysis and Cluster Maps

- Local indicators of spatial association (LISA), identifying hot spots and “cool spots” of vulnerability



Coverage Analysis and Coverage Maps

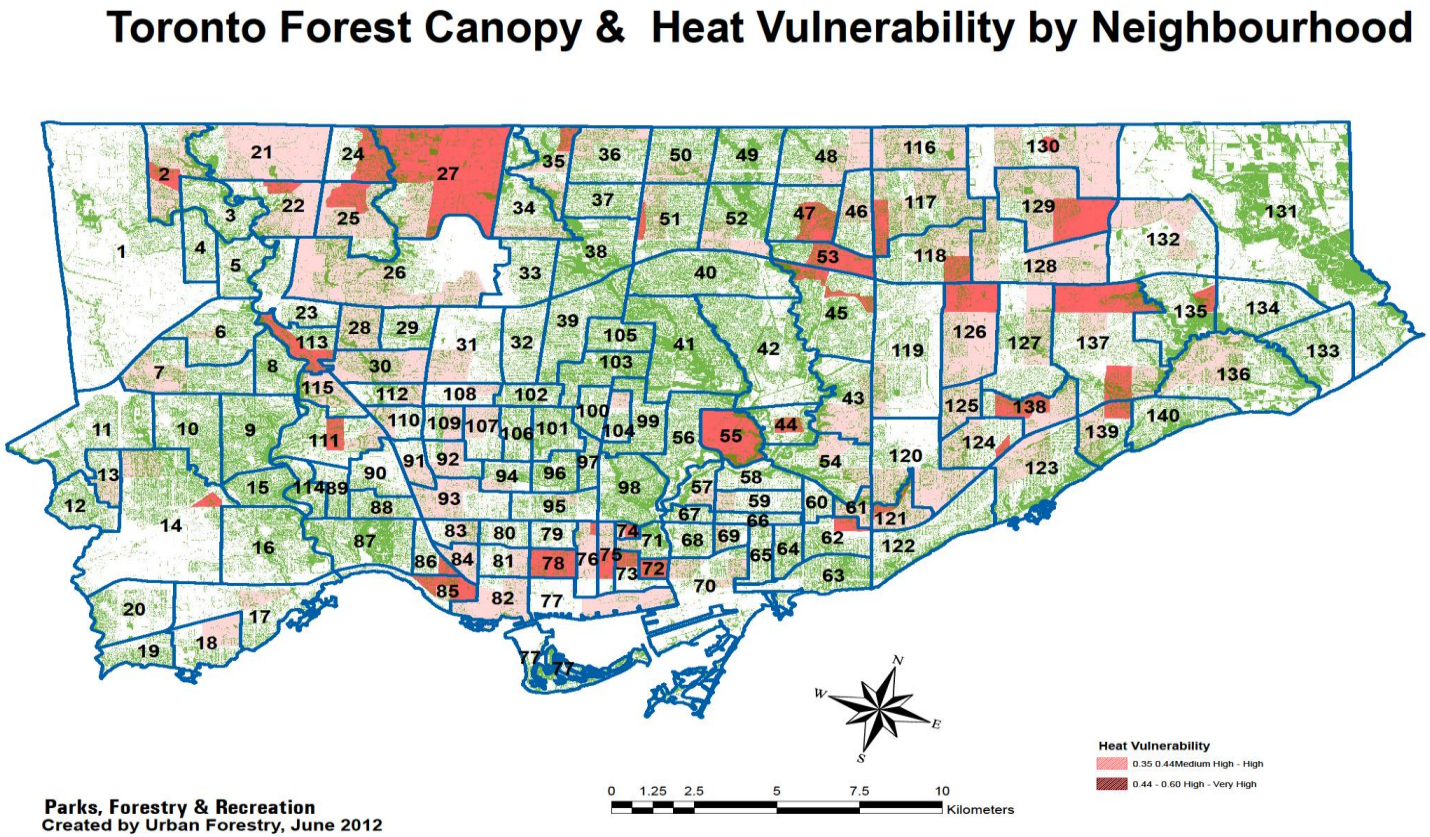
- Validity of area-based indices



Coverage by vulnerability index	At-risk population group
22.7%	Number of total occupied private dwellings
32.8%	Number of renter occupied dwellings
39.9%	Number of dwelling units in high rise buildings (5+ storeys)
45.9%	Number of rented apartments in building that has 5 +storeys built before 1986
22.3%	Population 2006 in private households – 20% data
34.9%	Number of low income persons (after-tax) 2005
40.8%	Number of children age <6 in low income families (after-tax)
34.0%	Number of persons not speaking English
38.3%	Number of recent immigrants (2001-2006)

Conclusion: Adapting to Climate Change Across Toronto

Partnerships to ensure heat vulnerability findings are considered for prioritizing greening across the City



Conclusion: Providing Mapped Information to the Public