Environment and Climate Change Canada / Environnement et Changement climatique Canada

# Multi-Criteria Geospatial Analysis for Mapping Social-economic Vulnerability to Air Quality and Heat Stress

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## ABSTRACT

Identification and characterization of vulnerability to air quality and heat stress is a key piece to health related services. The purpose of this study was to apply a GIS-based Multi-Criteria Geospatial Analysis approach to create heat-vulnerability mapping scenarios. Future work would be to apply a similar approach to a project focusing on air quality and health. This approach was developed by the Network Design Unit of the Meteorological Service of Canada, and has been applied to the design of a variety of monitoring networks, including weather radar, surface weather and marine. The study identifies and collects indicators of heat stressors, sensitivity and vulnerable populations to extreme heat, and combines these indicators using geoprocessing tools to visualize heat stress and vulnerability in the mapping scenarios. Data was collected from a variety of sources including Environment and Climate Change Canada, Statistics Canada, Environics Analytics, and the Public Health Information Management System (PHIMS).These integrated scenarios could be important sources of information that characterize, interpret and represent a spatial variation or requirements. Results for this study could be used in the design of monitoring sensors and planning services for a big event such as the Pan Am and Parapan Am Games in the future.

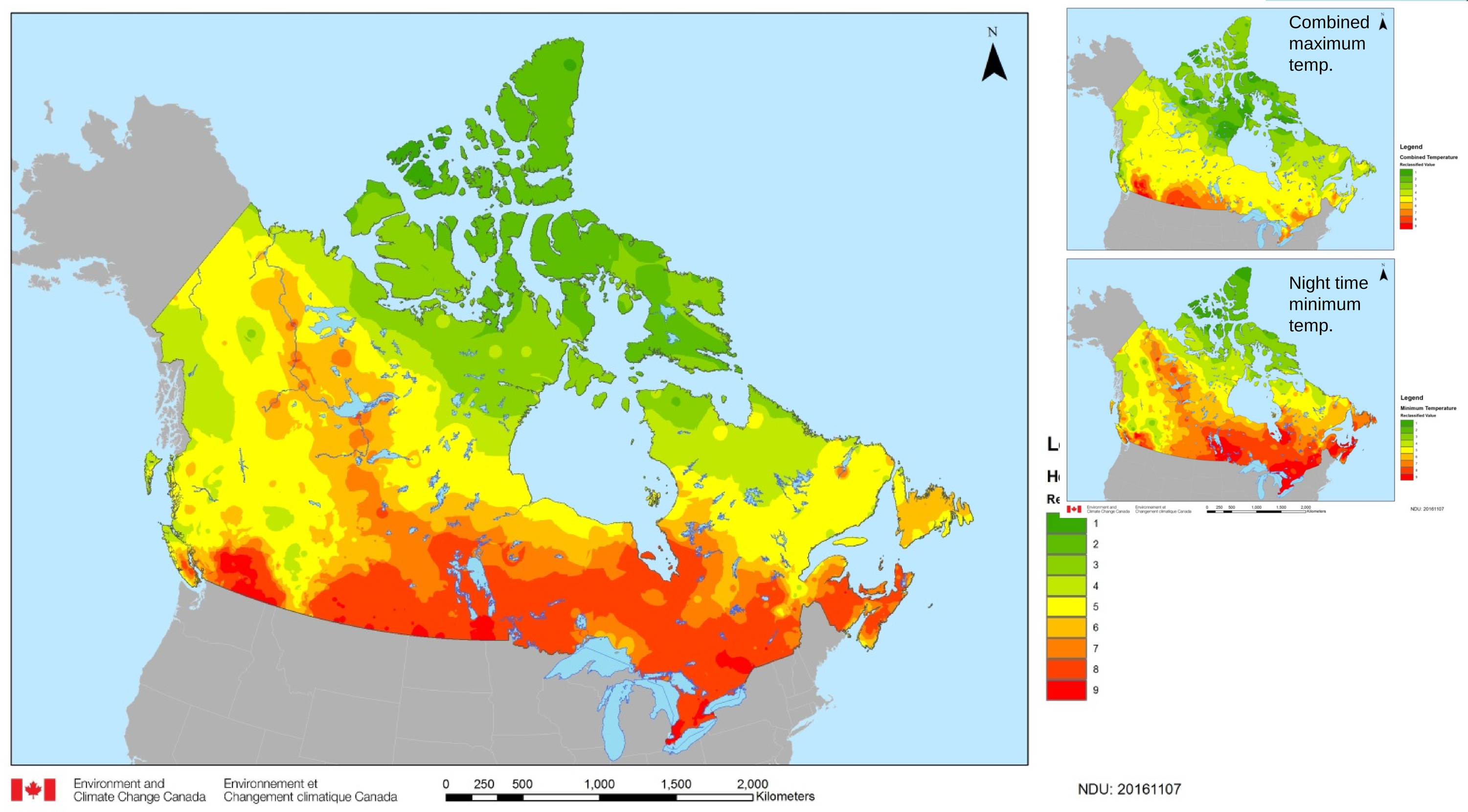

Figure 2 – Heat-stress scenario driven by 95th pct Tmax, Days per year with Tmax > 30°C and 95th pct night time low temperature

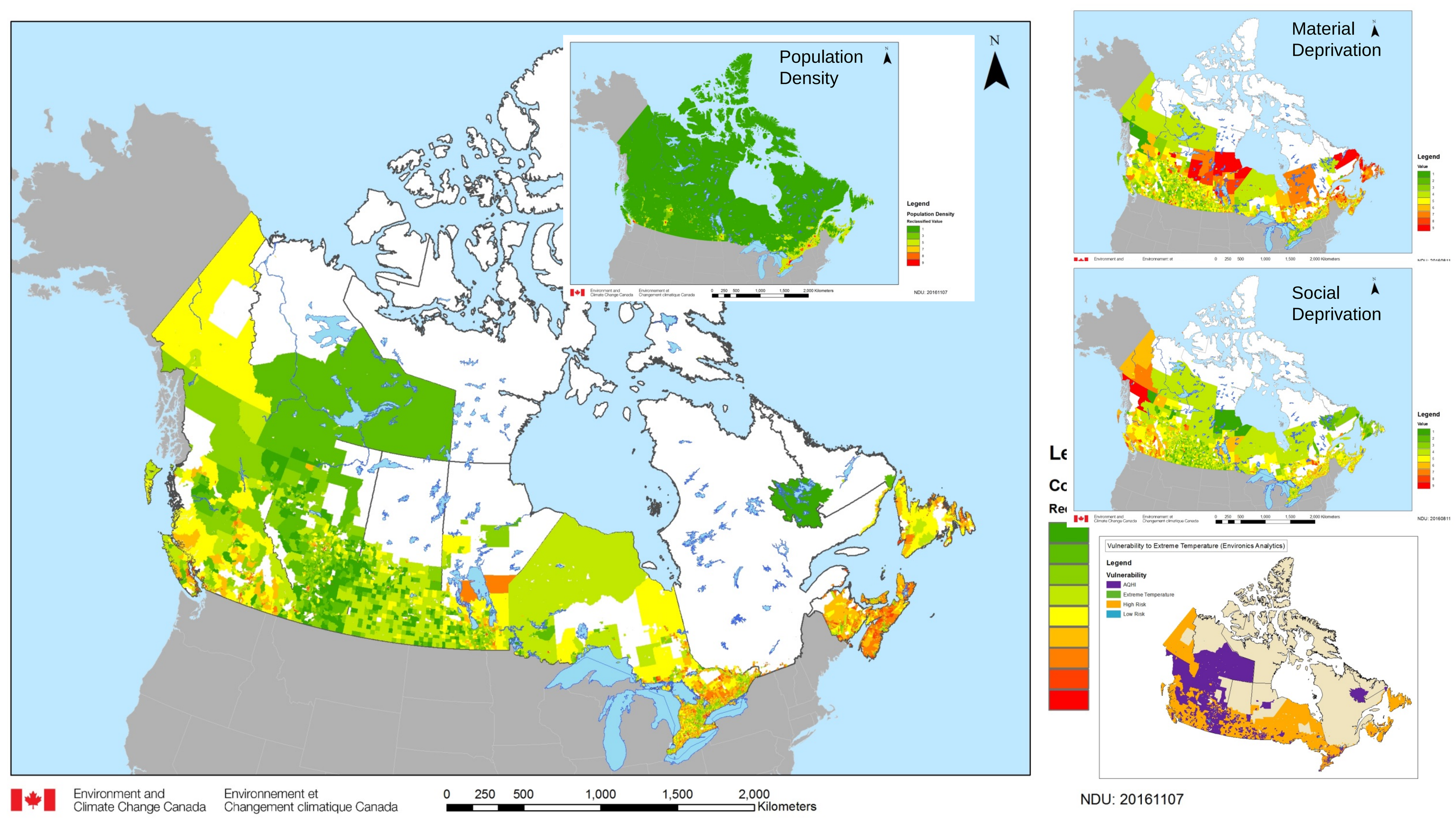

Figure 3 – Combined vulnerability scenario driven by social and material deprivation indices, vulnerability to air quality and extreme temperature and population density

## OBJECTIVES

- Develop a national geodatabase with consolidated geographic information from various data sources, including climatology of extreme temperature and air pollutants; social and material deprivations, heat- and air quality- related vulnerability and potential factors related to urban heat island effect.
- Apply a GIS-based Multi-Criteria Geospatial Analysis approach to create Heat-Vulnerability Index (HVI) mapping scenarios.
- Identify service and monitoring gaps in high heat stress and/or vulnerable areas.
- Analyze how network can be improved by evaluating the representativeness of existing monitoring networks including hourly weather stations (e.g. ECCC-Auto, Aviation, etc.) and daily climate stations (e.g. CCN)

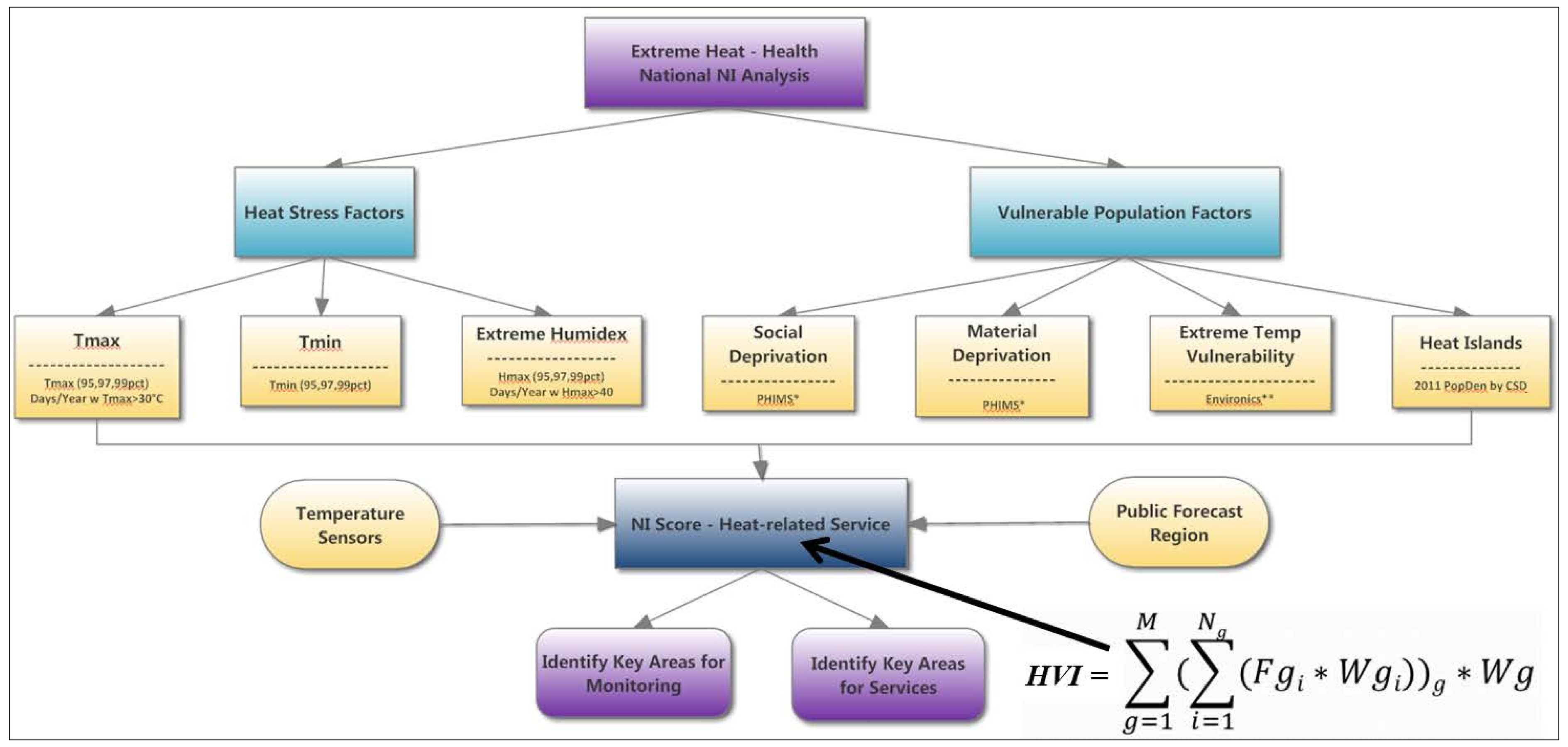


Figure 1 – Heat-Vulnerability (HVI) High-Level Flow Chart

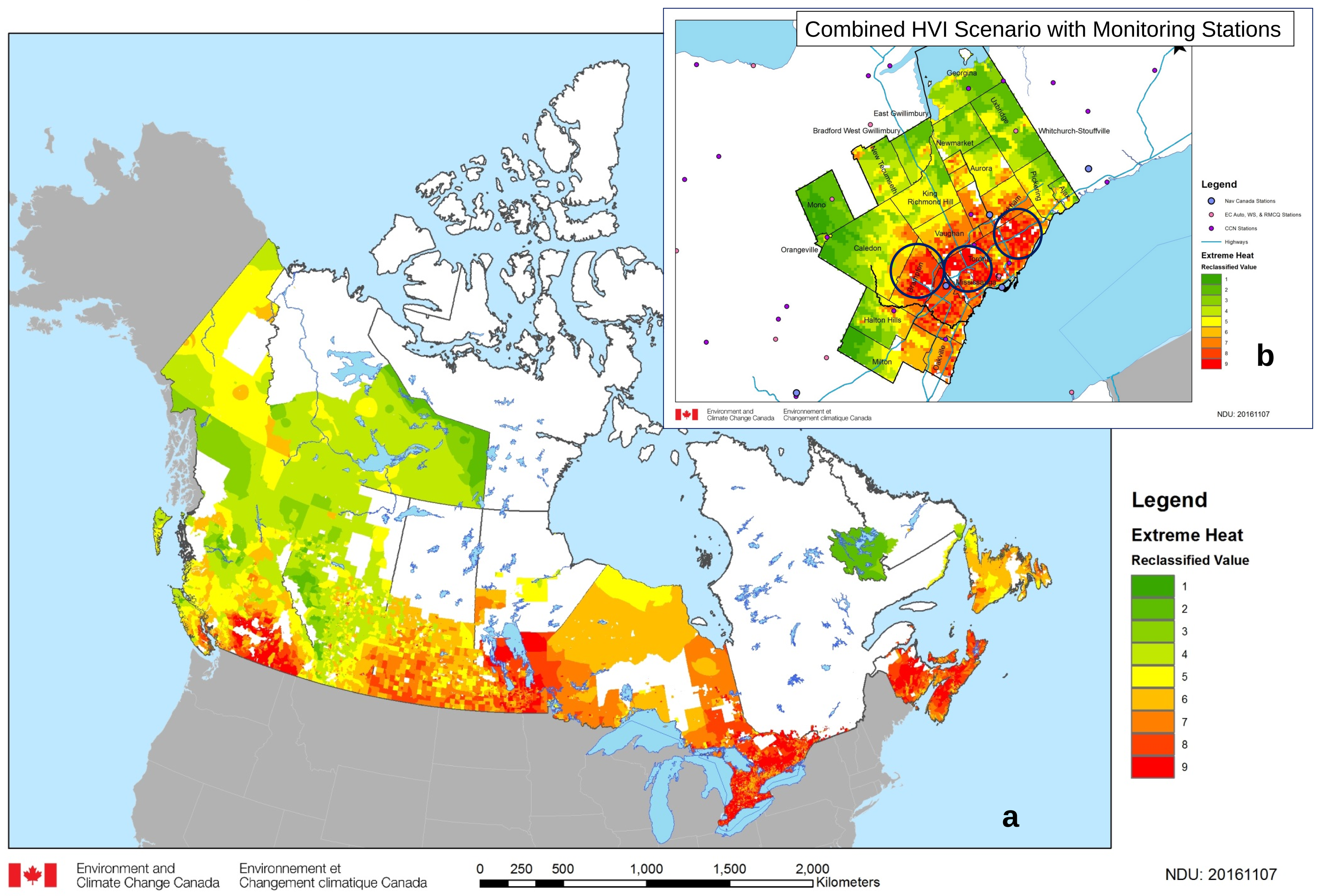


Figure 4 – An example of national heat stress-vulnerability index scenario (a) and a high resolution index map for the GTA area (b)

## DATASETS CONSIDERATIONS

### Heat Stress

- 95th, 97th and 99th percentile maximum temperature, 1981-2010
- 95th, 97th and 99th percentile maximum humidex, 1981-2010.
- 95th,97th and 99th percentile night time low temperature, 1981-2010.
- Days per year with maximum temperature > 30°C, 1971-2000.
- Days per year with maximum humidex > 40°C, 1971-2000.

### Vulnerability

- Material and Social Deprivation by Dissemination Area (DA) (Source: PHIMS)
- Vulnerability to Extreme Heat and Air Quality (Source: Environics Analytics)
- Heat Island/Population Density by Census Subdivision (CSD) and DA (Source: Stats Canada, 2011 Census)

### Social Deprivation Considerations

- Separated, divorced or widowed
- Living alone / Single-parent
- Unemployed / Low income / Low education

### Extreme Temp. & Vulnerability Considerations

- Age / Dwelling type / Outdoor occupations
- Public transit use / Outdoor activities
- Income / Living alone
- Mental & physical health conditions

### Material Deprivation Considerations

- Proportion of individuals aged 20+ years without a high school diploma
- Proportion of single-parent families
- Proportion of the population receiving government transfer payments
- Proportion of individuals aged 15+ who are unemployed
- Proportion of the population considered low-income
- Proportion of households living in dwellings that are in need of major repair

### Advantages of the Tool

- Provides supporting information for proposal of multiple strategies (Monitoring and Services).
- Accounts for both heat/AQ stress and vulnerable population/groups
- Supports prioritized network planning (e.g. gaps areas and redundancies).

### Limitations

- Interpolation of point data: greater uncertainties in data sparse areas or a smaller domain. Model reanalysis data could be a good source of data for future analysis
- Missing data: datasets from PHIMS and Environics has missing data values, which transfer over in the final mapped result.
- Subjectivities in prioritization methods – need input from SMEs
- Uncertainties accumulated from a variety of indices as model inputs