DRR PATHWAYS TECHNICAL REPORT: NEIGHBOURHOOD SOCIAL VULNERABILITY IN THE CITY OF VANCOUVER

Assessment of neighbourhood-level socio-economic vulnerability indicators for the City of Vancouver to support planning and policy scenarios

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NEIGHBOURHOOD SOCIAL VULNERABILITY IN THE CITY OF VANCOUVER

UBC SCHOOL OF COMMUNITY AND REGIONAL PLANNING

Our partners in the Disaster Risk Reduction (DRR) Pathways project are helping to redefine our understanding of disaster risk mechanisms throughout the B.C. Lower Mainland. In particular, the efforts of our colleagues at Natural Resources Canada and the City of Vancouver are greatly expanding our understanding of the structural impacts we can expect in the region following a significant earthquake event.

We know that the physical damage and **social impacts of disasters are not distributed evenly** across space, through time, or within affected populations (Cutter et al., 2003; UN/ISDR, 2009). Often, the groups with the least capacity to respond experience the most substantial impacts and, thus, experience the slowest post-disaster recoveries (Hartmann & Squires, 2006).

Our team at UBC partnered with Natural Resources Canada (NRCan), the City of Vancouver, and Sage on Earth Consulting to better understand the spatial distribution of socially vulnerable populations within Vancouver as part of the City's seismic retrofit program. The project aims to help policymakers determine which neighbourhoods are most vulnerable to disaster impacts and to link this information to the physical impacts described in NRCan's recent earthquake scenarios. Our end goal is to help reduce vulnerability and increase community earthquake resilience.

Together, we identified a set of **fourteen socioeconomic vulnerability indicators** at the Census Dissemination Area level (our "neighbourhoods") for the City of Vancouver. We combined these indicators into three themes to address specific aspects of social vulnerability:

Theme 1: Reduced Financial Capacity
Neighbourhoods with higher than average concentrations of resident sub-populations that resident sub-populations may have a lower financial capability to respond following a disaster

Theme 2: Greater Social Services Dependence
Neighbourhoods with above average concentrations of resident sub-populations that may have a greater dependence on social services

Theme 3: Housing and Shelter Challenges
Neighbourhoods with above average concentrations of resident sub-populations that may face difficulties acquiring emergency shelter or permanent housing

What is Social Vulnerability?

Social vulnerability refers to a combination of factors that determine the **susceptibility of a person, group or community to the effects of a disaster** due to their physical, social, or economic traits.

Vulnerable groups are often more deeply impacted by disaster events and may take longer to recover following such an event.

Common metrics used to assess community social vulnerability include:

- Age,
- Gender,
- Sexual identity,
- Health,
- Disability,
- Housing & shelter,
- Tenure,
- Income,
- Immigration status, *and*
- Employment status

Measuring Neighbourhood Social Vulnerability

Small changes made to community preparedness, emergency response, and disaster recovery plans and policies can **significantly reduce potential impacts to vulnerable populations** immediately following a disaster and help them to recover from such events more quickly.

Knowing which communities are most vulnerable allows policy makers and emergency managers to prepare better to assist these populations should a disaster strike. Materials, equipment, and human resources can be pre-positioned to locations where the need is likely to be greatest. When combined with physical risk modelling, social vulnerability assessments allow decision-makers to dispatch resources to the locations most likely to be in need following a disaster.

BACKGROUND

Two components contribute to how vulnerable a neighbourhood is to a given hazard. The first of these components is its *biophysical vulnerability*: its physical exposure to the hazard, the potential environmental and structural impacts, and the likely impacts to critical infrastructure. The second component is the neighbourhood's *social vulnerability*: the ability of residents to respond to and recover from a potential disaster (Figure 1).
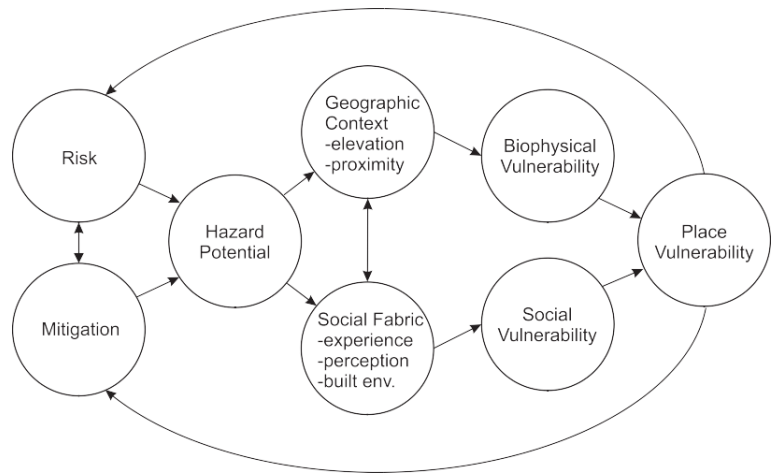
The study of social vulnerability has received significant attention across the social sciences.

Figure 1: *The Hazards-of-Place Model of Vulnerability (Cutter et al., 2003)*

The systematic mapping and assessment of social vulnerability related to hazards has become much more common since the 1990s when the popularization of geographic information systems (GIS) made vulnerability mapping and analysis much more approachable to social scientists (Morrow, 1999). The development of the Social Vulnerability Index (SoVI) by Susan Cutter and colleagues in 2003 cemented the use of census indicators and principal components analysis (PCA) to study social vulnerability. Others have adapted the Hazards-in-Place model created by Cutter et al. and their methodologies to study vulnerability at various scales and locations around the world.

Most measures of neighbourhood social vulnerability seek to establish a location's vulnerability by measuring the physical, social, and economic traits intrinsic to vulnerable groups (Oulahen et al., 2015), often through quantitative or qualitative "indicators." Each indicator provides information about a single dimension of potential vulnerability but is not sufficient to capture or understand a location's overall social vulnerability. Combining indicators into indices or themes allows researchers to highlight regions within specific geographies that have factors that may contribute to post-disaster vulnerability. Indicators selected for an index or theme usually address dimensions of social vulnerability that are directly relevant to the policy goals of planners and decision-makers.

Several groups have explored social vulnerability in Canada and the Vancouver region. Some recent examples include Jean Andrey and Brenda Jones (2008) who explored the dynamic nature of social disadvantage and vulnerability in Vancouver, Oulahen et al. (2015) who created a social vulnerability index for five municipalities in the Metro Vancouver region, and Chakraborty et al. (2020) who measured relative social vulnerability and socioeconomic inequalities across Canada.

Dana Brechwald and her colleagues (2015) established a social vulnerability index for the Bay Area in California to better understand seismic and flood risk in that region. This work helped to guide policy and decision-making related to public hazards education and building retrofits across the Bay Area. They established a simplified vulnerability index that used the number of indicators over specific thresholds to identify areas of concentrated vulnerability. Their assumption was that areas with several indicators above their respective thresholds were more likely to experience socially related issues following a disaster and throughout the post-disaster recovery phase. This approach is relatively easy for communities to implement and has the additional benefit of being a more transparent mechanism in demonstrating which neighbourhoods are more socially vulnerable than a single, aggregated, index value. This method also benefits from being relatively easy to explain to decision-makers and the public alike.

Project and Data Connections to Other DRR Pathways Projects

Our neighbourhood social vulnerability project was developed within a broader framework within the DRR Pathways project. This project shares connections with earthquake impact modelling scenarios being completed by our colleagues at NRCan and also informs the work we completed as part of our neighbourhood recoverability component (Figure 2).
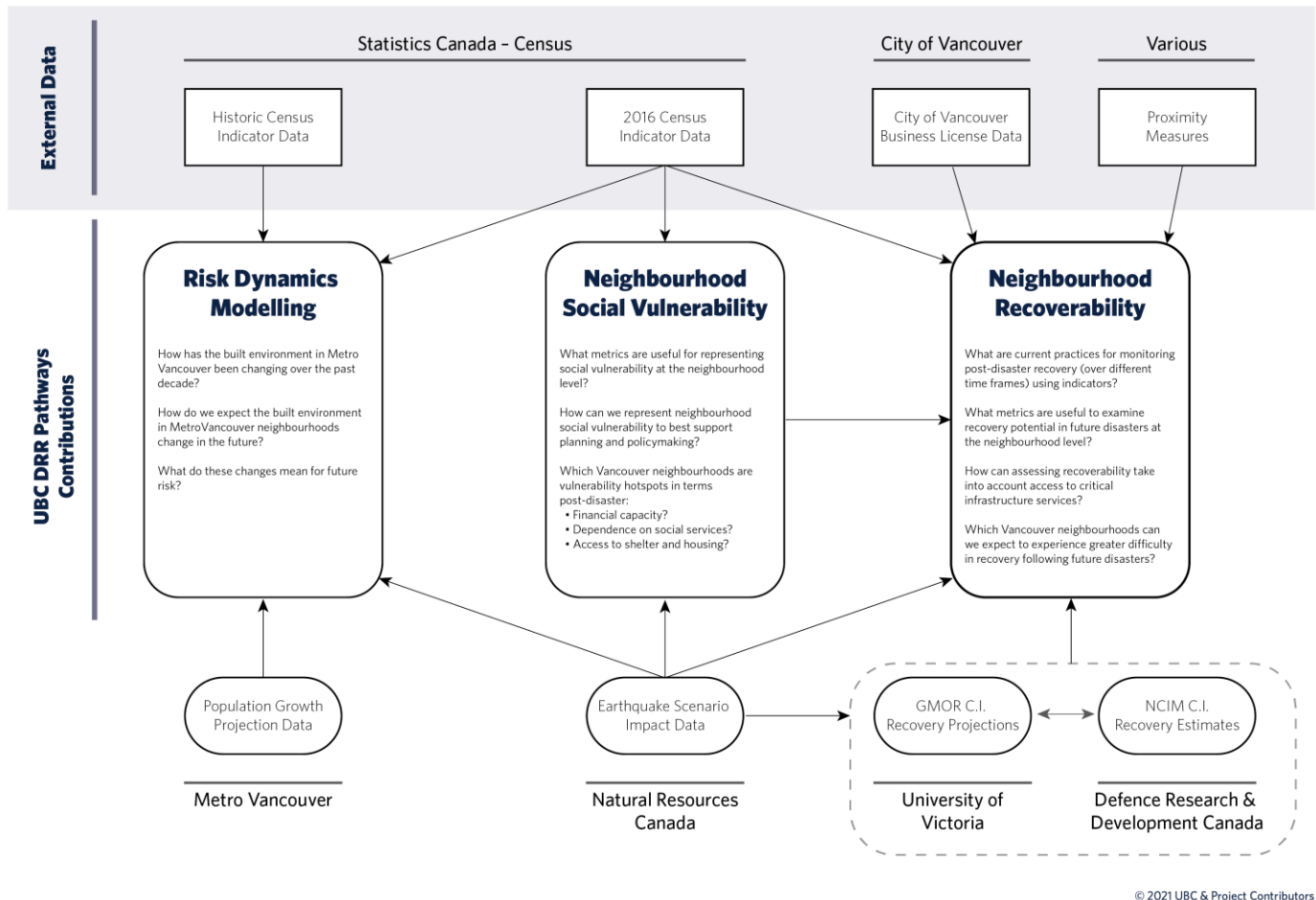

Figure 2: *UBC DRR Pathways Project, Data Sources, and Linkages to Pathways Partners*

Research Questions

As noted, the goal of this project was to assist and support policymakers within the City of Vancouver as part of that community's seismic retrofit program. Together with our partners, we established a set of three research questions to determine the best ways to meet the City's objectives and guide the project:

1. Which metrics are most useful for representing social vulnerability at the neighbourhood scale?

2. How can we represent neighbourhood social vulnerability to best support planning and policymaking in the context of seismic retrofit planning at the City of Vancouver?

3. Which Vancouver neighbourhoods are social vulnerability hotspots in terms of post-disaster:
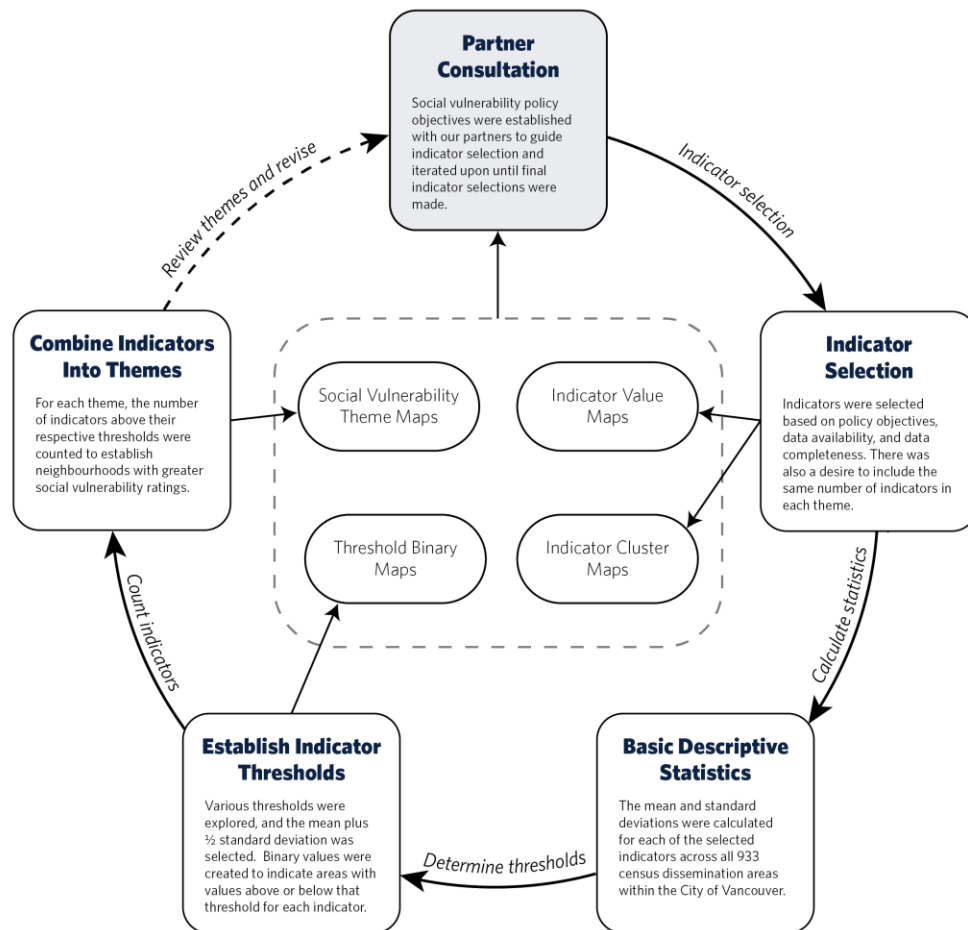
- Financial capacity?

- Dependence on social services?

- Access to shelter and housing?

METHODOLOGY

We established a six-step approach to measuring and summarizing information about social vulnerability and iterated upon this approach with our project partners (Figure 3).

Figure 3: *The process our team and partners used to establish and map social vulnerability within the City of Vancouver*

Step 1: Partner Consultation to Establish Community Policy Goals

The first phase of the project was to establish a set of policy objectives to place this project in context, establish scope, and guide model development. This involved discussions about how the deliverables from the project would be used, by

which groups, and to what purposes. While the primary goal was to support decision- and policy-making processes related to the City's seismic retrofit program, the information would also be of interest to other groups within the City of Vancouver and connected to work being undertaken within Natural Resources Canada.

Three social vulnerability themes became evident as policy objectives and goals were refined over several meetings:

- Vulnerability related to financial capacity,
- Vulnerability related to a reliance upon social services, and
- Vulnerability related to housing and shelter.

These three themes became the core of our work over several iterations.

Step 2: Indicator Selection

Our team conducted an initial review of academic and practitioner literatures to determine which indicators had been used in previous social vulnerability modelling in Canada, the United States, New Zealand, Japan, and elsewhere. This review resulted in a set of 84 indicators that could potentially be used to assess social vulnerability in Vancouver. Sharing this list with our partners allowed them to better understand how indicators had been used elsewhere and determine which might be best in the context of the study.

From this list, a short list of 35 indicators was identified by our partners. This list was reviewed in more detail to ensure that data for potential indicators existed and was reasonably complete for our purposes. A final set of 14 indicators were selected from the 2016 Census of Canada that met all our objectives and could be linked to at least one of the identified themes.

Maps of raw indicator values were created for each of the selected indicators. In addition, maps showing hot and cold spots were generated to help guide discussions around indicator selection. An example of each map type can be seen below:
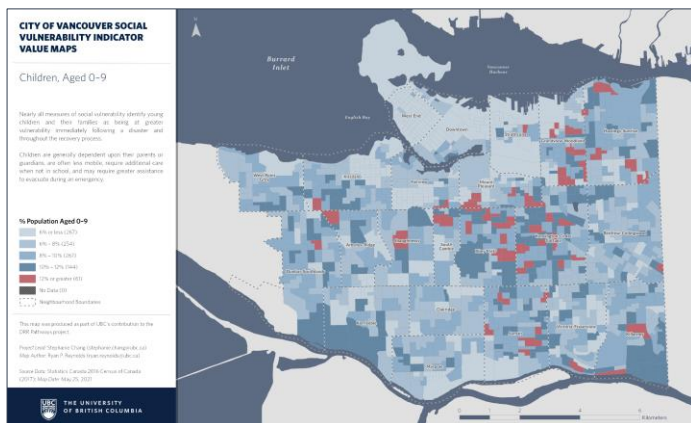

Figure 4: *Indicator Value Map for Children Aged 0–9*
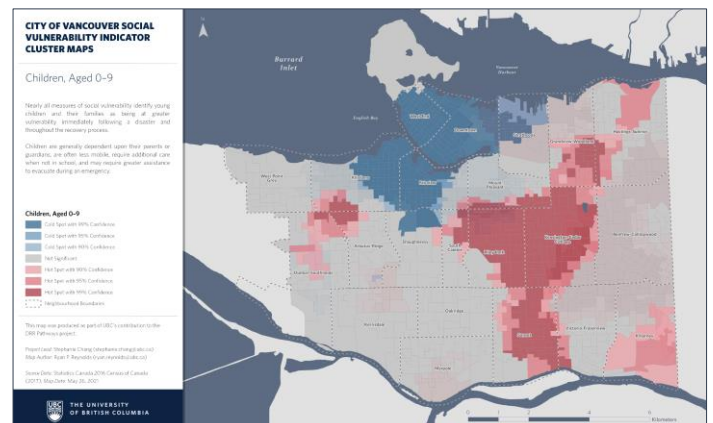*(Areas in dark blue and red show areas of elevated vulnerability)*

Figure 5: *Cluster Analysis Map for Children Aged 0–9*
(Areas in red show high vulnerability hotspots, while areas in blue are cold spots)

Step 3: Calculation of Basic Descriptive Statistics

Before our team could establish which indicator thresholds we wanted to use, basic descriptive statistics were calculated for the selected indicators for all 933 census dissemination areas (DA) within the City of Vancouver, including mean, median, mode, standard deviation, minimum and maximum values.

Step 4: Establish Indicator Thresholds

Several different approaches to establishing indicator thresholds were explored and assessed for suitability. The approach that best fit our needs was to set thresholds at the level of half a standard deviation above the mean for each indicator. This approach, described in Equation 1, provided a better balance between the number and spatial distribution of above-threshold areas compared to the simple mean or mean plus a full standard deviation:

$$t = \bar{x} + \sigma/2$$

Equation 1: Indicator Threshold Equation

where t is the threshold value, $\bar{x}$ is the sample mean of indicator values and σ is the sample standard deviation of the indicator values for the census dissemination areas within the City of Vancouver.

A binary variable was created for each of the indicators to indicate whether the value for a given DA was equal to or greater than the established indicator threshold or below that value. Threshold maps were created for each of the selected indicators, as shown in Figure 6.
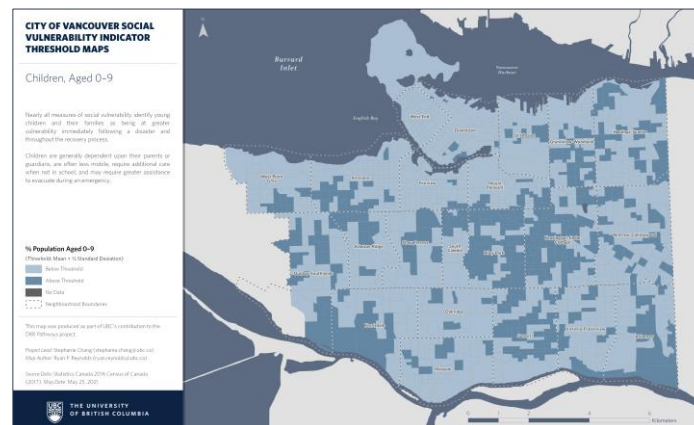

Figure 6: *Threshold Map for Children Aged 0–9*
(Areas in dark blue are above the indicator threshold, while light blue areas are below the threshold)

Step 5: Combine Indicators into Themes

We selected six indicators to contribute to each of the three social vulnerability themes. Having the same number of indicators in each theme helps make comparisons between theme maps easier for map readers. Indicators were selected based on how they contribute to a specific theme, and some indicators have been used in more than one theme.

For each theme, we summed the number of indicators that were above the established threshold values for each of the 933 census dissemination areas within the City of Vancouver. When data were not available for a specific DA, it was

treated as being below threshold for the purpose of these counts. This resulted in above-threshold counts ranging between zero and six.

We then generated two sets of choropleth maps for each of the social vulnerability themes using final indicator counts, highlighting areas *where four or more indicators were above threshold values*. The first set of theme maps focuses exclusively on the indicator counts, while the second also includes inset maps for each of the six indicators that contribute to the theme (Figure 7). Areas on the theme maps denoted in dark blue and red indicate areas of elevated social vulnerability related to the associated social vulnerability theme.
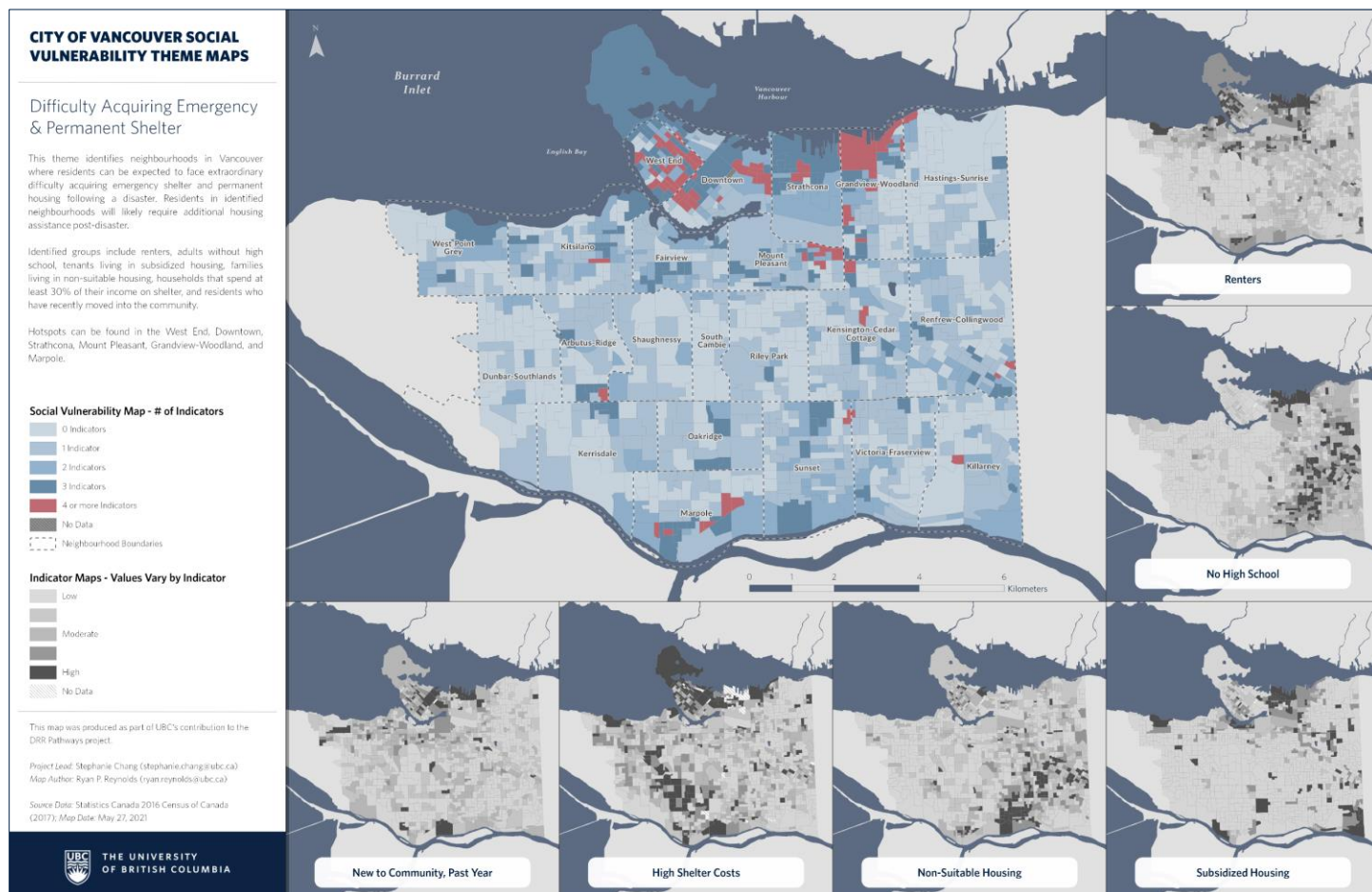

Figure 7: *Social Vulnerability Theme Map for Residents Facing Difficulty Acquiring Emergency and Permanent Shelter*

Step 6: Review and Iteration

Once theme maps were generated for all three themes, the maps were presented to our partners for review and to solicit further feedback. This process ensured that the themes were addressing the previously established policy objectives and appropriately identifying groups that should be included within each of the themes. With updated guidance, the process was repeated to refine the indicators selected, establish more idealized thresholds, and adjusting the theme maps to better address the project goals for further review.

The final set of indicators and themes shared with our DRR Pathways partners was completed September 18, 2019.
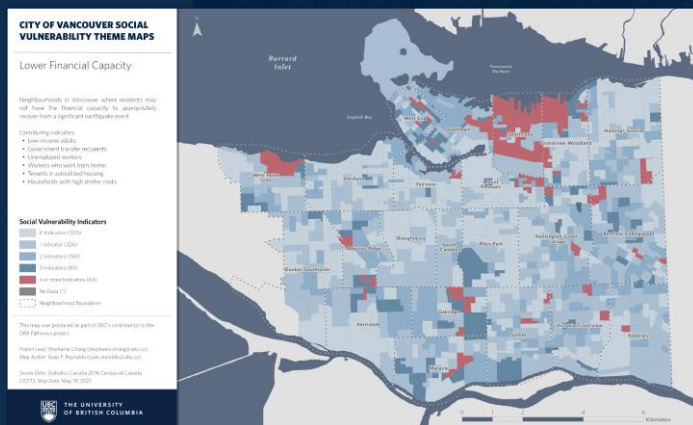
Figure 8: *Lower Financial Capacity Theme Map*

Lower Financial Capacity

This theme identifies neighbourhoods in Vancouver where many residents may not have the financial capacity to completely recover from a significant disaster event. Identified groups include low-income adults, government transfer recipients, unemployed workers, workers who work from home, tenants in subsidized housing, and households that spend at least 30% of their income on shelter. Hotspots include the West End, Downtown East Side, Strathcona, Grandview-Woodland, Mount Pleasant, Hastings-Sunrise, Oakridge, and Marpole, among others.

High Dependence on Social Services

This theme identifies neighbourhoods in Vancouver where residents are more likely to have a greater dependence on social services and will likely require additional assistance following a significant disaster event. Identified groups include young children, the elderly, low-income workers, unemployed workers, single-parent families, and residents who are not fluent in English. Hotspots include Strathcona, Oakridge, Kensington-Cedar Cottage, and Victoria-Fraserview.
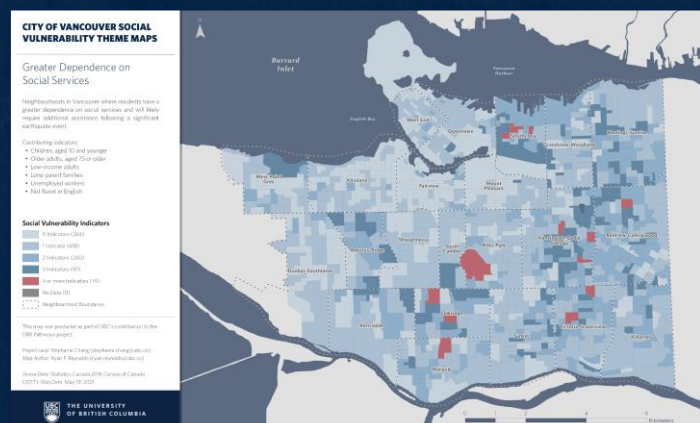

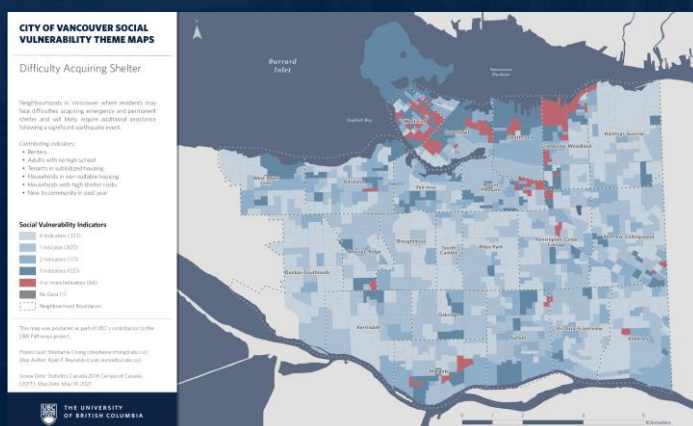**Figure 9:** *Greater Dependence on Social Service Theme Map*

Figure 10: *Difficulty Acquiring Shelter Theme Map*

Difficulty Acquiring Shelter

This theme identifies neighbourhoods in Vancouver where many residents can be expected to face particular difficulty acquiring emergency shelter and permanent housing following a disaster. Residents in identified neighbourhoods will likely require additional housing assistance post-disaster. Identified groups include renters, adults without a high school education, tenants living in subsidized housing, families living in non-suitable housing, households that spend at least 30% of their income on shelter, and residents who have recently moved into the community. Hotspots include the West End, Downtown, Strathcona, Mount Pleasant, Grandview-Woodland, and Marpole.

FUTURE ENHANCEMENTS

There is significant interest around measuring neighbourhood social vulnerability in BC, both as part of the DRR Pathways project, and by the BC disaster risk reduction community at large. This work introduces a new approach to that of Andrey and Jones (2008) and Oulahen et al., (2015) we feel may be simpler for interested groups to implement themselves. We are also aware of additional work exploring social vulnerability by other DRR Pathways partners and outside groups at various scales, including NRCan.

A Broader Focus

This work was specifically aimed at addressing policy objectives identified by the City of Vancouver as part of the City's seismic retrofit program. Future work could widen the scope to include additional factors affecting social vulnerability more broadly in Metro Vancouver, throughout BC, or across Canada.

Links to New Data

Our partners in the DRR Pathways project have completed several projects that have results that could be integrated into an improved social vulnerability assessment for the City of Vancouver. This includes growth projection work completed by Metro Vancouver, and a provincial exploration of social vulnerability underway by Natural Resources Canada.

Comprehensive Vulnerability

Finally, recent modelling of hazard risk from Fraser Basin Council and Natural Resources Canada (among others) could allow us to better connect physical and social impacts into a more comprehensive vulnerability assessment within our study area.

LINKS TO DISASTER RISK REDUCTION PATHWAYS

This work links to three aspects of disaster risk reduction identified by the DRR Pathways Steering Committee:

Emergency Response Planning

Identifying areas of elevated social vulnerability can allow emergency planners and responders to better plan for significant large-scale responses in these areas. This may include having additional staff and resources on hand to assist with temporary or long-term housing or directing affected households to available social services.

Community Resilience Building

Addressing the root causes of social vulnerability within communities prior to a disaster through targeted programs can help to reduce strain on response systems post-disaster. This work can help to identify those neighbourhoods best targeted by such programs.

Disaster Risk Reduction Policies

This work directly assists the City of Vancouver's seismic retrofit program by identifying areas of elevated social vulnerability related to financial, housing, and social service demand.

Citations

Andrey, J., & Jones, B. (2008). The dynamic nature of social disadvantage: Implications for hazard exposure and vulnerability in Greater Vancouver: The dynamic nature of social disadvantage. *The Canadian Geographer, 52*(2), 146–168. https://doi.org/10.1111/j.1541-0064.2008.00206.x

Brechwald, D., Kroll, C., Goodfriend, W., & Lowe, L. (2015). *Stronger Housing, Safer Communities: Strategies for seismic & flood risks Summary Report* (p. 26). Association of Bay Area Governments. Retrieved June 4, 2021, from http://www.adaptingtorisingtides.org/wp-content/uploads/2015/07/StrongerHousingSaferCommunities_SummaryReport.pdf

Chakraborty, L., Rus, H., Henstra, D., Thistlethwaite, J., & Scott, D. (2020). A place-based socioeconomic status index: Measuring social vulnerability to flood hazards in the context of environmental justice. *International Journal of Disaster Risk Reduction, 43*, 101394. https://doi.org/10.1016/j.ijdrr.2019.101394

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly, 84*(2), 242–261.

Hartman, C., & Squires, G. D. (Eds.). (2006). *There is No Such Thing as a Natural Disaster: Race, Class, and Hurricane Katrina.* Routledge.

Morrow, B. H. (1999). Identifying and Mapping Community Vulnerability. *Disasters, 23*(1), 1–18.

Oulahen, G., Mortsch, L., Tang, K., & Harford, D. (2015). Unequal Vulnerability to Flood Hazards: "Ground Truthing" a Social Vulnerability Index of Five Municipalities in Metro Vancouver, Canada. *Annals of the Association of American Geographers, 105*(3), 473–495. https://doi.org/10.1080/00045608.2015.1012634

APPENDIX A: MODEL INPUTS

We used the following data to establish our social vulnerability indicators at the census dissemination area within the City of Vancouver:

Dataset	Source	Release Date	Licensing	Link
2016 Census	Statistics Canada	November 27, 2017	Statistics Canada Open License	2016 Census Program
Local Area Boundaries	City of Vancouver Open Data Catalogue	March 8, 2019	Open Government License	Local Area Boundary

APPENDIX B: PROJECT DELIVERABLES

We are sharing the following data layers, documents, and maps with our DRR Pathways partners and the public:

Dataset	Release Date	Licensing	Notes
Social Vulnerability Indicators ArcGIS Geodatabase	June 30, 2021	DRR Pathways Partners	*None*
Indicator Value Maps	June 30, 2021	Public	*A map for each of the 14 indicators in* `.png` *and* `.pdf` *formats*
Indicator Threshold Maps	June 30, 2021	Public	*A map for each of the 14 indicators in* `.png` *and* `.pdf` *formats*
Indicator Cluster Maps	June 30, 2021	Public	*A map for each of the 14 indicators in* `.png` *and* `.pdf` *formats*
Social Vulnerability Theme Maps	June 30, 2021	Public	*A map for each of the three indicators in* `.png` *and* `.pdf` *formats*
Social Vulnerability Theme Maps with Indicator Insets	June 30, 2021	Public	*A map for each of the three indicators in* `.png` *and* `.pdf` *formats*