Subject:	Corporate Climate Adaptation Plan Milestone 2 Update
To:	Committee of the Whole – Community Services & Infrastructure
From:	Public Works Department

Report Number:	PW-10-20
Wards Affected:	All
Date to Committee:	Monday, July 13, 2020
Date to Council:	Monday, April 20, 2020

Recommendation:

Receive for information Report PW-10-20 Corporate Climate Adaptation Plan Milestone 2 Update.

Purpose:

Milestone 2 (September 2019 – February 2020) of the Corporate Climate Adaptation Plan has been completed. The purpose of this report is to provide Council with a project update including vulnerability results, touchpoints, and timelines.

Background:

On July 22, 2019 Council passed a resolution supporting the development of a Corporate Climate Adaptation Plan. The purpose of a Corporate Climate Adaptation Plan is to prepare the Town of Lincoln to adapt to anticipated climatic change and extreme weather, thereby minimizing the severity of the resulting impacts.

Report:

Vulnerability Assessment Results

Vulnerability refers to the susceptibility of a given region, municipality, social group or sector to harm arising from climate change impacts. Vulnerability is understood as a function of exposure, sensitivity and adaptive capacity to climate change impacts.

In fall 2019, a vulnerability survey was implemented in Lincoln. Based on an extensive literature review and expert opinion, a set of 50 indicators specific for the Niagara Region was developed. Indicators were subsequently ranked for their importance to Lincoln. Secondary and primary data were collected from multiple sources including Statistics Canada, Niagara Region Public Health, municipal input, and a community survey. In Lincoln, 150 members of the public completed the survey.

The results (found in Appendix A) provide critical insights into how people in the region experience climate change as well as their potential capacity to adapt. Sixty-four percent of respondents believe climate change is creating impacts in their community, and 83% of respondents support municipal resources going towards adaptation planning. A summary is presented below in Figures 1 and 2:

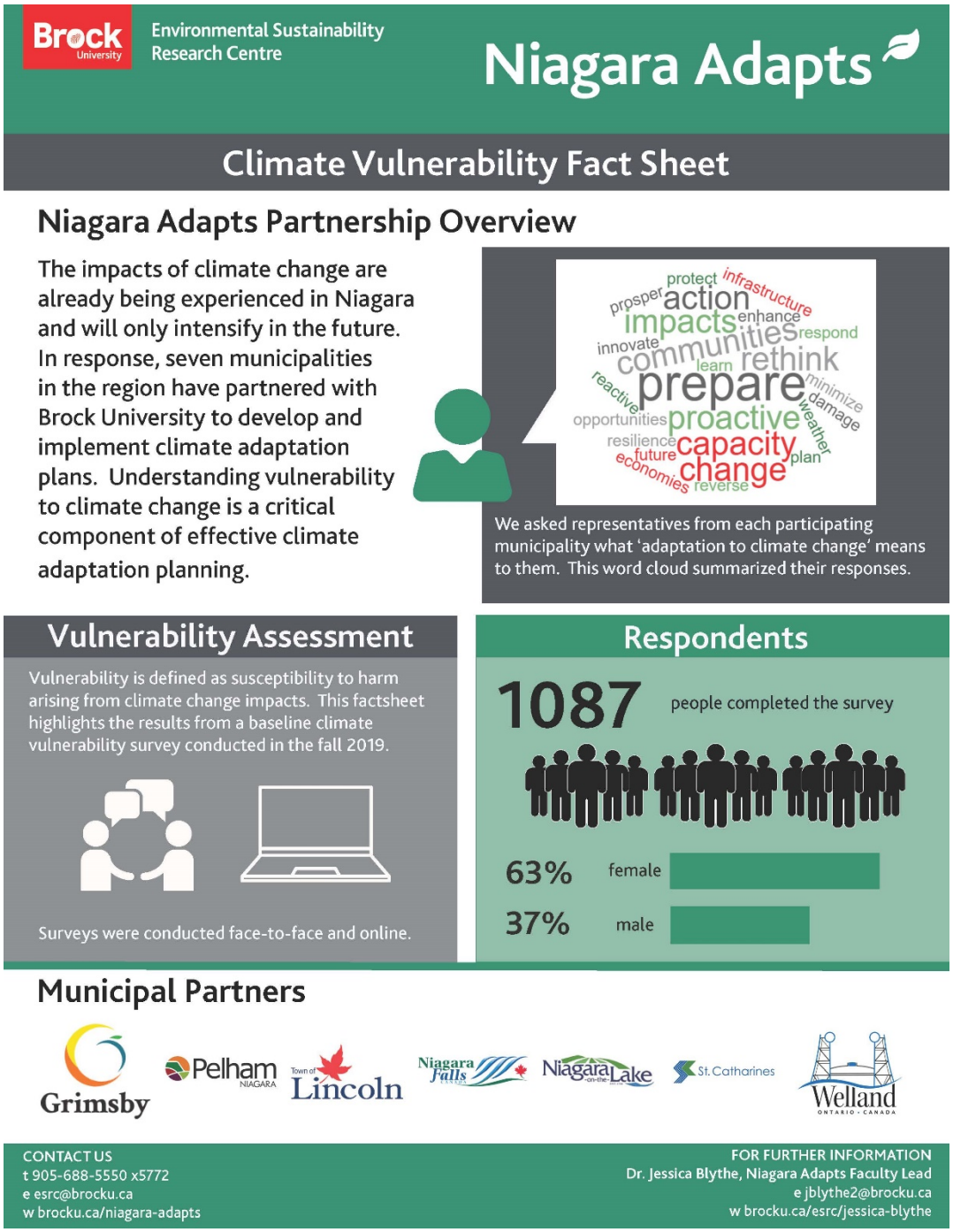


Figure 1: Climate Vulnerability Fact Sheet

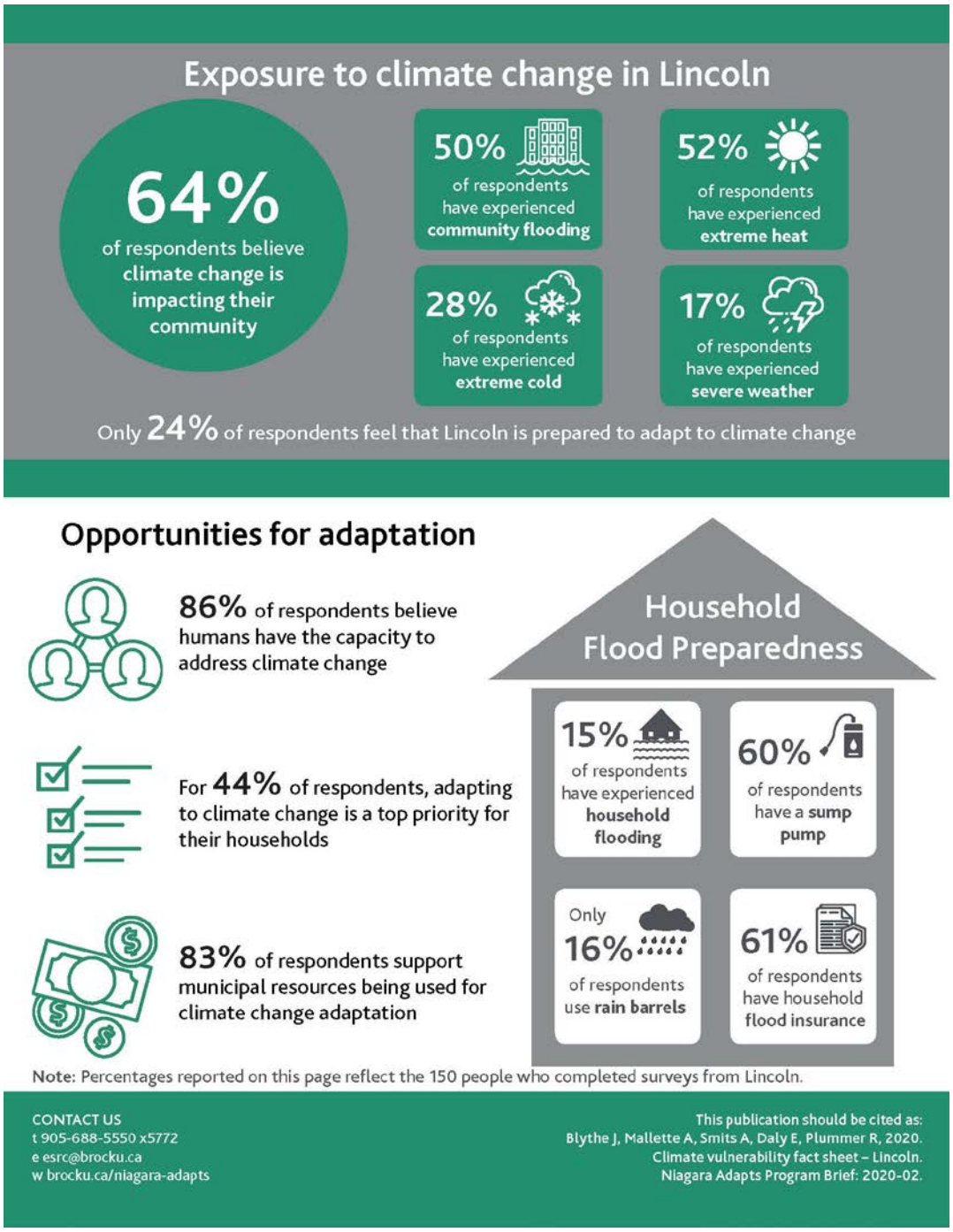


Figure 2: Town of Lincoln Fact Sheet

Council Touchpoints

A climate adaptation workshop was conducted with Council on Dec. 4, 2019. The purpose of the workshop was to identify Council's priorities and perspectives as they relate to how climate projections will impact the Lincoln, which areas of Lincoln are most vulnerable to those impacts, and a vision for the climate adaptation plan.

Figure 3 summarizes the vulnerability evaluation of each climate change impact activity. These preliminary data will be combined with data from Niagara Adapts and the Steering Committee to provide an overview of climate impacts, risk, and vulnerability.

Climate Change Impacts	Vulnerability
1. Increased annual temperatures leading to increased spread of respiratory, waterborne, and insect carried diseases	↑↑↑↑
2. More extreme summer and winter temperatures resulting in decreased use of outdoor recreation areas and facilities, and increased demand for indoor facilities	↑↑↑
3. Milder winter temperatures leading to more ice and freezing rain and less snow resulting in infrastructure damage and public safety concerns throughout the community and on rural roads (e.g. visibility with snow drift)	↑↑
4. Milder winter temperatures leading to more ice and freezing rain and less snow resulting in increased salt usage and impacts to soil and water quality	↑
5. More extreme hot days >30˚C and increased humidity resulting in increased heat stress in youth, elderly, vulnerable populations, and those with pre-existing health conditions	↑↑↑↑
6. More extreme hot days >30˚C leading to increased energy consumption resulting in increased energy costs	↑↑↑↑
7. Increased temperature variability in shoulder seasons, leading to less confidence in historical weather patterns and planting / harvesting schedules	↑
8. More extreme weather events (e.g. windstorms, thunderstorms etc.) and more extreme temperatures resulting in power disruptions	↑↑↑↑
9. More frequent/severe droughts leading to lower crop yields, damage to vegetation and gardens, and economic loss	↑
10. More frequent/severe droughts leading to water shortages and possible usage restrictions	↑↑↑↑
11. More frequent/severe rainstorms leading to rising lake water levels resulting in wave uprush hazards and impacts to shoreline access, water quality, and damage to infrastructure adjacent to shoreline	↑
12. More heavy rainfall events leading to increased flooding resulting in building damage, basement flooding, and public health water quality concerns	↑↑↑↑

Figure 3: Council Workshop Results

Adaptation Steering Committee Touchpoints

One-on-one interviews have been held with each Adaptation Steering Committee member to identify and review impacts, identify external stakeholders to include in the Stakeholder Advisory Group, and complete a vulnerability indicator ranking exercise. Future touchpoints will include risk assessments and adaptation action identification.

Community Touchpoints

Niagara Adapts Launch: An official Niagara Adapts launch event was held at the FirstOntario Performing Arts Centre on Nov. 27, 2019. Following a documentary screening featuring Resilience – A Climate Change Documentary of Hope, the Niagara Adapts team and municipal partners participated in a panel discussion.

Brock University Master of Sustainability Transdisciplinary Seminar: On Feb. 25, 2020, the Niagara Adapts team and municipal partners presented to graduate students and the public, speaking to the climate change impacts and challenges facing municipalities.

Project Timeline

Staff have requested from FCM, a 2-month extension on delivering the final climate adaptation plan due to COVID-19 delays. Until the extension is approved, staff will follow projected timeline presented in Figure 4.

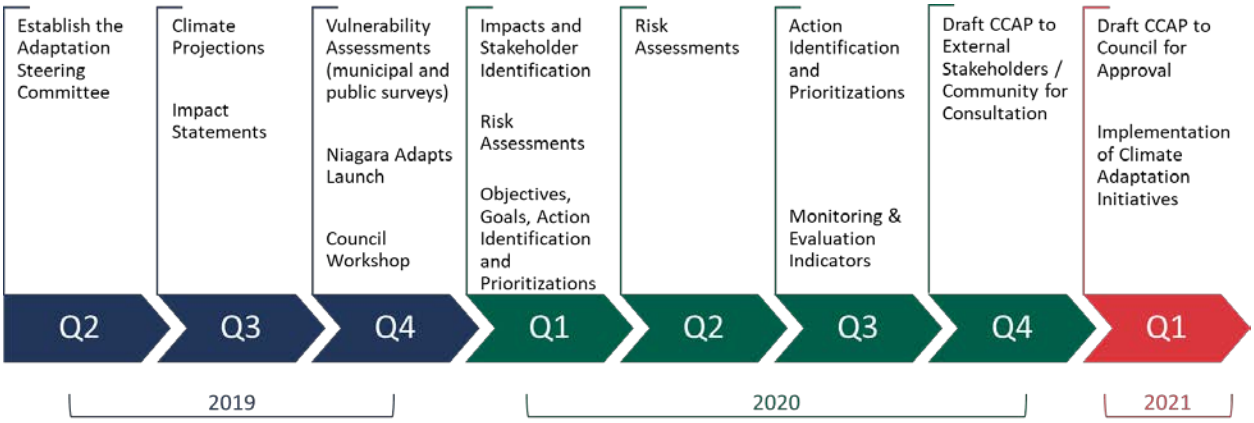


Figure 4: Corporate Climate Adaptation Plan Timeline

Financial, Legal, Staff Considerations:

Financial: N/A

Staffing: The purpose of this project is to build capacity for climate change and extreme weather adaptation with existing staff. No additional staff is required at this time. It is anticipated that the Town's communication staff are utilized to prepare materials for public engagement initiatives and to assist with the notifications relating to the program.

Legal: N/A

Public Engagement Matters:

Ongoing engagement with residents, businesses, stakeholders, and industry will continue to be an important part of the adaptation planning process. Due to COVID-19, community engagement methods are currently being revised to protect staff and public health and safety.

Conclusion:

Milestone 2 of the Climate Adaptation Plan has been completed and the project has moved into Milestone 3. To allow for the Town of Lincoln to adapt to anticipated climatic change and extreme weather, staff will continue to work closely with senior staff, Council, the Adaptation Steering Committee, the Stakeholder Advisory Group, Niagara Adapts, and Lincoln citizens and businesses.

Respectfully submitted,

Shannon Fernandes
Climate Change Coordinator
905-563-2799 Ext.281

Appendices:

Appendix A – Climate Change Vulnerability in The Town of Lincoln: A Baseline Study

Report Approval:

Report has been reviewed and/or approved by the Director of Public Works. Final approval is by the Chief Administrative Officer.

CLIMATE CHANGE VULNERABILITY IN THE TOWN OF LINCOLN: A BASELINE STUDY

SHANNON FERNANDES, JESSICA BLYTHE, ANGELA MALLETTE & RYAN PLUMMER






Brock University Environmental Sustainability Research Centre

Town of Lincoln

Acknowledgements

This work was supported by the Niagara Adapts partnership (brocku.ca/niagara-adapts/), a consortium of seven municipalities, including the Town of Grimsby, Town of Pelham, Town of Lincoln, City of Lincoln, Town of Niagara-on-the-Lake, City of St. Catharines and City of Welland, and Brock University. The research would not have been possible without the generosity of the survey respondents who shared their climate change experiences and perspectives. Thank you.

Citation

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Executive Summary

The impacts of climate change are already being experienced in the Niagara Region. It is anticipated that these impacts will only intensify in frequency and severity in the future. Understanding vulnerability to climate change is, therefore, a critical component of effective climate change adaptation planning.

Vulnerability refers to the susceptibility of a given region, municipality, social group or sector to harm arising from climate change impacts. Vulnerability is understood as a function of exposure, sensitivity and adaptive capacity to climate change impacts.

In the fall of 2019, a vulnerability assessment was implemented in Lincoln. Based on an extensive literature review and expert opinion, a set of 50 indicators specific for the Niagara Region was developed. Indicators were subsequently ranked for their importance to Lincoln. Secondary and primary data were collected from multiple sources including Statistics Canada, Niagara Region Public Health, municipal input by Niagara Adapts partners, and a community survey. For Lincoln, 150 members of the public completed the survey.

The results from the survey provide critical insights into how people in the region are experiencing climate change as well as their potential capacity to adapt. For example, 64% of respondents believe climate change is creating impacts in their community, and 83% of respondents support municipal resources going towards adaptation planning in Lincoln.

Findings from the analysis revealed a final vulnerability index value of 0.386 for Lincoln, where 0 represents highly vulnerable and 1 represents highly robust.

Some of the highly vulnerable indicators include: stormwater management (flooding in community, storm and wastewater infrastructure, rain barrels, green roofs, cisterns, low lying roads); extreme weather events (extreme heat); vulnerable populations (elderly residents, prevalence of infectious diseases, pre-existing health conditions, public transit); and gaps in asset management information.

The results provide data on the current state of vulnerability in Lincoln, highlight potential opportunities to build adaptive capacity, and shed light on areas of missing data that may be useful to collect in the future. These findings provide critical data to inform the ongoing climate change adaptation planning process.

This report provides an introduction to climate change and vulnerability assessments in Lincoln, describes the methods implemented, and summarizes the findings. The report concludes by highlighting what this information may mean for Lincoln going forward.

1.0 Introduction

1.1 Vulnerability to Climate Change in Niagara

Climate change refers to shifts in climactic patterns driven by increasing emissions of greenhouse gases from human activity (IPCC, 2014). In Canada, the climate is warming at twice the global average (Bush and Lemmen, 2019). This means the impacts of climate change are already widespread in Canada, bringing growing costs to governments, businesses, and ultimately all Canadians (Moudrak and Feltmate, 2019). For example, the average cost of a flooded residential basement is more than $40,000 (Moudrak and Feltmate, 2019). In Niagara, the impacts of climate change are already being experienced (Figure 1).

Recent events in Lincoln, such as the spring 2017 and 2019 flood events, also point to the need to adapt and build resiliency to changing climates and extreme weather patterns. Lincoln experienced approximately $1 million in damages resulting from back-to-back spring storms in 2017 that caused extreme flooding from Lake Ontario. These events led to the Town's first-ever voluntary evacuation notice for residents living near the Lake Ontario shoreline and caused significant flooding damage to Charles Daley Park and sewer systems in Jordan Station and Campden. In Spring 2019, significant rainfall and winds led to the Town's second voluntary evacuation as well as flooding, beach closures, and damage to boardwalks at Charles Daley Park. Over the last few years, the community has also issued multiple weather alerts, including extreme freezing rain, excessive heat, and extreme cold events.

As climate change impacts continue to rise in Canada, so does climate vulnerability. Vulnerability to climate change refers to the susceptibility of a given region, municipality, social group or sector to harm arising from climate change impacts (IPCC, 2014). Vulnerability of a system is understood as a function of the exposure and sensitivity of that system to hazardous conditions and the capacity the system adapt to the effects of those conditions (IPCC, 2014, Smit and Wandell, 2006, p. 286).

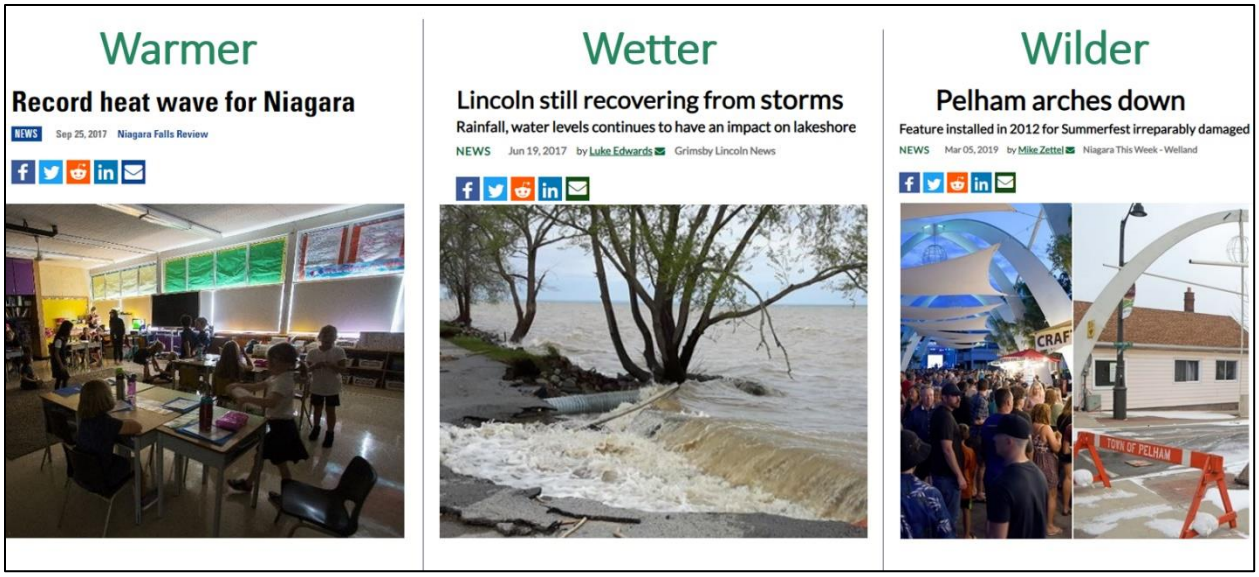


Figure 1. Climate impacts in the Niagara Region have included record heat waves, lakeshore flooding, and extreme weather events (Niagara Falls Review 2017, Niagara This Week 2017, 2019).

1.2 Climate Change Adaptation Planning

It is anticipated that the impacts of climate change will only intensify in frequency and severity in the future (Bush and Lemmen, 2019). Fortunately, Lincoln is engaged in climate change adaptation planning. Adaptation is defined as actions taken to minimize the harm, or exploit the opportunities, of a changing climate (IPCC, 2014, Figure 2a). Adaptation planning is the process of analysing, prioritizing and implementing actions to minimize the harm, and capitalize on opportunities, presented by climate change (Figure 2b).



Figure 2. a) What does climate change adaptation mean to you? Before the first Niagara Adapts workshop, a short survey was sent to representatives from the seven participating municipalities, asking them what climate adaptation meant to them. This word cloud represents their responses (the size of the word is proportional to the number of times it was identified by survey respondents). b) Climate change adaptation planning cycle.

Municipalities play a critical role in adapting to climate change and developing sustainable communities. Municipalities are on the front lines of preparing for climate change and have a responsibility to respond through strategic planning. Understanding vulnerability to climate change is, therefore, a critical component of effective climate change adaptation planning. Understanding vulnerabilities is one essential component for the development of robust adaptation actions. Additionally, vulnerability data should be considered in combination with climate impact data, and climate projections data.

2.0 Methods

Vulnerability assessments involve the systematic collection and analysis of information about exposure, sensitivity and adaptive capacity relevant to a system of interest. Vulnerability assessments can be conducted for any system and at any scale. We aimed to conduct a vulnerability assessment that captured a range of relevant systems and scales for Lincoln. Taking a holistic approach, the vulnerability assessment encompassed biophysical and socioeconomic determinants of vulnerability and adaptive capacity.

Typically, vulnerability assessments characterize the vulnerability of a system through a vulnerability index (IPCC, 2014; 1775). A climate vulnerability index is a metric that is derived by combining, with or without weighting, several indicators assumed to represent vulnerability. A vulnerability index can also identify which dimensions (e.g. exposure, sensitivity and adaptive capacity) and sub-dimensions of a particular system are the most vulnerable.

Figure 3 provides an overview of the steps that were implemented in the vulnerability assessment.

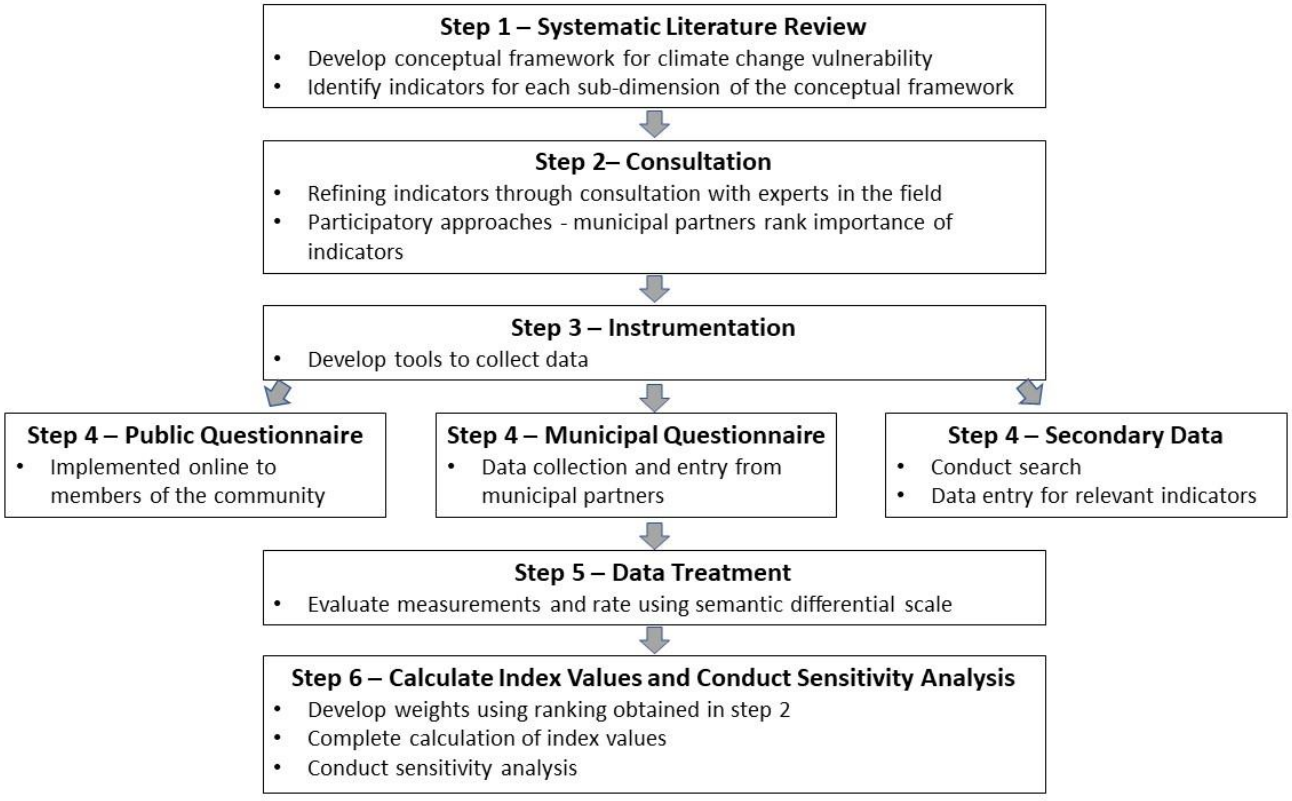


Figure 3. Steps of the research process.

2.1 Development of Vulnerability Indicators

An indicator is a gauge or measure of the state of something. Using peer-reviewed best practices for vulnerability assessments, indicators for exposure, sensitivity, and adaptive capacity were identified through a scholarly literature review and consultation with experts in the field (Figure 3). This process led to the selection of 50 indicators. These indicators provide insights into both the social and the bio-physical elements of vulnerability to climate change. Indicators covered the three dimensions of vulnerability (Figure 4).



Exposure

The nature and degree to which a system is exposed to significant climate variations

Determinants of exposure include:

- **Extreme temperatures** (*e.g. frequency and severity of extreme heat and cold*)
- **Flooding** (*e.g. frequency and severity of household and community floods*)
- **Other variables** (*e.g. other severe weather*)



Sensitivity

The degree to which a system is affected by climate

Determinants of sensitivity include:

- **Social & Health** (*e.g. elderly populations, younger children, agricultural livelihoods, population health, etc.*)
- **Infrastructure** (*e.g. the proximity of roads to coasts, low-lying roads, etc.*)



Adaptive Capacity

Adaptive capacity is the ability of a system to adjust to climate change, including to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Determinants of adaptive capacity include:

- **Assets** (*e.g. forests & wetlands, social capital, income level, etc.*)
- **Learning & Knowledge** (*e.g. public awareness and support, learning capacity, etc.*)
- **Flexibility** (*e.g. flexible institutional decision-making*)
- **Governance & Institutions** (*e.g. political leadership, community participation, policies*)
- **Psycho-social attributes** (*e.g. competing concerns, equity, etc.*)

Figure 4. Dimensions of Climate Change Vulnerability. Subdimensions are presented in bold. Examples of indicators are provided in italics.

Indicator Rankings

To ensure that the 50 indicators were highly relevant to Lincoln, municipal partner(s) from Lincoln prioritized the indicators, from most to least important (Figure 5). These rankings, specific to Lincoln, were then used to develop weights which were applied during the vulnerability analysis.

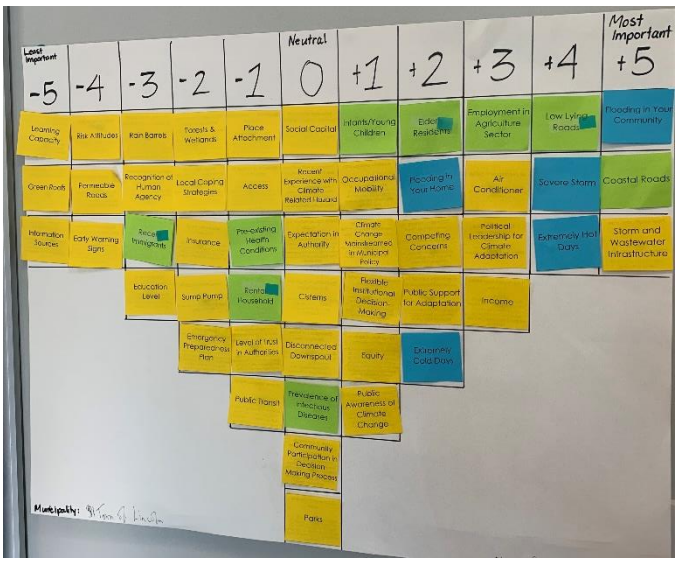


Figure 5. Indicator Rankings. Representatives from Lincoln prioritised the 50 vulnerability indicators, from least important (left hand side) to most important (right hand side).

2.2 Data Collection

Data included primary as well as secondary data. Secondary data was collected from sources including *Statistics Canada, Environment Canada, climatedata.ca, Niagara Region Public Health*, and others. In order to capture potential vulnerabilities at both the municipal scale and at the household scale, two survey instruments were implemented at the respective scales. At the municipal scale, partners collected relevant materials and consulted members of municipal staff in order to collect information on specific indicators.

Data at the household scale was collected through a public survey. Surveys were completed online and in person by 1,087 individuals across the participating seven municipalities in the Niagara region. In Lincoln, 150 residents participated. The results presented in this report represent the results for Lincoln.

2.3 Data Analysis

To begin the analysis, the data was normalized. Each indicator was rated on a scale from highly vulnerable to highly robust based on thresholds identified through literature and expert consultation. Scores for data were also linearly transformed onto a scale of 0 to 1, consistent with most vulnerability indices (Plummer et al., 2013; DeGrosbois &

Plummer, 2015). This process of normalization enables analysis of different types of data (e.g. binary, continuous, ordinal).

Following normalization, data were aggregated to create the composite index. Weighted averages were used as a method of data aggregation. Weighting can reflect local context and importance of certain indicators. As described above, municipal partner(s) from Lincoln ranked the indicators for the relative importance for Lincoln. These rankings were converted to weights (see DeGrosbois & Plummer, 2015 for full method followed), and these weights were then applied when aggregating the sub-dimensions and dimensions.

Critical values were also taken into consideration. Critical values are indicators that are below a threshold, indicating moderate or greater vulnerability. It is important to consider critical values due to the compensatory nature of linear aggregation in an index (Plummer et al., 2013; DeGrosbois & Plummer, 2015). Therefore, indicators were aggregated, taking into account the critical values (for full description of the process including equations, please see DeGrosbois & Plummer, 2015).

Finally, it is common that data is unavailable for certain indicators. Missing data should be accounted for in the calculation of an index. In instances where data was missing, the vulnerability index was also calculated assuming a pessimistic scenario (in which case, missing indicators was assigned the lowest possible vulnerability rating) and an optimistic scenario (in which case missing indicators were assigned the highest possible vulnerability rating). These scenarios allow for more informed climate change adaptation planning when full data are not available.

3.0 Results

The results for Lincoln are subdivided into summaries of the household survey results and the overall vulnerability results.

3.1 Household Survey Results

Respondents of the household survey were 33% male and 67% female. 77% were between the ages of 18 and 54, and 23% above the age of 55. Respondents completed 50 questions pertaining to demographics, their experience with climate change impacts, and their opinions on climate change adaptation. Select results are presented below.

Demographics

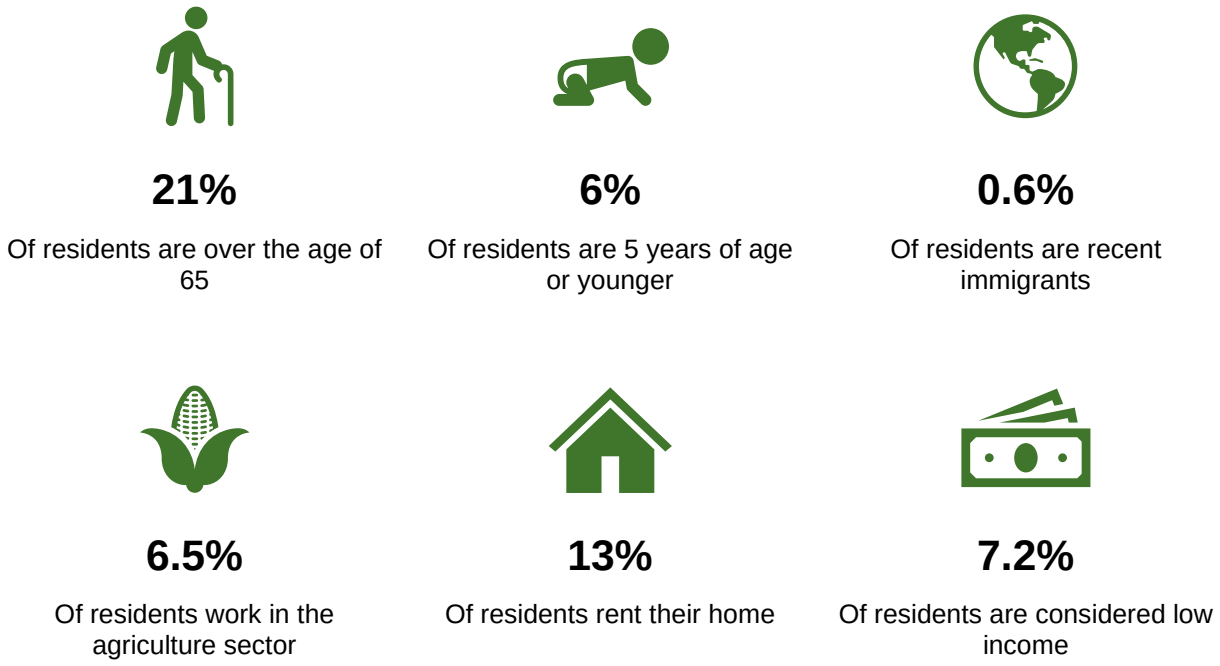


Figure 6. Social sensitivities in Lincoln.

Experiences with Climate Change Impacts

A. Flooding

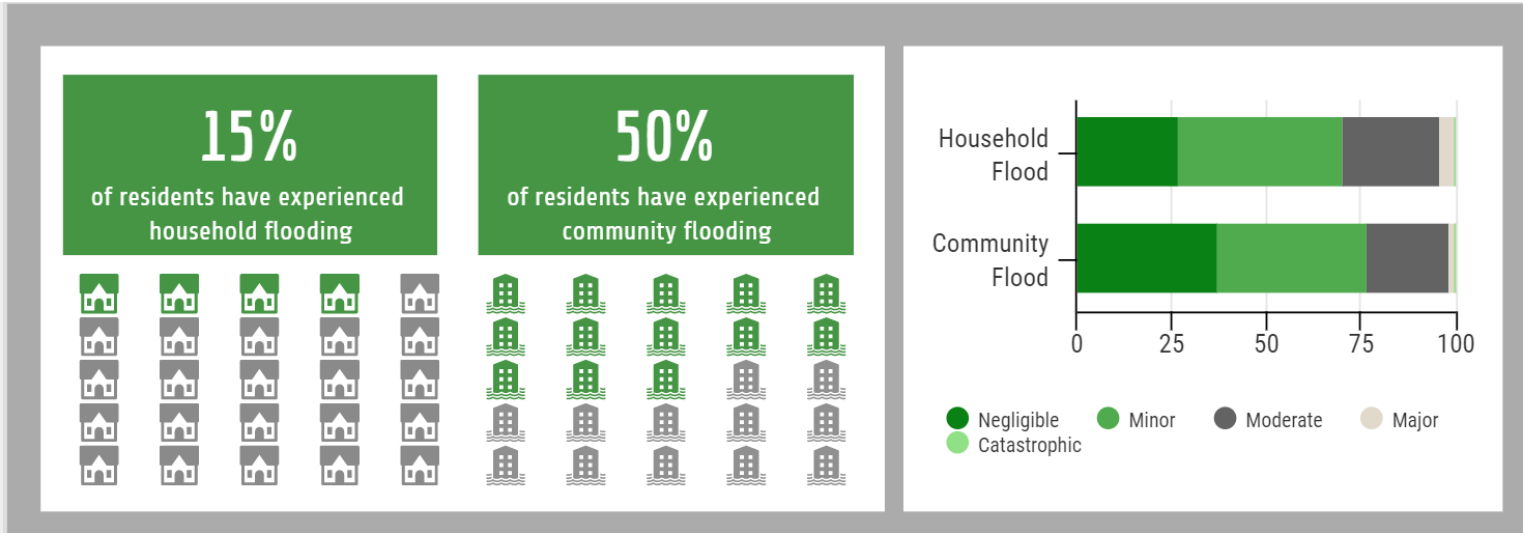


Figure 7.Residents experiencing flooding, and consequences of the floods

Experiences with Floods

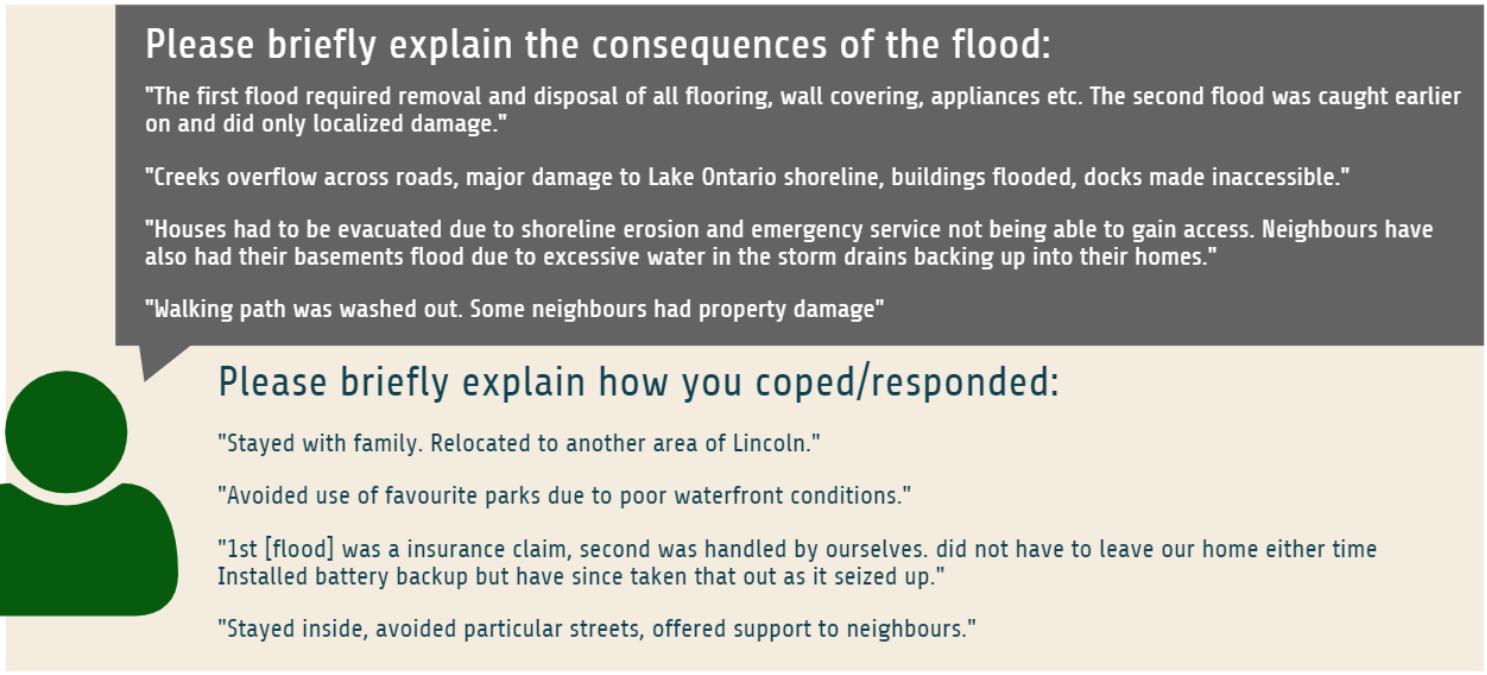


Figure 8. Responses from household survey on experiences with flooding (for a full list of responses, see Appendix A).

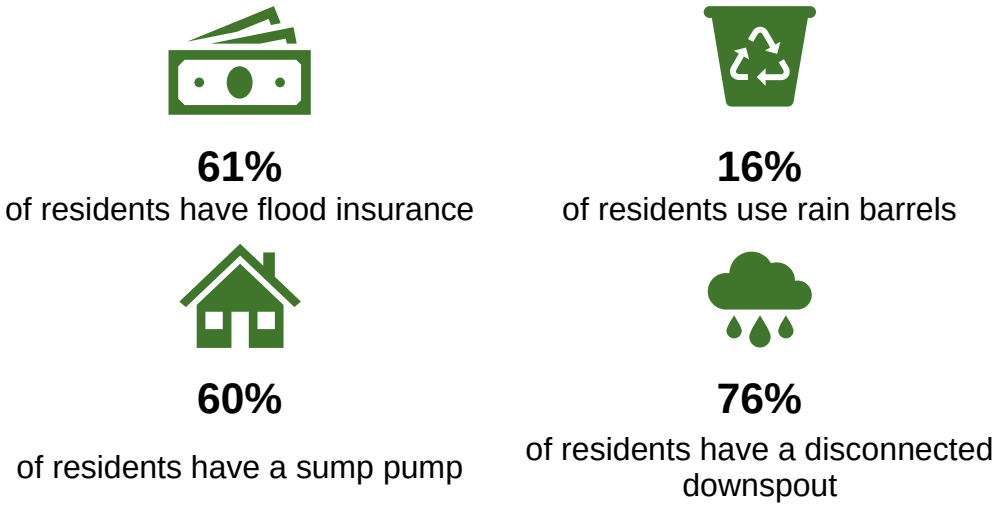


Figure 9. Assets for household and community flooding.

B. Changes in temperature

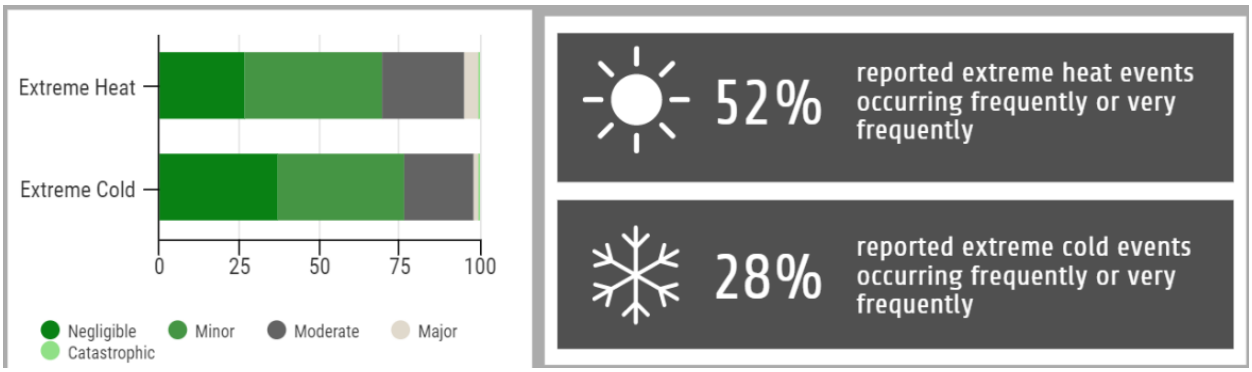


Figure 10. Residents experiencing extreme temperatures, and consequences of these events.

Experiences with Extreme Temperatures

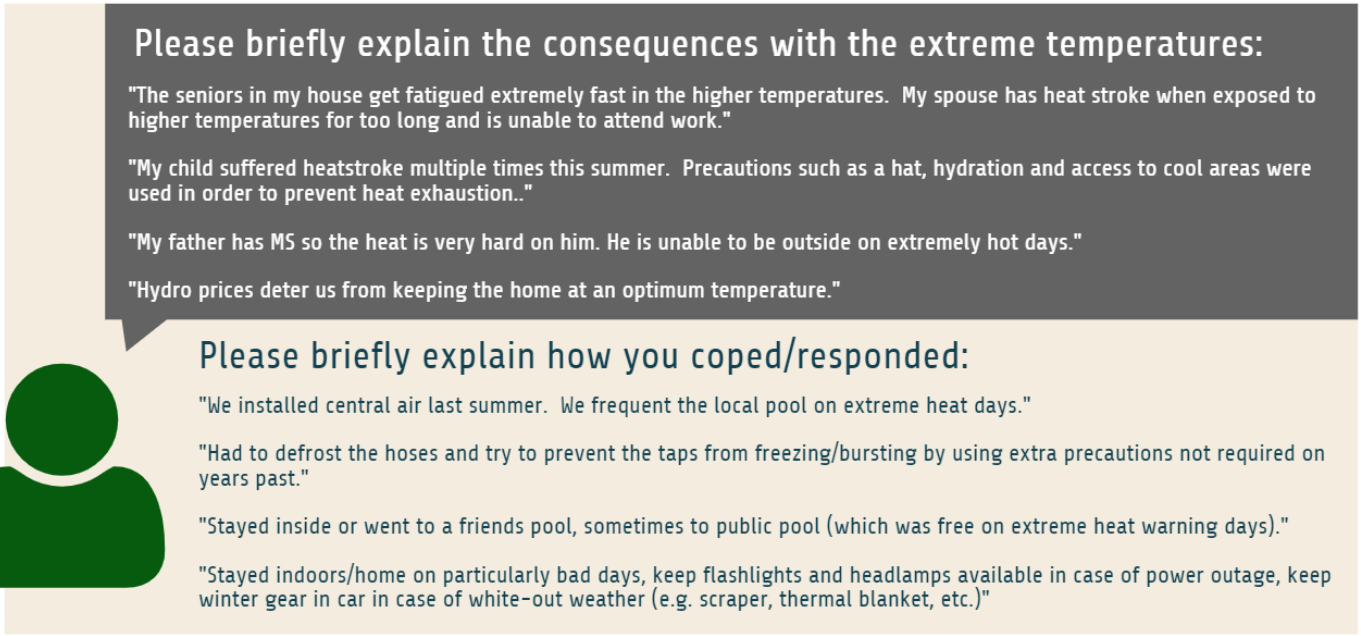


Figure 11. Responses from household survey on experiences with extreme temperature events (for a full list of responses, see Appendix A).

Public Awareness, Concerns, and Other Sources of Adaptive Capacity

23% Are aware of an early warning system within the municipality to alert of climate-related hazards

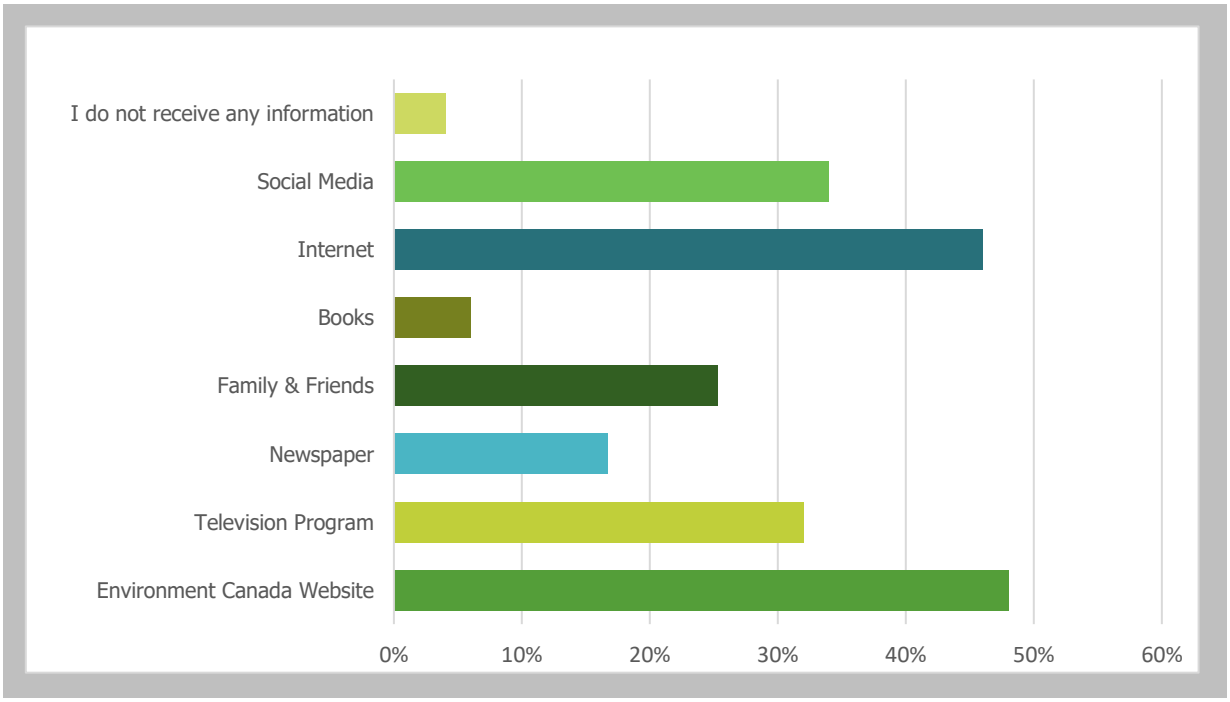


Figure 12. Where do most people receive information about climate change?

CONCERNS

64% agree that climate change is creating impacts in the community

77% believe that human activities are the main cause of climate change

26% believe that there is unequal access to climate change resources among the community

24% believe Lincoln is well-positioned to adapt to future climate change impacts

SUPPORT FOR LOCAL LEADERSHIP

34% have confidence in the ability of Lincoln to minimize the impacts of climate change for their household

23% believe that local leaders are supporting effective climate change adaptation action

18% have confidence in the preparedness of local leaders to address climate change impacts

83% support municipal resources being used for climate change adaptation

25% agree that there are municipal resources (such as forums or groups) available to help us learn from past climate change impacts

SOURCES OF ADAPTIVE CAPACITY

19% would be willing to relocate if the consequences of climate change become more severe

44% say that climate change is a top priority for their household

31% believe Lincoln has coped effectively to climate change impacts in the past

54% feel that they are able to participate in the climate change adaptation planning process

63% feel confident in their personal capacity to minimize the impacts of climate change for their household

43% agree that there are sufficient materials available to learn about climate change impacts

93% feel that they have adequate access to information on climate change

3.2 Vulnerability Analysis

The overall vulnerability index value for Lincoln is 0.386, on a scale from 0 (highly vulnerable) to 1 (highly robust). This represents a 'baseline scenario'. In the baseline scenario, the index was calculated by eliminating indicators with missing data, applying the weights for relative importance, and by taking into account 'critical values' or measurements that fall below a given threshold (Section 2.3).

Missing information may have important influences on the results and therefore multiple scenarios are constructed. As described in Section 2.3, to account for indicators with missing data, an 'optimistic' and 'pessimistic' scenario were calculated. This is represented by a confidence interval (see Figure 13). It is important to note that this is not a statistical confidence interval, but rather provides a range of possible outcomes (DeGrosbois & Plummer, 2015). The confidence interval for overall vulnerability in Lincoln is 0.379 (pessimistic scenario) to 0.389 (optimistic scenario).

Findings at the subdimension and indicator levels provide important information on the biophysical and social vulnerabilities, as well as areas with lacking information. The subdimensions of vulnerability and adaptive capacity are displayed in Figure 13. The circle represents the value found for the subdimension based on available data. The bar represents the range from a 'pessimistic' scenario to an 'optimistic' scenario in cases where there is missing data. The baseline scenario for the sub-dimensions and the corresponding indicators are presented in Figure 14 and 15.

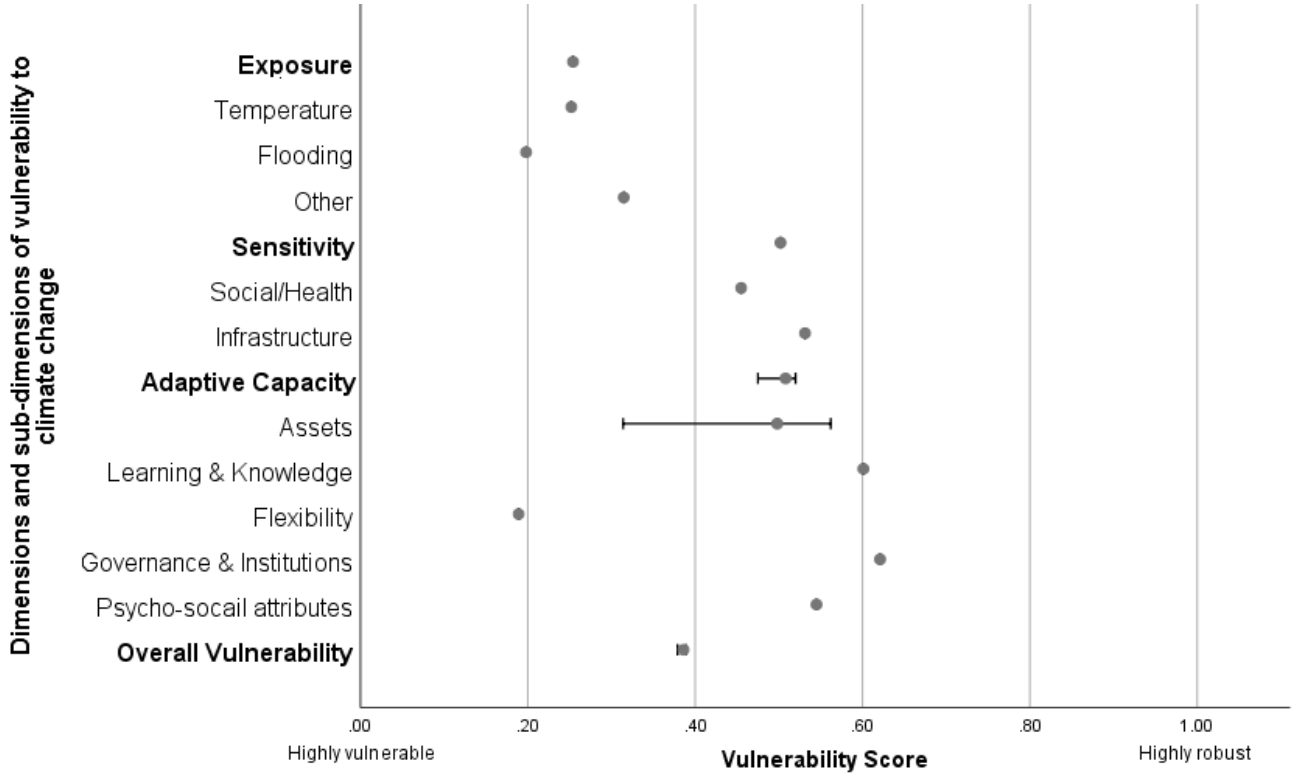


Figure 13. Dimensions and Sub-dimensions of vulnerability to climate change across dimensions and ten sub-dimensions for Lincoln. The grey dots represent the baseline scenarios. The confidence intervals represent the possible range from pessimistic to optimistic scenarios in cases where there is missing data.

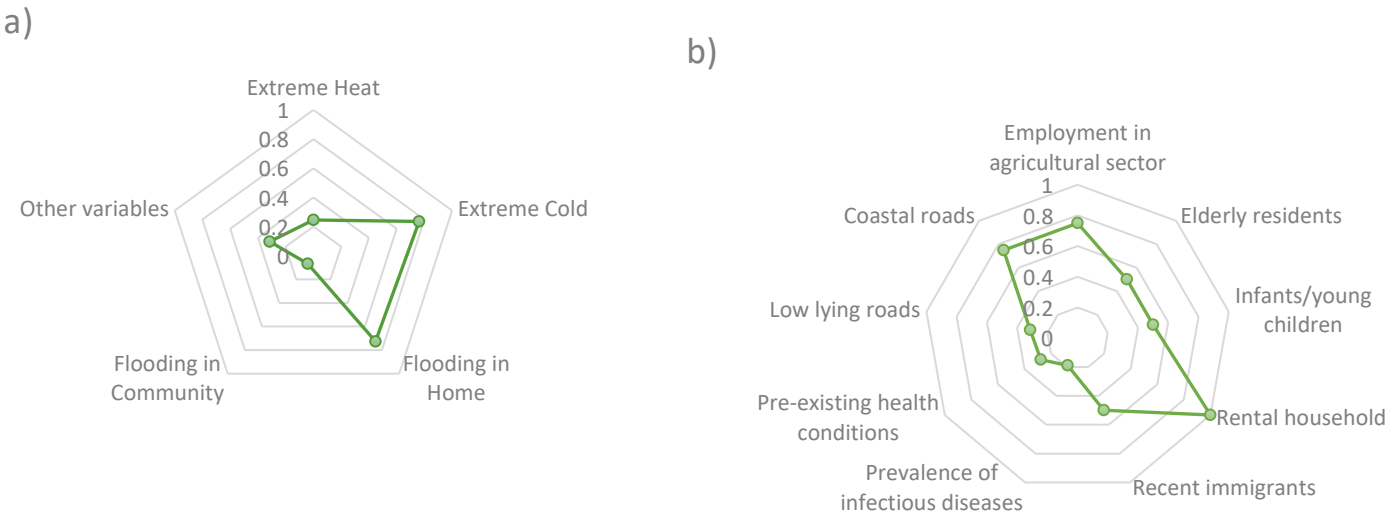
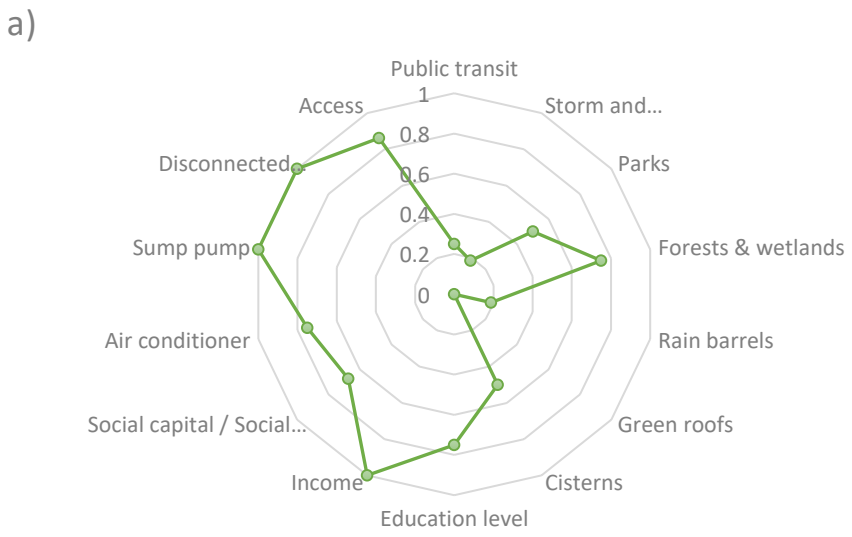


Figure 14. Indicators of exposure and sensitivity. Ratings from high exposure (0) to low exposure (1) for the five indicators of exposure (a) and from highly sensitive (0) to highly robust (1) for the nine indicators of sensitivity (b).



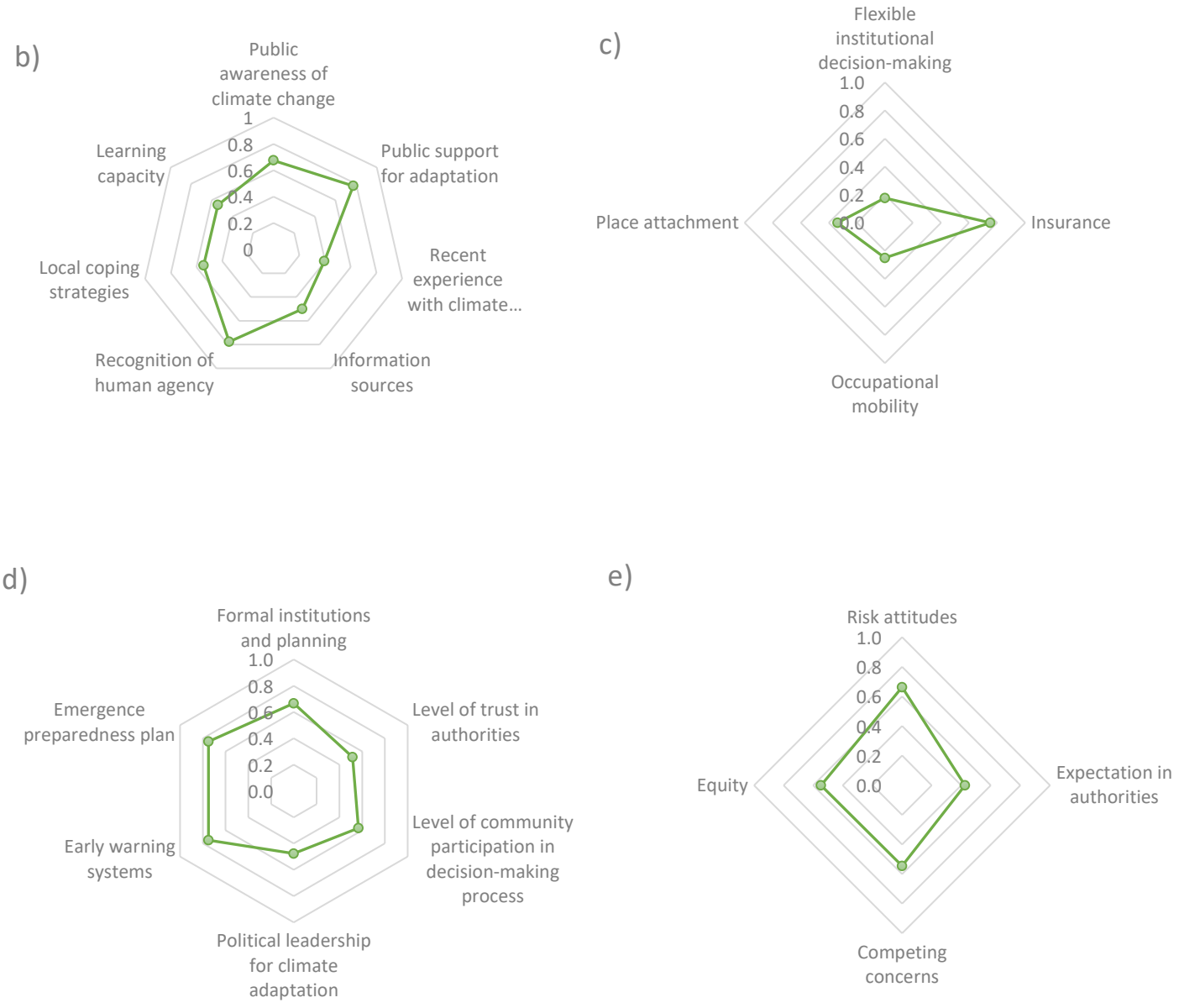


Figure 15. Indicators of adaptive capacity. Ratings from low adaptive capacity (0) to high adaptive capacity (1) for indicators for the five subdimensions of adaptive capacity: assets (a), learning and knowledge (b), flexibility (c), governance and institutions (d), and psycho-social attributes (e).

Critical Values and Missing Data

Critical values were identified in the data for Lincoln. In addition, data was not available for all indicators. Understanding areas where data is lacking is important for future monitoring and planning. This is especially important in cases where these subdimensions may be vulnerable and include critical values (i.e. have values that have fallen below a given threshold). Figure 16 shows subdimensions with missing data and that may be more vulnerable.

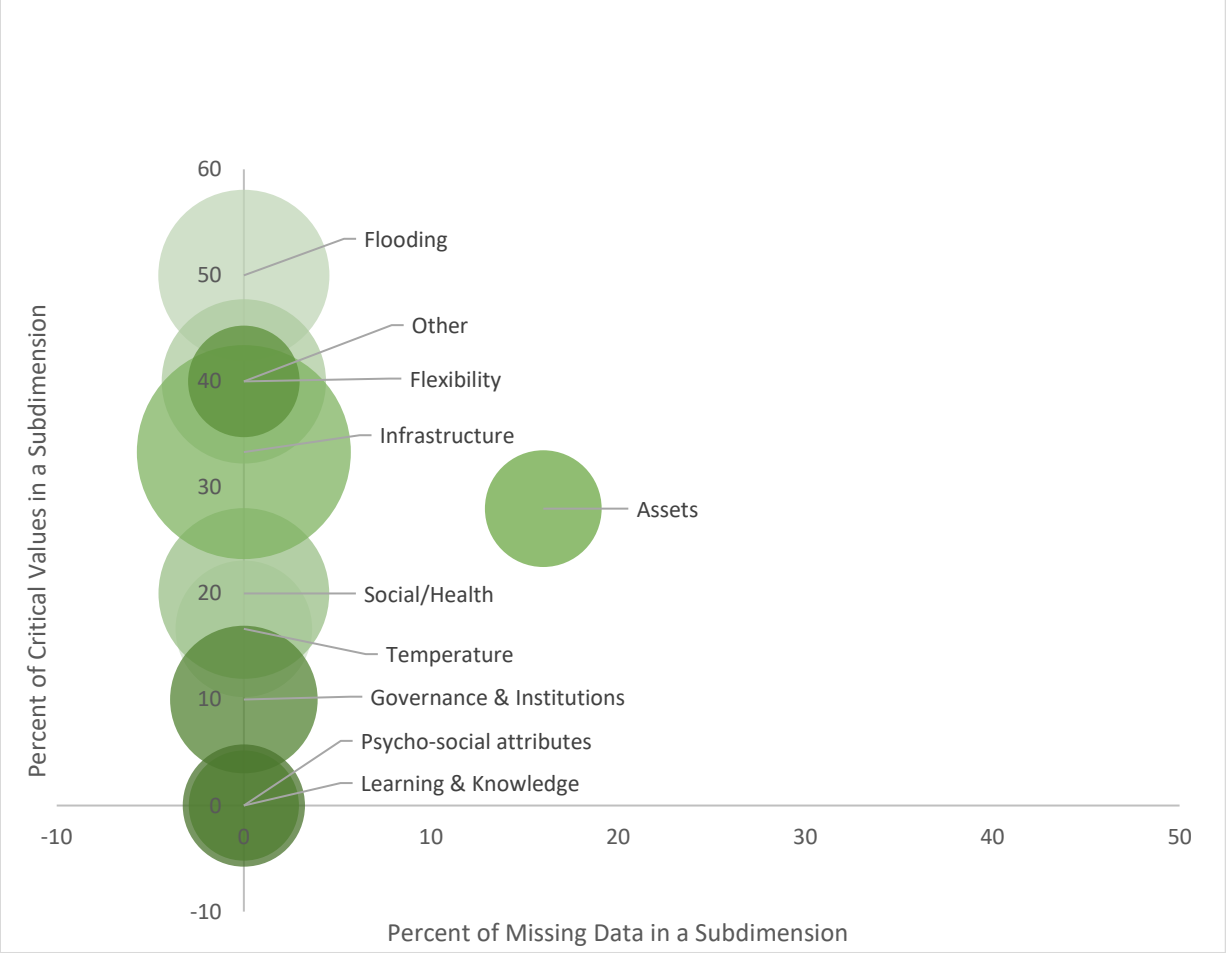


Figure 16. Critical and Missing Data. Size of the bubbles represents the relative expert weights of the sub-dimensions.

4.0 Where do we go from here?

On July 22, 2019 Council passed a resolution supporting the development of a Corporate Climate Adaptation Plan. The purpose of a Corporate Climate Adaptation Plan is to prepare the Town of Lincoln to adapt to anticipated climatic change and extreme weather, thereby minimizing the severity of the resulting impacts. This will be achieved through:

1. Identification of the potential impacts related to climate change and extreme weather in Lincoln, and the risk they pose to the Town's infrastructure, assets, operations, services, and shoreline;
2. Prioritized adaptation actions to reduce risk and vulnerability associated with climate change and extreme weather impacts; and
3. A detailed implementation plan, including estimated costs, funding sources, responsibilities, timelines, and a framework to monitor and evaluate progress.

The climate adaptation process is guided by the following Climate Action Vision: To be intentional in building stronger community resilience. To strengthen our community's response and adaptation to a wide array of future changes, the Town of Lincoln is committed to expanding and utilizing our available resources (people and assets) to prepare for, respond to, and move towards a more sustainable future. Our community-driven approach and progressive public policies are foundational to achieving our shared vision of One Lincoln.

The vulnerability data gathered from residents is integral to the adaptation planning process to ensure the plan reflects local context and community priorities. Identification and prioritization of climate impacts, risk, adaptation actions, and implementation opportunities are the next steps of the planning process (see Fig. 17 below) and will be informed by the vulnerabilities discussed in this report.

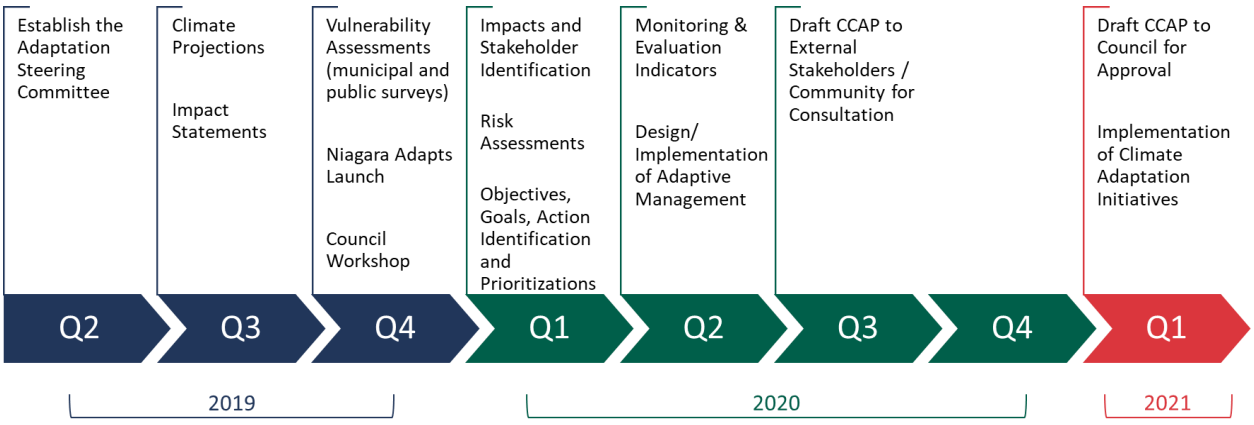


Figure 17. Town of Lincoln Corporate Climate Adaptation Plan Timeline

Some of the highly vulnerable indicators include:

1. Stormwater management (Flooding in Community, Storm and Wastewater Infrastructure, Rain Barrels, Green Roofs, Cisterns, Low Lying Roads)
2. Extreme weather events (Extreme Heat)
3. Vulnerable populations (Elderly Residents, Prevalence of Infectious Diseases, Pre-existing Health Conditions, Public Transit)
4. Missing information on Town owned assets

These indicators directly support the need for current and future Town initiatives. In order to address stormwater management and flooding, the Town is: conducting two shoreline assessment studies; developing Low-Impact Development/Green Infrastructure Design Standards and a Community Improvement Plan; installing a Rain Garden as part of the Jordan Hollow Cultural Park project; and replacing all water meters with Advanced Metering Infrastructure technology that allows for accurate real-time usage readings. When implemented in other municipalities, AMI has been shown to successfully improve efficiency, detect backflow events, and have proactive leak detection alerts.

Extreme weather events are a key climate focus of the climate adaptation plan. To ensure the plan reflects staff expertise and emergency management priorities, and can ultimately be integrated into departmental functions, municipal expertise will be gathered through workshops with an Adaptation Steering Committee. The Steering Committee is multi-departmental, comprised of mid-level management Town staff that have diverse expertise and experience with the Town's communities, infrastructure, assets, and services and play an essential role in the climate emergency management planning process.

The consideration of vulnerable populations is also integral to climate adaptation planning as social sustainability can straighten climate resilience. The Town is currently developing a Health Equity/Climate Lens to aid in project and program development, and Council decision-making and prioritization. This lens is championed by subject matter experts at Niagara Region Public Health and Brock University and will contribute to increase climate and social vulnerability literacy.

Lastly, missing municipal asset data is being addressed through the development of an Asset Management Plan. The Asset Management Planning process identifies gaps, solutions, and long-term management of Town owned assets and is being developed with inter-departmental collaboration and consideration of the risks a changing climate poses to assets, infrastructure, and service levels.

The Corporate Climate Adaptation Plan will address the vulnerabilities identified in this assessment that are within the Town's corporate leadership scope. In order to address the community and greenhouse gas mitigation vulnerabilities, the development of a Corporate Climate Mitigation Plan and a Community Low-Carbon Resilience Plan will be future initiatives.

Feedback from residents remains a valued and essential component of investigating, identifying, and implementing plans and programs. Ongoing engagement with residents, businesses, stakeholders, and industry will continue to be an important part of the planning processes for all the above-mentioned initiatives and empower Council to play a vital leadership role in increasing the resilience of the Town and the community to climate change.

References

Bush, E. and Lemmen, D.S., editors (2019): Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario, Canada. 444 p.

De Grosbois, D. & Plummer, R. (2015). Problematizing water vulnerability indices at a local level: A critical review and proposed solution. Water Resources Management, 29 (14), 5015-5035.

Intergovernmental Panel on Climate Change (IPCC) (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Moudrak N and Feltmate B (2019) Weathering the storm: developing a Canadian standard for flood-resilient existing communities. Intact Centre on Climate Adaptation, Waterloo, Ontario, Canada. 52 p.

Lincoln Review (2017) Record heat save for Niagara. https://www.niagarafallsreview.ca/news-story/8195859-record-heat-wave-for-niagara/

Niagara This Week (2017) Lincoln still recovering from spring storms. https://www.niagarathisweek.com/news-story/7379312-lincoln-still-recovering-from-spring-storms/

Niagara This Week (2019) Pelham arches down for the count – at least for now. https://www.niagarathisweek.com/news-story/9207160-pelham-arches-down-for-the-count-at-least-for-now/

Plummer, R., de Grosbois, D., Armitage, D., & de Loe, R. (2013). An integrative assessment of water vulnerability in First Nation communities in Southern Ontario, Canada. Global Environmental Change, 23(4), 749-763.

Appendix A

Table A.1

	Expert weight	Pessimistic scenario	Baseline scenario	Optimistic scenario	Lack of data	Critical data
Overall Vulnerability		**0.379**	**0.386**	**0.389**		
Exposure	**0.47222**	**0.254**	**0.254**	**0.254**		
Temperature	0.249	0.252	0.252	0.252	0	16.67
Flooding	0.39087	0.198	0.198	0.198	0	50
Other	0.36012	0.315	0.3147	0.3147	0	40
Sensitivity	**0.31**	**0.502**	**0.502**	**0.502**		
Social/Health	0.388889	0.455	0.455	0.455	0	20
Infrastructure	0.61111	0.53125	0.53125	0.53125	0	33.33
Adaptive Capacity	**0.2222**	**0.475**	**0.508**	**0.520**		
Assets	0.18187	0.314	0.498	0.562	16	28
Learning & Knowledge	0.16199	0.601	0.601	0.601	0	0
Flexibility	0.16608	0.189	0.189	0.189	0	40
Governance & Institutions	0.2906	0.621	0.621	0.621	0	10
Psycho-social attributes	0.1994	0.545	0.545	0.545	0	0

Key:

Expert weight: the weight derived from ranking of indicators (Section 2.1)

Pessimistic Scenario: Calculated by applying expert weights, accounting for critical values, and assuming the lowest possible score in cases where data is missing

Baseline Scenario: Calculated by applying expert weights, accounting for critical values, and eliminating indicators with missing data

Optimistic Scenario: Calculated by applying expert weights, accounting for critical values, and assuming the highest possible score in cases where data is missing

Lack of Data: Percent of missing indicators in a subdimension

Critical Data: Percent of indicators in a subdimension that are identified as critical values