Disaster Risk in Canada – A Data-Driven Discussion

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Abstract

In a haphazardly changing climate, decision makers and practitioners need new insights based on historical disasters, demographic and socioeconomic shifts, and modifications in the built environment. The COVID-19 has exposed systemic vulnerabilities at all levels. Reflections on past disasters and practices regarding measures to reduce disaster losses, overlaid with insightful understandings and interpretations to suit current times, must allow for new pathways. This study attempts to achieve just that. It examines natural disasters in Canada since the 1900s as well as census data to track the demographics and socioeconomic scenarios. At the initial assessment, considering the most frequent natural disasters (floods, extreme cold, severe thunderstorms, tropical storms and storm surge, landslides, drought, wildfires, earthquakes, and epidemics), Canada experienced 844 events since 1900. A province-based distribution of these disasters suggests that Ontario is ranked first with 158 major events, followed by Quebec, Alberta, and British Columbia, with over 100 events each. The maritime provinces have also had their share of disasters, and so have the northern communities and territories. In terms of population changes, between 1901 and 2019, Ontario has grown over 560%, Quebec 50%, Alberta 325%, and BC a whopping 2,700%.

The study specifically explores the following: disaster types and the scale of their impact on people, properties, and the environment; the demographic and socioeconomic status; an investigation of what measures are currently in place to ensure the building of resilience and coping capacity at the institutional level. The measures include provincial and federal tools for hazard identification and risk assessment that inform policy, emergency response plans, landuse planning, etc. Further investigation is recommended to cover a wide range of vulnerability indicators of the population, as well as the institutional systems and policies in place for developing a robust set of tools to mitigate disaster impacts in the future. This is a preliminary analysis of the entire country

in the hope of making a case for a national strategy for disaster adaptive capacities and resilience and climate adaptation.

Keywords: Disaster Risk, Canada, Resilience, Risk Reduction, Vulnerability, Historical data

Background and Objective

In an ever-changing climate, decision makers and practitioners need new insights based on past disasters triggered by natural causes (hydrometeorological, geological, biophysical), demographics, and modifications in the built environment. The topic is relevant today more than ever as the COVID-19 pandemic—a biophysical disaster caused by a novel and deadly coronavirus, SARS-CoV-2—has exposed systemic vulnerabilities at all levels, including social, physical, and economic. Although COVID-19 has compelled stakeholders to think about a paradigm shift from a 'disaster on demand' approach to longterm and sustainable measures, this paper is about all hazards, not just COVID-19. Reflections on past disasters and practices regarding measures to reduce disaster losses, overlaid with insightful understandings and interpretations to suit current times, must be a prerequisite to explore new pathways. This study attempts to focus on the two main components of disaster risk—hazards and their consequences.

The Sendai Framework for Disaster Risk Reduction [SF-DRR] 2015–2030 serves as a continuum to the commitment supported by the United Nations Office for Disaster Risk Reduction (UNDRR). The SF-DRR notes the need for an improved understanding of disaster risk in all its dimensions of exposure, vulnerability, and hazard characteristics, as well as the strengthening of disaster risk governance (UNDRR, 2015). Scholars have analyzed and explained risk as a component of the social factors, which interact with the geographic context to create vulnerability (Cutter 2003; 2008) as well as determinants of vulnerability (Messner & Meyer 2006; Kuhlick et al., 2011; Agrawal et al., 2020]. These determinants are based on people's physical (e.g., age, able-body), social (education, language, network), and economic (income, employment) attributes, as well as their access to resources, including essential infrastructure and services, such as clean water, electricity, hospitals, support systems, communication and transportation networks, etc. In the Canadian context, the Government of Canada (2019) has developed a comprehensive vision for a disaster-resilient country by highlighting the importance of considering that the impacts of disasters are not

uniform across society, and that different variables can intersect and contribute to the level of risk facing vulnerable populations (e.g., gender, age, disability, socioeconomic conditions). Ontario's Hazard Identification and Risk Assessment [HIRA] suggests that most definitions of risk involve two core components, people's interactions with danger and the degree of potential harm (Ontario Ministry of the Solicitor General, 2019**)**. Here, the danger is natural hazards, and the potential harm relates to the impact on people, infrastructure, and essential services. The impact will be greater in communities with demographics pre-disposed to being exposed and susceptible to dangerous events, making them vulnerable.

The paper examines natural disasters in Canada since the 1900s for a bird's-eye view of hazards and census data to highlight the demographics (with limited scope for establishing the arguments) for vulnerability assessment purposes. In terms of the most frequent natural disasters, such as floods, extreme cold, severe thunderstorms, tropical storms and storm surge, landslides, drought, wildfires, earthquakes, and epidemics, Canada experienced 844 events since 1900. A province-based distribution of these disasters suggests that Ontario (ON) is ranked first with 158 major events, followed by Quebec (QC), Alberta (AB), and British Columbia (BC), with over 100 events. The maritime provinces have also had their share of disasters, and so have the northern communities within the territories. In terms of population changes, between 1901 and 2019, Ontario has grown over 560%, Quebec 50%, Alberta 325%, and BC a whopping 2,700%.

This study is a preliminary conceptual discussion underscoring the importance of historical data on hazards and demographics in space and time for building adaptive capacities and resiliency. A national-level engagement on new approaches and innovative ideas toward disaster risk reduction, resilience building, and capacity enhancement may eventually convince policymakers to develop a national strategy to reduce disaster losses.

Data and Analysis

Figure 1 presents the natural hazards data in Canada since 1900, compiled using the Canadian Disaster Database [CDD], created by Public Safety Canada (2020), and the International Disaster Database [EM-DAT], developed and maintained by the Centre for Research on the Epidemiology of Disasters (CRED, 2020). The following sections discuss past hazards and the population's socioeconomic status in Canadian provinces based on the 2016 Canadian census. We use the two datasets to demonstrate their convergence and interactions in order to comprehend disaster impact.

Natural hazards

Figure 1 shows natural hazards that have caused a significant adverse impact on people, infrastructure, and the environment since the early 20th century. In this graph, the year 2008 ranks first with 41 disasters, severe enough to be recorded in either or both databases—CDD and EM-DAT. The year 2016 (28 disasters) ranked second, and years 2007 and 1998-99 (26 disasters) both ranked third. The low number of recorded disasters in the early 20th century can be attributed to a lack of streamlined record-keeping, as well as evolving criteria for an event to be entered in the database. Currently, at least one of the following criteria must be fulfilled for a disaster to be entered into the EM-DAT database (CRED, 2009, para. 2):

- Ten (10) or more people reported killed
- Hundred (100) or more people reported affected
- Declaration of a state of emergency
- Call for international assistance.

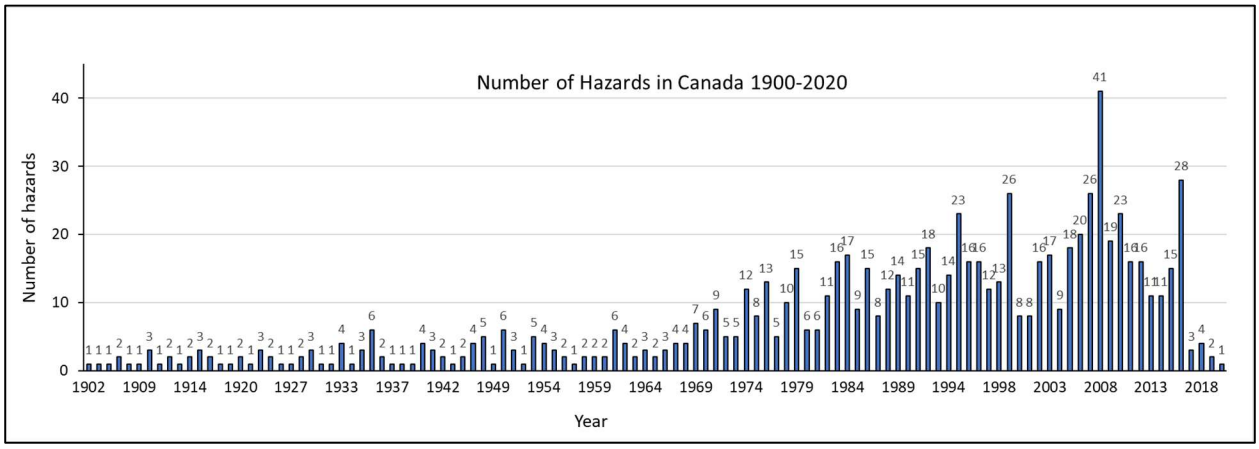

Figure 1: Number of natural hazards in Canada between 1900 and 2020. Data compiled from the Canadian Disaster Database (Public Safety Canada, 2020) and International Disaster Database [EM-DAT] (CRED, 2020).

Figure 2 presents an overview of natural hazards according to their frequency in Canadian provinces, suggesting that ON, QC, and AB rank as the top three provinces in experiencing the most number of natural hazards respectively, and BC places itself at a close 4th rank. Ontario, AB, BC, and QC experience the most floods in that order, while winter storms are most frequent in ON, Newfoundland (NL), and QC. The three prairies provinces—AB, Saskatchewan (SK), and MB—and ON face a high risk of thunderstorms and tornadoes. This insight is useful for incorporating caveats and nuances for a national approach to disaster risk reduction.

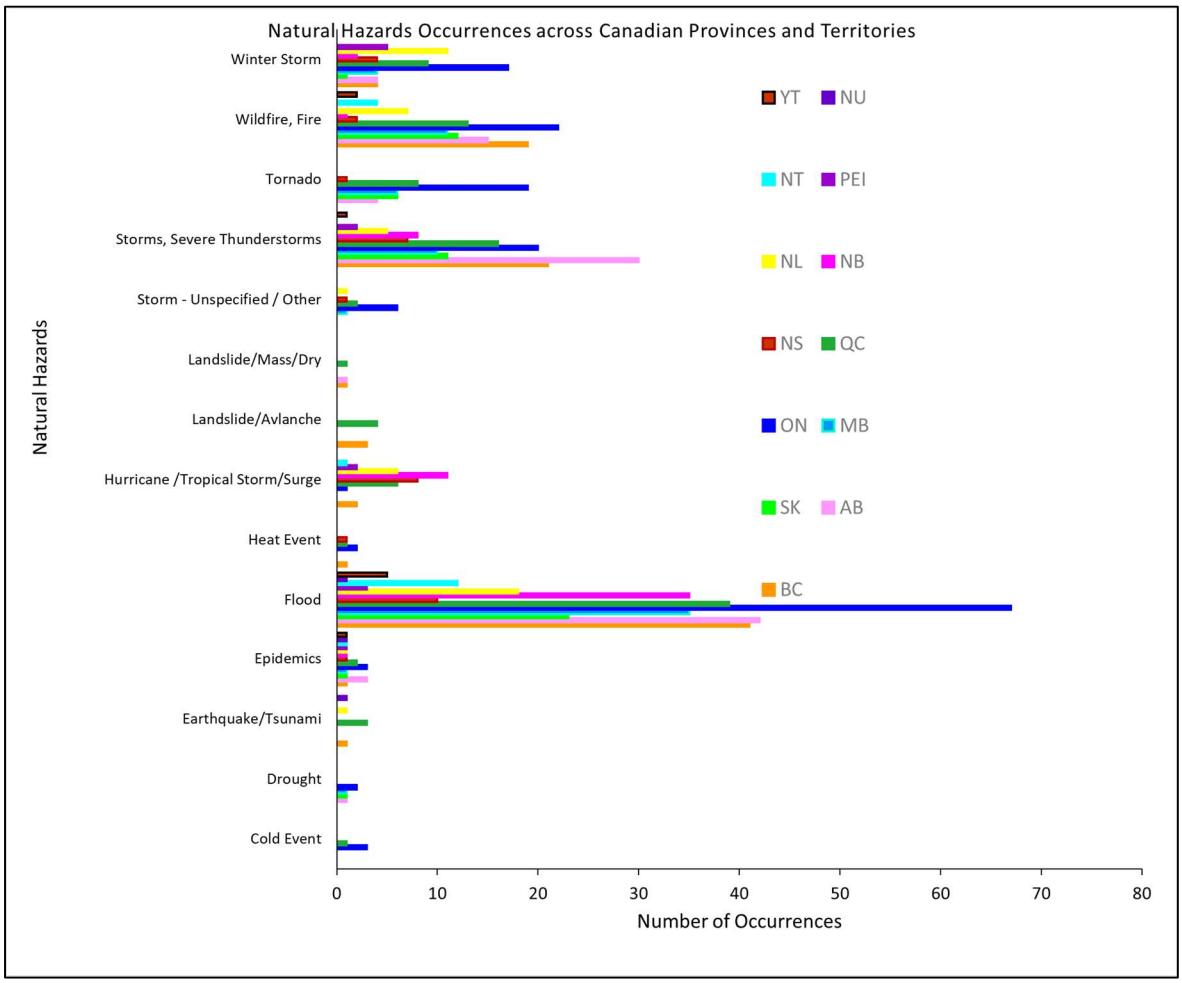

Figure 2: Natural hazards in Canadian provinces between 1900 and 2020. The ten provinces and three territories include BC (British Columbia), AB (Alberta), SK (Saskatchewan), MB (Manitoba), ON (Ontario), QC (Quebec), NS (Nova Scotia), NB (New Brunswick), NL (Newfoundland), PE (Prince Edward Island), NT (Northwest Territories), NU (Nunavut), and YT (Yukon) (Public Safety Canada, 2020; CRED, 2020)

As evident in Figure 2, floods, thunderstorms, wildfire, winter storms, tornados, and tropical storms are among the most frequent hazard types experienced in the country. For better comprehension, we have plotted the frequent hazards in Figure 3, in which the data does not suggest a specific pattern in any particular way, but Ontario bears the brunt of most of these hazards. Again, this perspective is useful for setting priorities, resource allocation for disaster risk

mitigation, and long-term strategies focused on adaptive capacities. In terms of the three northern territories, only the Northwest Territories gets included in the graph in Figure 3.

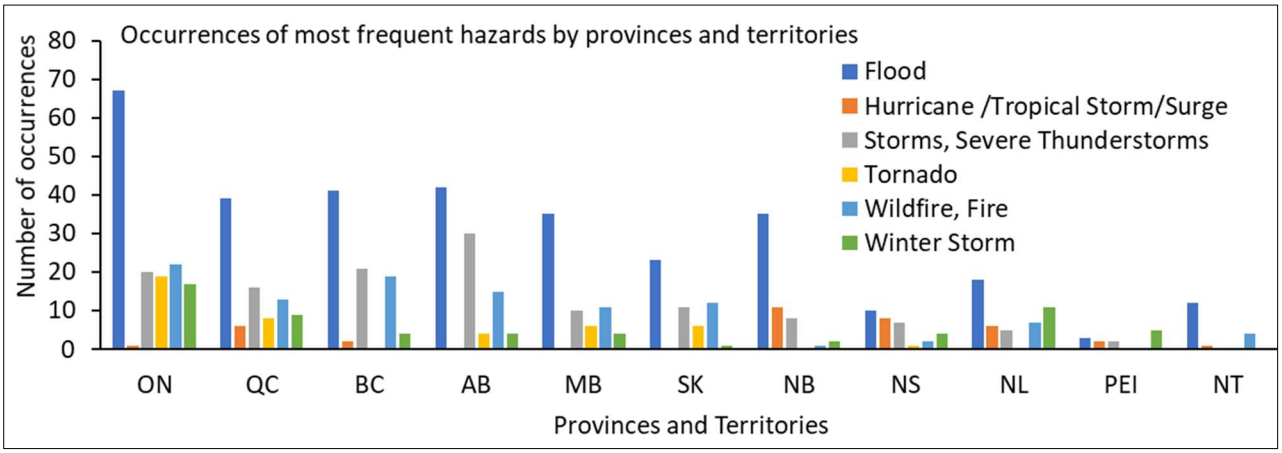

Figure 3: The top six most frequent hazards by province and territory between 1900 and 2020 (Statistics Canada, 2016). Nunavut and Yukon Territories did not make the top six list, hence excluded from this graph.

Demographic and socioeconomic scene of the population

Natural hazards and the population's socioeconomic scenario by provinces are presented in Figure 4, where ON, QC, and BC emerge as the three fastest-growing provinces, respectively. These three provinces also rank high on the number of disasters caused by natural causes (e.g. extreme weather events, infectious virus spread, etc.), potentially exposing more people to these disasters.

The literature on disaster risk reduction suggests that the assessment of disaster impact/consequences/vulnerability is a critical and essential step to comprehending risk, a function of vulnerability and hazards. Almost all of the available vulnerability assessment methods draw upon social, physical, economic, and environmental factors that contribute to the progression of vulnerability in communities (Welle & Birkmann, 2015; BC Emergency Preparedness, 2004; Twigg, 2007; Smith, 2009; Tobin & Montz, 1997). These methods follow a fundamental principle of identifying exposure and susceptibility to hazards, and the lack of coping capacity of individuals, communities, and the emergency management system at large. Various governments in Canada have developed tools and methodologies to assess disaster risk based on people's vulnerability and potential hazards. For example, Ontario first developed HIRA (Hazard Identification and Risk

Assessment) in 2004 and revised it in 2012, and again in 2019 (Ontario Ministry of the Solicitor General, 2019). British Columbia implemented its version, HRVA (Hazard Risk and Vulnerability Assessment), in 2004, and it is currently under revision (British Columbia Public Safety and Emergency Services, 2019). The federal agency, Public Safety Canada (2012), developed a methodology based on an all-hazard approach, AHRA (All-Hazard Risk Assessment), for guidance that stakeholders can adopt as a preliminary exploration. At the global scale, the Global Assessment Report for DRR (United Nations Disaster Risk Reduction [UNDRR], 2019) has issued a series of articles and reports on the current limitations of risk assessment and the need for systemic risk governance to support paradigm shift, which is especially relevant today in light of COVID-19.

Although this study is limited in terms of considering a select number of vulnerability indicators, it demonstrates the usefulness of this aspect of critical thinking and analysis based on understanding the vulnerabilities of people as identified in the literature (Government of Canada, 2019; Agrawal et al., 2020; Cutter, 2003).

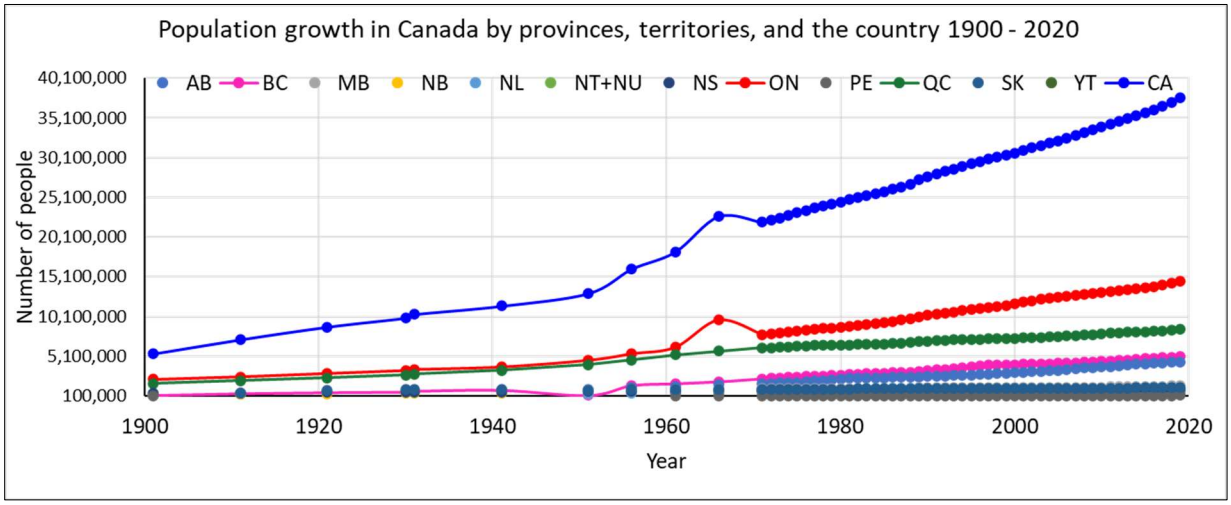

Figure 4: Population growth in Canada (CA - blue) and provinces. Ontario (ON - red), Quebec (QC – green), and British Columbia (BC – pink) stand out with high population growth (Data source: Statistics Canada, 2016).

Figure 5 illustrates a picture of the socioeconomics of the country's demographics using a select number of indicators well-established in the literature (United Nations International Strategy for Disaster Risk Reduction [UNISDR], 2004; Twigg, 2007; Welle & Birkmann, 2015; Wisner et al.,

2004) related to what makes people vulnerable within this study's limited scope. The data is extracted from Statistics Canada's 2016 Census. It is clear from this figure that Ontario, the most populous province in the country, is also home to the largest number of low-income families, renters, less educated persons, and non-vehicle owners (public transit users).

As established earlier, these attributes define vulnerabilities and are proven in the literature. For example, the widely used disaster models developed by Wisner et al. (2004), namely the Pressure and Release model and Access to Resources model, clearly demonstrate the negative implications of the lack of access to resources—income, property, education, and more—on the severity of disaster impact felt by those communities. Examples of livelihoods that may require a certain resource, a vehicle in this case, include pizza delivery and driving an Uber. Besides, many people in Ontario cannot communicate in either English or French, the two official languages in Canada. Quebec, B.C., and Alberta follow suit as they have similar sizeable vulnerable populations. The language barrier has been proven to be a factor that contributes to the vulnerability of the immigrant population in Ontario (Government of Canada, 2019; Nirupama & Maula, 2013; Agrawal et al. ,2020). As most public outreach is in English, immigrants with language barriers miss out on critical announcements, advisories, and initiatives related to early warnings, such as flash flooding and extreme weather.

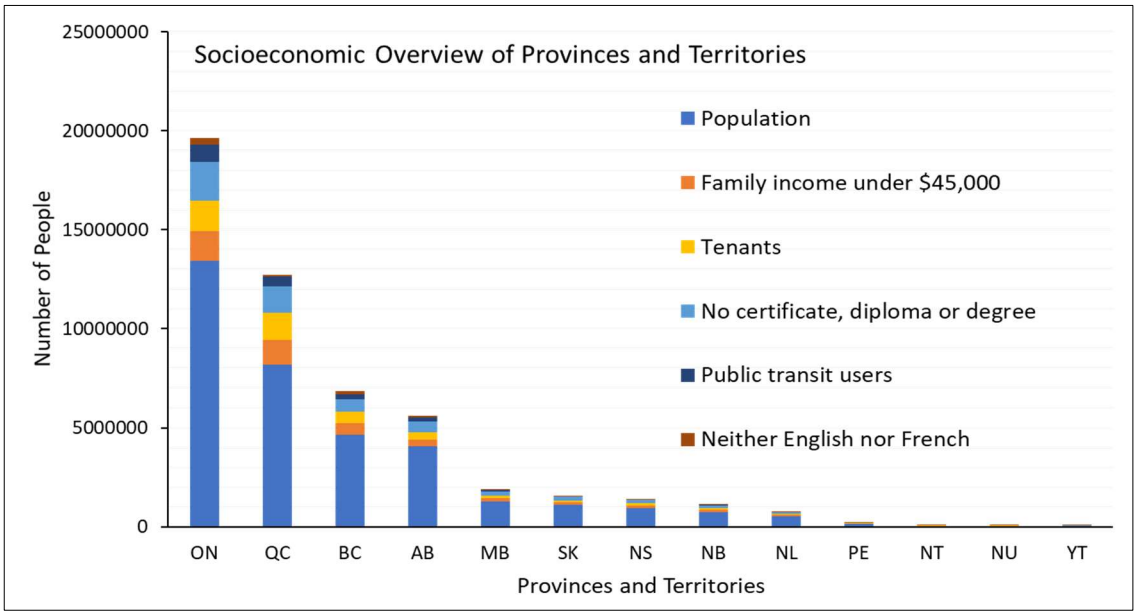

Figure 5: An overview of the vulnerable population in Canadian provinces using the 2016 Census data (Statistics Canada, 2016). Note: 'Population' is included at the base of each bar to provide a perspective on the vulnerability indicators in relation to the total population.

Figure 6 highlights another perspective of the socioeconomic scene in Canadian provinces. Here, each of the five vulnerability indicators is plotted as the percentage of the province's population as per the 2016 census numbers.

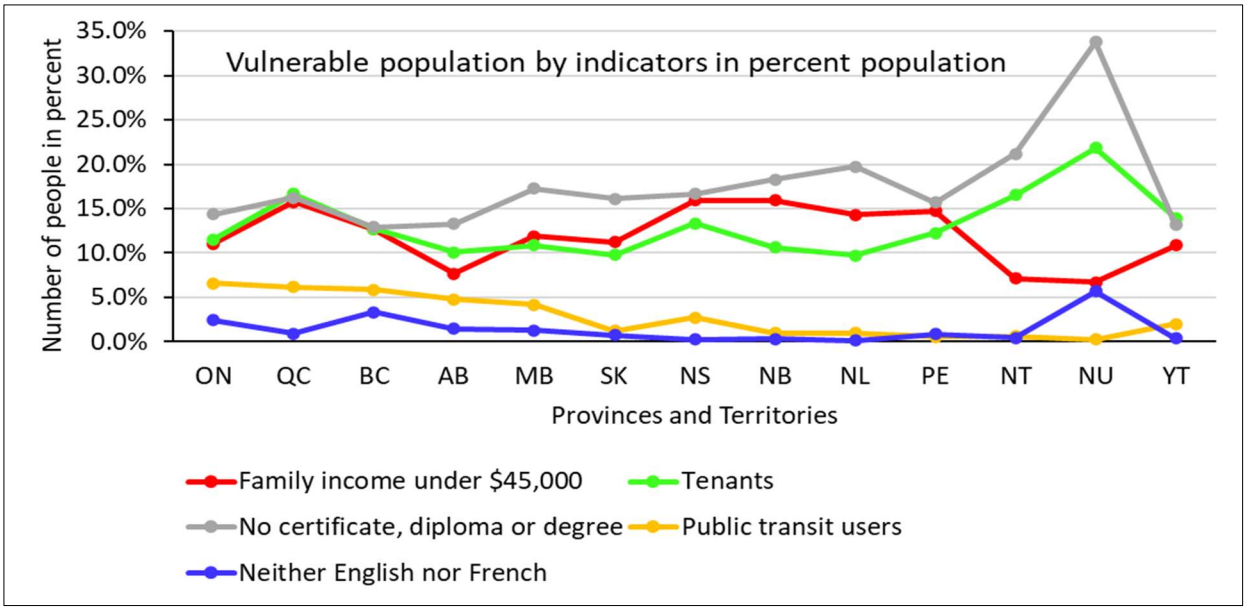

Figure 6: Socioeconomic overview of Canadian Provinces drawn from the 2016 Census of Canada (Statistics Canada, 2016).

It is clear from the graphic that challenges regarding education are significant in AB, MB, Newfoundland (NL), and the three Territories—Northwest Territories (NT), Nunavut (NU), and

Yukon (YT). A lack of education, which could be due to a variety of reasons, can lead to having low-paying livelihood options or no option at all if the available opportunities require a college degree. Disaster theories (Wisner et al., 2004) have analyzed various factors that contribute to building a livelihood access profile, and education is one of them.

Low family income, lack of education, and inability to own a home (tenants) are significant disparities in QC. Some of the challenges faced by the maritime provinces, Nova Scotia (NS), New Brunswick (NB), Newfoundland (NL), and Prince Edward Island (PEI), include lack of education, low family income, and inability to own a home.

This study does not intend to draw conclusions from the limited analyses presented but to encourage using a comprehensive set of vulnerability indicators, such as age (seniors, children under six), as well as single parents of young children, unemployed persons, new immigrants, persons with disability (physical and mental). Also, dwellings constructed in the mid-50s and needing major repairs, proximity to dangerous locations, and more should be included for a holistic understanding of people's vulnerabilities.

In addition to the socioeconomic indicators presented here, we examined households' size (not included in graphic representations) as a proxy variable for enhanced exposure and susceptibility to hazards, such as contagions, as well as a lack of coping capacity as discussed in the World Risk Index methodology (Welle & Birkmann, 2015) and its application (Agrawal et al., 2020). Two of the three territories occupy the top two spots in this category, with Nunavut recording 3.6 members per household and Northwest Territories recording 2.7 family members. Ontario and Alberta are tied at 2.6 members per household.

Discussion

This study focuses on historical disaster data and the socioeconomic status of demographics in various provinces and territories in Canada, highlighting the importance of a comprehensive understanding of natural hazards (extreme weather, geologic, endemics, etc.) that can become

disasters. In this short discussion, we have examined the seven provinces and three territories of Canada by taking a deep dive into the occurrences of natural hazards since the 1900s, the population growth, and the socioeconomic status of the demographics. We identified the top six most frequently occurring natural hazards—floods, severe storms, wildfires, winter storms, and tornadoes—out of which, floods are the most frequent in all ten provinces and the Northwest Territories.

Upon examining the population data, it is clear that Ontario, Quebec, and British Columbia are the fastest-growing provinces in Canada. These provinces also experience the largest proportion of the total disasters in the country caused by natural phenomena. From this fact, it is noteworthy that understanding the socioeconomic status of the demographics is a critical factor in developing long-term strategies to build adaptive capacities on a systemic level to deal with emergencies and disasters in an effective way. We used a limited number of vulnerability indicators for demonstrating the thought process that the most populous provinces also house the most vulnerable population, in addition to encountering the most natural hazards. For example, Ontario's major challenges include a high percentage of the population with a lack of education (15%) and low income families (about 11%), indicating a lack of coping capacity (Cutter, 2003; UNISDR, 2004; Twigg, 2007).

Concluding Remarks and Future Research Direction

This discussion is the first step in a series of perspective pieces in the works examining disasters caused by our planet's naturally occurring phenomena and their impact. The COVID-19 pandemic, a disaster triggered by biophysical/biological processes, is also a natural disaster, as classified by the Centre for Research on the Epidemiology of Disasters (CRED, 2020). According to the classification, the biological type is one of the five types of natural hazards, and is described as a hazard caused by the exposure to living organisms and their toxic substances or vector-borne diseases that they may carry. The COVID-19 pandemic is caused by a novel coronavirus, SARS-CoV-2, believed to be found in bats, even though other sources, such as pangolins, are being

explored. Although the bat population naturally carries coronaviruses that have the potential to transmit to humans, they rarely do. In the 21st century alone, we have seen many similar disasters including, SARS, a coronavirus disease in 2003, H1N1 in 2009, a respiratory disease of pigs, and the 2014 outbreak of Ebola Virus Disease (EVD), believed to originate in nonhuman primates. In each of these cases, the virus got transmitted to humans, followed by human-to-human transmissions, turning them into them deadly outbreaks. COVID-19 has generated a renewed interest in disaster risk mitigation and coping capacities at institutional and individual levels. It is a perfect example of varying impacts on communities facing underlying disparities in the systems. Consistent with the population numbers, Ontario and Quebec have seen a higher number of infections during the second wave of the pandemic (CBC News, 2020).

Many natural phenomena, such as extreme weather, can cause rapid-onset disasters, and so do geological events (earthquakes, tsunamis, volcanoes). Drought is a slow-onset disaster, and coastal erosion is considered a perennial one. Although these phenomena will continue to occur, as the Earth is comprised of the atmosphere, oceans, and the land, the goal is to minimize their social, economic, and physical impacts. The federal/provincial/territorial (FPT) governments in Canada recognize and acknowledge these facts and identify one of the top five priorities as improving understanding of disaster risks in all sectors of society (Government of Canada, 2019). Also underscored in the program is enhancement of the systemic capacity to adapt to disturbances resulting from hazards by persevering, recuperating, or changing to reach and maintain an acceptable level of functioning.

Further investigations into the following aspects are planned through continuing graduate research projects to obtain a holistic assessment of disaster risk on people and the built environment, and develop effective adaptive capacities to mitigate disaster impact.

- Understanding how and where the vulnerable population converges with hazard-prone regions, and the severity of the potential risk to them

- Identification of gaps between existing institutional capacities to cope with disaster impact and the extent of the need in society
- The tangible and intangible effects of natural disasters on businesses, essential services, and critical infrastructures to address issues arising from these challenges
- The availability and sharing of disaster risk information as it relates to the general public

Finally, future disaster risk reduction measures must include a robust combination of actions, including policy and legislation at all levels of government, inclusivity in terms of bringing partners at the decision table, meaningful implementation of hazard identification and risk assessment process, early warning systems, landuse planning tools, adaptation strategies, and community engagement, to name a few.

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