

Flooding crisis in Canada

Map the System 2020

CANADA

Flooding in four provinces prompts states of emergency, evacuations



- Images from 2019 Quebec, Ontario and New Brunswick floods

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Executive summary

The frequency and intensity of extreme weather events and natural disasters brought on by climate change has increased with each passing year¹. The global disaster impact has led to 5-year economic losses amounting \$280 billion, affected 564 million people, business and economic continuity losses and social & cultural losses (stress, safety and security)^{1,2}. The most prominent natural disaster in Canada is flooding with three events impacting Quebec, New Brunswick and Ontario in 2019³. This led to over 15 000 residences either flooded or isolated, 13 500 disaster victims and over 75 municipalities affected^{4,5}.

To lessen the impact of natural disasters, efforts are being made to enhance essential disaster planning, preparedness, response and recovery capabilities^{6,7}. Each phase & team can be imagined as a node in the disaster response network, operating at work sites with various demands^{8,9}, however, gaps do exist.

Motivation

In 2019, one of the author's country of origin, Zimbabwe, was hit by the third most destructive cyclone in the southern hemisphere and led to widespread flooding. A month after that, we witnessed flooding in Quebec and Ontario, in Canada which we collectively call home. Our research revealed that governments at the local, provincial/state and federal levels are under increasing pressure to reduce response times, risk exposure to human & animal life and infrastructure and lower response costs. Furthermore this report builds on the startup work, where he works as a cofounder. The startup, Holocene, is developing real-time and predictive resource planning software for disaster response teams and has won awards including acceptance to a Silicon Valley startup program.

Holocene market research

Our startup research (conducted via interviews with potential early adopters such as Emergency Management British Columbia and other disaster and emergency response departments) led to some profound inter and intradepartmental challenges and bottlenecks. We discovered that a cascading sequence of events is affected by the lack of accurate, real-time and predictive resource coordination, however, this systems thinking approach takes a more detailed approach.

Applying systems thinking methodology

Systems thinking provides deliberate and comprehensive guidance though tools and approaches to map, measure and understand dynamics related to challenges, dynamics, structures or interactions^{10,11}. This report applies the systems thinking approach to the flooding crisis in Canada, identifying the inputs, throughputs, inter-relationships and outputs, and furthermore highlighting the sequence of systems characteristics that have led to the flooding crisis encountered by communities, provincial and federal government.

Research Methods

This research was compiled through:

- Government publications, academic journals, and a variety of news articles
- 15 in-depth interviews with various professionals (government, intergovernmental) involved in disaster response & mitigation including emergency response planners & responders, volunteers of non-government organizations, victims, asset based community development committees
- Interviews with Insurance Bureau of Canada, and Geneva Association

Problem Landscape

Recent Impact of flooding in Canada

Economic & human

We focused our research efforts on flooding occurrences which are the most recent and costly natural disasters in Canada in terms of property damage¹². The cost burden in Canada is beginning to impact the ability of planners to make sound budgetary judgements. The average annual federal share of response and recovery costs has increased from \$10 million (1970-1995) to \$110 million (1996-2010), \$13 to \$360 million (2011-2016)^{3,13}. Using the Insurance Bureau of Canada estimate for flood losses, the Canadian Parliamentary Budget Officer estimates that on average, DFAA can expect annual costs of \$673 million for floods¹⁴.

The five most destructive floods in Canadian history have all occurred since 2010. Analyzing the 2019 Canada spring floods by the numbers, over 9500 people were evacuated in Quebec, 2000 Canadian Armed Forces troops were deployed to flood zones with half in Quebec, 600 troops were stationed in Ottawa alone. Over 15 000 residences were either flooded or isolated^{4,5,15}. In 2013, Alberta experienced flooding which affected Calgary, its largest city where 75 000 people were evacuated, the largest evacuation order in the city's history and 350 000 workers were requested to remain at home. The cost breakdown revealed by the City of Calgary municipality shows that the flood led to approximately \$5 billion worth of losses, a total of \$409 million in damages to City of Calgary infrastructure and \$55 Million to cover the emergency response for Calgary, and \$323 million for recovery costs¹⁶⁻¹⁸.

Factors influencing flooding frequency and severity

Environment

With over 80% of Canadians living in urban areas, flood risk is a high risk issue for most of Canada⁵. There is a strong link between urbanization and flooding vulnerability. Urban areas often have more impervious surfaces, which decreases the absorption capacity of the ground. According to Public Safety Canada, the cost of the federal Disaster Financial Assistance Arrangements (DFAA) program, will approach one billion dollars annually, 75% of this cost is attributable to flood events^{4,19,20}. Furthermore, according to the Insurance Bureau of Canada, 2.2 million are at risk of overland flooding out of 10.9 million residential properties in Canada^{13,14}.

Canada also has vast amounts of freshwater, in the form of rivers, and wetlands, glaciers, lakes, and the soil²⁰. Wetlands occupy an estimated 16% of the country's landmass and over 8500 rivers and more than 2 million lakes covering almost 9% of Canada²¹. These hydrological, catchment & watershed factors affect the frequency and intensity of flooding in Canada. The effects of climate change (extreme weather events e.g. rainstorms), deforestation and wetland drainage often exacerbate river floods. The occurrence and severity of extreme weather events in Canada will increase due to the fluctuations in global weather conditions²²⁻²⁴.

Resource coordination

Disaster management continuum involves four phases: planning, preparedness, response and recovery. For each phase the desired outcome is to mitigate the losses, impact and risk exposure to human life and infrastructure. Teams coordinate resources which further affects labor and materials planning efforts. A persistent problem in the management of response to disasters is the lack of real-time coordination of resources and assets in an efficient manner with real-time feedback loop system. Information systems are important instruments used for coordinating activities & resources, processing information, and communicating with stakeholders^{7,25,26}.

However, the current resource planning software solutions used by these teams lack real-time resource geolocation information, and lack dynamic and predictive demand forecasting which affects responsiveness (on-time delivery, service accuracy and effectiveness), operational efficiency (cost per response trip, resource utilization rates and volume, storage and custody), and organizational effectiveness (communication, inventory management, command and control, surveillance, asset losses and theft, and interoperability)²⁷⁻³⁰.

Strategic operations

The current response supply chains are dependent of static plans, and a system of "phone tag" to arrange, deploy and receive assets/resources. The decision making ability of responders and planners can be further impaired due to the multi-stakeholder environment, dynamic environmental conditions, lack of cross-stakeholder standardized work practices, interdependencies, survivor demands and time constraints affects the decision making ability of responders and planners. Their interdependency is typically unified by common objectives which include:

- Save lives and prevent escalation of the disaster
- Mitigate risk exposure to human life, infrastructure and animal life
- Protect property and safeguard the environment
- Restore normality and business continuity as soon as possible

The planning phase is designed to structure the disaster response prior to the occurrence of a disaster. The response phase can likely be minutes or hours after a disaster and the goal of this phase is to mobilize emergency services such as fire and medical.

Solutions Landscape

This solutions landscape was designed by applying a mapping of various systems that are affected by flooding which include: physical, information, cognitive and institutional/cultural norms and training.

Institutional: Insurance-focused Policy and Planning

Given the frequency of flooding events and insured damage cost, the Insurance Bureau of Canada (IBC) is advocating for federal government commit to a National Action Plan on Flooding¹². IBC has identified three components critical to ensuring that the National Action Plan on Flooding succeeds. This includes using flood maps to educate and empower consumers to reduce their own risks via an authoritative flood portal that highlights properties risk exposure and measures to better protect themselves. In addition, relocation and protection of homes in flood prone areas should be considered³¹⁻³³. This may include financial assistance, expanding the breadth of the federal Disaster Mitigation and Adaptation Fund and amending land-use planning and permitting processes to prohibit development on flood plains. Moreover, local, provincial and federal acts, regulations and policies associated with flood management should be further developed as detailed in Ontario's Special Advisor on Flooding Report to Government³⁴.

Flood mapping identifies the boundaries of potential flood events and is critical to support actionable insights and investments to reduce the impacts of flooding in communities across Canada¹⁵. The majority of urban areas are also major flood zones, which presents a significant risk to homeowners. According to Craig Stewart, Vice President of Federal Affairs at Insurance Bureau of Canada, about a third of Canadians have insurance for overland flooding which has only been offered by insurers across the country since 2015^{3,15}. It appears that this relatively low number for flooding insurance coverage is due to affordability; currently 16 carriers offer overland flood insurance and few publicly advertise³⁵. One might speculate that two things are in order; there is no consumer demand because the coverages are too expensive and further on, the insurers may be reluctant to expose themselves to the expensive payouts that occur when flooding occurs. Despite the fact that the Munk School of Global Affairs released a report that showed flood-related losses surpassing fire and theft as the primary source of property insurance claims, the federal government is yet to implement a coverage remotely close to the recommended plans that have coverage administered by insurers but with capital provided by government³⁵.

Multi-stakeholder Engagement

Asset-Based Community Development (ABCD) is an approach that recognizes the existing strengths and resources of individuals in communities and uses those strengths and resources to further build the community and to sustain development³⁶. These assets include mobile equipment, vehicles, materials and supplies and food and shelter. This approach focuses on the capacities and assets rather than needs and deficiencies³⁷. In practice, this approach to community directed response and recovery is a promising method as seen elsewhere. However, Canada is yet to fully adopt this approach due to funding, culture and attitudes towards relief and broad community engagement³⁸⁻⁴⁰.

Though clusters of ABCD-based groups may exist, they are yet to gain public recognition and further hone on their network, strength and citizen leadership capabilities to strongly advance their agenda in the arena^{41,42}. This may be due in part to urbanization where distinct behavioral differences exist compared to rural areas related to moral obligation, togetherness, community safety and community well-being. More interoperable and priority-sensitive communications can add tremendous help to the efforts of the government disaster response teams⁴³.

Individual behaviors around flooding in Canada appear to lack the heightened risk perception of individuals in more flood-prone countries such as Vietnam, USA etc. In Vietnam, there is a framework used based on the Protection Motivation Theory (PMT) which assesses the determinants of household flood protective behaviors⁴⁴. We suspect that the same motivations stemming from threat experience appraisal, threat appraisal and observational learning is only confined to specific demographic of the population i.e. asset-based community development groups and others. Through our consultations and research, we believe that these proactive, and cognitive mediating processes can be adopted by the general public through public awareness campaigns and can address actual barriers such as income and knowledge and can facilitate collective coping responses^{38,44-46}.

Integrated Operations Planning & Learning

According to interviews conducted with leading emergency and disaster response experts, there are integrated operations planning activities that could significantly benefit pre, peri and post disaster operations. Ideas and measures that consistently came up included provincial, territorial and federal institutions and community-based disaster & emergency response teams defining common outcomes, establishing joint strategies and identifying roles and responsibilities. According to one leading expert and consultant to three provincial governments establishing compatible procedures, policies and cross-agency borders will enhance stakeholder retention during adaptive learning, peer learning and reflective learning activities such as lessons learned workshops and reporting frameworks. Furthermore, nations such as Singapore, Thailand currently have small and medium scale information sharing, consultations and awareness programs focused on raising public awareness. Executives within the ministries are also encouraged to develop planning standards, guides and best practices that promote and strengthen flooding resilience. This can be conducted through multi-stakeholder engagements between infrastructure, prevention, mitigation, response and recovery teams/groups.

Infrastructure: Resilience and detection

A blend of green and manmade infrastructure investment is required to further enhance flood resilience in Canada^{47,48}. This may include government efforts to support municipalities and conservation authorities to ensure the conservation, restoration and creation of natural green infrastructure (i.e. wetlands, forest cover, and pervious surfaces) to reduce runoff and mitigate the impacts of flooding⁴⁹. This also includes maintenance of flood mitigation infrastructure such as dams, dikes, flood channels and shoreline protection to reduce flood risk^{50,51}. Structural health monitoring sensors can be used to detect damage, monitor impact and strain measurement in real-time and forecasting in the future. This helps with prioritizing response plans, route planning etc. and structural health monitoring sensors should be applied to buildings, roads, dam walls, rivers and soil mechanics⁵²⁻⁵⁵.

Gaps and Levers of Change

Gap: Lack of infrastructural resilience

National and provincial emphasis should be placed on specifications and guidelines that:

- Certify the resiliency plans of roofs to extreme weather events, by 2020.
- Optimize concrete mixes for pavement to mitigate flooding
- Establish new structural design rules for buildings to take into account the changing climate
- Establish new standards for basement flood protection
- Establish new guidelines for climate resilience for existing storm water systems^{46,56}

Lever

Identifying the resilience indicators and developing provincial and national building codes that mitigate the impact of flooding in Canadian communities^{57,58}. It's worth noting that building codes exist, but due to socio-economic and political conditions, compliance is generally lacking or limited. Furthermore, the federal government through the National Research Council in collaboration with associations such as Canadian Home Builders' Association are working on the "first substantive" introduction of climate change considerations for infrastructure in Canada^{59,60}.

Gap: Lack of economic resilience

- Federal and provincial governments need to develop a low-cost national flood insurance program and a national action plan to help homeowners in high-risk areas⁶¹
- Discrepancy in public awareness investments such as digital mapping technologies to monitor in real-time sewage overflows, flow rates and water levels^{62,63}
- Provincial and federal government cover the cost of large-scale floods and Canada is the only G8 country where individuals cannot purchase overland flooding insurance offered by private insurers⁶⁴

Lever

A strong correlation exists between economic resilience and recovery rate⁶. This includes socio-economic capacity through further support of programs such as the National Disaster Mitigation Program (NDMP) established to better plan for and prevent the effects of flooding^{3,13}. This includes cost-shared, merit-based projects with provinces and territories to reduce the impacts of natural disasters, investing in public awareness activities and risk and resiliency tools like the Federal Flood Mapping Guidelines and funding for provincial and government level planning and policy making to integrate climate resilience into the National Building Code and conducting research to factor climate resilience into the design of buildings^{15,65-67}.

Gap: Lack of institutional resilience

- The absence of disaster response provincial ties (knowledge transfer, information sharing, technical skills) and adequate institutional capacity results in greater dependency on federal interventions⁶⁸
- Continuity of government and operations (services and functions) are important parameters that communities and governments must focus on

Lever

Local, provincial and federal disaster and emergency management institutions (units, teams and departments) contain characteristics related to disaster planning and preparedness, response, recovery and mitigation^{69,70}. The ability to create cross functional organizational linkages, information sharing and dissemination, communications technology is important to delivering proactive and timely response to flood victims.

Knowledge transfer between provinces should also be encouraged to help improve technical and cognitive skills training and organizational memory. Due to the dynamism of response sites, and complexity of resource, responder and survivor coordination, there is a significant opportunity to improve the situational awareness before, during and after a disaster occurs⁷¹⁻⁷³.

Gap: Lack of community capital & social capacity

Lever

Urban communities need to foster, encourage and grow better relationships that exist between individuals and their larger neighborhoods and communities. This includes sense of community, place attachment and citizen participation. There is a country-wide opportunity to enhance adaptive capacity before and during disasters through the application of asset based community development practices⁷⁴⁻⁷⁹.

Key insights and lessons learned

This report sought to shed more insight on the impact of flooding in Canada, map the network of social, economic, sociocultural and technology challenges, and explore potential solutions and identify gaps and levers of change. Though the information presented is accrued from various sources with knowledge, we have realized that this is a micro view of a macro challenge that requires multi-stakeholder engagement.

For instance, planning and policy instruments are evaluated on the basis of efficiency, equity, acceptability and administrative feasibility and other parameters/criteria that the authors are not privy to. The extremes and frequency of climate change-related natural disasters has inspired an international climate action coalition (e.g. United Nations Framework Convention on Climate Change parties) that focuses on low-carbon economy, carbon tax, and carbon offsetting and carbon neutrality⁸⁰⁻⁸⁴. With the federal government establishing mechanisms that address this at public and private sector levels, it's possible that planning and policy implementation related to interagency flooding response and coordination, public alerting, and emergency management capacity may be considered a lower priority though that may change.

Technological (predictive and real-time decision support and resource planning), investments (overland flooding insurance, transportation systems, municipal infrastructure) considerations should be made. Furthermore, the emergence of asset based community development approaches at the provincial levels inspires stakeholder engagement that can assist with flooding response, and recovery⁸⁵⁻⁸⁸. These are community level groups that focus on people as citizens, co-creators and community assets to combat the impact of natural disasters etc.

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