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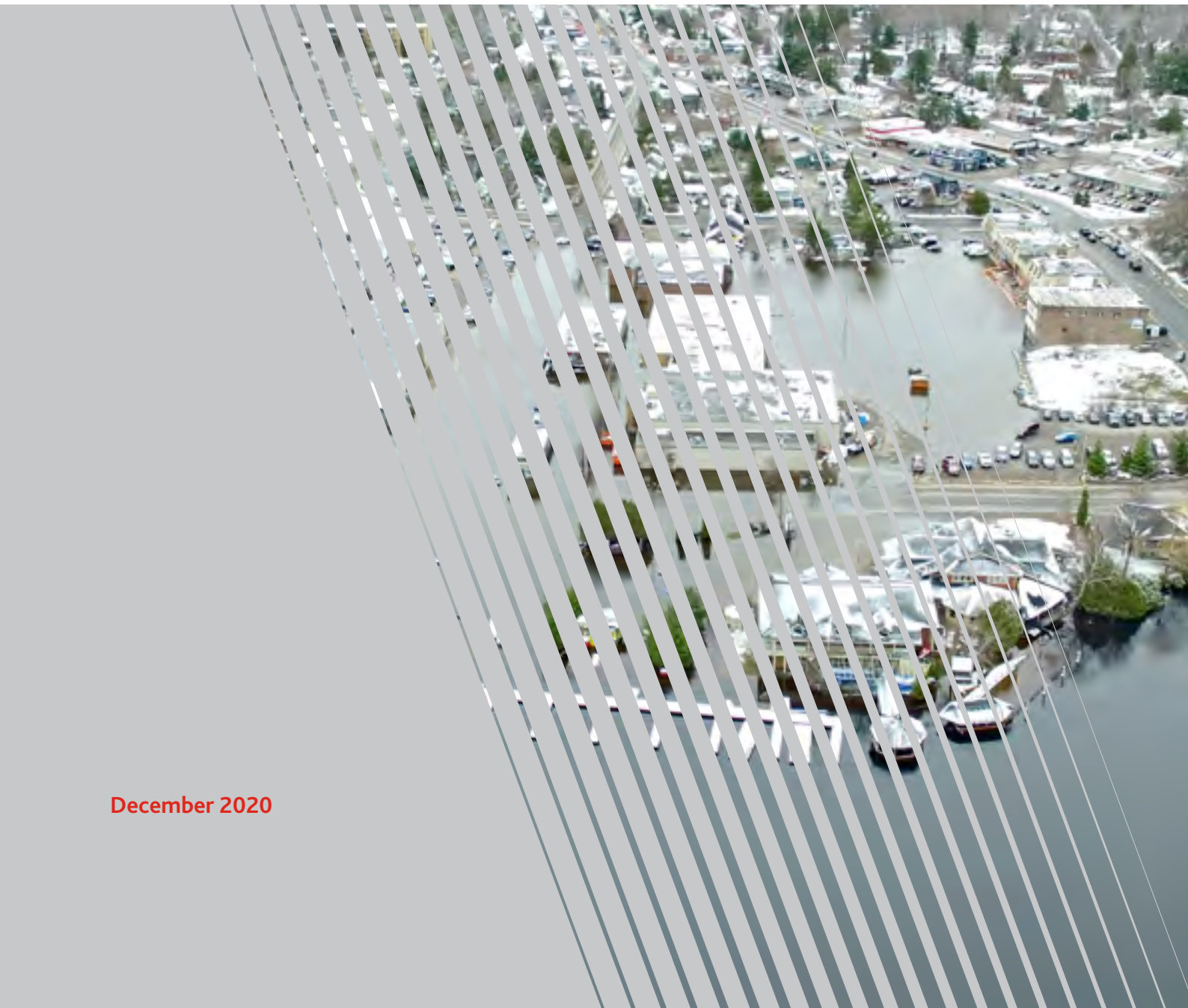
Flood Risk Management in Canada

Building flood resilience in a changing climate



December 2020

Flood Risk Management in Canada

Building flood resilience in a changing climate

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The Geneva Association

The Geneva Association was created in 1973 and is the only global association of insurance companies; our members are insurance and reinsurance Chief Executive Officers (CEOs). Based on rigorous research conducted in collaboration with our members, academic institutions and multilateral organisations, our mission is to identify and investigate key trends that are likely to shape or impact the insurance industry in the future, highlighting what is at stake for the industry; develop recommendations for the industry and for policymakers; provide a platform to our members, policymakers, academics, multilateral and non-governmental organisations to discuss these trends and recommendations; reach out to global opinion leaders and influential organisations to highlight the positive contributions of insurance to better understanding risks and to building resilient and prosperous economies and societies, and thus a more sustainable world.

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Published by The Geneva Association—International Association for the Study of Insurance Economics, Zurich.

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Acknowledgements

We are grateful to Munich Re's NatCatSERVICE for providing critical data for this project and would like to extend our special thanks to Petra Löw and Sabine Schlüter-Mayr (Munich Re) for supporting us in this process. We extend our deepest thanks to Intact Financial for providing the financial support that has enabled the development of this report and to Mandy Dennison (Intact Financial) for hosting the first consultation with FRM stakeholders in Canada to support the analysis. The Geneva Association Flood Project Advisory Team provided invaluable insights on the overall design of the project, including Shiraj Khan (formerly of AIG), Wolfgang Kron (Munich Re, retired), Leigh Wolfrom (Organization for Economic Cooperation and Development – OECD), Darius Pissulla (Hannover Re), Cameron Rye (formerly of SCOR), Michael Szoenyi (Zurich Insurance Company), Mandy Dennison (Intact Financial), Masaaki Nagamura (Tokio Marine), Jacki Johnson (IAG), Alan Milroy (AXA XL), Iain Hamilton (Aviva) and Xiaoting Hu (Tokio Marine Technologies). Licelott Carvajal (former intern, The Geneva Association) contributed to the analysis of this report. We extend our deepest gratitude to the following Canadian experts who engaged in the discussions, provided input and/or reviewed this report: Stéphanie Durand, Matthew Godsoe and Erin Gee (Public Safety Canada); Robin Bourke (Natural Resources Canada); Natalia Moudrak and Joanna Eyquem (Intact Centre on Climate Adaptation, University of Waterloo); Anna Ziolecki (Partners for Action, University of Waterloo); David Etkin (York University); Andrei Belik, Jonathan Gadoury, Laura Willett and Gerry Lashley (Intact Financial); Shawna Peddle (The Cooperators); and Chris Rol (Insurance Bureau of Canada). We would like to thank all members of The Geneva Association Working Group on Climate Change and Emerging Environmental Topics for their support, with particular thanks to Jennifer Waldner, Anthony Zobl and John Laxa (AIG); Chris Boss and Dilip Arora (Aviva); Mario Di Marco (Tokio Marine HCC); Junaid Seria, Guillaume Ominetti and Maurizio Savina (SCOR); Lutz Wilhelmy (Swiss Re) and Kei Kato (Tokio Marine & Nichido Fire Insurance Co) for their review and feedback. Finally, we thank Kai-Uwe Schanz and Christophe Courbage (The Geneva Association) for their comments.

1. Executive summary

As the world responds to the COVID-19 crisis, the potential compounding effects of weather-related extremes such as floods, tropical cyclones and wildfires could significantly challenge a country's emergency management capacities and slow down the socio-economic recovery. This report is part of a series on *Building Flood Resilience in a Changing Climate*, with focus on mature economies. It points to the need for a paradigm shift from reacting to crises towards a risk-based, anticipatory, holistic and all-of-society approach to managing the potential impacts of catastrophes.

Flooding is one of the most important physical climate risks in many countries, affecting households, communities, businesses and governments on a regular basis. There are several kinds of floods, including fluvial floods (river floods), pluvial floods (surface water flowing towards rivers) and coastal floods (storm surge and coastal tidal flooding). Each kind differs in terms of occurrence, potential damage and management measures.

The rising costs associated with floods are due to the combined impacts of increasing concentrations of people and assets in areas of high flood risk, land use, urbanisation and development practices, as well as the increasing frequency and severity of weather-related events linked to climate change (e.g. changing storm and precipitation patterns and rising sea levels) (Intergovernmental Panel on Climate Change (IPCC) 2018).

The Geneva Association has undertaken this study to take a deeper look at the evolution of flood risk management (FRM), offering a holistic, multi-stakeholder, forward-looking review of FRM in five high-income countries with mature insurance markets: the U.S., England, Germany, Australia and Canada (Annexes 1 and 2). Special attention is given to mapping the evolution of governance, institutional frameworks and the interplay of different components of FRM, including risk assessment, risk communication and awareness, risk reduction, risk prevention, risk financing, risk transfer (e.g. insurance and alternative risk transfer) and reconstruction measures. Trends and patterns are identified, although the study did not set out to draw comparisons among the five countries.

An overview of the methodology used to analyse FRM and overall recommendations are provided in The Geneva Association (2020a). Case studies for the U.S., England, Germany and Australia are available in The Geneva Association (2020b), (2020c) (2020d) and (2020e), respectively. This report provides a review of FRM in Canada and highlights successes, lessons learned and continuing challenges.

Key findings

1. **Flood risk:** In Canada, flood risk is rising due to the high exposure of people, property and infrastructure to riverine, coastal and surface water flooding. Major flood events have shaped Canada's policy response, including floods in Manitoba (1950), Alberta (2013) and more recently Quebec (2017, 2019), which is largely directed towards riverine FRM, although urban flood risk has recently become more costly.

2. **Governance of flood risk management:** The federal, provincial and municipal governments share responsibility for FRM in Canada. While the federal government takes a leading role in coordination, fragmentation remains a challenge with differing capacities, interests and resources among provinces and local governments. Policies have evolved over time to reduce dependency on structural defences and disaster assistance. These have been criticised for failing to encourage a risk-based, anticipatory strategy, since most funding remains allocated to structural defences and rebuilding rather than pre-disaster mitigation.

3. **Risk information and communication:** The production and dissemination of flood hazard and risk maps is highly decentralised, with many municipal governments generating their own maps and data. Most maps are outdated and rely on hazard extents designed for planning and engineering rather than providing decision-relevant information for the public. This has contributed to confusion among property owners about their role and responsibility in managing their own flood risk. The federal government and several provinces have endeavored to address this gap by developing guidelines to standardise mapping, providing funding to update maps and coordinating with map providers, including insurers, academia and local governments, to improve data sharing. Strategies to link mapping data to policy decisions, such as disclosing flood risk in real estate transactions, remain underused. However, following extensive discussions engaging federal and provincial governments and the insurance industry, there is evidence of increasing government investments to expand and improve flood risk mapping in Canada.

4. **Risk reduction and prevention:** While both structural (e.g. structural flood defence measures) and non-structural (e.g. risk mapping, risk communication, property-level flood protection (PLFP), land zoning) flood measures are employed, strategies are evolving towards the use of more non-structural measures. However, funding remains limited relative to structural defence measures. Municipal governments and Indigenous communities, in particular, lack the resources required to enforce the risk reduction objectives set out by national and provincial governments.

   Legal restrictions on land use and development criteria to manage flooding are gaining popularity. Provinces are responsible for incorporating these restrictions into their land use legislation. Implementation remains a challenge since municipalities are the administrative agents with the authority to restrict development in high-risk flood areas and they rely on property taxes for their main source of revenue. Damage from riverine flooding in particular has been attributed to poor prevention through land use planning but data measuring its contribution are difficult to generate.

   At the property level, although most residential property owners have yet to adopt most PLFP measures, municipalities and NGOs actively promote these measures to reduce growing urban flood risk. A number of municipalities, for example, use subsidies and credits to incentivise investment in PLFP.

5. **Risk financing:** Public disaster assistance programmes are the main source of risk transfer, sharing the burden of flood losses across the provincial (and often the national) tax base. These programmes are under significant scrutiny due to mounting costs and their failure to incentivise rebuilding to reduce or prevent future flood risks. Some questions arise around the proportion of disaster assistance that is used to support municipalities in repairing and rebuilding infrastructure versus funding (e.g. in the form of loans and grants) for individuals to restore their property. More data on Canada's disaster assistance spending is necessary to inform a broader analysis on the strengths and weaknesses.

6. **Risk transfer (e.g. flood insurance):** Insurance coverage was expanded in 2016 to include damage caused by overland flooding[1] in addition to sewer backup, which had historically been included in standard property insurance. This marked a significant shift in Canada's approach to FRM by introducing a risk-based flood recovery mechanism. Since flood insurance is not regulated and companies can choose their own policy design, most offer an optional endorsement limited to overland flooding, or a bundled product that includes sewer backup. As a result, market penetration remains below 50% and coverage is not widely available in high-risk areas. The development, sustainability and affordability of insurance products deeply rely on the ex-ante efforts of governments, businesses and homeowners to invest in risk reduction and risk prevention measures. Canada's insurance industry has been proactively engaging with the government to address gaps in coverage and affordability, but more work is necessary to inform banks, mortgage lenders and other financial institutions about their roles in risk reduction.

7. **Reconstruction:** Funding for reconstruction comes from government disaster assistance programmes that require restoration of damaged property to its pre-flood condition. As a result, reconstruction rarely involves increasing investment in 'building back better'. Reform is necessary to increase incentives for risk reduction and prevention measures for new builds.

8. **Multi-sectoral collaboration:** Canada has adopted disaster risk reduction as a principle, and its emergency management framework is an important effort to align stakeholders with FRM objectives. These efforts are coordinated through Canada's Platform for Disaster Risk Reduction (DRR) – a national multi-stakeholder mechanism involving more than 700 government and non-governmental stakeholders. Monitoring and evaluating whether this coordination improves the effectiveness of FRM constitute a gap.

In summary, FRM in Canada is transitioning from a hazard-based approach towards a more risk-based anticipatory model. Path dependence favouring structural defence measures and government disaster assistance, however, continues to be a barrier to more substantial reform. Indeed, critical elements of effective FRM need to be further developed in Canada, including publicly available flood risk maps, risk-based incentives for community- and property-level flood protection and increased market penetration for flood insurance. These gaps are a consequence of limited political will and fragmentation between federal, provincial and municipal governments, who have varying roles, interests and capacities in supporting FRM. However, there is also evidence of reform, with recent federal and provincial government investment in expanding flood insurance, flood risk mapping and programmes for relocation and incorporation of climate change considerations into infrastructure and risk assessment. Better monitoring and evaluation of FRM in Canada could improve multi-stakeholder coordination and highlight improvements that should be replicated and weaknesses that should be prioritised.

1 Overland flooding occurs when water flows overland and seeps into buildings through windows, doors and cracks. It is one of the most frequent and costly natural hazards in Canada (Source: Government of Canada).

The flood risk management system in Canada

Response and reconstruction

- Recent recurring flooding has motivated provincial and local governments to prioritise 'building back better' but disaster assistance limits these efforts by requiring that properties are restored to pre-flood conditions.
- Managed retreat programmes have been successfully employed to limit reconstruction in high-risk areas.

Risk assessment and risk information

- Most of Canada's flood maps are generated by provinces and municipalities, incorporating a hazard-based rather than a risk-based approach. Maps are rarely publicly available, limiting their effectiveness for assessment and communication.
- Public- and private-sector organisations are working to improve flood mapping through a Federal Floodplain Mapping Framework designed to standardise approaches across the country.
- In response to recent major floods, provinces are updating and expanding flood map coverage to improve risk communication and the federal government recently committed CAD 150 million to complete countrywide flood mapping.

Risk financing and transfer

- Government-run disaster assistance programmes remain the main means of flood risk financing and transfer.
- Each province has its own disaster assistance programme designed to cover damage that does not qualify for insurance.
- Programmes are becoming more restrictive as costs become unsustainable.
- Flood insurance was introduced for the first time in 2016 to reduce the pressure on government programmes.
- Coverage is voluntary, provided by private insurers and is sold as an optional endorsement or bundled with existing sewer backup coverage.
- Risk awareness remains low, limiting demand and market penetration.

Risk governance

- Legal authority and relevant policy tools are divided between federal, provincial and municipal governments
  - » Federal: convenes, coordinates and provides resources.
  - » Provincial: has authority over FRM, preparedness, mitigation, response and recovery.
  - » Municipal: implements and enforces FRM legislation and manages pluvial flood risk.
- FRM is coordinated by a Federal, Provincial and Territorial Framework that establishes the country's emergency management strategy.
- Provincial government authority over FRM leads to fragmentation due to different capacities and interests in FRM.
- Major floods have triggered efforts to embrace flood risk governance in Canada, whereby responsibilities and resources are more clearly aligned towards common goals.

Source: The Geneva Association

Early warnings linked to emergency preparedness

- Each province has a unit that provides flood forecasting and warnings, but capacity varies.
- Municipalities are mandated by provincial law to identify hazards and develop emergency management plans.
- The Federal Canada Centre for Mapping and Earth Observation supports local efforts by providing real-time satellite remote sensing data to emergency responders.

Risk reduction

- Structural and non-structural measures are used to support risk reduction, but mitigation remains the weakest element.
- Resistance-based structural defences have historically been prioritised, leading to development in high-risk areas, and continue to be funded through a Disaster Mitigation and Adaptation Fund.
- Mitigation, including risk assessment, risk mapping and non-structural measures, has increased through federal funding provided by the National Disaster Mitigation Program.
- Property-level flood protection (PLFP) is being incorporated into building codes and is supported by local subsidies, but is not required in most areas.

Risk prevention through planning and land use

- Provinces increasingly use land use regulations to restrict the location, type, scale and density of development in high-risk areas.
- Implementation remains a challenge as municipalities are the administrative agents responsible for enforcement and restrictions limit their revenue collected through property taxes.
- The Province of Ontario adopts a robust and unique approach whereby authority over development in high-risk areas is delegated to an apolitical watershed-based conservation authority.

Other considerations for FRM

Many barriers remain

- The path dependence of a government-dominated approach limits the shift from resistance- to resiliency-based FRM.
- There are no formal requirements and limited incentives to adopt FRM.

Incentivise risk-based decisions

- Credits and subsidies are available for PLFP, but insurance price signals remain insufficient, with low market penetration.
- The federal government has announced a programme to expand insurance in high-risk areas.

Multi-stakeholder coordination platforms

Cross-sectoral collaboration to address:

- Emergency management and disaster risk reduction goals.
- Alignment of land use planning with flood risk.
- Expansion of flood risk mapping and flood insurance.
- Deployment of resources for local FRM.

Climate change considerations

- Municipalities are developing climate change plans but adaptation and resiliency are lacking due to insufficient resources.
- Flood risk is a priority for the Pan-Canadian Framework on Climate Change and Clean Growth.

Strengths and weaknesses:

- Emergency management is well coordinated and embedded in local planning.
- Governments and insurers support cross-sectoral collaboration to improve FRM knowledge and strategies for implementation.
- Flood risk is a priority for the Pan-Canadian Framework on Climate Change and Clean Growth.
- Hazard-based approaches that rely significantly on the government are predominant.
- Limited engagement and allocation of responsibility among non-governmental and private-sector stakeholders.
- Frameworks and policy endorsement and planning for FRM are established, but resources supporting implementation remain scarce.

Flood risk management in Canada: 1945–2019

	1945–1955	1960s
Approach to managing flood risk	**Federal:** Canada Water Conservation Act	**Federal/Provincial:** Construction of the Red River Floodway (1962 to 1968) at a cost of CAD 63 million by the Government of Manitoba and the Government of Canada **Provincial:** Alberta Water Resources Act, Land Assembly Program – Alberta
Major flood events	**May 1948:** Fraser River Flooding (British Columbia). Ten fatalities, 16,000 evacuated, almost 10% of the area of the Fraser Valley was flooded **May/June 1950:** Winnipeg Flooding. One fatality, 107,000 (a third of the city) evacuated **October 1954:** Hurricane Hazel flood in Toronto. Caused damages ranging from CAD 152 million to 769 million	
Major laws	**1953: Canada Water Conservation Act** • Provided cost sharing arrangements between the federal government and provinces for structural flood control measures • Funding provided only for structural adjustments • Clarified roles of all levels of government • Ensured higher levels of government became involved in flood management • First federal legislation directly concerned with water management	**1960:** Alberta Water Resources Act for the establishment of flood control zones **1966:** Land Assembly Program – Alberta **1968:** Fraser River Flood Control Program established by the Government of British Columbia and the federal government to reconstruct and maintain dykes in the lower Fraser Valley

Source: The Geneva Association

1970s

Federal: Canada's Disaster Financial Assistance Arrangements (DFAA), Environment Canada, National Flood Damage Reduction Program (FDRP), Canada Water Act

Provincial: Floodplain management in British Columbia, Land Registry Amendment Act (British Columbia)

May 1972: Fraser River at Prince George (British Columbia). Freshet flooding caused significant damage along the Fraser River; an above-average snowfall and substantial mountain snowpacks, followed by high temperatures in late May, resulted in severe flooding at the end of May and into June. The Fraser River peaked three times in June, flooding both the upper and lower Fraser River Valley and affecting several communities

January–June 1974: Maniwaki (Quebec). Over 300 municipalities were affected. Flooding centered on the Gatineau, Ottawa, Richelieu, Saint Lawrence, Chateauguay, Saint-Maurice and Chaudière Rivers. 10,000 people were evacuated with costs exceeding CAD 21 million

April–May 1979: Red River region (Manitoba). A major flooding event with 10,000 evacuated and costs estimated at CAD 18.5 million

1970: Canada's DFAA. Framework for federal-provincial cost sharing for disaster recovery

1970: Canada Water Act. Supported joint federal-provincial initiatives. Allowed for funding of non-structural measures, and allowed for implementation of the FDRP and Joint Emergengy Preparadness Program (JEPP)

1971: Environment Canada was created

1972: Initiation of floodplain management in British Columbia due to the large Fraser River flood of 1972

1974: Land Registry Amendment Act. Set out flood control requirements for inclusion in zoning by-laws and for approval of new subdivisions

1975: FDRP Environment Canada. Promoted floodplain mapping studies to discourage future flood-vulnerable development. The FDRP is carried out jointly with the federal government and the provinces under cost-sharing agreements. Such agreements were signed for all provinces and territories except Prince Edward Island and the Yukon Territory

1980s

Federal: JEPP

December 1980: Squamish River (British Columbia). A combination of heavy rain and melting snow caused floods along the Squamish River and other nearby rivers. Several bridges were washed out. An estimated 3,000 people had to be evacuated and 200 homes were damaged. Estimated cost of CAD 10.1 million

June 1987: Montreal (Quebec). Intense rainfall, with 100 mm of rain in one hour, flooded major expressways, forcing closure of the subway system and flooding approx. 40,000 homes and businesses. It resulted in two deaths and had an estimated total cost of more than CAD 64 million

July 1988: Lesser Slave Lake (Alberta). A severe rainstorm resulting in damages in excess of CAD 35 million closed major highways north of Edmonton, flooded homes and required the evacuation of 2,800 people

1980: JEPP
Provides partial financial assistance for emergency preparedness planning. Assistance to municipalities is provided through provincial governments

1985: The Federal Deparment of Indian and Northen Affairs entered a flood mapping agreement with Environment Canada

	1990s	2000–2004
Approach to managing flood risk	**Federal:** National consultations to start development of the National Disaster Mitigation Strategy (NDMS) **Provincial:** Assistance programme for homeowners affected by flooding – Edmonton, City of London, City of Ottawa, City of Saskatoon	**Federal:** Second discussion on the NDMS. Public Safety and Emergengy Preparedness Canada founded **Provincial:** Quebec's Civil Protection Act. Flood Prevention Home Check-up service – Edmonton
Major flood events	**July–August 1993:** Winnipeg (Manitoba). The city was declared a disaster area as a result of prolonged heavy rainfall, including three severe rainstorms in a five-week period. Estimated costs in excess of CAD 214 million. Actual costs were more than CAD 498 million **June 1995:** Southern Alberta. Heavy rain and snowmelt caused widespread flooding, resulting in costs of over CAD 154 millon **July 1996:** The Saguenay flood. Resulted in significant stream bank erosion and caused significant damage to bridges and dam infrastructure. At least 10 deaths and a total of 15,825 people had to leave their homes. At least 20 major bridges heavily damaged with total costs of CAD 300 million **April 1997:** Red River Flood in Manitoba. The province declared a state of emergency on 22 April. Five days later, Emerson was hit. Over 25,447 people were evacuated	**2004:** Severe storm in Edmonton resulted in approxiately CAD 166 million in insured damages; CAD 143 million was associated with sewer backup. Water was ankle deep and roof damages resulted in the evacuation of 30,000 people from the West Edmonton Mall (the world's largest shopping mall)
Major laws	**Since 1991:** The City of Edmonton has offered an assistance programme to homeowners affected by flooding; it provides CAD 975 for the installation of backwater valves and up to CAD 1,400 for sump pump installation if necessary. The City of London provides 75% of the costs of installation of plumbing devices or alteration of plumbing. The City of Ottawa provides up to CAD 4,000 for the installation of protective plumbing devices. The City of Saskatoon provides up to CAD 2,500 for protective plumbing to homeowners who have been affected by past flooding events **1995:** Fraser River Flood Control Program ended **1995–1997:** The government decided to phase out the FDRP over the next two years with no consideration for continuance agreements **1998:** National consultations to start development of the NDMS **1999:** Canada's P&C insurers established the Institute for Catastrophic Loss Reduction (ICLR), a non-profit research institute affiliated with Western University. The ICLR is a world-class centre for multidisciplinary disaster prevention research and communication	**2000:** Quebec's Civil Protection Act. Purpose of the act is the protection of persons and property against disasters and major accidents through mitigation measures, emergency response planning, response operations in actual or imminent emergency situations and recovery operations **2002:** Second discussion on the NDMS **2003:** Public Safety and Emergengy Preparedness Canada founded **July 2004:** Flood Prevention Home Check-up service developed as a direct response to the flooding of 4,000 Edmonton homes in July 2004

Source: The Geneva Association

2005–2008

Federal: NDMS and DFAA. Expansion of the Red River Floodway

Provincial: The British Columbia Flood Protection Program

June 2005: Alberta Floods, heavy rainfall and associated flooding resulted in CAD 300 million in insured damages and CAD 129 million in other costs. Officials reported that the 200-year flood event resulted in significant damages to approximately 40,000 homes. The government commissioned the Groeneveld Report

2005: August heavy rainfall event in Southern Ontario. Resulted in CAD 247 million in sewer backup payouts and total payouts of more than CAD 500 million

March–May 2009: Southern Manitoba. Overland flooding caused by a combination of snowmelt, seasonal precipitation and the spring breakup affected southern Manitoba's watershed areas of several rivers causing flooding, evacuations and damage to bridges, roads and highways costing over CAD 76 million

2005: Governments of Canada and Manitoba invested CAD 628 million to further expand the Red River Floodway

September 2007: The British Columbia Flood Protection Program began providing CAD 100 million in flood protection assistance over a 10-year period

September 2008: NDMS and DFAA. Intended to coordinate piecemeal mitigation undertaken by lower levels of government across the country. Supports all-hazard mitigation at local, provincial levels. When implemented, may serve to fill the gap left by withdrawal of the FDRP

2010–2014

Federal: National Building Code update

Provincial: Fraser Basin Council (FBC) implemented phase 1 of the Lower Mainland Flood Management Strategy

June 2010: Southern Alberta and Saskatchewan. Record rainfall resulted in extensive flooding. Disaster financial assistance was provided by both provinces, resulted in estimated costs of CAD 1 billion

May 2012: A storm system affected Thunder Bay and moved through to Montreal. Resulted in CAD 260 million in insured damages

June 2013: Flooding in southern Alberta. Largest disaster loss ever recorded in western Canada. A massive storm system crept through Alberta then British Columbia, causing significant flooding throughout the provinces. Four deaths were attributed to the floods. Insurance payments estimated at CAD 1.7 billion; total payments amounted to nearly CAD 2.71 billion. This disaster is estimated to have reduced Gross Domestic Product (GDP) in southern Alberta by CAD 550 million (2013 dollars). An additional CAD 10 million in federal disaster aid flowed to British Columbia

July 2013: Toronto (Ontario). A thunderstorm producing 126 mm in precipitation caused flash flooding in the Greater Toronto area (GTA), resulting in over CAD 1 billion insured losses

August 2014: Burlington experienced a flash flood event, during which over 190 mm rain fell over eight hours. Roads, highways and more than 3,000 homes were flooded

2010: National Building Code update

2013: The federal government commissioned a National Floodplain Mapping Assessment. The final report by MMM Group was completed in 2014.

2014 (to 2016): FBC implemented phase 1 of the Lower Mainland Flood Management Strategy

2015–2016

Approach to managing flood risk

Federal/Provincial: Construction of the Red River Floodway (1962 to 1968) at a cost of CAD 63 million by the Government of Manitoba and the Government of Canada

Provincial: Alberta Water Resources Act, Land Assembly Program – Alberta

Major flood events

June 2016: Northeastern British Columbia. Heavy rainfall throughout the Peace River region caused flooding in several communities. Federal aid surpassed CAD 65 million. The districts of Chetwynd and Dawson Creek were particularly hard hit. Over 2,000 homes and businesses (approximately 6,000 individuals) were without power throughout the region

July–August 2016: Fort McMurray. Only weeks after the devastating wildfire that swept through the Regional Municipality of Wood Buffalo, the city of Fort McMurray was struck by a flash flood (the city was still undergoing recovery efforts following the fires). Insured losses in Fort McMurray and other Alberta communities affected by the storm totalled CAD 480 million

Major laws

2015: National Building Code update

2015: Integrated Storm Management Plan (Vancouver)

April 2015: Public Safety Canada announced it would invest CAD 200 million to 'modernise' hazard risk reduction through a new National Disaster Mitigation Program

2015: Study (The Financial Management of Flood Risk – An International Review) initiated following the 2013 Alberta and GTA flooding completed by the Insurance Bureau of Canada (IBC). Outlined four preconditions necessary for the establishment of private flood insurance in Canada

2016: The Parlamentary Budget Office (PBO) reported on the unsustainable cost of Canada's DFAA programme

2016: HFPP launched by the Intact Centre on Climate Adaptation, University of Waterloo, to assess home flood risk and provide advice to homeowners on practical means to address it. The programme is piloted in the Cities of Burlington, Toronto and Saskatoon. Results feed into Pan-Canadian Home Inspector and Insurance Broker training on flood risk

2016: The Pan-Canadian Framework on Clean Growth and Climate Change (PCF) is published. Adaptation and climate resilience prominently featured

Source: The Geneva Association

2017–2019

2017: Infrastructure Canada launches the Climate-Resilient Buildings and Core Public Infrastructure (CRBCPI) Project that aims to integrate climate resiliency into building and infrastructure design, guides and codes. Code changes are expected to take effect in 2025 and include flood resilience updates

April & May 2017: Quebec and Ontario. Storms led to major flooding in southern Quebec, resulting in insured losses of CAD 106 million. A month later, severe rainfall led to flooding across eastern Ontario and southern Quebec. The storm, which dumped up to 155 mm rain in some areas, caused nearly CAD 177 million in insured damages and was severe enough for Quebec to request military assistance

August 2017: Windsor Tecumseh, Essex (Ontario). A slow-moving storm led to heavy rainfall and major flooding, with up to 290 mm rainfall in some areas. Forced the closure of a local mall, hospital and businesses. Insured losses exceeded CAD 166 million

2017: Federal Floodplain Mapping Framework is published through Natural Resources Canada

November 2017: Regina (Saskatchewan) Minister Goodale hosted a National Roundtable on Flood Risk, which in turn launched a national dialogue on flood risk. An Advisory Council on Flooding was established in early 2018 to advance the national discussion on flood risk management

2018: CSA Group published a national guideline on basement flood protection and risk reduction (CSA-Z800) and commenced the development of a new national standard of Canada for flood-resilient new community design (CSA-W204). Canadian Home Builders' Association (CHBA) is engaged in flood resilience standards development

2019: Intact, REALPAC and Building Owners and Managers Association (BOMA) Canada support the development of guidelines for commercial real estate properties, with a focus on office tower retrofits to improve flood resilience

2. Introduction

Flooding is the most costly source of property damage in Canada (KPMG 2014; Oulahen 2014; Public Safety Canada 2015a); it accounts for 78% of all government disaster assistance payments, with urban damage comprising 80% of these losses over the last 20 years (Kovacs and Sandink 2013; Henstra et al. 2019), and has now passed fire damage as the primary source of property insurance claims in Canada. Increasing urban development and more frequent extreme weather triggered by climate change are expected to significantly increase flood damage in the future (Casey 2015; Winsemius et al. 2016).

Canada's approach to FRM is largely focussed on risk associated with riverine (fluvial) flooding. Major riverine floods in Ontario (1954), Manitoba (1979, 1997) and Quebec (1995) have justified significant government investment in both structural defences and recovery efforts. However, FRM in Canada is evolving in response to a significant increase in the social and economic burdens associated with flooding and evidence that people, property and infrastructure in pluvial and coastal areas face significant exposure. Vulnerability to flooding is diverse and growing in urban, rural and coastal areas and among Indigenous communities.

This report examines FRM in Canada using a multi-stakeholder, forward-looking framework. For this assessment, we utilise a holistic approach to FRM that includes a suite of measures to build societal resilience to floods (The Geneva Association 2020a; Annex 1). Such measures include the availability of risk information and risk awareness for informed decision making, reduction of existing risks and prevention of new risks, early warning and emergency preparedness measures, risk financing for the public sector and risk transfer (insurance and alternative risk transfer measures) and building back better after an event (Annex 2).

The next section describes the main drivers of flood risk in Canada. Section 4 describes the evolution of FRM in Canada, focusing on institutional roles and responsibilities, key legislative frameworks and major flood events that have led to policy change. Section 5 breaks down the different elements of Canadian FRM and section 6 describes Canada's efforts to improve FRM governance through multi-stakeholder coordination. Section 7 summarises the findings.

3. Flood risk in Canada

3.1. Types and impacts of flood risk

Canada is a federation divided into 10 provinces and three territories. Its largest river catchments are shared across three jurisdictions: (i) the Mackenzie River in the Arctic, Fraser and Columbia in the Pacific; (ii) the Saskatchewan-Nelson system east of the Rocky Mountains; and (iii) the Great Lakes and St. Lawrence system in the east (Figure 1).

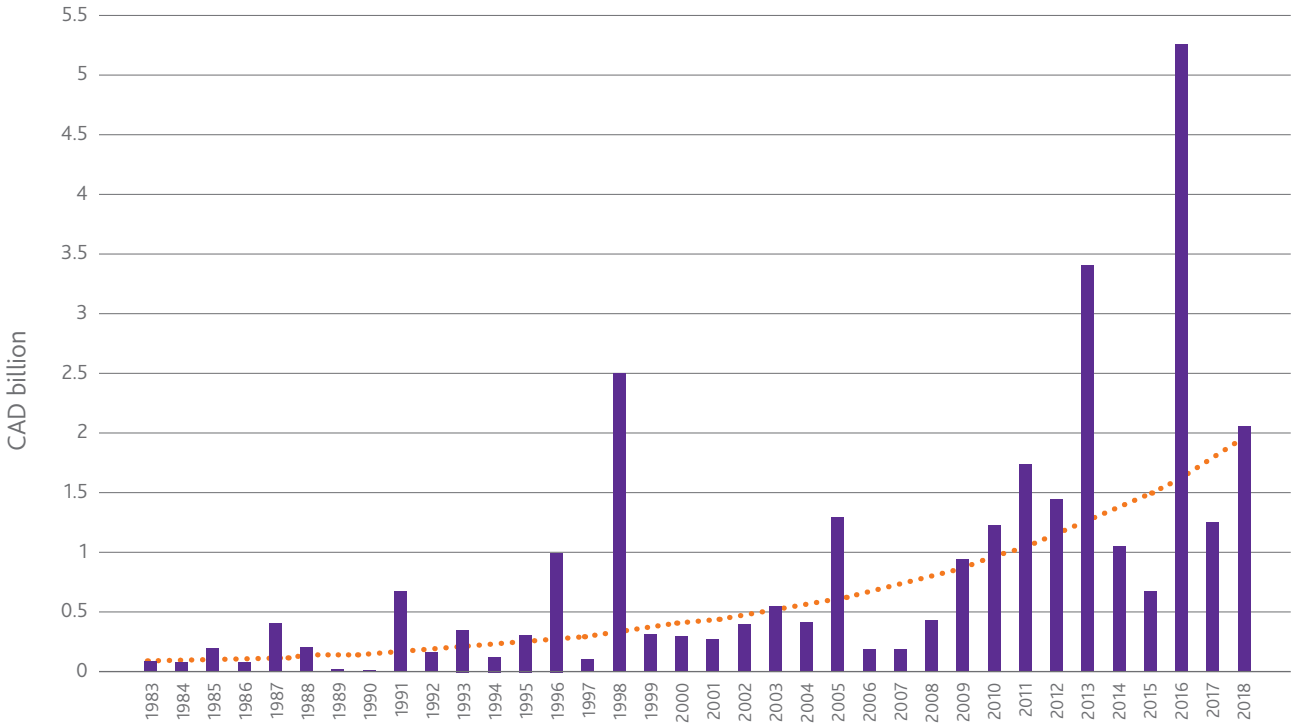
Figure 1: Major rivers and lakes in Canada

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN and the GIS User Community

Flooding has emerged as a significant priority for all levels of government (federal, provincial and municipal) in Canada, as evidence shows that existing efforts to reduce its growing social and economic impacts are proving insufficient. Government payments for recovery increased tenfold between 2005 and 2014, largely driven by flooding. Between 2017 and 2022, annual recovery costs for the federal government are expected to average CAD 902 million, with CAD 673 million attributable to flood events. This substantially exceeds the CAD 100 million budgeted annually for the Disaster Financial Assistance Arrangements (DFAA) programme (Office of the Parliamentary Budget Officer (PBO) 2016). Similar to public losses, insured losses have also increased substantially from an average of

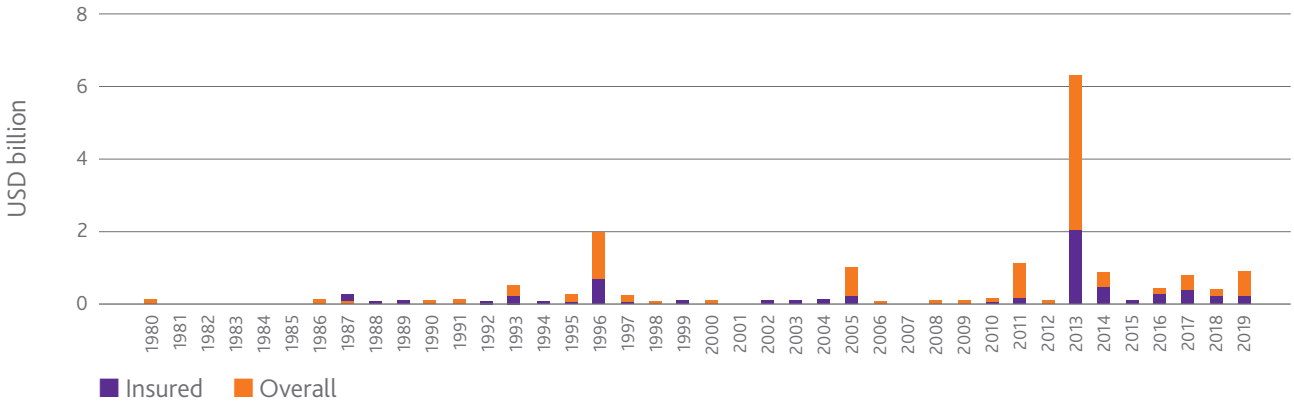
CAD 405 million annually between 1983 and 2008 to over CAD 1.8 billion between 2009 and 2018 (Figure 2a), largely driven by water damage. These losses substantially underestimate the total out-of-pocket costs of flooding in Canada, which were recently estimated at almost CAD 600 million annually (Swiss Re 2016). Figure 2a demonstrates the rising insured catastrophe losses for the property and casualty (P&C) industry in Canada. Figure 2b shows the total and insured losses from floods in Canada.

Figure 2a: Insured catastrophe losses for the P&C insurance sector in Canada (1983–2018)



Source: IBC Facts Book, PCS, CatIQ, Swiss Re, Munich Re & Deloitte. Values in CAD 2018; total natural catastrophe losses normalised by inflation and per-capita wealth accumulation

Figure 2b: Insured and overall losses for floods in Canada (USD billion,adjusted to 2019 values based on national CPI)



Source: NatCatSERVICE Munich Re

Flooding in Canada is driven by a mix of meteorological processes and geographical characteristics. Riverine flooding is often generated by a mix of heavy snowpacks that melt during spring, overwhelming flood defences in downstream communities (Whitfield 2012). Ice jams further magnify the impacts of the hazard. Major floods, including the 1997 and 2009 Red River floods and the 2011 Richelieu River floods, are attributed to such exposure to melting snowpacks. The magnitude of these floods increases if snowmelt is mixed with an extreme synoptic rain event, as demonstrated in Alberta in 2005 and 2013 and along the Assiniboine in Manitoba and Saskatchewan in 2014 (Buttle et al. 2016).

Heavy rainfall events in urban areas with high concentrations of people, property and infrastructure have also been formative in Canada's experience with flooding. In 1954, for instance, Hurricane Hazel killed 81 southern Ontario residents in addition to causing significant property and infrastructure damage (McGillivray 2017). The financial risk associated with these events has grown, as demonstrated by the 2013 Toronto flooding after 126 mm of rain fell in a short period and overwhelmed storm sewer capacity, causing Ontario's most costly disaster to date (Kovacs and Sandink 2013).

Many Canadian communities face coastal flooding and some of the most damaging coastal floods have been related to storm surge caused by hurricanes; for example, Juan (2003) and Igor (2010) together caused almost CAD 100 million in losses (Government of Canada 2016).

3.2. Drivers of flood risk

Population growth and development

In addition to a dynamic range of hazards, population growth and development are major drivers of flood risk in Canada. Almost 80% of Canadian cities are located on riverine floodplains due to historical settlement around waterways that provided access to commerce and resources (Public Safety Canada 2019a). In some communities, development on floodplains has exceeded that on non-floodplains (Robert et al. 2003). For example, in early 2019, the Insurance Bureau of Canada (IBC) found that about 840,000 properties in Canada (approximately 8% of all residential structures) were at high risk of flooding. High-risk properties were found across all provinces and territories (Table 1).

Table 1: Number of properties at high risk of flooding by province and territory

Province/territory	Addresses	Number of high-risk properties	Percentage of high-risk properties (%)
Newfoundland and Labrador	151,201	8,498	5.62
Prince Edward Island	72,464	6,787	9.366
Nova Scotia	431,914	52,456	12.145
New Brunswick	299,723	40,039	13.359
Quebec	2,749,674	221,527	8.056
Ontario	3,988,655	252,236	6.324
Manitoba	296,822	8,600	2.897
Saskatchewan	340,451	4,806	1.412
Alberta	1,336,113	93,693	7.012
British Columbia	1,177,764	146,177	12.411
Yukon	13,986	1,242	8.88
Northwest Territories	7,828	679	8.674
Nunavut	4,228	107	2.531
Canada	**10,870,823**	**836,847**	**7.698**

Over 6.5 million Canadians live along Canada's coastlines, which are the longest in the world. Major ports in large coastal cities such as Vancouver and Halifax are critical entry points for over CAD 400 billion in goods (Government of Canada 2016). Population growth in Canadian cities continues, with over 80% of people living in urban areas as of 2018. Investments in development to accommodate urbanisation have contributed to an increase in flood risk, with some experts estimating that pluvial flood damage has surpassed riverine (Kovacs and Sandink 2013). The vulnerability of marginalised populations has also contributed to Canada's flood risk exposure, particularly among lower-income populations and Indigenous communities (Chakraborty et al. 2020).

Climate change

There is emerging evidence that climate change is increasing flood risk in Canada, but its effects are highly regional given the country's vast geography. The federal government recently updated its analysis on climate change in Canada and summarised the major impacts (Bush and Lemmen 2019).

Both total precipitation and extreme precipitation are projected to increase across most of the country according to recent climate change projections, with some decreases in summer precipitation in southern areas (Zhang et al. 2019). Extreme precipitation is anticipated to increase in frequency, with more high-magnitude events. For example, by the mid-century, a 20-year precipitation event is anticipated to become a 10-year event under a high emissions scenario (RCP 8.5). Under the same emissions scenario, a 50-year event is likely to become a 10-year event by the late century, although less significant changes are also possible under lower emissions scenarios. Anticipated increases in extreme precipitation are remarkably consistent across the country, which confirms climate change as a significant future driver of flood risk. Indeed, recent analysis using some of these climate change scenarios found that economic damage in Canada could increase by as much as 300% by the end of the century (Thistlethwaite et al. 2018). Recent analyses have attributed the severity of recent flood events in southern Alberta (2013) and the Prairies (2014) to climate change (Teufel et al. 2017; Szeto et al. 2015).

For Canada's coastal communities, sea-level rise associated with climate change will intensify storm surge. Sea-level rise varies by region due to different coastal geographies, but both the populated east and west coasts are anticipated to experience as much as a 100 cm increase by the end of the century (although it should be noted that there is significant uncertainty involved in these projections). This has the potential to increase high-water-level frequency in major areas of commerce, such as Halifax, Nova Scotia, and Vancouver and Richmond in British Columbia. As a result, the provinces of Nova Scotia and British Columbia have incorporated a 100 cm increase in sea level into their coastal planning guidance (Government of Canada 2016).

Flooding in Manitoba, 2011

4. Evolution of flood risk management in Canada

4.1. Major floods driving FRM action

Several major flood events in Canada have challenged the political, economic and social acceptability of the existing approach to FRM (see Table 2). Specifically:

- Flooding that occurred as a result of Hurricane Hazel in Toronto in 1954 prompted the Government of Ontario to delegate floodplain land use management to conservation authorities (Environment and Climate Change Canada 2019). These organisations are arms-length technical bodies mandated at the watershed scale to regulate land use in known flood areas. Conservation authorities are a unique organisational structure in Canada, in that they provide a layer of regional oversight with the authority to disallow development in flood-prone areas that might otherwise be permitted by a local government.

- Canada's *Water Conservation Act* (1954) emerged in response to significant riverine flooding along the Fraser River (1948), which inundated almost 10% of the surrounding area, and in Winnipeg (1950), where flooding necessitated the evacuation of more than 107,000 people.

- Discussion on a National Disaster Mitigation Strategy was prompted by the Red River (1997) and Saguenay floods (1996). The Red River flood caused a state of emergency and over 25,447 people were evacuated. The Saguenay flood caused 10 deaths, forced 15,825 people from their homes and cost CAD 300 million in damage.

- In 2013, a massive storm system combined with the spring snowmelt caused Canada's most costly flooding event in Alberta and British Columbia. Four deaths were attributed to the floods. Insurance payments were estimated at CAD 1.7 billion and total costs exceeded CAD 6 billion. This disaster prompted the federal government and insurance industry to explore the expansion of flood insurance to reduce the growing burden of costs on government budgets (Thistlethwaite 2016).

- A thunderstorm producing 126 mm in precipitation caused flash flooding in the Greater Toronto Area in June 2013, resulting in over CAD 1 billion in insured losses. This flood was Ontario's most costly natural disaster to date and brought attention to the growing risk associated with pluvial flooding in Canada (Kovacs and Sandink 2013).

- Recurring spring floods in Quebec (2017, 2019), Ontario (2017, 2019), New Brunswick (2018, 2019) and British Columbia (2019) compelled the federal government to significantly expand policies on FRM, including an increase in funding for property relocation from high-risk areas, a new public flood insurance programme and CAD 150 million investment in new flood maps (Lowrie and Rabson 2019).

Table 2: The 10 most expensive flood events in Canada (1980–2019)					
Period	Event	Affected area	Losses (original values, in USD million)		Fatalities
			Overall losses	Insured losses	
19–24.6.2013	Flood, severe storm	Alberta: Calgary, Canmore, High River, Medicine Hat, Bragg Creek; British Colombia: Elkford, Fernie	5,700	1,500	4
8–9.7.2013	Flash flood, severe storm	Ontario: Toronto area and other parts of southern Ontario, Mississauga	1,500	900	
18–26.7.1996	Flood	Quebec: La Baie, Saguenay–Lac-Saint-Jean, Montreal, Chicoutimi	1,100	370	10
1.6–4.7.2005	Flood	Alberta: Calgary, Drumheller and others; Manitoba: Winnipeg and others	860	200	4
16.4–31.5.2011	Flood	Manitoba: Arborg, The Pas, Winnipeg, Brandon, St. Lazare, Poplar Point, St. Francois Xavier, Headingley	860	210	5
28.6–1.7.2014	Flood, severe storm	Saskatchewan: Melville, Yorkton, Carnduff, Mount Pleasant, Maryfield, Moosomin, Gainsborough; Manitoba	850	500	
18.4–14.5.2019	Flood	Quebec: Chaudière Appalaches, Sainte-Marie, Beauceville, Outaouais, Montérégie, Laurentides, Estrie, Centre-du-Quebec, Laval, Gatineau; Ontario: Huntsville, Kawartha Lakes, Woodlawn, Clarence-Rockland, Bracebridge, Ottawa; New Brunswick: Fredericton, Saint John; Manitoba: St. Jean Baptiste	800	220	1
17.6–4.7.2011	Flood	Saskatchewan: Souris Basin, Weyburn, Roche Percee, Radville, Yellow Grass, Estevan; Manitoba	370	0	
1–20.5.2017	Flood	Quebec: Montréal, Gatineau, Laval; Ontario: Peterborough, Cumberland, Minden, Ottawa, Toronto; New Brunswick: St. John River; Nova Scotia, Cape Breton	350	85	2
22.7–14.8.1993	Flood	Manitoba: Winnipeg; Saskatchewan: Regina	300	140	

Source: NatCatSERVICE Munich Re

4.2. Institutional roles and responsibilities

FRM in Canada is conducted under a multilevel structure, in which legal authority and relevant policy tools are divided between the federal, provincial and municipal governments. Federal authority is national in scope, including income and consumption taxation, spending, interprovincial regulation and trade. Provincial governments are the strongest order of government in Canada, due to their broad powers over natural resources, health, the environment and market regulation within their borders. Provinces also have significant taxation powers, with the authority to impose income and consumption taxes that are additive to federal measures. Municipalities are corporate bodies empowered by provincial legislation and have limited fiscal capacity due to their few sources of revenue and dependence on property taxes. Yet, municipalities in Canada have gradually inherited greater responsibility for FRM, including approval of local development projects. These divisions of authority and revenue constraints, as well as the land use planning approval hierarchy, are central to understanding the evolution of FRM in Canada.

Federal government

With a nationwide mandate and substantial economic resources, the Government of Canada's role in FRM is primarily to support provincial and local efforts to mitigate, prepare for, respond to and recover from flood emergencies. It provides this support in several ways (see Table 3 for a breakdown by ministry). Specifically:

- The federal government produces weather, climate and water volume data that are used as inputs for regional and local flood prediction and warning systems.
- Several federal government departments generate geospatial data that are used to produce flood maps to support decision making.
- The federal government provides economic resources to mitigate flood risk. It does this through several programmes whereby local governments and provinces apply for funding under different project classifications ranging from risk assessment to large-scale infrastructure.
- The Government of Canada supports the restoration of infrastructure and personal property after a flood event, primarily through the DFAA, a federal programme created in 1970 that reimburses provinces and territories for a portion of disaster response and recovery costs (Public Safety Canada 2007). The programme has paid out more than CAD 5 billion in post-disaster assistance since its inception, the bulk of which has been associated with flood events.
- Another important responsibility of the federal government is supporting FRM in Indigenous communities, where flooding is a particularly serious problem. Through Indigenous Services Canada, the Government of Canada provides funding for flood mitigation and preparedness in First Nations communities and its regional officials work closely with Indigenous leaders, the Red Cross and NGOs to support response efforts when flooding occurs.
- The federal government supports general flood emergency preparedness and response by:
    - Producing and distributing informational materials to encourage citizens to take responsibility for emergency preparedness
    - Sponsoring conferences, workshops and other venues that bring together public officials and stakeholders to share ideas and learn about flood emergency management
    - Monitoring flood hazards at the Government Operations Centre, which also coordinates the federal response if a provincial or territorial government requests assistance.

Table 3: Federal departments and their roles in FRM

Department	Role
Environment and Climate Change Canada	Provides meteorological information, weather forecasts and severe weather warnings through the Meteorological Service of Canada
Indigenous Services Canada	Preparation and recovery support for Indigenous communities
Infrastructure Canada	Infrastructure standards, codes and funding
National Defense	Canadian Armed Forces deployment
Natural Resources Canada	Floodplain mapping, data collection
Public Safety Canada	Emergency management, disaster recovery and mitigation funding, flood insurance

Source: The Geneva Association

Provincial governments

With control over key policy tools such as land use planning and building standards, as well as their exclusive constitutional authority over municipal institutions, provincial governments play a pivotal role in FRM, as detailed below:

- First, they set the regulatory flood standard (meaning the return period of a flood, e.g. '100-year flood' or '1% Annual Exceedance Probability'), that is used as the baseline for land use planning, shielding public infrastructure and designing flood protection (Jakob and Church 2011). Although the 100-year flood is the baseline for all of Canada, several provinces have adopted more stringent standards, such as British Columbia and Saskatchewan, which use 200-year and 500-year floods as baselines, respectively. The regulatory flood standard informs provincial legislation that empowers or directs municipalities to regulate development in flood risk areas.
- Second, they specify and enforce standards on the design, construction and maintenance of buildings and infrastructure systems, which are embedded in building codes. Whereas some provinces have formulated a jurisdiction-specific building code, such as Alberta, British Columbia, Ontario and Quebec, others have legislation that enforces the National Building Code, a model framework issued and maintained by the National Research Council.

- Third, provincial governments set out expectations for municipal emergency management programmes, the quality of which influences the effectiveness of local responses to flood hazards and the efficacy of post-flood recovery (Henstra 2013). All provinces have emergency management legislation that sets out municipal responsibilities for emergency preparedness and response.

- Finally, provinces have formal disaster financial assistance programmes that provide funds to eligible individuals and organisations to facilitate recovery after a flood disaster. These funds are the first to be made available to citizens and municipalities in the aftermath of a flood. If the costs exceed a threshold based on the province's population, federal disaster assistance is made available.

Municipal governments

Municipalities are largely responsible for the enforcement and implementation of FRM. They implement provincial legislation on land use, enforce standards for the design and maintenance of buildings and infrastructure, invest in structural defenses (often via cost-sharing with upper-tier governments) and operate emergency management programmes.

Flood risk is growing for municipalities as climate change drives more frequent extreme precipitation events and sea-level rise, infrastructure reaches the end of its lifespan and investment in high-value development continues in urban cores (Cunderlik and Simonovic 2005; Government of Canada 2014). Moreover, Canada's existing FRM framework prioritises riverine and coastal flood damage and has been slower in responding to the costlier risk from urban flooding associated with sewer backup and groundwater infiltration (Kovacs and Sandink 2013).

- One of the most important municipal contributions to FRM is stormwater management; a coordinated effort to reduce and manage the volume and quality of water runoff from developed land into storm sewers, streams and lakes (Government of Ontario 2019). A key objective of stormwater management is to reduce flood risk to properties, and municipalities use various tools to achieve this objective (Sandink 2013).

- Responsibility for identifying flood risks and implementing mitigation measures to reduce the impact of floods on people and property through investments in flood defence infrastructure also lies with municipal governments. These efforts often involve collaboration with provincial and federal governments, which offer guidance and resources.

- Municipal governments also contribute to FRM via emergency management. Municipalities in all provinces are expected to establish plans for responding to and recovering from emergencies, including those caused by flooding (Kuban 1996; Scanlon 1995). As a consequence, municipalities are often the first line of defence in the response and recovery phase of FRM.

Indigenous communities

There are three distinct groups of Indigenous peoples in Canada – First Nations, Inuit and Métis – and their communities are spread across all provinces and territories. Numbering nearly 1.7 million, Indigenous peoples are the fastest growing and youngest population in Canada. Flood risk is a constant source of disruption in Indigenous communities; nearly 70 experienced damage between 2006 and 2016. A recent study confirmed that almost 22% of residential properties on reserve lands are exposed to flood risk (Thistlethwaite et al. 2020). This risk reflects a broader injustice caused by the deep inequities and vulnerabilities associated with colonisation. Forced settlement and resource exploitation have increased flood risk exposure for many of these communities (Patrick 2017).

Indigenous Services Canada plays a role in supporting FRM in Indigenous communities by funding mitigation projects, flood monitoring, forecasts and warnings, whereas emergency management is governed by the provinces and territories. In particular, the Emergency Management Assistance Program provides funding and other support to Indigenous communities to mitigate, prepare for, respond to and recover from hazards (Public Safety Canada 2020c). However, the unique social and cultural conditions within Indigenous communities are often ignored in FRM strategy. Indeed, many communities have been leading and managing their own flood risk for generations using local and traditional knowledge of the ecosystem and floodplain. Some federal projects are attempting to engage more with traditional knowledge, and the Pan-Canadian Framework on Clean Growth and Climate Change recognises that much more needs to be done to protect Indigenous communities (Thistlethwaite et al. 2020).

Coordination within and across layers of the government

Canada has adopted a Federal, Provincial and Territorial (FPT) ministerial framework for coordinating disaster risk reduction, including FRM. Emergency management practices and guidelines are harmonised by the Senior Officials for Emergency Management (SOREM), which reports to FPT Ministers and includes representation from emergency management organisations and Public Safety Canada (Public Safety Canada 2020a). The FPT framework is also responsible for Canada's Platform on Disaster Risk Reduction, which involved consultation with over 700 stakeholders on the design of risk reduction strategy.

The platform is intended to guide implementation of the Sendai Framework on Disaster Risk Reduction, which Canada has adopted, and it hosts regular meetings and conferences to improve harmonisation across stakeholders. FPT ministers also developed Canada's emergency management strategy, which strongly aligns with the principles identified in the Sendai Framework (Public Safety Canada 2019b). Emergency management is further coordinated via provincial legislation that requires municipalities to develop and implement emergency management plans.

While there is evidence that governments are working to coordinate disaster risk reduction, research has yet to evaluate whether these efforts are proving effective in supporting flood risk resiliency (Thistlethwaite and Henstra 2019). A recent report found that a lack of coordination around floodplain mapping and land use planning represented a barrier to limiting development in high-risk areas (ICCA 2020). A common criticism of Canadian coordination efforts is that insufficient resources are allocated to support governments and stakeholders seeking to implement legislation. This is particularly the case at the local level, where investment in structural and non-structural measures imposes a disproportionate financial burden given municipalities' limited access to revenue.

4.3. Legislative action and programmes

In Canada, legislation and programmes concerning FRM have emerged largely in response to significant riverine floods. The federal government has historically assumed a largely passive role, offering recovery funding without requiring measures to reduce future risk. More broadly, governments have not adequately used their legislative authority to clarify the responsibilities of relevant stakeholders involved in FRM, which has led to fragmentation of efforts. On balance, Canada's approach is largely reactive, marked by limited legislative efforts to encourage proactive risk mitigation or communicate flood risk information to the public. One exception is a national flood mapping programme launched in the 1970s – the Flood Damage Reduction Program (FDRP) – which improved the availability and quality of maps used by decision makers. More recently, governments have recognised gaps in local mitigation and increased funding and coordination. These efforts have been met with praise from local governments, but evidence of risk reduction remains uncertain without more research.

Canada Water Conservation Assistance Act

Flood management in Canada has evolved considerably over time. From the early 1950s to the early 1970s, referred to by Shrubsole (2013) as the 'Structural Control Era', FRM was dominated by strategies to resist flooding by erecting structural defences in a bid to physically separate water from settlements. This approach was formalised through the *Canada Water Conservation Assistance Act*, which committed the federal government to water resource management, and was incentivised through federal grants that covered up to 75% of the cost of provincial and local structural protection works. Perhaps the most prominent example of a major structural control project designed and built during this period is the Red River Floodway, a (roughly) 50 km floodwater diversion channel that was completed in 1968 at a total cost of around CAD 60 million (Shrubsole et al. 2003) (see Box 1). The project, funded jointly by the federal and provincial governments, has since prevented tens of billions of dollars in flood damages in Winnipeg (Manitoba Infrastructure 2020).

The design and dynamics of the multilevel governance arrangement during this period led to two notable weaknesses in Canadian FRM (Shrubsole 2013). First, it entrenched a general bias towards structural controls and the diminishment of non-structural, community-level flood mitigation. Second, it forged an intergovernmental division of labour whereby municipalities and provinces engage directly in FRM planning, the Government of Canada contributes primarily as a distant funder and the costs of flood protection are shared among the three levels of government.

The Flood Damage Reduction Program

The weaknesses of the resistance-focused approach to FRM were recognised in the early 1970s and gave rise to the FDRP, an intergovernmental effort launched in 1975 to improve FRM (Bruce 1976). The CAD 20 million, cost-shared programme sought to coordinate federal and provincial efforts to discourage development in flood-prone areas, primarily through flood hazard maps that would be made publicly available.

Based on this mapping, a total of 957 'designated flood risk areas' were identified, meaning land that is 'subject to recurrent and severe flooding'. By identifying this land, the programme intended to achieve two ambitious objectives. First, provincial governments would direct municipalities to regulate or prohibit development in high-flood-risk areas (de Loë and Wojtanowski 2001). Second, disaster assistance would be refused to new developments in high-flood-risk areas once the public had been made aware of the hazard (Page 1980).

Although evaluations found that the FDRP helped to identify high-risk areas and made flood risk more transparent, the enforcement of floodplain regulations varied considerably across provinces, and elected politicians were unwilling to refuse requests for disaster assistance. As a result, in 1999 the Government of Canada withdrew from the FDRP, opting not to renew the agreements with the provinces (de Loë 2000; Robert et al. 2003).

Box 1: Red River Floodway – A shared responsibility across layers of the government

In 1950, southern Manitoba and its most populous city, Winnipeg, experienced the largest and most costly flood in Canada to date. This flood overwhelmed local governments, which at the time were responsible for FRM, and triggered a shift towards an expanded role for federal and provincial governments in funding risk reduction (Passfield 2001).

To avoid a similar flood in future, the provincial government secured a cost-sharing agreement with the federal government to construct a floodway that redirected the Red River around the City of Winnipeg. Construction initially took place between 1962 and 1968 at a cost of CAD 63 million, with a design standard of preventing a 160-year flood. According to the Government of Manitoba, the initial construction was 'the second largest earth moving project in the world' after the Panama Canal. Operational guidelines based on different levels of flood risk inform how much water is redirected into the floodway using a floodgate (Manitoba Infrastructure 2020).

In 1997, a devastating flood along the Red River almost exceeded the capacity of the floodway and forced evacuations in many of the surrounding communities. The Government of Manitoba, in partnership with the federal government and the City of Winnipeg, responded with a massive expansion project for the floodway. At a cost of CAD 628 million, the expansion increased the design standard to protect against a 700-year flood. The floodway has been used more than 25 times, with some calculating the benefits at over CAD 10 billion in avoided costs. Indeed, some estimates suggest that the expansion floodway protects the local economy from over CAD 12 billion in damages that would result from a repeat of the 1997 flood (Canadian Centre for Policy Alternatives (CCPA) 2009).

Following this abrupt withdrawal, experts warned that progress that had been made towards a more comprehensive and risk-based approach to flooding could be lost (e.g. Shrubsole 2000). One year later, an independent expert panel outlined a plan to revive efforts to improve FRM that would involve, among other things, updating flood maps and sharing responsibility with private-sector actors such as banking institutions, real estate professionals, developers and insurers (Kumar et al. 2001), but the plan was never implemented.

The FDRP produced hundreds of flood hazard maps, which indicated geographic areas, typically along waterways and coasts, that could be inundated by 100-year floods. The outputs were divided into a series of 'engineering maps' and 'public information maps' that had different characteristics. The engineering maps were designed to accurately delineate the flood inundation areas to support planning and engineering functions, for example by setting zoning regulations, enforcing development standards and prioritising mitigation measures. Public information maps depicted the approximate location of the flood zones, as well as some local features such as roads and bridges, in order to share information with the public.

Although they provided a rational basis for public policies and administrative decisions, the FDRP's flood hazard maps contained highly technical data, lacked information on the potential adverse consequences associated with flooding and failed to distinguish between different flood sources (Minano et al. 2019). This limited their utility for strengthening public understanding of flood risk. Flood risk maps, by contrast, include information about assets at risk and the potential adverse consequences associated with floods, typically denoted in terms of number of households affected, the likely impact on economic activity and so on (Stevens and Hanschka 2013). They are intended to support policy dialogue, promote public risk awareness and inform decisions about strategic interventions to mitigate flood risk.

Disaster Financial Assistance Arrangements

A key element of FRM governance in Canada is the DFAA, a federal transfer payment programme created in 1970 that provides financial assistance to provinces and territories for disaster response and recovery costs that exceed their fiscal capacity. A province or territory is eligible to receive assistance through the DFAA programme when its eligible expenses exceed an initial threshold of CAD 3.25 per capita, with the federal share determined based on the formula shown in Table 4 (Public Safety Canada 2020b). In addition, the DFAA guidelines were revised in 2008 to allow up to 15% of the recovery funds to be devoted to 'mitigative enhancements' that would reduce vulnerability to future emergencies (Public Safety Canada 2017a).

Table 4: The DFAA programme's cost-sharing formula	
Eligible provincial expenses (per capita)	Share paid by the Government of Canada (%)
First CAD 3.25	0
Next CAD 6.51	50
Next CAD 6.51	75
Remainder	90

Source: Public Safety Canada 2020b

The DFAA has reimbursed over CAD 5 billion in disaster assistance since its inception and the vast bulk of these funds has been related to flood disasters. Furthermore, the annual cost of DFAA payments has increased considerably over the past decade, growing from an average of CAD 10 million for the period 1970–1995 to CAD 110 million for 1996–2010 to CAD 360 million for 2011–2016, now far surpassing the programme's nominal CAD 100 million annual budget (Public Safety Canada 2017b). Based on the insurance industry's flood loss estimates, average annual DFAA costs due to floods were projected to increase to more than CAD 650 million in the near future (PBO 2016); however, more recent government estimates suggest these losses are underestimated.[2]

These escalating costs call into question the sustainability of the DFAA programme and, recognising its growing economic liability, the Government of Canada has begun making upward adjustments to the expense thresholds at which federal funding is triggered (Public Safety Canada 2015b). The initial threshold for provincial assistance of CAD 1.00 per capita was raised to CAD 3.00 in 2015 and it will continue to increase in tandem with the rate of inflation.

In the late 1990s, a series of national consultations on the country's emergency preparedness policies were held, in which a range of stakeholders called for a greater emphasis on disaster mitigation to reduce the impacts of extreme events. Two noteworthy champions of disaster mitigation as a policy priority were the Institute for Catastrophic Loss Reduction (ICLR), an independent research centre committed to the development and communication of disaster prevention knowledge, and the IBC, a national industry association representing Canadian P&C insurers. The former cosponsored and coordinated the national consultations with Emergency Preparedness Canada (now Public Safety Canada) and published a report in 1998 that argued disaster mitigation would save lives, reduce personal losses, ease human suffering, diminish economic disruption and reduce public expenditure on disaster recovery and response (ICLR 1998). The latter published an influential discussion paper in 2001 that urged federal and provincial governments to adopt a disaster mitigation strategy that would coordinate resources to build resilient communities and 'create a culture of disaster prevention' (IBC 2001).

The National Disaster Mitigation Strategy

These discussions prompted the Government of Canada to launch a more focused consultation on a proposed National Disaster Mitigation Strategy. Approximately 170 stakeholders were asked to identify 'sustained actions… to reduce or eliminate the long-term impacts and risks associated with natural and human-induced disasters' (Schneider and Schneider 2002). Through a deliberative dialogue process, the federal government sought to clarify the roles and responsibilities of governments and stakeholders, learn about mitigation measures that had been implemented at the national, regional and local levels and identify priority areas for action (Hwacha 2005). Participants ultimately recommended a risk management approach, whereby local governments would be encouraged to conduct hazard, risk and vulnerability assessments, provincial governments would create all-hazard risk assessment maps and disaster mitigation plans and the federal government would create guidelines for risk assessment maps and mitigation plans and adopt mitigation as an appraisal lens for all projects.

The National Disaster Mitigation Strategy was not adopted until 2008, due in part to a series of large-scale emergencies that drew attention away from it, including the 9/11 terrorist attacks, the SARS crisis of 2003 and a widespread, prolonged power outage that affected Ontario and parts of the U.S. in 2003 (Hwacha 2005). Its release was heralded as a 'recognition by federal, provincial, and territorial governments that mitigation is an important part of a robust emergency management framework' (Public Safety Canada 2008) and it further entrenched the idea of 'building resilient communities' that has continued to this day.

The National Disaster Mitigation Program

To address the growing demand for investment in community-level initiatives to increase resilience, the federal government funded the National Disaster Mitigation Program (NDMP) in 2015. A primary objective of the five-year, CAD 200 million initiative was to fund investments that would reduce the impacts of flooding and facilitate the introduction of private residential insurance for overland flooding (Public Safety Canada 2019c). Before the NDMP, the federal government took a relatively passive stance towards flood insurance, essentially deferring to the industry to determine its own coverage and pricing. As a result, insurance for overland flooding was not made available due to concerns around high concentrations of risk and adverse selection (see

2 Based on personal communication between the authors and Public Safety Canada. The actual figures were not publicly available for citation at the time of publication of this report in December 2020.

section 5.8.) The programme remedied this gap by fulfilling a critical insurance industry pre-condition for expanding coverage through increased investment in risk reduction and risk prevention measures.

NDMP funds were disbursed to provinces to redistribute on a 50% cost-sharing basis to eligible projects proposed by municipal governments, public-sector bodies, private-sector bodies and Indigenous band councils (Box 2).

Box 2: The National Disaster Mitigation Program

The NDMP was divided into four funding streams, based on insurance industry pre-conditions:

- *Risk assessment:* Identification of flood hazards, their potential impacts and community and infrastructure vulnerabilities to inform disaster mitigation
- *Flood mapping:* Development and/or modernisation of maps, including funding for the expansion of risk mapping to identify the boundaries of a potential flood event and the exposure of structures, people and assets
- *Mitigation planning:* Development of strategies to reduce flood risk
- *Mitigation investments:* Non-structural and small-scale structural projects to prevent or mitigate flood damages.

Source: Public Safety Canada 2019c

Climate change adaptation

The idea of 'building resilient communities' was given further salience in the early 2000s as part of Canada's emerging policy regime around climate change adaptation, a core objective of which was to reduce the vulnerability of populations, assets and operations to climate change and to strengthen their resilience to climate-related stress (Henstra 2017; Smit and Wandel 2006). The impacts of extreme weather, particularly flooding, have been a central focus of adaptation research and policy in the intervening years. Indeed, an increase in the frequency and magnitude of flooding is perhaps Canada's most significant climate change risk and, as a result, FRM figures prominently in policy and funding programmes that aim to enhance community resilience to climate change.

For example, the Municipalities for Climate Innovation Program (MCIP) is a five-year, CAD 75 million grant initiative funded by the Government of Canada and administered by the Federation of Canadian Municipalities, a national association representing more than 2,000 municipalities that collectively house 90% of Canadians. The MCIP supports municipal projects to address climate change by mitigating greenhouse gas emissions and adapting services and infrastructure to a changing climate. By the 2018–2019 budget cycle, the MCIP had provided more than CAD 50 million in funding to 322 projects, 45% of which addressed adaptation and a further half of which involved strengthening stormwater management and developing climate risk response plans (Federation of Canadian Municipalities (FCM) 2019).

The Pan-Canadian Framework on Clean Growth and Climate Change

More recently, the Canadian government adopted the Pan-Canadian Framework on Clean Growth and Climate Change, which emphasises enhancing resilience across the country to the impacts of climate change and flood risk. Several actions were included in the framework, including: (1) commitments to increase funding for flood adaptation through the Disaster Mitigation and Adaptation Fund (DMAF, see section 5.4.); (2) adoption of a climate change 'lens' for designing infrastructure projects that incorporate future changes in climate and extreme weather; (3) development of standards to accompany changes in the national building code that incorporate climate change; and (4) expansion of investment in natural infrastructure to reduce flood risk (Government of Canada 2019a).

The emergence of knowledge and guidance on integrating climate change adaptation into FRM is an important strength in Canada. There is a clear effort among experts, governments and non-governmental stakeholders to improve coordination and harmonise approaches across jurisdictions, although the extent to which climate change adaptation is permeating FRM policy in Canada remains unknown. However, a recent study on Ontario's effort to integrate climate change adaptation into stormwater management policy to reduce flood risk found little evidence that climate change considerations are taken into account in the design and funding for FRM (Henstra et al. 2020).

5. Components of flood risk management in Canada

5.1. Flood risk information, communication and flood risk awareness

Effective flood risk communication is one of the most significant gaps in FRM in Canada. Governments have recently committed to provide funding and direct policy to update flood risk maps and expand their role in FRM. Currently, it is too premature to assess whether this will result in improved communication and awareness, but it is clear that flood risk awareness levels are very low in Canada. Behavioural change is difficult to attain, particularly individual investment in risk reduction. This is consistent with findings from other jurisdictions, where individuals consider the cost of these investments as too significant compared to the benefits, regardless of their level of awareness. There is evidence, however, that improving communication around who is responsible for FRM, along with readily available policy support (e.g. subsidies for PLFP), can improve flood risk awareness (Thistlethwaite et al. 2018).

Flood hazard and risk maps

The vast bulk of existing flood maps in Canada are hazard maps intended largely for land use planning and engineering; flood risk maps that incorporate information about potential consequences are rare (MMM Group Limited 2014).

Although Canadian flood hazard maps provide a rational basis for public policies and administrative decisions, they typically contain highly technical data, lack information on the potential adverse consequences associated with flooding and fail to distinguish between different flood sources (Figure 3). These characteristics limit their utility for strengthening public understanding of flood risk.

Flood hazard map production in Canada is decentralised and fragmented. Local organisations, such as municipalities and conservation authorities, are tasked with developing their own maps and flood information. This approach to flood map production was reinforced by the NDMP, which encouraged individual communities to create their own maps (Public Safety Canada 2019c). Most maps are outdated, with a median age of 18 years, and development in flood-prone areas has continued (MMM Group Limited 2014).

Figure 3: Variation in the quality of flood maps

(a) Scanned hazard map of Barriere, BC lacks many features; (b) map of Saint-Césaire, QC contains address search functionality, local context, legend and legible flood zone; (c) map of Cox's Cove, NL contains identifiable buildings, local context, legend, historical photographs and descriptions, legible flood zones, explanations of technical terminology and a brief description of property-level flood risk reduction.

Source: Henstra et al. 2019

Canadian flood maps are rarely made publicly available and typically lack additional, context-specific information, such as photographs of previous flood events and stories of personal hardship in dealing with floods. When assessed against basic characteristics of effectiveness for increasing public awareness and informing FRM decisions established by existing European research (searchable by postal code, contain identifiable landmarks, legible flood extents and so on), Henstra et al. (2019) found Canadian flood maps to be largely unsuitable for communicating flood risk to the public. Even in FDRP-designated flood risk areas, most flood maps are difficult to find and are generally poorly designed for public use or informing FRM decisions.

Fortunately, there are signs that both public- and private-sector organisations are taking a renewed interest in expanding and improving flood mapping. In response to the findings of a study on the state of Canadian floodplain mapping, Public Safety Canada, Natural Resources Canada, Environment and Climate Change Canada, the National Research Council of Canada, Defence Research and Development Canada and Indigenous Services Canada partnered to form a Flood Mapping Committee that would work to standardise and improve flood maps. Advised by a Technical Working Group comprising representatives from provincial governments, industry and academia, the committee released a Federal Floodplain Mapping Framework in 2017, the core objective of which was to 'facilitate a common national best practice and increase the sharing and use of flood hazard information' in order to generate a 'comprehensive understanding of hazard exposure in order to inform mitigation and preventative measures' (Natural Resources Canada 2017). Since each individual province performs flood mapping within its boundaries, this framework is a useful instrument for aligning approaches and practices.

Several provinces have recently initiated a concerted effort to update and expand flood map coverage within their boundaries, largely in response to major flooding that had devastating social and economic impacts (see Figure 4). After severe flooding across the province in 2017 and again in 2019, for instance, the Government of Quebec used aerial photography and satellite imagery to create new flood maps, which were used to establish 'special intervention zones' along waterways where the rebuilding of properties would be prohibited if flood damages exceeded half the home's value (Anhoury 2019). Similarly, after widespread flooding in Saskatchewan between 2011 and 2015, the province was awarded funding under the NDMP to create new flood maps for 21 high-risk communities, which collectively account for more than half of the province's population (Public Safety Canada 2019d).

Some municipalities are developing flood maps that visualise pluvial flood risk, despite concern that it could lead to increases in insurance prices and even depreciation in property value (Stolte 2016). In 2017, for instance, Edmonton launched a city-wide flood mitigation study in partnership with EPCOR, a utility company responsible for maintaining stormwater infrastructure. The project generated nine maps for four different areas of the city using a 100-year rain event over a period of four hours. These projections are now being used to prioritise areas that require flood mitigation and to better measure the cost-benefit ratio of these investments (City of Edmonton 2017).

In 2018, the Canadian Water Network (CWN), a national network that provides decision support for water management, partnered with the IBC and Natural Resources Canada to integrate high-resolution topographic data and flood defence information into flood models used by the insurance industry to generate flood maps for select municipalities. The results of this partnership demonstrated the value of cross-sector data sharing to improve the quality of flood maps (Canadian Water Network 2019).

To support efforts to improve flood risk mapping, the Liberal Party of Canada committed CAD 150 million in 2019 for new flood map production. This funding will support the Minister of Environment and Climate Change and the Minister of Natural Resources to work with provinces, territories and Indigenous communities to 'complete all flood maps in Canada' (Government of Canada 2019b).

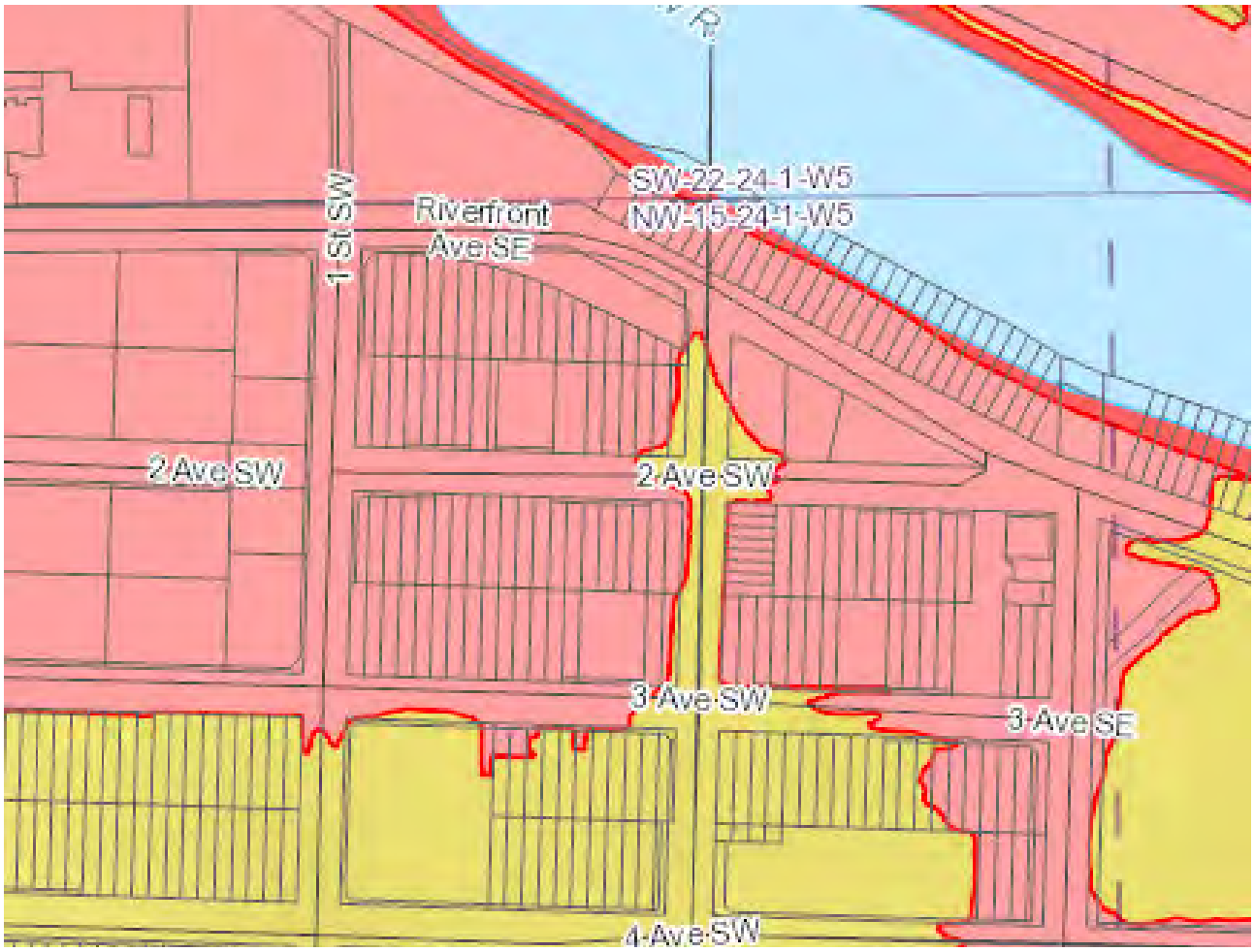
Flood risk awareness

Given the paucity of publicly available flood risk information in Canada, as of the date of this report, many individuals remain unaware of their flood risk. Indeed, in a 2020 survey of Canadians living in designated flood risk areas, only 6% of respondents correctly reported that they lived in a high-risk flood zone, half expressed no concern at all about flooding and less than one quarter believed that the risk of flooding will increase in the future (Ziolecki et al. 2020).

Several organisations have recently launched efforts to improve public flood risk awareness in Canada. For instance, the Government of Canada's Flood Ready website, launched in 2016, offers advice on flood emergency preparedness, lists actions homeowners can take to reduce flood damage and provides ideas for communities on how they can better prepare for flood events (Government of Canada 2020).

Figure 4: Alberta's Flood Hazard Map Application

The extract from Alberta's Flood Hazard Map Application shows parcel-level flood exposure along the Bow River in Calgary, which is colour-coded to indicate relative severity.



Source: Government of Alberta 2020

A second initiative is *FloodSmart Canada*, an online resource launched in 2017 by Partners for Action (P4A), an applied research network at the University of Waterloo that is dedicated to reducing the risk of flood damage (P4A 2019). Drawing on evidence-based best practices and using straightforward, easily understandable infographics, the website informs users about flood hazards, steps to reduce personal and property risk and ways to prepare for flood response and recovery. With funding from the NDMP, P4A has also partnered with the Royal Canadian Geographical Society to produce flood risk awareness materials for elementary school students, which were promoted nationally to more than 20,000 educators (Ziolecki and Thistlethwaite 2019).

P4A is also pioneering the use of community-based strategies for improving flood risk awareness. In contrast to top-down government strategies (e.g. flood risk maps), community-based strategies recognise that information alone is insufficient for changing behaviour to support risk reduction. Bottom-up strategies that identify specific local contexts (e.g. urban flood risk vs. riverine flood risk) and community needs and capacity (e.g. socio-economic vulnerability) can frame messaging in ways that improve behavioural change. This approach, combined with identifying and empowering community members to disseminate flood risk knowledge, is a parallel effort that supports and reinforces that of governments (P4A 2018).

The Home Flood Protection Program (HPFF), an initiative of the Intact Centre for Climate Adaptation,[3] is a third effort designed to raise public awareness of flood risk (Evans and Feltmate 2019). The programme connects homeowners with trained inspectors who perform an in-home assessment and provide advice about actions that can be taken by residents to reduce the risk of basement flooding. Critically, the HFPP has expanded to improve training among housing inspectors in recognition of the fact that flood risk awareness needs to permeate a wide range of sectors and engage stakeholders who can translate it into practices that reduce risk (see Box 3).

Box 3: Helping Canadians help themselves to reduce flood risk

An all-of-society approach relies heavily on leveraging expertise across a range of societal actors and expanding upon the often exclusive reliance on governments to manage all aspects of emergency management. As an example, the Intact Centre on Climate Adaptation (ICCA)[4] is an applied research centre, housed in the Faculty of Environment at the University of Waterloo, which helps homeowners, communities, governments and businesses to identify and reduce risks associated with climate change and extreme weather events in Canada. The centre was launched in 2015, with funding support from Intact Financial Corporation.

As it relates to flooding, the Intact Centre leads research to develop best practices to limit flood risk to homes, new and existing communities and commercial real estate in Canada (see the Programs and Reports sections of the ICCA website). This research has served as a foundation for new national guidelines and standards on flood resilience which are being adopted by local governments, developers and homebuilders across the country.

To secure the uptake of flood resilience measures by homeowners in Canada, the Intact Centre developed the Home Flood Protection Program (HFPP). The programme originally started as a flood risk 'audit' – trained professionals assessed flood risk for individual homes and provided customised reports on measures homeowners could implement to reduce potential flood damage. After conducting 500 flood risk assessments across pilot municipalities (the City of Toronto, the City of Burlington and the City of Saskatoon), the Intact Centre determined the most common flood vulnerabilities for homes in Canada and identified a list of 'top 10 flood resilience measures' that homeowners could implement to improve flood resilience. This research informed policy guidance in the Province of Ontario, with the top 10 flood resilience measures referenced in the Made in Ontario Environment Plan.[5]

Findings from the HFPP also informed a new training course on flood risk for home inspectors, which was developed by the Intact Centre with support from Seneca and Fleming Colleges. There are approximately 40,000 certified home inspectors in Canada, who engage in one-on-one conversations with Canadians during real estate transactions. Training home inspectors about flood risk equips them to help homeowners assess flood risk and to provide advice on flood resilience measures to reduce this risk. The training is available online to home inspectors across Canada. With support from the Insurance Brokers Association of Canada (IBAC), similar training is being developed for insurance brokers, with the objective of offering it to IBAC's 38,000 members.

3 The Intact Centre is an applied research centre at the University of Waterloo that is focused on reducing the impacts of extreme weather and climate change.
4 https://www.intactcentreclimateadaptation.ca
5 https://prod-environmental-registry.s3.amazonaws.com/2018-11/EnvironmentPlan.pdf

5.2. Early warnings and emergency preparedness

Flood warnings and emergency and response coordinated through emergency management plans and implemented by local authorities are recognised as an important strength of Canadian FRM. Local emergency management responders, such as fire, police and paramedics, are an integral part of emergency preparedness decisions and deployment, aiding in the effectiveness of evacuations and localised response (e.g. sandbagging).

Flood forecasting and issuance of warnings are primarily a provincial government responsibility and every province has a unit that carries out these tasks, though the technical capacity and resources allocated to them vary considerably between provinces (Zahmatkesh et al. 2019) (Box 4). These warnings are provided to local governments, who are responsible for coordinating the emergency response. Emergency warnings are also more frequently disseminated through warning apps such as Alert Ready, Environment Canada or the Weather Network.

Monitoring of the transboundary waters flowing between Canada and the U.S. is managed by the International Joint Commission, for which Environment and Climate Change Canada plays a critical supporting role. Indigenous Services Canada works with Indigenous leaders to monitor water levels and issue warnings on reserve lands.

In Alberta, for instance, the River Forecasting Centre monitors water conditions on a real-time basis, gathering data from weather stations and stream gauges throughout the province to produce flood forecast models and issue watches, advisories and warnings for communities where flooding is expected. The information produced by the centre is made available to emergency managers and the public through a mobile application that provides current details on river flows, river and lake levels, precipitation, snowpack and ice conditions across the province. Similarly, New Brunswick River Watch is a monitoring, forecasting and warning portal administered by the Department of Environment and Local Government, which provides public information on water levels along the Saint John River. Information from the portal is used by provincial emergency management officials to issue warnings about flood risk to specific parts of the province.

The federal government supports preparedness and response through the Canada Centre for Mapping and Earth Observation in Natural Resources Canada. The centre houses an emergency mapping unit that provides first responders with information on evolving flood hazards, which it generates from satellite-fed remote sensing data and supplements with crowd-sourced first-hand accounts from news reports and social media (Natural Resources Canada 2019).

Box 4: Federal and provincial water monitoring and warning websites

Environment and Climate Change Canada's Water Office makes real-time water level and discharge data available by province and territory, as well as real-time and historical streamflow, at the following website: https://wateroffice.ec.gc.ca/mainmenu/real_time_data_index_e.html

Canadian provinces and territories are responsible for monitoring flood conditions and issuing advisories. This information is made available at the following websites:

Alberta	https://rivers.alberta.ca/
British Columbia	https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/drought-flooding-dikes-dams/river-forecast-centre
Manitoba	http://www.gov.mb.ca/mit/floodinfo/index.html
New Brunswick	http://www2.gnb.ca/content/gnb/en/news/public_alerts/river_watch.html
Newfoundland & Labrador	https://maps.gov.nl.ca/water/
Ontario	https://www.ontario.ca/law-and-safety/flood-forecasting-and-warning-program
Quebec	https://geoegl.msp.gouv.qc.ca/adnv2/ http://www.cehq.gouv.qc.ca/suivihydro/info_validite.htm http://www.cehq.gouv.qc.ca/prevision/index.asp
Saskatchewan	https://www.wsask.ca/Lakes-and-Rivers/Flood/
Yukon	https://yukon.ca/en/water-levels

5.3. Preparedness and response

Municipal governments bear primary responsibility for emergency preparedness and response in Canada. They are mandated by provincial law to identify hazards and develop plans to minimise threats to public health and safety (Kuban 1996).

In British Columbia, for example, the Emergency Program Act (1996) directs local authorities to 'establish and maintain an emergency management organization to develop and implement emergency plans and other preparedness, response and recovery measures for emergencies and disasters'. Local emergency management programmes must include periodic response exercises, a training programme for response staff, identification of resources such as equipment and facilities, notification procedures and priorities for restoring essential services (British Columbia 1995).

Similarly, Quebec's Civil Protection Act requires regional county governments to work with local municipalities within their boundaries to identify major disaster risks and assess vulnerability to those risks. They are then required to adopt a civil protection plan that sets out safety objectives and strategies, establishes an emergency operations centre, specifies the conditions and mechanisms for public warnings, designates temporary housing for victims and enumerates evacuation procedures (Quebec 2018, 2020). All provinces and territories have similar legislation that sets out requirements for municipal emergency planning and response.

Although governments play a crucial coordinating role, emergency preparedness and response involves a broader network of actors that includes private-sector firms, non-profit agencies, military personnel, academics and some interested members of the public, each of whom brings expertise and resources to the table. In Alberta, for instance, municipal emergency social services are supported by the Canadian Red Cross, air ambulance transfers are supplied by a private contractor and the large municipalities participate in regional emergency management partnerships involving a range of stakeholders including educational institutions, utilities and industrial associations (Hale 2013).

5.4. Risk reduction

Risk reduction is prioritised through funding commitments for improving infrastructure and local risk mitigation (e.g. assessment, mapping) and outlining guidance on limiting development in high-risk areas. While funding is welcomed by local governments, without further assessment it is uncertain whether it actually contributes to widescale risk reduction. More specifically, communities may not use risk assessment as a means of prioritising where funding should be allocated to structural defences and other mitigation measures. More could be done to improve the monitoring and evaluation of how government funding is supporting FRM. In addition, efforts to leverage land use planning to limit property development in high-risk areas struggle with a lack of resources and authority at the local level. Some provincial governments are strengthening planning legislation but local governments' reliance on development for their operating revenue limits their incentive to comply.

Risk reduction involves structural and non-structural actions to eliminate or reduce flood risk to life and property (Cigler 2017). Although historically mitigation has been the weakest element of FRM in Canada, it has gained greater prominence over the past two decades as the costs of flooding have increased dramatically. All levels of government engage in flood mitigation efforts, employing a variety of policy tools to prevent flooding and reduce its impacts. For example, the Red River Floodway is Canada's largest structural flood mitigation project and it exemplifies how the different levels of government in Canada share responsibility for risk reduction (Box 1).

The Government of Canada's primary economic contributions to flood mitigation are the NDMP and the DMAF. The NDMP funded more than 300 projects across Canada between 2015 and 2020, each of which was designed to prevent or reduce flood damage. In 2016, for instance, the Government of New Brunswick received CAD 280,000 towards the cost of new flood hazard mapping along the ocean coastline; the City of Pitt Meadows, British Columbia was awarded CAD 42,000 to support a comprehensive flood risk assessment; and the Regional Municipality of Halton, Ontario secured CAD 1.5 million to support a strategy to reduce the risk of basement flooding from severe weather events. These initiatives exemplify the varied nature and scale of projects funded by the NDMP, which awarded funding on a competitive and cost-shared (50%) basis.

A 2019 evaluation reported that the NDMP had funded 363 projects in 117 communities, most of which involved flood mapping and non-structural and small structural mitigation projects (Public Safety Canada 2019e). However, the evaluation also noted that provincial/territorial participation in the programme was lower than expected, positing that its focus on flooding was too narrow, the budget cycle of the programme misaligned with provincial budgeting, administration was too burdensome for small communities and reporting requirements were more focused on cash flow than project effectiveness and efficiency. In its July 2020 Economic and Fiscal Snapshot, the Government of Canada earmarked funding for renewal of the NDMP (Department of Finance Canada 2020).

The DMAF was developed in 2018 as a competitive and cost-shared programme, similar to the NDMP, but it is aimed specifically at infrastructure investments to increase community resilience to natural hazards and extreme weather in a changing climate. The projects solicited through the DMAF are large – eligible projects must have a minimum of CAD 20 million in expenditure – and they are expected to reduce hazard impacts on critical infrastructure and essential services, the health and safety of Canadians, economic activity and vulnerable regions, all of which are considered to be of 'national significance' (Infrastructure Canada 2018). An assessment of the success of the DMAF in terms of risk reduction has yet to be completed, but the programme has been criticised for its high budget threshold. Many communities seeking to strengthen local structural defences require less than CAD 20 million for their projects and so do not qualify for an application as they do not meet the threshold.

Provincial governments are actively engaged in flood mitigation, primarily through structural controls such as the construction of dams, dikes, levees and diversion channels that are designed to separate water from people and property. In Ontario, for instance, the conservation authorities manage more than 900 dams, dikes and channels along rivers and shorelines, which are estimated to prevent an average of more than CAD 100 million in flood damages annually (Conservation Ontario 2009). Similarly, British Columbia has a vast network of flood protection infrastructure, especially in the Lower Mainland – the broader region surrounding the City of Vancouver – where about 2.8 million people are protected by dikes, pump stations and relief wells (British Columbia 2020). Responsibility for the maintenance of these flood control works rests largely with the local municipalities that benefit from their protection.

In British Columbia, the Community Emergency Preparedness Fund, administered by the Union of British Columbia Municipalities, offers grants to communities of up to CAD 750,000 for the construction of structural flood mitigation projects. There is growing concern that many of these flood mitigation projects lack the funding needed for maintenance and the end of their life-cycle. Conservation Ontario, for example, identified an annual flood infrastructure deficit of almost CAD 100 million in a 2013 report (Conservation Ontario 2013).

5.5. Prevention through development planning and land use

Due in part to the enormous cost of building and maintaining structural flood control works, Canada's provincial governments are increasingly embracing non-structural measures such as land use regulation and development criteria. In Canada, land use planning involves legal restrictions on the location, type, scale and density of development in flood risk areas (e.g. residential construction in the floodway – outer portion of the floodplain) and flood fringe (inner portion of the floodplain required for safe passage of flood flow). Development criteria include rules attached to building permits that impose construction requirements meant to minimise flood risk (e.g. minimum setback distance from waterway; minimum elevation above groundwater table). As noted in a recent ICCA report, provinces lack the formal authority to enforce their own land use requirements within municipal jurisdictions, which limits their ability to prevent development in high-risk flood areas (ICCA 2020). Box 5 provides a summary of the approaches taken in five Canadian provinces.

Box 5: Examples of land use practices in different Canadian provinces

Newfoundland and Labrador

Newfoundland and Labrador's *Provincial Land Use Policy* includes a section on development in flood risk areas, the goal of which is to 'protect public safety and property from the risk of flooding and to reduce the requirement for flood defences and flood damage remediation' (Newfoundland and Labrador Ministry of Municipal Affairs and Environment 2005). It specifies that municipal councils must strictly control development in flood risk areas mapped under the FDRP and require floodproofing measures, such as minimum ground floor elevation, when development is permitted. It also prohibits post-flood reconstruction of existing properties in flood risk areas unless floodproofing measures are adopted.

Prince Edward Island

Prince Edward Island's *Environmental Protection Act* outlines the establishment of a 15 m 'watercourse and wetland buffer zone' along every stream, creek, pond, river, bay, wetland or coastal water body, which creates a physical separation between property and watercourses (Prince Edward Island 2012). No construction is allowed within this buffer zone and property owners are prohibited from altering the landscape. These rules apply to both new and existing structures. In communities with an Official Plan, the regulations are enforced by municipal planning officials, whereas provincial officials monitor compliance in unincorporated areas.

Box 5: Examples of land use practices in different Canadian provinces (continued)

Ontario

In Ontario, the *Provincial Policy Statement* (PPS) gives direction on community-level land use planning issues, including the use of 'hazardous lands' such as those 'adjacent to river, stream and small inland lake systems which are impacted by flooding hazards' (Government of Ontario 2020). The PPS articulates a 'two-zone concept for floodplains', whereby development and site alteration may be permitted (with appropriate floodproofing) in the flood fringe – where the depth and velocity of flooding are generally less severe – but not in the floodway. These planning policies are enforced by the 36 conservation authorities, which are empowered by provincial legislation to make decisions on development in floodplains, independent of municipalities (Henstra and Thistlethwaite 2017).

Alberta

Alberta uses the 100-year flood as the general design standard and has long employed the 'two-zone' concept for land use planning, which delineates lands along rivers into a floodway and flood fringe. The Government of Alberta has traditionally encouraged (but not required) local governments to disallow new development in the floodway and to require floodproofing for structures built in the flood fringe (Kovacs and Sandink 2013). Following devastating flooding in Calgary and surrounding areas in 2013, the provincial government passed the *Flood Recovery and Reconstruction Act*, which authorised greater provincial control for the regulation or prohibition of development in the floodway. In 2014, provincial officials began consultations on a *Floodway Development Regulation* that would supersede municipal by-laws and apply a consistent, minimum level of land use control in flood hazard areas across the province by preventing any new residential structures in the floodway (Alberta Municipal Affairs 2014). To date, however, the regulation has not been implemented.

British Columbia

In British Columbia, land use management is one pillar of the provincial *Integrated Flood Hazard Management* programme, and local governments are empowered (but not required) to develop by-laws that restrict development in flood hazard areas. When passing a by-law, local governments are encouraged by the Government of British Columbia to follow the Flood Hazard Area Land Use Management Guidelines it published in 2004, which include recommendations on setbacks, construction levels and other development considerations, but they are not legally obligated to do so (Stevens and Hanschka 2013). The province's permissive policy framework, which grants local governments broad discretion over development in flood-prone areas, seems out of step with other provinces where a more prescriptive approach is taken. Moreover, as Stevens and Hanschka (2013) argue, it has been largely ineffective at generating compliance among municipalities, since only about one third have adopted a flood by-law or have included FRM provisions in their zoning by-laws.

As this section has demonstrated, provincial approaches to non-structural flood mitigation through land use management vary considerably across the country. Whereas some are highly prescriptive, setting out rules for development in flood-prone areas, others confer discretion on local governments and merely offer guidelines to support their decisions.

While provinces establish legislation on land use, municipalities are the administrative agents that carry out provincial laws, regulations and guidelines. Municipal officials are typically responsible for enforcing provincial land use regulations and development controls, which are operationalised through local planning and zoning by-laws. This delegation of provincial authority can be problematic. Because municipalities rely heavily on property taxes as their primary source of operating revenue, local councils feel pressure to encourage development to increase the value of land, including in flood risk areas along waterways and coasts. Much of the damage from the 2013 Alberta flood, for example, was attributed to inadequate enforcement of restrictions on development in flood-prone areas (McClure 2015).

Development criteria to manage flood risk

Municipalities also design and enforce development criteria in areas prone to flooding. The City of Calgary, for example, manages development with by-laws in the floodway, flood fringe and overland flow area. In the floodway, development is forbidden unless an existing structure is being replaced with the same building footprint. Buildings in the flood fringe and overland flow areas have prescribed setbacks and must incorporate measures to mitigate damage from flood waters (e.g. electrical equipment must be installed above the flood level) (City of Calgary 2007).

The ICCA worked to standardise development criteria that support risk reduction through various proactive measures. In partnership with the Standards Council of Canada, the ICCA supported the development of standardised guidance for any municipality to reduce risk; examples include strategies to mitigate flood risk on properties adjacent to water courses through the installation of floodwalls and regrading paved surfaces. To manage stormwater flood risk, the standards suggest expanding storage facilities and using regrading to channel overland flow away from vulnerable infrastructure (Moudrak and Feltmate 2019).

Most other municipal contributions to flood prevention and mitigation target urban flooding caused by extreme precipitation. Several Canadian cities have implemented stormwater charges, a fee added to the monthly water bill of properties based on their impervious surface area, and the revenues from these are used to pay for stormwater management (Aquije 2016). In 2018, for instance, the City of Mississauga, Ontario used the funds to retrofit a park with a 60,000 m^3 retention pond to protect nearby neighbourhoods from stormwater runoff.

Green infrastructure and low-impact development (LID) are increasingly being considered as strategies for flood risk reduction in Canada, in addition to traditional measures. Research by the IBC and the ICCA has found that green infrastructure can substantially reduce the financial risk of flooding in and around Canadian cities (ICCA 2018a). In response, green infrastructure and LID guidance is being adopted in provincial and local FRM plans, such as Ontario's guidance document on how LID can absorb extreme rainfall that overburdens stormwater systems (Minsitry of Environment and Climate Change (MOECC) 2017).

Managing natural infrastructure for flood risk reduction

To assist governments, practitioners and investors with land use planning and infrastructure investment decisions relative to flood risk reduction through the use of natural infrastructure (e.g. ponds, wetlands and vegetated areas, which can act as a 'sponge' to absorb and store excess rainwater) the IBC, ICCA and the International Institute for Sustainable Development produced an analytical framework that practitioners can use to develop the business case for natural infrastructure conservation and restoration.

As a general rule of thumb, the most cost-effective means to mitigate flood losses utilising natural infrastructure were (in order of preference):

1. Retain what you have
2. Restore what you've lost
3. Build what you must.

The framework is now being used by a range of groups in Canada, including the Municipal Natural Assets Initiative (MNAI)[6], which conducts inventories of natural infrastructure assets and, through partnerships with local governments and engineering firms, assesses their economic contributions in terms of flood risk reduction and other services. This helps local governments to understand and manage natural infrastructure assets within asset management systems. However, despite growing recognition of the importance of ecosystems and the economic and societal benefits of natural infrastructure, rapid losses continue to be seen in Canada. Clearly, a more concerted effort to conserve and restore natural infrastructure assets to mitigate against growing flood risk is required (Box 6).

Box 6: Managing natural infrastructure assets in Canada

The following examples, from assessments conducted by MNAI, illustrate the significance of natural assets for stormwater management and flood resilience:

- A 7 km riverbank in the Oshawa Creek watershed in Ontario provides CAD 18.9 million in stormwater conveyance benefit to nearby communities
- Naturally occurring ponds in White Tower Park in Gibsons, British Columbia provide CAD 3.5 to CAD 4 million in stormwater storage services annually
- Widening and naturalising 1,292 m of the Courtenay River riverbank in Courtenay, British Columbia provides CAD 2.4 million in flood damage reduction to downstream properties under the condition of a 200-year flood event
- Protection of four wetlands covering an area of 13,791 m^2 in the Mill Creek Watershed, New Brunswick delivers CAD 1.4 million in benefits, under the condition of a 100-year flood event.

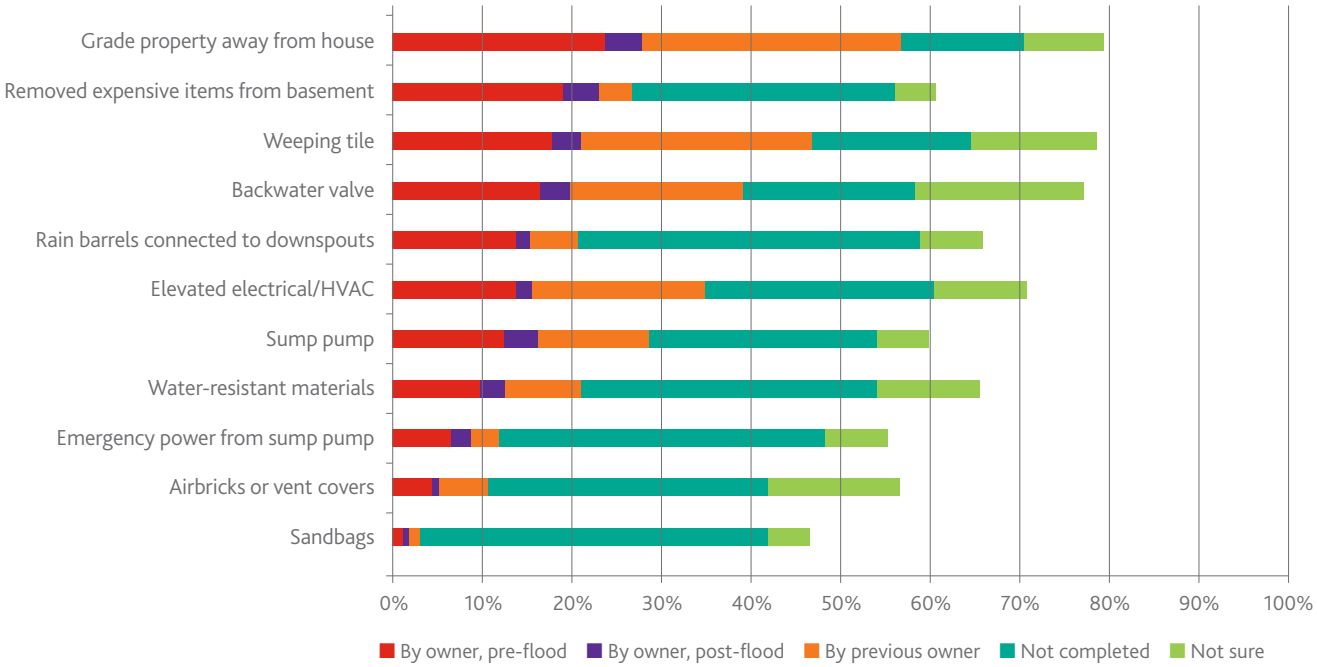
Source: MNAI 2020

6 https://mnai.ca/

5.6. Property-level protection measures

Focus on PLFP measures is increasing in Canada, particularly as a form of prevention against stormwater and urban overland flooding. According to a 2016 survey, about 30% of Canadians have adopted at least one form of PLFP, including installation of a backwater valve, grading their property away from the foundation or elevating expensive items from the lowest level of their property (Thistlethwaite et al. 2018). However, uptake of PLFP measures generally remains low among homeowners (see Figure 5). The survey found that low levels of awareness on the roles and responsibilities of property owners contribute to this low uptake.

Figure 5: Adoption rates of property-level protection measures



Source: Thistlethwaite et al. 2018

Municipalities encourage the uptake of PLFP measures through various economic and by-law interventions. For instance, Toronto's Basement Flooding Protection Subsidy Program offers up to CAD 3,400 per property towards the cost of installing a backflow prevention valve or sump pump to protect against flooding caused by extreme precipitation (City of Toronto 2019). Other cities provide subsidies to encourage the diversion of stormwater away from overburdened sewer systems through the use of rain barrels, planting of trees and installation of green roofs (Kovacs et al. 2014). In Calgary, the Drainage Bylaw requires that downspouts must be positioned two metres away from any roadway to divert stormwater from the sewer system, and residents must keep any surface drainage instruments (such as swales) clear of debris (City of Calgary Water Services 2005).

The insurance industry has enabled critical research and its translation into practical guidelines for property- and community-level protection measures and offers incentives for further risk reduction through reduced premiums. For example, the ICCA has prioritised increasing the uptake of PLFP through the HFPP. Between 2016 and 2018, this programme was deployed in Toronto and Burlington, Ontario and Saskatoon, Saskatchewan to offer free online resources, a home flood protection assessment and an outreach strategy that was designed based on different local needs and conditions. The programme identified a range of common risks (e.g. cracks or gaps in windows or frames) and strategies for mitigation (e.g. window wells and covers). This direct form of education and engagement with homeowners increased the uptake of PLFP compared to many municipal subsidy programmes. According to a recent analysis of the programme, 71% of participants had adopted some of the recommendations six months after its deployment (ICCA 2019) (Box 7).

Box 7: Making risk reduction know-how more accessible to homeowners

The ICCA's research subsequently served as a foundation for new national guidelines and standards on flood resilience, supported by the National Research Council of Canada and Standards Council of Canada, including:

- *CSA Z800:* Guideline on basement flood protection and risk reduction
- *CSA W204:* Flood-resilient design for new residential communities
- *CSA W210:* Prioritising flood resilience work in existing residential communities.

The Real Property Association of Canada (REALPAC) and the Building Owners and Managers Association of Canada (BOMA Canada) have also supported the development of national guidelines for flood resilience for commercial real estate.[7]

To encourage on-the-ground implementation of flood risk reduction by homeowners in Canada, the ICCA partnered with industry associations to provide continued education and professional development opportunities on flood risk reduction to their members. Currently, the following industry associations offer 1.5-hour training on home flood protection to their members, who in turn educate homeowners on flood resilience:

- **Insurance Brokers Association of Canada (IBAC):** A national association, representing over 38,000 P&C insurance brokers to advocate for the best interests of insurance brokers and consumers.
- **Mortgage Professionals Canada (MPC):** A national mortgage industry association representing 12,000 individuals and 1,000 companies, including mortgage brokers, lenders, insurers and industry service providers.
- **Canadian Association of Home & Property Inspectors (CAHPI):** A national association representing over 500 professionals, whose mission is to promote and develop the home inspection profession.
- **Carson Dunlop:** An international inspection and training company that provides education for inspectors, report writing solutions and successful inspection concepts. Represents over 1,500 professionals in Canada.
- **Canadian Real Estate Association (CREA):** A national real estate association representing 130,000 real estate professionals and 90 boards and associations in all 10 Canadian provinces.

As of Q2 2020, the efforts of these industry organisations to advance the awareness of home flood risk protection have the potential to reach over 16 million Canadians.

Source: ICCA

A key strength of the HFPP is the direct engagement between experts and homeowners, which improves the retention of flood risk information and increases uptake of strategies to reduce risks. This interaction helped simplify and increase priority for actions that appealed to homeowners, specifically strategies that can be completed by an individual with limited financial resources. A lack of financial resources was a consistent barrier to the success of the HFPP; the majority of participants cited cost as the most significant barrier to further risk reduction. This is consistent with existing research on PLFP and is unfortunate because the most effective PLFP measures for reducing risk (e.g. backwater valves, cleaning sewer lines) can be expensive (ICCA 2019).

To improve the flood resilience of new developments, Canada's national building code is being updated to incorporate climate change risk (National Research Council Canada 2019).

Led by the National Research Council, this effort involves an investment of CAD 42.5 million from the federal government. A five-year study on how buildings, roads and other infrastructure can be designed to manage climate change risk is almost complete. More than 100 researchers, universities, provinces and municipalities are involved in the consultations. For flooding specifically, the code updates will increase requirements for on-site rainwater retention and require backflow prevention tools in some areas (Canadian Press 2020). Prior to the federal election in October 2019, Justin Trudeau, Prime Minister of Canada, promised that the Liberals, if re-elected, would offer a retrofit programme with interest-free loans of up to CAD 40,000 to assist 1.5 million homes with becoming more energy efficient and resilient to floods and wildfires caused by climate change.[8] The extent to which these funds may be available and applied to flood retrofits during and post-COVID-19 is yet to be seen.

7 https://www.intactcentreclimateadaptation.ca/wp-content/uploads/2019/10/Ahead-of-the-Storm-1.pdf
8 https://www.cbc.ca/news/politics/liberal-climate-change-plan-home-retrofits-1.5296400

5.7. Risk financing

Canada's disaster assistance programmes presently make the implementation of more proactive, risk-based FRM challenging. Although these programmes have introduced small incentives for communities to invest in risk mitigation, uptake is minimal and insufficient to manage risk. Political intervention to expand the availability of disaster assistance in response to local pressure continues to create a moral hazard that limits the motivation of communities and property owners to reduce risk. This is a major barrier to expanding the market penetration of flood insurance in Canada, because property owners and municipalities rightly assume that the provincial and federal governments will continue to finance their recovery, regardless of the actions they take to reduce risk.

Historically, Canada has relied on government-run disaster assistance programmes as a means of flood risk financing and transfer. Unlike private insurance, this approach shares the financial burden of individual losses across the provincial and national tax base. These programmes are designed to return property to a pre-disaster condition that is considered livable and safe. Consultation between municipalities and provinces determines whether programmes should be initiated based on the criteria that flood recovery and emergency management costs are 'extraordinary' (Henstra and Thistlethwaite 2017). Governments set aside an annual budget for disaster assistance without anticipatory considerations of costs going up, leading to consistent deficits in the programme.

Each province applies similar requirements for disaster assistance, such as covering only damage that does not qualify for insurance, but there are some small distinctions. In Ontario, disaster costs that exceed 3% of a municipality's taxation levy qualify for assistance, but other provincial programmes are more flexible, requiring the event to be significant and widespread (Ministry of Municipal Affairs and Housing (MMAH) 2016; Alberta Emergency Management Agency (AEMA) 2016). Ontario has also separated its programmes between municipalities seeking assistance and individuals or property owners (MMAH 2020). Other provinces have a general programme.

Provincial programmes are designed using a similar approach to private insurance, with caps on the total amount of assistance available and deductibles. In British Columbia, assistance will cover 80% of the costs up to a total of CAD 300,000. In Ontario, assistance is capped at CAD 250,000, covers up to 90% of the total costs and requires the applicant to pay a CAD 500 deductible. In the event that provincial costs are substantial, they become eligible for federal disaster assistance, with the share of the costs being determined by a cost threshold on a per capita basis (see Table 4).

Canada's approach to disaster recovery has been criticised in recent years as costs have escalated to unsustainable levels. Payouts for federal disaster assistance increased tenfold between 2005 and 2014 and Canada's Parliamentary Budget Officer estimates that the programme could shortly incur costs of over CAD 900 million annually (PBO 2016). To reduce this financial burden, the federal government worked with Canada's insurance industry to expand existing property insurance to include overland flooding. This expansion of coverage represents an important shift in Canada's approach to disaster recovery as property insurance had historically only covered damage created by sewer backup flooding.

Flooding in Montreal, 2019

5.8. Flood risk transfer: Insurance in Canada

A review of private market development for flood insurance and the types of products available is provided in Box 8.

Box 8: Types of insurance coverage for water damage to homes in Canada

Water damage is typically separated into four categories:

1. **Seepage** refers to flooding resulting from water from rain or snowfall that penetrates the structure due to inadequate roofing protection or a lack of sealant around windows or doors. Seepage is caused by water that has not touched the ground and is typically localised to a specific problem area in the structure.

2. **Sewer backup** refers to flooding resulting from the water table rising to surcharge sewer systems or when urban sewer pipes become pressurised during a storm event. The build-up of pressure causes water to reverse back through the main outflow pipe in the house and emerge through drains in showers and sinks or toilets. This type of damage can be prevented through installation of a backwater valve on the main outflow drain in a house.

3. **Internal plumbing** can be compromised due to the freezing of water pipes, which can burst in the winter.

4. **Overland flooding** is defined as water from an external source which runs over the surface of the ground and enters structures through cracks and lowest building openings (e.g. under doors and through basement windows). Overland flooding events can last for weeks and the prolonged exposure to water can cause structural damage. Contaminants from local landfills, oil tanks and septic fields can enter homes and render them unlivable. Fungus and mould can seep behind drywall, causing health issues if not removed. Reconstruction can take months to a year, and often requires homeowner relocation.

Insurance policies typically cover seepage and accidental freezing of pipes. Sewer backup is offered as a low-cost optional endorsement, and coverage is often capped at CAD 10,000–20,000. Coverage for all of these types of damage has been available for decades in Canada. Because damages accruing from these types of events are often localised to a particular structure(s), they do not usually represent significant losses for insurers. Overland flood insurance is different. The cost of any single event can be significant because often entire communities are affected. Overland and sewer backup damage can occur simultaneously, and it can be difficult to disentangle the two. Houses which are elevated may only experience sewer backup during an overland event whereas their neighbours may experience both.

Source: The Geneva Association

Each firm chooses its own approach towards overland flood insurance in Canada. While some offer an optional endorsement, others 'bundle' coverage with the existing policy, and others limit the availability of coverage geographically. As of 2019, 80% of Canadians had access to some form of overland flood insurance. This expansion of coverage has allowed provincial governments to exclude overland flood damage as an eligible cost for disaster assistance, effectively shifting the financial responsibility to property owners.

Market penetration for overland flood insurance remains below 40% and coverage for those living in high-risk areas is either unaffordable or not readily available. Barriers include the continued availability of disaster assistance (which limits incentives for property owners to purchase coverage), inadequate flood risk awareness and uncertainty about the benefits of flood insurance given a low willingness to pay (Thistlethwaite et al. 2020). This gap in coverage undermines provincial and federal government efforts to reduce the financial burden on disaster assistance programmes, and fails to capture the benefits of risk-based pricing as an incentive for property owners to invest in risk mitigation (Thistlethwaite and Henstra 2018) (Table 5).

By 2017, the Canadian government had realised that a considerable flood protection gap would persist, despite the entry of new overland flood insurance products the previous year. In the midst of yet another significant spring flood event in eastern Canada, the IBC urged the Honourable Ralph Goodale, Federal Minister of Public Safety Canada, to convene a National Roundtable on Flood Risk, which took place in November 2017. Minister Goodale invited representatives from all levels of government, Indigenous leaders, insurers, NGOs and academics to launch a formal dialogue on flood risk (Boyer 2017). Following this roundtable, Public Safety Canada established a National Advisory Council on Flooding (ACF) to improve the financial management of flood risk. The ACF established two working groups, one to make recommendations on flood mapping and the other on financial risk management.

The latter – the National Working Group on Financial Risk of Flooding, co-chaired by Public Safety Canada and the IBC – was tasked with enumerating options for managing the financial costs of high-risk residential properties (IBC 2019). To establish a foundation for its work, two catastrophe modelling firms were contracted to estimate the number and location of properties that could be considered 'high-risk' due to their exposure to potentially serious flooding. These analyses helped to illuminate the scope and spatial extent of Canadian flood risk.

The working group assembled national representation from federal and provincial ministries, academia, NGOs and the insurance industry to develop a framework that clarified the responsibilities of governments and insurers in flood recovery. The objective of the working group was to develop a solution for properties in high-risk flood areas where flood insurance is not affordable or available. Critically, the working group established a set of six principles to guide policy design for sustainable flood insurance: affordability, inclusivity, efficiency, optimal compensation, shielding the taxpayer and financial sustainability (see Box 9).

Box 9: Guiding principles for financial risk management of floods in Canada

1. AFFORDABILITY: Affordable protection should be provided for high-risk properties to ensure maximum participation.
2. INCLUSIVITY: Insurance solutions should be available to all primary-residence property owners, irrespective of the level and type of flood risk they face, e.g. pluvial, fluvial or coastal. Indigenous residences, which are often covered by commercial insurance, and other vulnerable communities require particular attention and possibly a concurrent programme.
3. EFFICIENCY: The price of insurance should reflect as much of the risk as possible to incentivise appropriate flood risk reduction among all stakeholders.
4. OPTIMAL COMPENSATION: Insurance solutions should provide predictable and wholesome compensation to residential property owners and therefore diminish residential pressure on publicly-funded disaster assistance programmes.
5. SHIELDING THE TAXPAYER: Reliance on ongoing taxpayer-funded subsidies should be reduced by creating the conditions necessary for the expansion of private market insurance coverage.
6. FINANCIAL SUSTAINABILITY: An optimal approach should be financially self-sufficient, with a reduction in systemic losses over time.

Source: IBC 2019

In 2019, the working group released a report outlining strategies for managing the financial risks in areas that face recurrent flooding. The report evaluated three options: (1) the status quo, where insurers are free to determine their own pricing and coverage; (2) a system where governments are responsible for absorbing the costs of damage in high-risk areas; and (3) a 'high-risk flood insurance pool'. Upon presentation to federal, provincial and territorial ministers responsible for emergency management in January 2019, the risk pool was identified as the most effective means of balancing risk-adjusted premiums with affordability (IBC 2019). These deliberations led directly to a commitment by the Government of Canada in late 2019 to implement a National Action Plan on Flooding. In July 2020, Finance Canada committed CAD 12 million to Public Safety Canada and Indigenous Services Canada to support the creation of a taskforce to develop options for a national high-risk flood insurance programme and a national action plan for potential relocation.

Table 5: Overview of insurance in Canada		
Market characteristics	**Current system**	**ACF working group model**
Pricing	Risk-based, determined by individual insurers	Risk-based outside of high-risk areas, where a pool would support subsidies
Mandatory or voluntary?	Voluntary	Mandatory in high-risk areas, voluntary elsewhere
Coverage design	Privately-sold separate endorsement that covers flood damage or is bundled with existing water coverage	Insurers would decide whether to insure via the pool or offer existing coverage options
Incentivising risk reduction	Some insurers offer incentives to mitigate risk, but they are often insuffi-cient for changing behaviour	Subsidised coverage would limit incentives in high-risk areas
Market penetration	40%	N/A

Source: The Geneva Association

5.9. Reconstruction

Federal and provincial governments have recently committed to improving reconstruction in the recent Emergency Management Strategy for Canada by 'building back better'. This is a response to limits in the existing recovery strategy, whereby funding cannot be used to support risk mitigation. The strategy commits federal and provincial governments to find links between recovery policy and mitigation to improve and expand efforts to build back better. Manitoba's Individual Flood Protection Initiative is one example of such efforts. Initiated in 2011, the programme offers funding to support property owners investing in flood protection measures (Public Safety Canada 2019b).

Using recovery funding to support risk mitigation is limited by the requirement that properties must only be restored back to their pre-flood condition, without any improvements. The federal disaster assistance programme has tried to address this by making 15% of funding available to support risk mitigation. A 2016 Auditor General report found, however, that this funding is rarely tapped by provinces and risk mitigation more broadly is not prioritised in federal emergency management responses (Office of the Auditor General (OAG) 2016).

Despite this barrier, there is growing support in Canada for improving reconstruction by developing 'managed retreat' programmes, which involve the relocation of people and property from vulnerable flood areas through government acquisition of property. These programmes are growing in popularity as governments realise that protecting communities using structural defences is too costly and unlikely to withstand climate change. Property buyouts have been employed successfully in communities such as High River, Alberta, Perth-Andover, New Brunswick and, more recently, Gatineau, Quebec.

The design of buyout programmes varies, but most are voluntary, offer compensation ranging from pre-flood market price to a capped amount and eligibility can either be based on a damage threshold or a targeted geographical area (e.g. the 100-year floodplain). Quebec's buyout programme, for example, was voluntary, capped compensation at CAD 200,000 and allowed only properties with repair costs that exceeded 50% of the property value to qualify. High River's programme identified specific properties based on location, offered pre-flood market value as compensation and required property owners to accept the buyout or face the risk of expropriation by the municipality (Thistlethwaite et al. 2020). While highly effective at reducing exposure, buyouts often face opposition from local property owners who refuse to relocate, and from municipalities concerned about the upfront costs and potential loss of property tax revenue.

To address these barriers, the federal government announced in 2019 that it was developing a relocation programme that would fund municipal and provincial programmes (Lowrie and Rabson 2019). This extra support could ease opposition by increasing compensation levels and decreasing costs for municipalities.

6. Towards an all-of-society approach to flood risk management

As flood risk has increased across Canada, policymakers have started to shift policy design to support FRM to address the limits and gaps in historical approaches. The adoption of a more effective approach to FRM, however, requires overcoming several barriers and working towards a multi-stakeholder approach in which responsibilities are clearly delineated and resources are sufficiently allocated.

6.1. Limits of the current approach to flood risk management

FRM in Canada has historically been government-dominated with most policy emphasis placed on resistance and recovery strategies informed by flood hazard design standards. Governments invested heavily in structural defences to protect against the 100-year flood. In the event that these defences are overwhelmed, disaster recovery programmes are implemented to compensate people to rebuild. This compensation, however, creates a moral hazard that limits investment in PLFP and reduces incentives to relocate to lower-risk areas.

Although investment in structural defences continues in Canada, the significant costs of building and maintaining structural flood controls often lead to deferred investment. Investment in structural defences also creates a false sense of security and encourages further development in high-risk areas. Defences focus predominantly on protecting against riverine flooding, which ignores the growing risk of urban flooding associated with extreme rain events that overwhelm stormwater infrastructure (Kovacs and Sandink 2013).

Reliance on this hazard-based approach to FRM has inhibited investment in important risk-based strategies, such as the assessment and prediction of risk using flood mapping. In fact, Canada recently received a C grade for flood preparedness in the era of climate change from the ICCA, based on interviews with over 100 senior government officials (ICCA 2020). With the costs of flooding continuing to increase over a 20-year period, the once government-dominated approach to FRM is slowly starting to shift to more active, multi-stakeholder engagement involving insurers, the real estate and banking industries, developers, local governments, Indigenous communities and property owners.

6.2. Intersectoral collaboration in the insurance industry

Insurers are leading collaborative efforts to engage stakeholders in data collection, research and public outreach initiatives. They are also working

with the government to reform FRM in ways that will incentivise risk reduction and prevention, while also providing financial protection against flooding. The IBC in particular has engaged in a range of initiatives designed to support collaboration in FRM. It has initiated and supported research on the viability of flood insurance, funded Canada's first ever flood risk modelling and leads advocacy at all levels of government on FRM. The IBC played an important role in establishing the ACF by encouraging a range of stakeholders from the government, real estate, banking, Indigenous communities and municipal organisations to set out a workplan for addressing gaps in Canadian FRM. In particular, the ACF played an important role in identifying the conditions governments and insurers need to achieve sustainable flood insurance. The IBC is also encouraging investment in natural infrastructure as well as offering a needed insurance perspective in updating Canada's building code to support climate change adaptation (IBC 2020).

The ICLR also offers a platform for collaboration in support of FRM. For example, it works closely with builders, municipalities, insurers, researchers and homeowners to facilitate practical solutions to flood risk. In particular, the ICLR has developed important education and awareness campaigns for property owners and municipalities on urban FRM. This research has forged relationships with home builders, who have worked with the ICLR to develop lot-level interventions to reduce flood risk that can be integrated into Canada's building code. The ICLR has also established an important relationship between insurers and the research community for risk reduction through its Insurance Advisory Committee (ICLR 2020).

Individual insurers are also initiating flood-focused collaboration to improve FRM. The ICCA is a partnership between the University of Waterloo and Intact Insurance to advance action on adaptation in Canada. As mentioned previously, the ICCA has played a significant role in championing PLFP and acts as a significant convener of different stakeholders involved in FRM. Efforts to generate standards for flood-resilient communities have drawn on the expertise of a wide range of stakeholders, including engineers, planners, municipalities, realtors, banks and conservation, mental health and environmental organisations (ICCA 2018b).

P4A is an applied research network at the University of Waterloo supported by The Co-operators Insurance and Farm Mutual Reinsurance. P4A is a community-focused organisation seeking to build a broad-based constituency of advocates for Canadian flood resilience. The organisation supports innovative and practical research, disseminates and shares findings widely, builds partnerships and collaborations and improves awareness around flood risk and actions for risk reduction (P4A 2020).

6.3. Cross-sectoral collaboration

The Government of Canada is embracing cross-governmental and cross-sectoral collaboration to overcome some of the barriers to more effective FRM. These collaborations help to generate common goals that balance the interests of different stakeholders, integrate risk management principles into existing laws and institutional norms, negotiate roles and responsibilities and ensure adequate deployment of resources towards non-structural strategies.

The adoption of disaster risk reduction in Canada's national emergency management strategy is an important catalyst for establishing a common goal for FRM stakeholders. This was achieved through a FPT framework that brought together all Canadian governments and a range of non-governmental stakeholders in a process that recognised that authority is distributed between jurisdictions but must be guided by a common set of goals. The emergency management strategy clearly reflects the principles of FRM through a set of priorities that include (Public Safety Canada 2019b):

- Enhancing collaboration and governance to strengthen resilience
- Improving understanding of disaster risks in all sectors of society
- Increasing the focus on all-of-society disaster prevention and mitigation
- Enhancing disaster response capacity and coordination
- Strengthening recovery efforts by building back better.

In addition to establishing a common set of goals, cross-sectoral collaborations are also facilitating the distinction of clear roles and responsibilities in an attempt to balance the often competing interests of different stakeholders. The development of a Canadian framework for expanding flood insurance through the ACF exemplifies this effort. Recovery in Canada has suffered from an ambiguous division of responsibility between insurers and the government. Property owners are often unaware that they need to purchase property insurance because they believe flood damage is covered by government disaster assistance. Insurance is also too expensive in the high-risk areas that need it most (Thistlethwaite 2016).

Aligning policy instruments across jurisdictions is another area in which cross-sectoral collaboration is emerging in Canada. This effort is critical for ensuring federal and provincial FRM strategies are adopted at the local level where enforcement can come with significant opportunity costs (e.g. foregoing property taxes to limit development in high-risk areas). Nova Scotia's proposed Coastal Protection Act is one example of an effort to improve policy alignment by requiring that local governments

adhere to a common set of rules that reduce flood risk (e.g. setbacks from the coastline for new development). These rules 'level the playing field' between municipalities that might otherwise compete for development by reducing restrictions on development in flood risk areas.

Another example of policy alignment is the collaboration between the Canadian Water Network (CWN), municipalities and insurers to ensure that local investments in flood mitigation are reflected in flood risk maps and insurance premiums (CWN 2019). This work is critical to aligning local FRM with insurance and federal objectives for risk-based management. Municipalities often have a good knowledge of the hazards, but can use insurance data on risk to prioritise local mitigation with the most benefits relative to costs. Insurers can then reward these investments by lowering the premiums for areas that receive enhanced protection.

A final example involves improving resource allocation from governments seeking to share FRM responsibility among a broader range of stakeholders. The federal government's recent commitment to spend CAD 150 million on flood mapping, funding a managed retreat relocation programme and subsidising flood insurance through a public insurance option are all examples of this effort. These commitments all require high levels of collaboration between government and non-government stakeholders. The managed retreat relocation programme is supported by the ACF (IBC 2019), but was also developed in response to experiences with the Quebec, British Columbia and New Brunswick programmes, where additional resources could have increased compensation and reduced opposition to accepting a buyout.

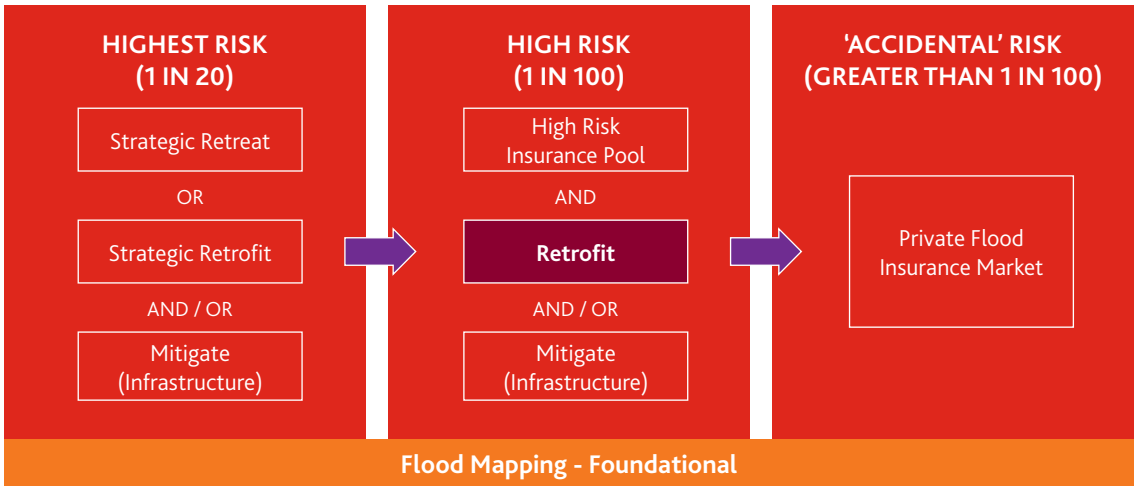
These efforts to support flood risk governance reflect the demand from multiple stakeholders to reduce the barriers to better FRM in Canada. While it is clear that there is growing support for FRM, several cross-sectoral challenges remain, including:

- Hesitation among federal and provincial governments to increase FRM requirements due to limits in resources and the capacity of local governments and stakeholders
- Failure to adequately engage Indigenous communities in policy discussions on FRM
- Opposition to the deployment of a national set of flood maps among provinces and municipalities who are concerned that they are redundant or confuse existing maps and create additional liability
- Low risk perception among property owners, which limits the adoption of PLFP and flood insurance purchases
- Uncertainty over how flood insurance will be made consistent since each province has its own regulatory approach.

6.4. Towards a National Action Plan on Flooding

As a direct result of national deliberations throughout 2018 and 2019 by the ACF, the IBC proposed that the Government of Canada commit to an expansive National Action Plan (Figure 6) to address FRM. After 17,000 homes were flooded across Quebec and Ontario (spring 2019), Prime Minister Trudeau directed his cabinet ministers to prioritise the plan.

Figure 6: National Action Plan on Flooding



Source: Insurance Bureau of Canada

Flooding in Montreal, 2019

This action plan consists of six mutually supportive programmatic elements designed to either move or intensely mitigate those at highest risk of coastal or fluvial flooding and then to defend and insure the rest. A national strategic retreat programme is currently being developed in consultation with provinces and territories to move those at highest risk out of harm's way. Simultaneously, the federal DMAF is being expanded and additional funds are being made available to spur job creation related to COVID-19 recovery. Infrastructure Canada has reduced matching fund requirements so that project applicants only need to raise 20% of project costs – the federal government will cover the rest.

In relation to COVID-19 economic recovery, new residential and commercial retrofit programming is being designed, which will consist of new resilience labelling standards and funding to increase the insurability of homes – particularly those exposed to pluvial (urban) flooding. As mentioned earlier, Public Safety Canada and Indigenous Services Canada are to support the creation of a taskforce to develop options for a national high-risk flood insurance programme and a national action plan for potential relocation. Finally, significant upgrades to national flood mapping, including upgrades to national digital terrain data, are now underway to support these efforts. The plan is designed to provide the correct incentives to move high-risk residential properties into the private flood insurance market over time. It draws heavily from lessons learned in other jurisdictions, particularly the establishment of Flood Re in the U.K. However, significant work lies ahead before the plan is fully implemented.

7. Conclusion: Successes, continued challenges and lessons learned

All levels of the Canadian government are embracing FRM as it is increasingly recognised that flood risk is no longer politically, socially or economically sustainable. The transition towards more effective FRM, however, remains incomplete and Canada's approach remains largely reactive with continued emphasis on the use of structural defences and disaster assistance (see Table 6). Pressure to embrace more fundamental reforms are increasing given the country's high levels of exposure and vulnerability due to the concentration of people and infrastructure in areas susceptible to flooding. Significant floods in Alberta (2013) and more recently in Quebec and Ontario (2017, 2019) have revealed that, in addition to reducing exposure, Canada's approach to FRM needs reform.

Table 6: Strengths and weaknesses of the flood risk management system in Canada

Strengths	Weaknesses
• Emergency management plans are required at the local level • Wide array and scale of emergency warnings and forecasting at the federal, provincial and local levels • Adoption of the Sendai Framework for Disaster Risk Reduction and creation of a Canadian Platform for Disaster Risk Reduction is increasing levels of collaboration and knowledge generation for FRM • Increasing investment in local flood risk mitigation through the NDMP and DMAF • Leadership from the Canadian insurance sector, which is pursuing cross-sectoral and governmental collaboration to improve risk awareness and uptake of flood insurance • Provincial governments initiating managed retreat programmes in areas with recurring flooding • Growing investments in local flood mitigation and mapping from federal and provincial governments	• Hazard-based approaches that rely on historical flood design requirements remain predominant • The government remains disproportionately responsible for managing flood risk with limited engagement among non-governmental and private-sector stakeholders • FRM is fragmented with provinces pursuing varying approaches that reflect different interests and capacities • Resources supporting the implementation of policy commitments (e.g. Sendai Framework, Emergency Management policy) are insufficient • Flood mapping is outdated, not publicly available and fails to incorporate risk and climate change • Development continues to occur in high-risk flood areas with weak or limited guidance on land use regulation • Flood insurance market penetration remains low and insurance is largely unavailable in high-risk areas • Low levels of flood risk perception and awareness, and willingness to pay for PLFP and flood insurance among property owners • Government disaster assistance promotes a moral hazard that limits incentives for investment in risk mitigation, relocation and purchasing flood insurance

Source: The Geneva Association

Evolution towards more effective, better coordinated and integrated FRM is occurring, but in a fragmented fashion as different jurisdictions adopt their own standards of protection and investment in mitigation varies. Provincial governments are primarily responsible for FRM in Canada. Each province manages its own mapping and warning systems, sets design standards for defences, specifies rules around land use, issues development criteria and determines budgets for investment in risk reduction and reconstruction. This fragmentation creates a governance challenge that the federal government has recognised and is attempting to address through several new funding commitments for mapping, relocation and expansion of insurance in high-risk areas. These efforts acknowledge that more needs to be done to coordinate government and non-government stakeholders to support FRM.

As a result, it is difficult to assess the efforts to improve FRM in the areas of risk communication, risk reduction, risk financing and risk transfer. This is further complicated by the absence of formal monitoring and review processes. Although the federal government has reviewed some programmes (e.g. the NDMP), there is no comprehensive system for assessing efforts at the provincial and municipal levels. Canada's Platform for DRR and SOREM are organisations in which a formal monitoring and review process should be established. There is, however, some ongoing work evaluating Canada's progress towards its emergency management priorities as part of its commitment to the Sendai Framework.

Improvement in coordination between levels of government is particularly needed to address the lack of accessible and high-quality flood risk maps. Publicising information on the location and severity of flood risk across the country is a critical first step in supporting the transition towards more effective, risk-based FRM, which would help governments improve land use planning, prioritise investments in risk reduction and reconstruction and evaluate the design of flood insurance. Current flood maps are largely hazard-based, not available to the public and often inconsistent between local governments, provinces and insurers.

Canada's inadequate approach to flood mapping represents a significant barrier to supporting broad cultural and behavioural change towards active management and reduction of risk. Surveys continue to show that risk perception and awareness are insufficient, particularly among property owners. Stakeholders including municipalities, insurers and emergency responders are, however, starting to prioritise flood risk through collaboration with universities and upper-tier governments.

The introduction of overland flood insurance is an important example of Canada's effort to support the behavioural change necessary; however, the limited availability of flood risk mapping and ambiguity over the role of government disaster assistance limits demand. Most Canadians are unaware that they should purchase flood insurance and that they are not eligible for disaster assistance. As a result, market penetration remains low and insufficient for generating price incentives for property owners and communities to invest in risk reduction and risk prevention measures. The Canadian insurance industry is working with the federal government to improve market penetration in addition to funding research networks that promote flood awareness and risk reduction best practices for homeowners, communities and infrastructure.

Despite gaps in flood mapping, the federal government's commitment to investment in risk reduction represents another good example of the rise of FRM in Canada. In particular, the NDMP has been praised by many municipalities and practitioners as an important catalyst for improving local FRM. Although the programme did not impose specific requirements for funding, it focused on key elements of risk management, including risk assessment, flood mapping, mitigation planning and investment. This focus marks a clear departure from historic federal government funding that was directed largely towards structural defences and hazard mapping. It is encouraging that the Government of Canada renewed the programme in 2020.

As governments work to implement FRM, engagement with Indigenous communities is an ongoing challenge. Research has found that these communities are disproportionately exposed to flood risk, due in part to the legacy of colonisation. Further engagement is necessary to better understand how these communities wish to manage flood risk. Certain aspects of FRM, such as managed retreat away from high-risk areas, may not appeal to these communities, which have cultural, historical and traditional ties to flood-prone areas.

Climate change provides additional motivation to improve flood resilience in Canada. The Pan-Canadian Framework on Clean Growth and Climate Change identifies several measures that support enhancing resilience, including

expanding funding for climate change adaptation, integrating climate projections into infrastructure projects, building code reforms and prioritising investment in natural infrastructure. These commitments demonstrate that resilience and adaptive management are being encouraged in federal policy, but it remains uncertain whether similar initiatives are occurring at the provincial and local levels.

Canada's unique geographical exposure to flooding, combined with the uncertainty associated with climate change, have led to a clear departure from existing hazard- and resistance-based strategies in favour of risk-based FRM. Path dependence favouring structural defence measures and government disaster assistance, however, continues to be a barrier to more substantial reform. Indeed, Canada lacks some critical elements of effective FRM, including publicly available flood risk maps, risk-based incentives for community- and property-level flood protection and limited market penetration for flood insurance. These gaps are a consequence of limited political will and fragmentation between federal, provincial and municipal governments, who have varying interests in supporting FRM as well as different capacities to do so. There is evidence of reform, with recent investments by federal and provincial governments in expanding flood insurance, flood mapping and programmes for relocation and incorporating climate change into infrastructure and risk assessment. Monitoring and evaluation of FRM in Canada would improve coordination and highlight areas of improvement that should be replicated and weaknesses that should be prioritised.

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Annex 1: Overarching questions used for mapping and analysing the evolution of flood risk management

1. **What is the evolution of flood risk in the country?**
    a. What are the types of flood risk, who is at risk and why?
    b. What are the underpinning causes of flood risk?
    c. What are the socio-economic impacts?
    d. Is flood risk growing? What are the drivers of rising flood risk in the country?
    e. Has addressing financial and social risks associated with floods become a national concern for people, businesses and the government? In what ways?
2. **Is reliable flood risk information available and accessible to support decision-making?**
    a. What are the underpinning data sources for flood risk analysis (hazard, exposure and vulnerability)?
    b. Are there official flood risk maps and are they publicly available? What types of information are being developed? What are the strengths and weaknesses of the official flood risk maps? How often are they updated?
    c. Are there other sources of flood risk information? Who is processing and providing flood risk information? What types of information is being developed? To whom is this information provided? How is this information provided to target stakeholders?
    d. Is flood risk information provided to target stakeholders? E.g. people, businesses, community organisations, different government agencies, local government and utilities? Are these maps decision-relevant?
    e. Has the level of risk (e.g. high, medium, low) been identified in different regions? Is this information used to zone the regions according to the level of risk? What are the fundamental assumptions?
    f. Are there targeted risk communication programmes? If yes, who provides them?
    g. What are the benefits, challenges and concerns associated with available risk information and the way it is being provided?
    h. What is the level of flood risk awareness in the country among different stakeholders? Is risk information impacting decisions (e.g. by people, businesses and government)?
    i. Are there any mechanisms for monitoring, assessing and incorporating the changing risk landscape (hazards, exposures and vulnerability) in the risk maps? Are the underpinning causes of the changing risk landscape investigated and monitored (e.g. climate change, development patterns and practices?) What are the main challenges and concerns?
3. **How is FRM governed in the country and how is it evolving? How are different stakeholders engaged in the system?**
    a. Who are the key stakeholders with official responsibility to manage floods and their impacts?

i. Who has official responsibility for FRM in the country? Is this reflected in national to local legislative processes (e.g. government at the national, state and local levels, the insurance sector, banking and mortgage lenders, public utilities, the media, NGOs and other community-based orgs, homeowners)? What are their roles?

ii. Who is responsible for addressing the needs and challenges faced by the most vulnerable groups of the population?

iii. What is the perception of homeowners, businesses and other stakeholders in terms of who is responsible? Does the existing system require that homeowners and business owners manage their own flood risks? Please describe.

4. **What is the approach to risk reduction (existing risks) and risk prevention (new risks), particularly in relation to rising risks associated with climate change and other socio-economic drivers?**

   a. Is FRM considered an integral element of socio-economic planning, budgeting and development in the country? Is FRM an integral element of climate adaptation policies and decisions, as opposed to being a stand-alone objective?

   b. Have (or are) disaster risk reduction and risk prevention plans been (or being) developed, implemented and supported/enforced by public policy and regulatory frameworks (at all levels of government)?

      i. Who is responsible for development and implementation of these measures? Are the interlinkages of these measures considered part of the overall development and risk management strategy? Or are they implemented in isolation?

      ii. Is there a dedicated budget supporting these plans? How is the budget allocated between levels of government?

      iii. Are there incentive mechanisms to promote and enable the implementation of risk reduction and risk prevention by different stakeholders (homeowners, businesses, community-based organisations, local, state and federal governments, public and private utilities, etc.)?

      iv. Is there a process for monitoring and evaluating the impacts of these measures to improve them over time (what level, by whom, how)? For example, monitoring the impact of retrofitting for residential homes, businesses, government assets, infrastructure (public or privately owned) and communities; or the impact of floods on homes and buildings built based on new building code standards versus old ones?

5. **Are early warning systems and emergency preparedness in place and if so, how is this helping to reduce risks (reducing loss of life, livelihoods and economic damage)?**

   a. Who is responsible for developing and issuing the alerts and warnings? Are these warnings accessible, understood and responded to by different stakeholders?

   b. Who is responsible for ensuring alerts and warnings are linked to emergency preparedness on the ground?

   c. What is the receptivity of the general public, businesses and communities to these warnings?

   d. Are warnings leading to increased risk awareness, reduction of property damage and expedited response to and recovery from flooding?

   e. What types of actions are being taken by government (at all levels), businesses, communities and people, based on warnings, to reduce risk?

6. **Are those that are directly impacted by floods incorporating risk financing and contingency planning in their budgets and plans to increase financial resilience and expedite their ability to respond to floods (e.g. government (all levels), businesses, people)?**

   a. Is the government taking a strategic approach to its financial protection by combining financial instruments? E.g. prioritising cheaper sources of funding, ensuring that the most expensive instruments are used only in exceptional circumstances, using pre-planned budgetary instruments, contingent financing and risk transfer measures (e.g. risk pools) and insuring public assets?

b. How has post-disaster aid funding been approached and appropriated?

c. Does the country remain reactive (focused on post-disaster response and recovery) or is it strategically considering the need to build resilience to reduce current risks and prevent new risks? Describe in more detail with examples.

d. Have post-disaster aid programmes undergone any reforms or modifications to incentivise and/or enable risk reduction and prevention and help with the expansion of insurance for the protection of people, businesses and government?

e. Does the government arrange for any contingency plans to protect its budget to ensure access to cheaper funds in case of disasters?

7. **Is there an active flood insurance market in the country? Is the value proposition of the insurance sector leveraged in building flood resilience in the country? Is the value proposition of the insurance sector understood by governments, businesses and people?**

a. What is the status of insurance in the country? Is it provided as a national government service, through the private insurance market or as a combination (public–private partnerships, PPPs)?

b. What is the nature of the insurance programmes (insurance pools, integral part of home insurance or separate insurance products)? Is the insurance delivery:

i. Risk-based?

ii. Mandatory versus voluntary?

iii. Incentivising risk reduction through reduced premiums or other mechanisms (please describe)?

iv. Aimed at residents, SMEs, businesses, government?

v. Market-based or enabled through policies and regulatory frameworks (if so, how)?

c. Is there insurance-backed securitisation of CAT and green bonds?

d. What is market penetration and coverage?

e. Is the insurance programme sustainable?

f. What is the receptivity of government in engaging with the insurance sector?

g. Is the insurance industry proactively engaged with government and other stakeholders to address strengthening of flood resilience? Please describe.

i. Is the insurance industry engaged with government in reviewing flood risks to residents, business, government, and infrastructure and identifying innovative market-based solutions?

ii. Is the insurance industry developing innovative risk transfer measures (with or without collaboration with the government?). Are these solutions available, accessible and affordable and are they being used by those at risk to distribute or pool the residual economic risks?

iii. Are insurance solutions (by industry, government or both) incentivising behavioural change (e.g. insurance solutions available to residents, SMEs, etc.)?

h. Are the government (at all levels) and/or the insurance industry engaged with customers and businesses to educate about risks, preventive mechanisms and the benefits of insurance?

8. **Following a disaster, are there systematic mechanisms to revisit, re-evaluate and decide on reconstruction plans and decisions?**

a. Are there formal mechanisms and legislation in place to enforce the need to build back smarter (e.g. build back using updated building codes, relocate and do not build at all if the region(s) has been identified as a high-risk zone)?

b. Are there efforts to reconsider land zoning in high-risk regions that experience recurrent risks? Are there any government plans for buy-outs and relocation from high-risk zones? Have these programmes and their impact been assessed?

9. **Are there monitoring and review processes in place for assessing/measuring the impact of risk communication, risk reduction, risk prevention, risk financing and risk transfer decisions and for providing feedback to improve the different components of FRM in the country?**

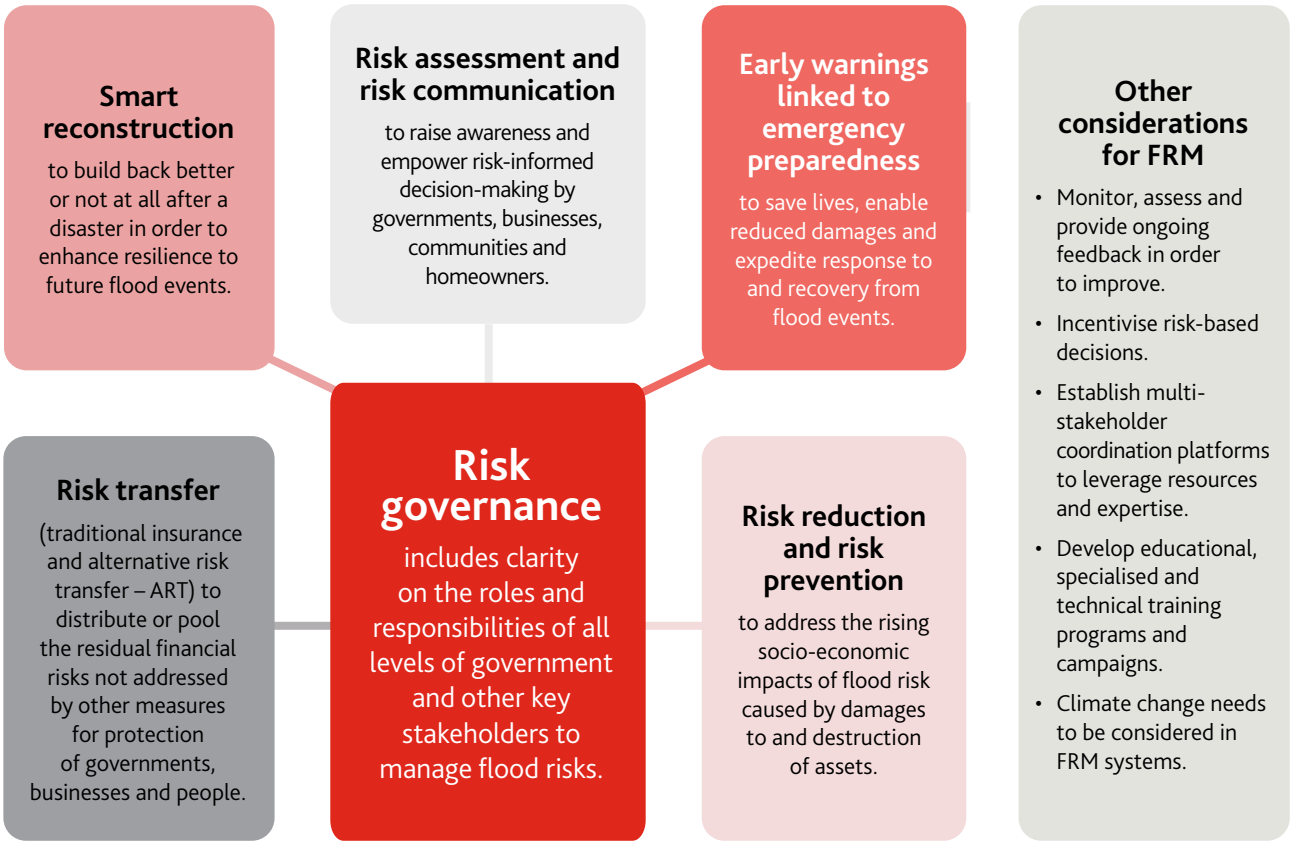
10. **Overall:**

    a. a. Is the FRM approach transitioning toward a greater focus on flood resiliency? E.g. is the approach focused not only on reducing current risks but also prevention of future risks linked to factors such as climate change?

    b. b. Is the approach characterised as fragmented (i.e. engaging many organisations with different but disconnected roles and initiatives) or is it evolving towards a holistic all-of-society approach (leveraging all components of the system)?

    c. c. Is there any evidence of cultural/behavioural change towards active management and reduction of risk (e.g. people, businesses, communities and all levels of government)? Is it linked to the level of risk? Are there incentives for this change?

Annex 2: Framework for assessing flood risk management systems



Source: The Geneva Association

As the world deals with the COVID-19 pandemic crisis, the potential compounding effects of weather-related extreme events, such as floods, tropical cyclones and wildfires, could significantly challenge a country's emergency management capacities and slow down its socio-economic recovery. Floods are the most concerning and costly weather-related hazard globally. Part of a major study on flood risk management (FRM) in five mature economies (the U.S., England, Germany, Australia and Canada), this report takes an in-depth look at the FRM system in Canada – governance, institutional frameworks, stakeholder engagement and implementation of different components of the FRM system based on a holistic framework – against an analysis of the changing risk landscape.

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