



**COASTAL CITIES AT RISK:
ASPECTS OF VULNERABILITY AND RESILIENCE FOR VANCOUVER, CANADA**

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ABSTRACT: Extreme weather events have always been part of life in Canada, a rugged and vast country with enormous variations in geography and climate, from mountains to desert, to prairies to coasts; however, climate change is continually elevating the severity and frequency of the floods, storms and droughts that Canadians have to weather. Current and projected impacts are driving governments at all levels to develop policies and plans designed to reduce the vulnerability of communities and industry sectors and strengthen their resilience, or capacity to cope with weather-related challenges. Of these, flooding has become the biggest issue, representing the greatest source of insurance claims in Canada in the past few years as catastrophic events become more common and infrastructure damage increases.

Key Words: Flooding, climate change, sea-level rise

1. INTRODUCTION

As the climate warms, an overall global increase in winter precipitation is projected, with more water falling as rain than as snow, although potential for heavy snowfall remains depending on temperatures and timing. More rapid and extensive snowmelt associated with rising temperatures, and increasingly intense rainfall associated with summer storms, could heighten the flood risk in many Canadian communities. Sea level is rising faster than was earlier projected, meaning a greater risk of inundation on low-lying lands, beach erosion, increasing salinity of fresh water aquifers and agricultural soils, and intense coastal flooding resulting from storm surges associated with more intense storms driven by a warming climate. Responses to these challenges are emerging around the country, most often at the municipal level as cities struggle with the costs and pressures. Canada has no overland flood insurance industry, and discussions are underway at all levels of government as to how best to meet the enormous damages now being incurred on an annual basis by the federal Disaster Financial Assistance program, provincial and municipal programs, and individual homeowners.

2. CLIMATE CHANGE AND EXTREME WEATHER IN CANADA

A number of recent extreme weather events in Canada indicate that climate change is already starting to make its effects felt on Canadian communities, which are on the front lines. In July of 2013, major cities Toronto and Calgary experienced the worst floods in history. The Calgary flood was the costliest disaster in Canadian history, killing four, displacing 100,000, and costing \$1.7 billion (Wikipedia, 2014). Toronto's flood was the costliest natural disaster in the province's history, with insured losses of \$850 million; it was the second hit for many residents who had been inundated in 2009, and were therefore not 100% covered by insurance because companies are beginning to change their policies. This left many homeowners no choice but to move before the third flood they know is coming (Carys Mills, 2013).



3. BRITISH COLUMBIA AND VANCOUVER RESPONSES

The British Columbia provincial government released guidelines for sea level rise in 2012, estimating a 1.2 metre rise by 2100 and double that by 2200 (BC Ministry of Environment, 2012). This caused consternation amongst municipal governments because, in 2003, the province downloaded responsibility for diking and coastal flood infrastructure maintenance to them with no associated financial or information resources. To date, there is still no provision of funding to assist the municipalities to respond to the costly implications of these guidelines – despite the fact that, in 2013, the provincial government estimated a cost of \$9.5 billion just to upgrade the Lower Mainland municipalities’ coastal defenses. A major push is underway by local groups, including the Fraser Basin Council and the BC Real Estate Association, to finance updated floodplain mapping. ACT has convened a group of coastal municipalities – the Sea Level Rise Collaborative – in partnership with West Coast Environmental Law to facilitate collaborative approaches to coastal adaptation.

The OECD (Nicholls R.J. et al, 2008) report “Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes,” that looked at projected damage from coastal flooding and sea-level rise driven by climate change for cities around the world, placed Vancouver, BC at 16th for exposed assets, with USD \$55 billion at risk; and 32nd in terms of population at risk, with 320,000 people exposed. Vancouver was identified again in 2013 as one of the top 10 cities in the world at risk from sea level rise on the basis of exposed assets (Stephane Hallegatte, Colin Green, Robert J. Nicholls & Jan Corfee-Morlot, 2013). Coastal infrastructure at risk includes highways, sewer systems, waste treatment, shipping and ferry terminals and Vancouver International Airport. A one-metre rise in sea level would inundate more than 4600 ha of farmland and more than 15,000 ha of industrial and residential urban areas.

Approximately 220,000 people live near or below sea level in Vancouver suburbs Richmond and Delta, protected by 127 km of dykes that were not built to accommodate sea-level rise. Richmond spent \$2 million on dike improvements in 2007, has a \$13 million coastal reinforcement fund, and a plan to increase the height of the city’s 49-kilometre dike network. Delta underwent a risk management study to evaluate the resilience of their infrastructure to flooding events, and has also begun monitoring sea level to further mitigate this threat to Delta’s dyke system. However, there is general reluctance amongst many municipalities to act due to costs and fear of deterring investors and compromising property values.

Where there is a risk to people and assets from sea level rise there is accompanying increased risk from storm surge. Changes in the frequency and magnitude of heavy precipitation and storm surge are projected for most future climate scenarios, particularly during winter when high tides and large winter storms frequently co-occur. Vancouver and its surrounding municipalities are vulnerable to both erosion and storm-surges associated with sea-level rise, and extreme high-water events are increasing at a rate faster than sea level rise overall (McBean, G. & Hensworth, D, 2008). Key sectors, including tourism, agriculture, and transportation will be affected by sea-level rise and increased coastal erosion and flooding hazards, and associated impacts on infrastructure and services. Sea-level rise is also likely to cause saltwater intrusion into aquifers, affecting fresh water supplies.

4. THE NEED FOR ADAPTATION

The primary response to climate change thus far has focused on mitigating it by reducing harmful greenhouse gas emissions. While such action is crucial, it is also inadequate. Current atmospheric concentrations of greenhouse gases are substantial enough to mean that further climate change will occur regardless of our success in reducing greenhouse gas emissions (Raupach et al, 2007). Therefore, it is important to both work on reducing GHG emissions and adaptation to the current and anticipated effects of climate change. Adaptation is intended to reduce vulnerability and enhance resilience, which is defined as



follows by the Intergovernmental Panel on Climate Change: Resilience is “the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change” (Parry et al, 2007).

The most commonly recommended adaptation options for the water resources sector all represent ‘no-regrets’ adaptation options, meaning that their implementation would lead to benefits irrespective of the effects of climate change. These include water conservation measures, improved planning and preparedness for severe floods, improved water quality protection, and enhanced monitoring (Fiona Warren et al, 2004). It is important to emphasize that adaptation involves more than merely reinforcing infrastructure and investing in new technology; rather, truly effective adaptation demands a holistic approach, which includes “adjusting *decisions, activities, and thinking* because of observed or expected changes in climate in order to moderate harm or take advantage of new opportunities” (Policy Horizons Canada, 2009).

4.1 Unique Challenges for Coastal Delta Cities

Coastal delta cities are exposed to a uniquely elevated level of flooding risk due to their location between the sea and the low-lying land at the mouth of the river they are built on. Climate change-driven impacts of both river and ocean flooding result in potential for extreme events that can affect not just the local economy but also national GDP through compromised port facilities including rail, road and freight routes. In addition to river and ocean flooding, the Metro Vancouver region includes municipalities located on extremely steep terrain on the shoulders of the mountains in the north, where creek floods and landslides in highly populated areas are an additional concern. There is therefore significant need for municipalities in the region to create and implement adaptation plans as they face a range of damages that will lead to loss of property values and investor confidence, and even loss of life, if they do not.

In the Metro Vancouver region, the real estate and development sectors are expressing increasing concern over property investment decisions and are pressing for updated floodplain maps, as the current mapping is outdated and has never factored in future climate conditions. Downscaled data and hydrologic and hydraulic modeling, plus innovative visualization techniques, are increasingly available; however, the widespread need for updated mapping is not simple to fulfill, partly because it requires investment in expensive LiDAR to contribute the elevation aspects.

Unfortunately, due partly to the fact that Canadian municipalities have only one income stream – property taxes – there is a high level of discomfort around proactive planning and even access to updated floodplain maps, while climate change still seems at best like a future issue rather than a pressing crisis. Canada has no overland flood insurance, so there is no risk signal in place yet either to guide homeowners in terms of purchases or to contribute to a feeling of security if covered. Another contributor to this reluctance is the fact that Canada’s national leadership demonstrates a high level of political support for oil and gas development and a corresponding deficit in leadership on climate change, and skepticism about the reality of climate change still persists at an extraordinarily high level in the political sphere.

5. MUNICIPAL AND LOCAL RESPONSES

Canadian municipalities face a costly prospect: update floodplain maps, reveal a vastly increased level of flood risk than previously realized, and risk seeing existing properties devalued while experiencing a drop in investment until they have mitigated the risk – which may be extremely expensive as mentioned earlier – or wait, and risk storm damage and even lawsuits, as the potential for legal charges of nuisance or even criminal negligence grows with the increasing availability of downscaled climate information. That said many municipalities have highly sophisticated engineering and planning responses to the flood risks that are



6TH INTERNATIONAL CONFERENCE ON FLOOD MANAGEMENT

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already known, and in many cases are effectively practicing and implementing adaptation measures without necessarily naming them as such.

To date only two of Metro's 23 municipalities – the Cities of Vancouver and Surrey – have official adaptation plans, both of which were ratified in the past two years. These plans focus on flooding and stormwater management, urban forestry and ecosystems, infrastructure and health. Surrey's approach also includes agriculture and food security as the city is home to nearly 500 farms in Surrey with a total value of farmland and buildings estimated at over \$1.4 billion dollars in 2011, employing over 3,300 workers, and a greenhouse industry operating 44 greenhouses, containing over 475,000 square meters of capacity and producing a wide variety of flowers, herbs and vegetables.

The provincially-owned power utility, BC Hydro, which powers the region with almost 100% hydropower generated from BC's enormous rivers, commissioned its own climate change-based flood research after major storms created power outages for millions in the winter of 2006. It also consulted with engineers from Manitoba, which experiences some of the worst flooding in the country on a regular basis due to confluence of major rivers in relatively flat prairie land. Resulting updates to power facilities included shifting the location of power infrastructure to the top of generation installations to reduce vulnerability to flooding as well as updates to transmission infrastructure designed to bolster resilience to storm winds and water.

Metro Vancouver also has a number of companies working in adaptive stormwater management and green/blue solutions, as professional expertise begins to respond to the increasing challenges posed by climate change. There is an enormous amount of work left to do to ensure the Metro Vancouver region is resilient to climate change; however, the process is underway and there are many excellent examples of innovation and progress that can be cited. The key barriers to progress are funding, climate skepticism, uncertainty, financial caution resulting from the 2008 recession, access to high-quality climate data, and capacity at the municipal level. As climate change progresses, highlighting the risks, and other jurisdictions push ahead with action – especially the US, which is Canada's largest trading partner, it is expected that resilience development will accelerate.

6. THE SCIENCE-POLICY INTERFACE

ACT's key contribution to progress in this regard is the goal of translating science into policy measures that can be easily accessed by decision makers. Governments require not only simplified information, but also recommendations that take into account the current policy regime and low-hanging fruit in terms of opportunities to implement adaptation practices. In developing such resources, it is essential that professionals and practitioners be engaged in order to ensure practicality of policy guidelines, and ACT has convened a group of advisers from a variety of sectors to assist in this endeavour. To date, ACT has produced five major reports on climate change adaptation and biodiversity (2008), extreme weather (2009), low carbon economy (2010), water governance (2012), and crops & food supply (2013).

ACT is also part of the international Coastal Cities at Risk project led by Dr. Gordon McBean at the University of Western Ontario, which partners Metro Vancouver with researchers from Manila, Bangkok and Lagos in collaborative work on the physical, social, economic, health and organizational challenges facing delta megacities. This work brings together researchers from the natural and social sciences to explore common issues and potential solutions. Although the cities have widely differing challenges, it is interesting to note that all of them have the same challenges present, albeit in different proportions, and the opportunity to learn from one another about solutions and approaches already underway in each of the cities is an excellent example of one of the key principles of adaptation – namely, that we must collaborate across silos and disciplines in order to achieve solutions that can be implemented effectively and sustainably.



7. LEADING INNOVATORS

Innovative responses to flooding are being modeled around the world by vulnerable peoples including Holland, which has pioneered approaches such as retreat as well as enhanced seawalls and diking; Denmark, which recently won an international design award for a “blue-green” approach to adaptation in Copenhagen that overlands stormwater and creates permeable street ecosystems and parks that become lakes; and the Philippines, which are implementing social programs to assist vulnerable populations due to their extraordinary geographical and population challenge (2,000 islands, 93 million people) that makes hard engineering solutions an impossible route to take.

8. CONCLUSION

Flooding is one of the biggest climate change challenges facing countries all over the world. Spanning causes such as increases in precipitation due to more moisture falling as rain rather than snow plus increased evaporation due to higher temperatures, the sudden onset of snowmelt due to rapid spring warming after unusually heavy snowstorms, storm surges and sea level rise, it is essential that cities gain access to high-quality hydrologic data and the resources to understand how they can adapt. Building resilience to too much water will be one of the greatest challenges of the 21st century, but it can be done.

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