Coastal Hazards in Canada: Impacts and Building Community Resilience

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Sea Change Canada

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COASTAL HAZARDS, AN INTRODUCTION

Coastal hazards are threats associated with areas near or bordering coastlines that can have significant effects on Canadian shores (Griggs & Reguero, 2021; Statistics Canada, 2016). As of 2023, over 7 million Canadians live in seaside communities (Government of Canada, 2023b); however, climate change is threatening the stability and future of these populations. Climate change is increasing the intensity and frequency of coastal hazards such as flooding, storm surges, tsunamis, and harmful algal blooms (Huber & Gulledge, 2011; Panteli & Mancarella, 2015). As a result, Canadians will face more severe coastal hazards compared to past generations, with climate change-driven threats such as sea-level rise threatening the existence of Canada's shorelines. The ability for coastal communities to respond to these coastal hazards, using mitigation and adaptation strategies, is considered *coastal resilience*.

WHAT IMPACTS DO COASTAL HAZARDS HAVE ON OUR COMMUNITIES?

Across Canada, residential properties and community infrastructure like ferry docks, healthcare facilities, and water treatment plants are located in close proximity to the water (Gordon, 2015). Unfortunately, much of this infrastructure is at risk of damage and loss due to coastal hazards. Losing these vital infrastructures could also impact human health as Canadians could lose access to healthcare and clean water after major coastal hazard events. Altogether, loss of this infrastructure, loss of healthcare, and displacement caused by coastal hazards could also have vast economic impacts. A paper by Withey, Lantz, and Ochuodho (2015) has estimated that climate-related sea-level rise and storm surges could cost Canada $4.6-$25.5 billion in welfare and $53.7-$108.7 billion in Gross Domestic Product (GDP).

Coastal hazards can additionally lead to feelings of a loss of place, loss of community, and loss of culture. Many coastal communities have distinct ways of life that involve the ocean. As the land continues to be washed away, many coastal communities are in a race against time to preserve their way of life. For individuals and communities, losing their land and lifestyle can be an overwhelming experience. The psychological impacts of coastal hazards can include a deep sense of instability and mental health conditions like depression, anxiety, and post-traumatic stress disorder (PTSD) (Hayes, Berry, & Ebi, 2019; Wade, 2022).

Environmental degradation is another way for coastal hazards to impact our shorelines. In many areas, there are already degraded intertidal zones through human development and related pollution (United States Environmental Protection Agency, 2013); however, elevated sea-levels, storm surges, flooding, and tsunamis all have the potential to further aggravate these zones (Schaefer et al., 2020). Human-induced climate change has caused quick changes to sea levels, leaving species vulnerable to habitat loss, severe population declines, and extinction (Kaplanis, Edwards, Eynaud, & Smith, 2020; Kunze, Wölfelschneider, & Rölfer, 2021).

Figure 1: Canadian Coastal Hazards, made using Canva.

Sea-level Rise

Sea-level rise is a phenomenon that describes the ocean's surface rising compared to land elevation. According to the US National Oceanic and Atmospheric Administration (NOAA), the global sea level has risen between 21-24 cm since 1880 (Lindsey, 2020). Under unmitigated warming, projections for average global sea-level rise are estimated to be close to 1 m (Horton et al., 2020; James, Robin, Henton, & Craymer, 2021). Figure 2 depicts modeled sea-level changes by 2100 across Canada if climate change is unmitigated. Unless greenhouse gas emissions are reduced, sea-level rise could be higher than 1 m in the coming centuries.

Storm surges and flooding

Storm surges are temporary rises in sea level that occur during intense storms when strong winds move water further inland. In Canada, storm surges have been known to reach 2-3 m, leading to coastline damage, evacuation orders, and potential loss of life (Government of Canada, 2022a). Flooding can also happen because of storm surges or general sea-level rise. Striking in September 2022, Post-tropical storm Fiona struck Nova Scotia and caused coastal flooding, widespread power outages, and loss of life affecting the Maritimes and the St. Lawrence (Hanna, Cullinane, & Maxouris, 2022).

Erosion

Coastal erosion is the loss of land due to waves, coastal flooding, and elevated sea level, resulting in infrastructure loss and damage, habitat degradation, and terrestrial land loss (Prasad & Kumar, 2014). In Canada, coastal erosion has been a growing issue particularly in the Arctic and in Maritime provinces. Prince Edward Island has been eroding at a rate of 30 cm per year, which is expected to increase due to sea-level rise, increase in storms, and climate-related decreases in sea ice (Government of Prince Edward Island, 2021a).

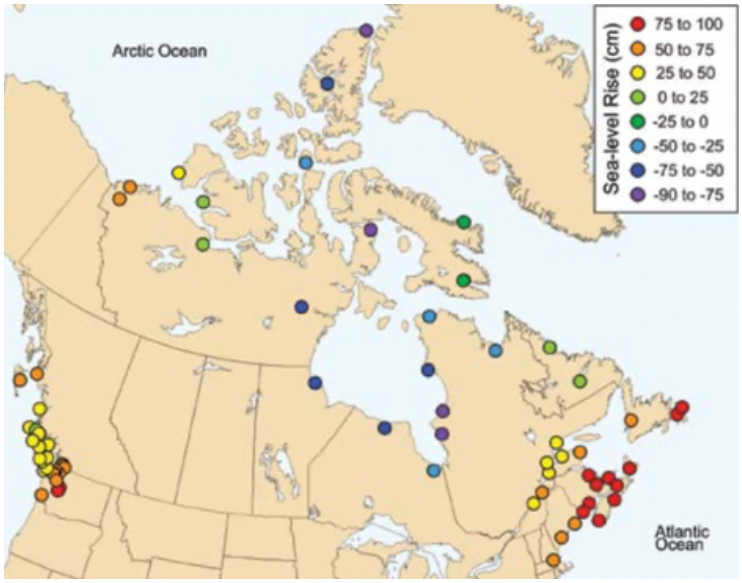

Figure 2: Projected sea-level rise for 2100 at Representative Climate Pathway of 8.5 (unmitigated climate change; Lennmen et al., 2016).

Tuktoyaktuk, an arctic community in the Northwest Territories, has been losing 1 m of coastline every year due to erosion, storm surges, and thawing permafrost caused by warming temperatures (Taylor & Kyle, 2022). In less than 50 years there's a possibility the island will be gone (Canadian Broadcast Company, 2022).

Harmful algal blooms

Algal blooms occur when warm, slow-moving, nutrient-rich water promotes the out-of-control growth of algae. Harmful algal blooms cause a plethora of issues for both humans and the environment, which includes illness and death of marine animals, human health risks, and economic impacts such as decreased tourism and food security risks (Waston et al., 2015; Denchak & Sturm, 2019; Gobler, 2019). Additionally, for native species, algal blooms can cause population declines (Colin & Dam, 2002). Warmer ocean temperatures from global warming alter ocean currents and even nutrient distribution due to alteration of precipitation patterns to increase occurrence of algal blooms (Gobler, 2019; Pick, 2016).

Tsunamis

Tsunamis are essentially walls of displaced ocean water moving as a wave, occurring as a result of tectonic plate activity and earthquakes. In Canada, tsunami risk is especially prevalent in B.C. due to the province's proximity to the active Cascadia subduction zone (Leonard, Rogers, & Mazzotti, 2013). With sea-level rise, tsunamis have the potential to reach further inland communities that would otherwise not be impacted.

COASTAL RESILIENCE THROUGH ADAPTATION AND MITIGATION STRATEGIES

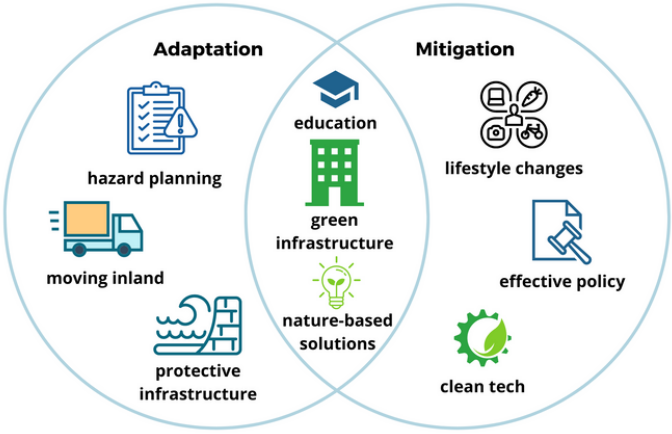

Figure 3: Venn Diagram depicting coastal adaptation and mitigation strategies, made using Canva.

Adaptation

Adaptive strategies focus on adapting to the changes global warming creates and include actions like hazard planning, protective infrastructure, and moving inland away from coastlines. Hazard planning involves comprehensive risk assessment, evacuation plans, and post-hazard recovery strategies, exemplified by PEI's online flood and storm surge mapping tool for risk awareness (Government of Prince Edward Island, 2021b). Protective infrastructure is climate-resilient infrastructure that can protect communities against coastal hazards and includes structures such as levees, sea walls, and breakwaters. Protective infrastructure exemplified by Vancouver's 28 km stone sea wall provides both defense against ocean threats and recreational opportunities for people (City of Vancouver, 2019). However, some communities in Atlantic Canada face the prospect of relocation. Across Atlantic Canada, it is estimated that over 60% of the population live within 5km of the shoreline (British Columbia Ministry of Environment, 2013).

University of Prince Edward Island's climate lab director has estimated that across PEI, 1000 homes, 146 commercial buildings, and 45 km of road will be lost to sea level rise and coastal erosion by 2100 (Canadian Broadcast Company, 2022). For families and communities, the extent of these losses will continue, as adaptive strategies do not halt drastic environmental changes.

Mitigation

Mitigation strategies for climate and coastal changes focus on finding solutions to curbing emissions and negative consequences through effective policy, clean technology, and lifestyle changes. One such policy is Canada's 2030 Emissions Reduction Plan, which seeks to reduce greenhouse gas emissions to reach net zero by 2050. However, current climate policies have been deemed insufficient and have the potential to result in 4°C warming above pre-industrial levels (Climate Action Tracker, 2023; Government of Canada, 2022b). Clean technology functions to reduce the environmental impacts of daily life through technology are on the rise across Canada. These clean technologies include more sustainable transportation systems and increasing the use of renewable energy sources like solar and wind. Additionally, Canadians produce almost three times the amount of CO2 compared to the global average, indicating a need to reduce individual carbon footprints (BC Hydro, 2022). For this reason, encouraging lifestyle changes like using public transportation as an alternative to individual use vehicles and purchasing local products where possible is another mitigation strategy (David Suzuki Foundation, n.d.). Overall, mitigation efforts are crucial to combatting coastal hazards and decreasing emissions.

Adaptation and mitigation strategies

Education, green infrastructure, and nature-based solutions are all strategies that fall under both adaptation and mitigation strategies. Education is an important aspect of building community resilience by raising awareness about potential coastal hazards and ways to mitigate risks that utilize handouts, information sessions, and social media infographics. For instance, the provincial government of PEI is offering residents a free online course about protecting homes from flooding and erosion (Government of Prince Edward Island, 2021b). Green infrastructure encompasses a range of nature-integrated solutions, including sustainable stormwater management via permeable pavement and rain gardens. An example in Kitchener, Ontario, is a permeable parking lot situated near Huron's Natural Area. The permeable parking lot serves as a demonstration site for sustainable stormwater management and has prevented soil oversaturation while facilitating improved plant water absorption (Canada Broadcast Company, 2016). Most nature-based solutions rely on restoring Earth's natural carbon sinks while offering resilience to environmental and coastal hazards. In Canada, nature-based solutions include actions like wetland and grassland restoration, sustainable agricultural land management, and improved forest management (Drever et al., 2021). Niagara Coastal is a non-profit organization whose Seed project is working on natural shoreline restoration by replanting locally harvested Champlain beach grass along the Lake Erie north shoreline (Niagara Coastal, 2021). The roots of the Champlain beach grass play a crucial role in sand stabilization, erosion prevention, and serve as a natural buffer against wave action and storm surges.

CONCLUSION

Coastal hazards compounded by climate change present communities with challenges unique to our shorelines. As climate change accelerates, sea-level rise and weather events become more frequent and intense, thus heightening the vulnerabilities of coastal communities. Coastal hazards, including erosion, storm surges, tsunamis, harmful algal blooms, and flooding threaten lives, infrastructure, our economy, and ecosystems. Addressing these complex coastal hazards warrants the need for a multi-faceted approach focused on building coastal resilience that encompasses both adaptive and mitigative strategies.

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