Final Report

Cost of Climate Change Adaptation Measures Menu

Submitted to:

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Image Source: McLaughlin, M. (2017, February 9). British Columbia's marine parks make boat-camping easy. BC Parks Blog. https://engage.gov.bc.ca/bcparksblog/2016/06/07/british-columbias-marine-parks-make-boat-camping-easy/

Executive Summary

Communities across British Columbia have made admirable progress in adapting to climate change; however, many other communities in the province are still in the early stages of climate change adaptation. While lists of adaptation options exist, oftentimes these lists leave out costs, making it more challenging for communities to weigh the options.

West Coast Environmental Law (WCEL) and Kerr Wood Leidal (KWL) identified this need, and from the fall of 2020 to the spring of 2021, they engaged a team of three master's students in the School of Community and Regional Planning. The project aims to create a "menu" of climate change adaptation options with associated costs, based on the actual experiences of communities that have implemented the adaptations. The team scoped the project to two climate change risk events: wildfires and stormwater flooding.

Working with project partners, the team conducted a five-stage, multi-method process:

1. a grey literature review,
2. interviews with seven practitioners,
3. interviews with municipal staff from 11 communities in BC,
4. two review workshops, and
5. menu design/creation.

The final menu included 11 adaptations, four for wildfires and seven for stormwater flooding:

Wildfire:

1. Community Wildfire Protection Plans (CWPPs)
2. Fuel Management
3. FireSmart
4. Development Permit Areas (DPAs)

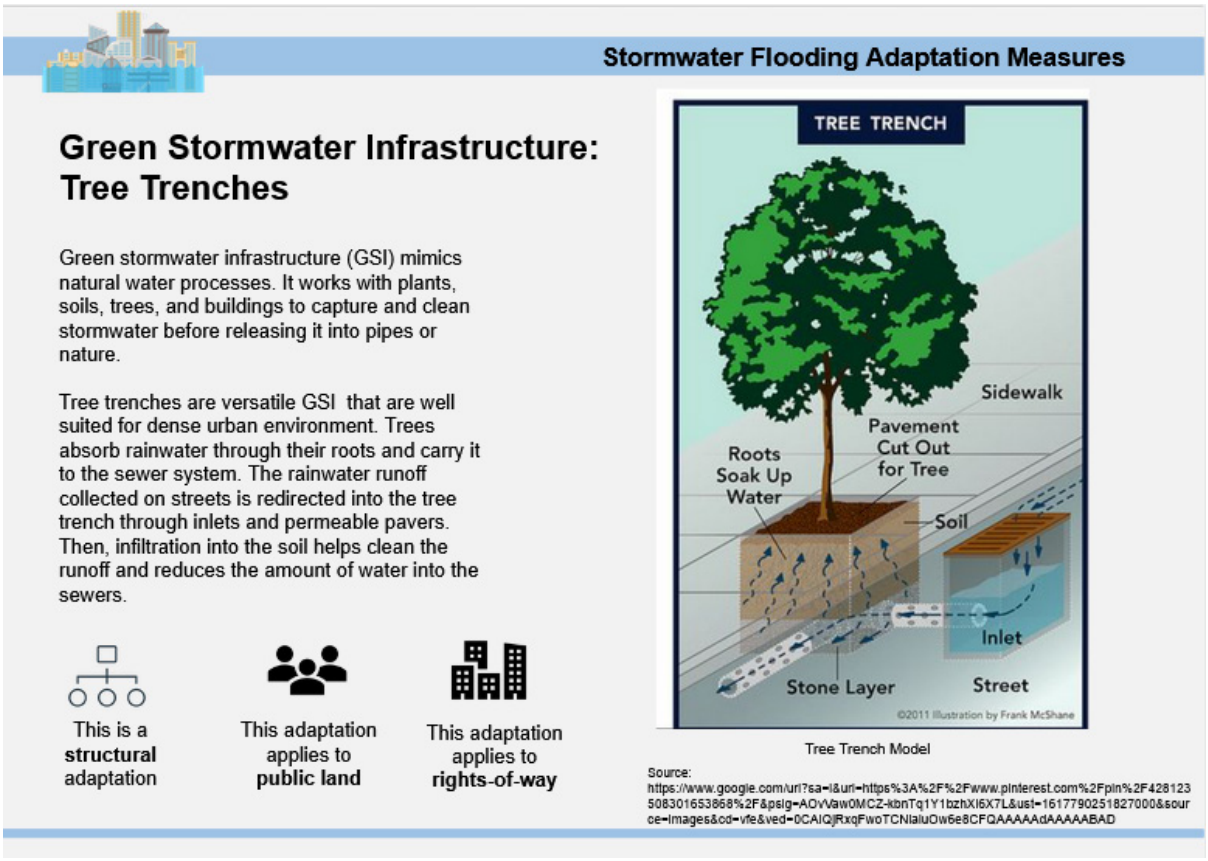
Stormwater flooding:

1. Integrated Stormwater Management Plans (ISMPs)
2. Tree trenches
3. Stormwater ponds
4. Prioritizing infrastructure using LIDAR
5. Wetland Enhancement
6. Developing business cases for natural assets
7. Stormwater utility & rewards program

Going forward, besides expanding the menu to include other risk events, further work could include adding case studies, quantifying benefits, breaking costs/benefits down by stakeholder, and publicizing the menu.

Image Source: Snowdon, W. (2017, August 4). Mountain pine beetle fuelling wildfire fears in Jasper. CBC. https://www.cbc.ca/news/canada/edmonton/mountain-pine-beetle-wildfire-jasper-1.4235253

Sample menu item from the final cost menu for climate change adaptations for stormwater flooding:



Stormwater Flooding Adaptation Measures

Green Stormwater Infrastructure: Tree Trenches

Green stormwater infrastructure (GSI) mimics natural water processes. It works with plants, soils, trees, and buildings to capture and clean stormwater before releasing it into pipes or nature.

Tree trenches are versatile GSI that are well suited for dense urban environment. Trees absorb rainwater through their roots and carry it to the sewer system. The rainwater runoff collected on streets is redirected into the tree trench through inlets and permeable pavers. Then, infiltration into the soil helps clean the runoff and reduces the amount of water into the sewers.

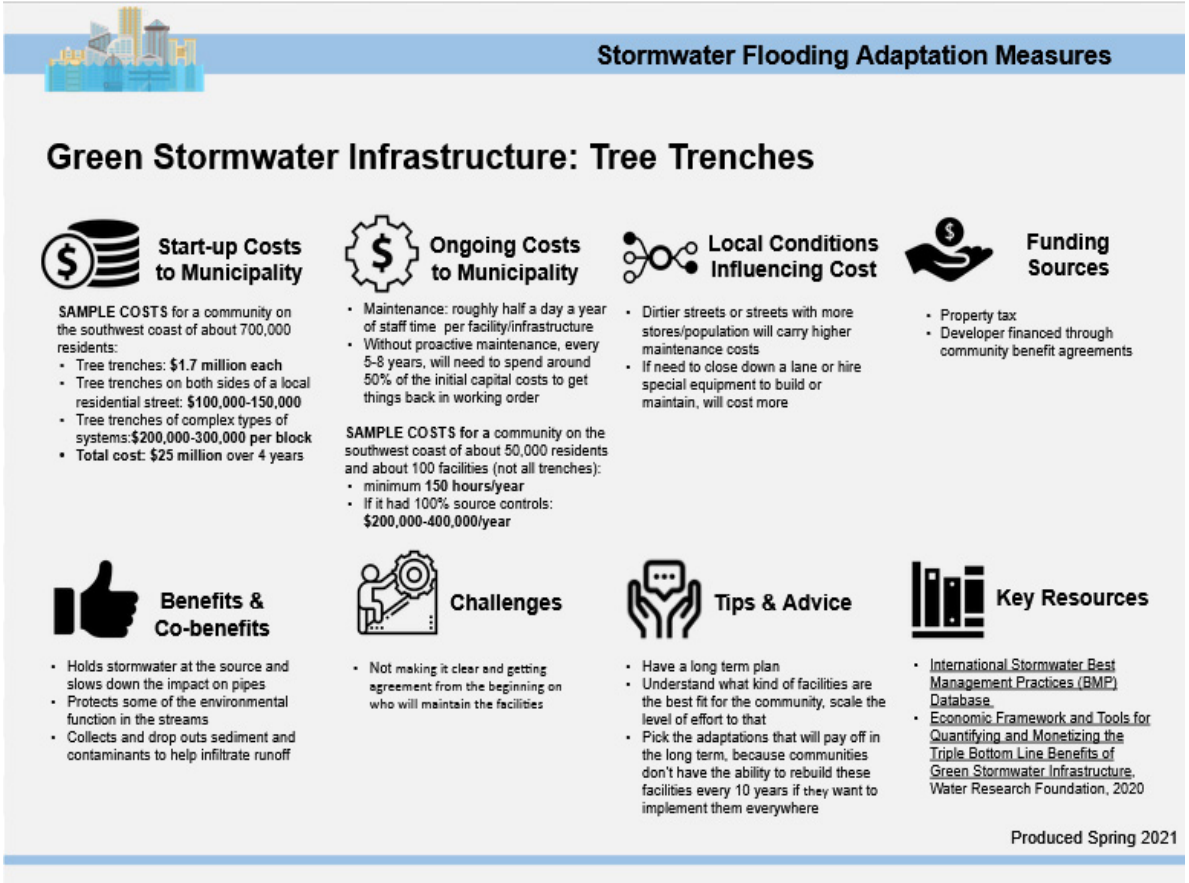
This is a **structural** adaptation

This adaptation applies to **public land**

This adaptation applies to **rights-of-way**

Tree Trench Model

Source: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.pinterest.com%2Fpin%2F428123508301653868%2F&psig=AOvVaw0MCZ-kbnTq1Y1bzhXI6X7L&ust=1617790251827000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCNiaiuOw6e8CFQAAAAAdAAAAABAD



Stormwater Flooding Adaptation Measures

Green Stormwater Infrastructure: Tree Trenches

Start-up Costs to Municipality

SAMPLE COSTS for a community on the southwest coast of about 700,000 residents:

- Tree trenches: **$1.7 million each**
- Tree trenches on both sides of a local residential street: **$100,000-150,000**
- Tree trenches of complex types of systems:**$200,000-300,000 per block**
- **Total cost: $25 million** over 4 years

Ongoing Costs to Municipality

- Maintenance: roughly half a day a year of staff time per facility/infrastructure
- Without proactive maintenance, every 5-8 years, will need to spend around 50% of the initial capital costs to get things back in working order

SAMPLE COSTS for a community on the southwest coast of about 50,000 residents and about 100 facilities (not all trenches):

- minimum **150 hours/year**
- If it had 100% source controls: **$200,000-400,000/year**

Local Conditions Influencing Cost

- Dirtier streets or streets with more stores/population will carry higher maintenance costs
- If need to close down a lane or hire special equipment to build or maintain, will cost more

Funding Sources

- Property tax
- Developer financed through community benefit agreements

Benefits & Co-benefits

- Holds stormwater at the source and slows down the impact on pipes
- Protects some of the environmental function in the streams
- Collects and drop outs sediment and contaminants to help infiltrate runoff

Challenges

- Not making it clear and getting agreement from the beginning on who will maintain the facilities

Tips & Advice

- Have a long term plan
- Understand what kind of facilities are the best fit for the community, scale the level of effort to that
- Pick the adaptations that will pay off in the long term, because communities don't have the ability to rebuild these facilities every 10 years if they want to implement them everywhere

Key Resources

- International Stormwater Best Management Practices (BMP) Database
- Economic Framework and Tools for Quantifying and Monetizing the Triple Bottom Line Benefits of Green Stormwater Infrastructure, Water Research Foundation, 2020

Produced Spring 2021

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Image Source: Resort Municipality of Whistler. (2015, December 17). Cheakamus community forest and the province of B.C. sign carbon offset program agreement. https://www.whistler.ca/media/news/cheakamus-community-forest-and-province-bc-sign-carbon-offset-program-agreement

1 Introduction

Canada is experiencing climate change. Canada's Changing Climate the 2019 report of the Government of Canada illustrated that the annual average temperature in Canada has increased by 1.7 Celsius degrees since 1948. The report also pointed out that the frequency and severity of extreme weather events are increasing across Canada as a result of climate change, which would increase flooding and wildfire risks as well as other impacts. Like many other regions in Canada, communities, residents, infrastructure, and natural resources in British Columbia (BC) are experiencing critical dangers caused by climate change.

In response, many communities in BC have implemented adaptation measures to increase their resilience and reduce future losses from hazard events (IBC & FCM, 2020). However, many other communities in BC are still in the early stages of developing adaptation strategies. West Coast Environmental Law (WCEL) and Kerr Wood Leidal (KWL), consultancies in BC, assessed that while general lists of possible adaptation measures are readily accessible to BC communities, those lists rarely come with cost figures, making it challenging for communities to weigh both the benefits and costs of a variety of measures at once. Therefore, WCEL and KWL wanted to create a "menu" of adaptation measures along with their costs to support BC communities on their path of climate change adaptation.

As part of the 2020-2021 winter session of the studio course in the Master of Regional and Community Planning program at UBC, instructors matched WCEL and KWL (hereafter also referred to as "partners") with a team of three students, Pulkit Kathuria, Emma Wang, and Charles Pan (hereafter also referred to as "the team" or "we") to work on this project over the course of the session. The team carried out the project while the partners and course instructors provided mentorship.

At an early stage of the project, in conversation with partners, the team decided to narrow the scope of the menu to two climate change risks: wildfires and stormwater flooding. This choice was the result of a combination of the team's interests, partners' assessment of community needs, and which risks were higher priority for BC.

Image Source: BC National Forest Week Coalition. (2021, March 4). BC National Forest Week. https://www.bcnfw.ca/

2 Aim and Objectives

2.1 Aim

The project aims to create a menu of climate change adaptation measures, along with costs, that have been adopted by communities across British Columbia for the risks posed by wildfire and stormwater flooding.

2.2 Objectives

The project aim can be broken down into four objectives:

- To gain a broad understanding of the field of wildfire and stormwater flooding adaptation in BC
- To find out the adaptations communities in BC have used
- To find out how much those adaptations have cost BC communities
- To communicate our findings in a menu format that's easy to understand and useful to other communities looking to adapt to wildfires and stormwater flooding

Weaver, A. (2018, November 7). It's time to stop spraying glyphosate on BC forests. Archived Andrew Weaver, MLA Page. https://www.andrewweavermla.ca/2018/11/07/time-stopping-spraying-glyphosate-bc-forests/

3 Methodology

To achieve the objectives, the team carried out five broad stages, each broken down into smaller tasks.

1. Literature review - Review the literature related to adaptation measures used for wildfire and stormwater flooding in BC.
- Review the causes and impacts of wildfire and stormwater flooding in BC
- Review the existing adaptation measures undertaken by communities in BC
- Review the sources of funding used by the communities to fund their adaptations

2. Practitioner interviews. Engage with practitioners in wildfire and stormwater flooding adaptation to become more familiar with these fields and the on-the-ground experiences.
- Conduct semi-structured interviews with practitioners in wildfire adaptation
- Conduct semi-structured interviews with practitioners in stormwater flooding adaptation

3. Community interviews. Engage with municipal staff and planners to understand the adaptation measures undertaken and the costs attached with the measures.
- Conduct semi-structured interviews with BC communities that have undertaken adaptations for wildfires
- Conduct semi-structured interviews with BC communities that have undertaken adaptations for stormwater flooding

4. Review workshops. Conduct workshops with interviewees to review the menu design.
- Create four sample menu items
- Conduct two workshops, one for wildfire adaptations, and one for stormwater flooding adaptations
- Incorporate suggestions from workshops into new menu design

5. Menu creation. Organise the data collected into a menu
- Extract the key information from all interviews, grouped by adaptation
- Put the data collected into menu templates
- Add introductory pages to help users understand the menu and the items
- Obtain feedback from interviewees and partners on the content and design

The following sections present summaries of the tasks and findings from each of the five stages.

II. PROJECT INSIGHTS

1. Literature review
2. Practitioner interviews
3. Community interviews
4. Review workshops
5. Menu creation
6. Recommendations for future work

Image Source: Richardson, The Denver Post via Getty Images, H. (2017, December 14). One-third of forests aren't growing back after wildfires. Grist. https://grist.org/briefly/one-third-of-forests-arent-growing-back-after-wildfires/

1 Literature Review

The team started the project by reviewing the grey literature available on wildfire and stormwater flooding adaptation in BC. While we reviewed background information on the two risks, such as their definitions, occurrence in BC, and impacts, the primary purpose was to identify communities in BC that have conducted adaptations for the two risks, in view of shortlisting some communities to speak with later on. We summarize our findings in Tables 1 and 2. Given our time limitations, these lists are not exhaustive and were meant to be complemented by other communities we expected practitioners to mention in interviews with them.

Community	Sample Adaptations for Wildfire
City of Kamloops	Covenants: mandate homeowners and developers to undertake measures to reduce the risk posed by wildfires (City of Kamloops, 2008, as cited in Richardson & Otero, 2012)
City of Prince George	Community Wildfire Protection Plan: responsible for carving out strategies to reduce the long-term impact of the wildfires in the city (Picketts & Coady, 2012). Strategies include public awareness of risks, Fire Smart initiatives and others. Fuel Management Program: manage wildfire risks due to Mountain Pine Beetle in the parks managed by the city (Picketts & Coady, 2012). Community Forest Future Opportunities: development of agroforestry - support required for the conversion into agricultural land, using the dead lodgepole pine for generating bio energy (Picketts & Coady, 2012)
Resort Municipality of Whistler	Community Energy and Climate Action Plan: risk assessment and vulnerability mapping, lists key adaptation measures (CECAP, RMOW, 2016)
City of Vancouver	Energy Cogeneration – An example of resilient energy infrastructure generates, stores and provides energy during natural calamities and disaster events. It provides more than one community benefit at a time.
District of Elkford	Development Permit Areas & Subdivision and Servicing Bylaws: prescribe certain measures to regulate the development of the area (OCP for District of Elkford 2010 cited by Carlson, D. 2012)
Cariboo Regional District	Explore use of water storage dams for agriculture in fighting wildfires (BC Agriculture & Food Climate Action Initiative, 2018)

Table 1. Communities in BC identified in the literature review that have done adaptations for wildfires

Image source: Fuel management | Balfour | Revelstoke — Loki tree service. (n.d.). Loki Tree Service. https://www.lokitree.com/fuel-management

Community	Sample Adaptations
City of North Vancouver	Integrated Stormwater Management Planning (ISMP): allow more rainwater to seep into the ground (City of North Vancouver, n.d.) Policies for greener buildings: amending zoning bylaw to support the construction of greener buildings (City of North Vancouver, n.d.)
City of Vancouver	Climate change-informed infrastructure design: integrate climate change projections in designing stormwater management systems (City of Vancouver, 2018) Urban Forest Strategy: extend conditions which require permits for tree removal on private property (City of Vancouver, 2018)
Town of Gibsons	Natural asset policy: recognize natural assets as an asset class and creates obligations to operate, maintain and replace them (Town of Gibsons, 2020a) Stormwater pond maintenance: conduct general maintenance and dredge ponds in local park (Town of Gibsons, 2020b).
City of Victoria	Stormwater utility: charge properties that have a greater impact on the stormwater infrastructure more (City of Victoria, 2020) Rainwater Rewards Program: providing rebates and credits for properties to install or that use “an approved rainwater management method” (City of Victoria, n.d.)

Table 2. Communities in BC identified in the literature review that have done adaptations for stormwater Flooding

2 Practitioner Interviews

After becoming more familiar with the grey literature available on wildfire and stormwater flooding adaptation in BC, the team conducted interviews with practitioners in the field, introduced to us through project partners. We spoke with seven practitioners in all (Table 3). For more details on how the team carried out this phase of engagement, please see Appendix C.

Contacts	Organisations	Risk
Bruce Blackwell	Blackwell Associates	Wildfire
Conor Corbett	Diamond Head Consulting	Wildfire
Francis J Reis	WSP formerly Metro Vancouver	Wildfire (Air Pollution Monitoring)
Harshan Radhakrishnan	Engineers and Geoscientists British Columbia	Flooding in general
Laurel Morgan	Kerr Wood Leidal	Stormwater Flooding
Gemma Dunn	GHD	Stormwater Flooding
David Reid	Lanarc Consultants	Stormwater Flooding

Table 3. Practitioners the team interviewed

Speaking with practitioners provided us further high-level insights into the climate change adaptations pertaining to wildfire and stormwater. In addition to helping us find communities to speak with, practitioners also shared what they thought would be useful to communities in a menu and insights related to the costs of adaptations to wildfire and stormwater flooding.

Guaiquin, N. A. (2018, October 28). City receives 128 calls about overnight flooding in Vancouver. Daily Hive Vancouver: Latest Stories in Vancity. https://dailyhive.com/vancouver/flooding-vancouver-response-october-2018

2.1 Wildfire

There are two broad streams of managing wildfire risk: physically modifying the vegetation surrounding the communities to reduce the likelihood of igniting a wildfire, and policy changes to incentivize private landowners to reduce the risk to their property from wildfire. Communities usually identify these adaptations in a community wildfire protection plan before embarking on them. Several factors influence whether communities focus more on structural/physical or policy:

Land ownership : Private lands also get affected from wildfire, and it's difficult legally to make requirements or make changes on private land. Practitioners advised that in such scenarios, policy options are the most effective to reduce wildfire risk. Policy options include Development Permit Areas and FireSmart.

Institutional comfort zone : Most communities are more interested in policy changes rather than physical modifications of forests because the language of policy is the language of communities, whereas fuel modification is more of a forestry activity, and they're not familiar with it.

Lack of supporting research : One practitioner stated that largely there is no scientific research to support their fuel management practises, and there is limited funding that has been allocated to do that research. That creates problems for professionals because community members don't like trees being cut, and the ones carrying it out don't have any direct measurable science to back them up.

Funding agencies : The most common funding source is a program called the Community Resiliency Investment (CRI), which is set up by the Union of BC municipalities. This program probably pays for 90%-95% of all wildfire work that happens in BC. CRI is trying to allocate and focus most of its money towards policy and planning initiatives and the provincial government is trying to focus on physical and structural initiatives, however, this transition would take some time.

Local capacity : The biggest challenge communities have is that the communities that are most at risk are the smaller, more isolated communities who usually have the smallest capacity for pursuing more initiatives. Capacity influences action in multiple ways:

- **Administration costs -** Even if there's money available (e.g., CRI) to pursue these initiatives, there's still a huge amount of administration costs associated with pursuing them.
- **Ability to hire consultants -** Some of the wealthier communities can afford to hire consultants to administer these contracts and these grants for them while some communities cannot.
- **Resource person on staff -** Many communities don't have a resource person to implement anything, and usually the easiest thing is trying to do the education so the communities will have an idea of how to implement the adaptations.

Paul, B., & Local Journalism Initiative Reporter. (2021, February 4). B.C. will consider recommendations of report linking climate change to logging practices. Victoria News. https://www.vicnews.com/news/b-c-will-consider-recommendations-of-report-linking-climate-change-to-logging-practices/

2.2 Stormwater Flooding

There are two main infrastructure types to manage stormwater: grey infrastructure and green infrastructure. Grey infrastructure refers to structures such as dams, pipes and water treatment plants Green infrastructure, such as tree trenches and wetlands, tries to mimic natural water processes by using plants, soils, trees, and buildings to capture and clean stormwater before returning it to nature. Grey infrastructure tends to have higher capital costs and lower maintenance costs, while green infrastructure tends to have lower capital expenditure but higher operations and maintenance costs in the longer term.

Practitioners pointed out a few areas of consideration when creating a cost menu for stormwater flooding adaptations.

Site-specific factors : For the costs of the adaptations, most practitioners mentioned that they don't expect generalized costing information will be available or helpful. Costs vary all the time and from place to place. There are also too many site-specific variables, such as flood protection levels, land use context, land need and cost, site access, ground conditions, environmental issues and mitigation costs.

Scale : Costs largely depend on the scale as the adaptations can be implemented on a building scale, street scale, neighborhood scale and watershed scale. For example, there's a stormwater infrastructure in the Hinge Park of the City of Vancouver, it collects stormwater and it treats it and then gets to a wetland habitat area, at the end of the park that goes into False Creek.

Unawareness of full costs : But a big challenge is that communities are not clear enough with how much operations and maintenance, how much knowledge they have to look after the infrastructure, how much staff capacity is needed to monitor the site, all of those things will add cost. Communities need to think about where's the best place to implement the adaptations that are going to have the biggest impact as every community is really limited in terms of financial resources. So, one particular adaptation could be effective at its most simple form, but a community might want to increase its effectiveness and then build more effectiveness and that makes it more expensive. Hence, mentioning some of the above information in the menu will be of great help to communities to implement the adaptations.

Funding sources : There are multiple choices for communities who are looking for funding sources. Programs that are coming from the Federal Government are aimed at mitigating costs of disaster relief, so the provincial and federal governments could be their choices. There is planning funding (disaster relief or emergency funding) that's filtering down from the federal government to the province. These programs are funding money through Union of BC municipalities, which are funding a series of flood mitigation studies right now.

Moreover, general revenue from taxpayers is one of the most common sources and then the development charges is also a good choice for communities.

Ultimately, there is no silver bullet for communities; they need to consider all the variables before implementing an adaptation. Therefore, communities should pay attention to their very specific circumstances, and adaptations should be coordinated so that their limited resources are used efficiently.

3 Community Interviews

After the practitioner interviews, the team proceeded to interview communities. While the literature review and practitioner interviews revealed many communities which had implemented adaptations for wildfire and stormwater flooding, time limitations constrained the team to create a shortlist. The team, with partner input, chose communities based on a combination of innovativeness of adaptations, geographical location, and community size.

We interviewed municipal staff and planners in 11 municipalities: six that had conducted wildfire adaptations and five that had conducted stormwater flooding adaptations (Table 4). For more details on how the team carried out this phase of engagement, please see Appendix D.

Contacts	Organisations	Risk
Andrea Byrne	City of Prince George	Wildfire
Tara Bergeson	City of Kelowna	Wildfire
Megan Latimer	District of Squamish	Wildfire
Heather Beresford	Resort Municipality of Whistler	Wildfire
Heather Keith	District of West Vancouver	Wildfire
Guy Exley	District of North Vancouver	Wildfire
Melina Scholefield	City of Vancouver	Stormwater
Brianne Czypyha Nina Sutic-Bata Summer Goulden	City of Victoria	Stormwater
Emanuel Machado	Town of Gibsons	Stormwater
Dave Matsubara	City of North Vancouver	Stormwater
Geoff Mulligan	City of Vernon	Stormwater

Table 4. Local government staff the team interviewed.

Image Source: Jordan, D. (2015, July 9). Can B.C.'s forests cope with climate change? BCBusiness. https://www.bcbusiness.ca/can-bcs-forests-cope-with-climate-change

Interviewees provided us with detailed insights into the adaptation measures undertaken by their communities, the related costs, benefits, challenges and the funding sources. They also provided recommendations for other communities who would be using the information to undertake relevant adaptation measures.

3.1 Wildfire

Wildfire being a growing threat due to the changing climate was one of the top priority risk areas in communities we interviewed. Communities are using four different types of adaptation measures to reduce the risk of wildfire in their communities. The adaptation measures include Community Wildfire Protection Plan, Fuel Management, Fire Smart and Development Permit Areas (DPA).

Each adaptation measure is unique and is categorically different in its approach towards tackling wildfire risk. One of the differences lies in the responsibility of carrying out the adaptation measure. Since, Fire Smart and Development Permit Areas (DPA) affect private lands and properties, the onus is on the property owners to undertake the measures, unlike fuel management which is done on government land particularly forests and parks. Community Wildfire Protection Plan (CWPP) on the other hand is a policy document which is usually the first step of municipalities towards undertaking wildfire adaptations since it helps strategize and set targets.

Fuel management was identified as one of the most expensive adaptation measures. It requires financial support from the senior levels of government (provincial and federal). Density of forest is one of the major factors that influences the cost of fuel management. Through the interviews it was observed that fuel treatment cost is higher for denser forests. Forests in the coastal communities being denser result in higher fuel treatment cost as compared to the interior communities.

Challenges : Communities face several challenges while adopting and implementing adaptation measures. Lack of adequate funding is one of the major challenges faced by the communities, which could potentially hinder the continuity of the process. Other challenges include lack of staff especially in the northern and interior communities. Lack of public support is also a challenge in scenarios where municipalities did not properly communicate.

Funding : In addition to the property taxes collected by the municipalities, Union of British Columbia Municipalities (UBCM) is one of the agencies responsible for funding the adaptation measures. The names of the funding programs change quite frequentl. The current Community Resiliency Investment (CRI) funding provided by UBCM for wildfire adaptation was earlier known as Strategic Wildfire Prevention Initiative (SWPI). Municipalities usually hire professional foresters for filing the grant application in addition to creating the CWPP.

Climate Change and Public Support : Another important point raised in the interview was that the municipalities and especially the public are much more cognizant of the risks associated with climate change and its effect on wildfires. Major wildfire incidents like Fort McMurray, Alberta, 2016 and other frequently occurring fires in communities across British Columbia have prompted efforts from the municipality and the much-needed public support to undertake adaptation measures. Furthermore, effective communication between the municipality and public was described as a key towards successful adoption and implementation of wildfire adaptation measures.

3.2 Stormwater Flooding

As one of the top priority risks, the threat of stormwater flooding in BC has been increasing over the past decades. Through our conversations with communities in BC, we distilled six adaptations which other communities could implement to mitigate or prevent the results of stormwater. These adaptations include integrated stormwater management plans (ISMP), tree trenches, prioritizing infrastructure using LIDAR, wetland enhancement, stormwater ponds, natural asset management planning, and stormwater utility and rewards.

Though every adaptation is unique, they all try to deal with the quantity and quality of stormwater. Green stormwater infrastructure (GSI) such as rain gardens, tree trenches, and permeable pavers is one of the most common stormwater adaptations as it helps absorb and treat rainwater where it falls, slowing the flow of rainwater and cleaning it before returning it to nature.

Integrated stormwater management plans (ISMP), wetland enhancement, and stormwater utility and rewards are more or less related to GSI as one or more GI might be used during the implementation of these adaptations. Stormwater pond can help settle out sediments and remove pollutants from stormwater. Natural Asset Management Plan refers to creating a plan that accounts for the jurisdiction's natural assets such as parks and streams.

Challenges : There are several challenges that communities are facing while implementing these adaptations. A big challenge for most communities is that they do not have effective long-term financial planning or funding, which could directly cause problems to the maintenance process. Another common challenge is that obtaining regulatory approval will waste a lot of time. Also, getting the public and political support in the beginning of the adaptation is a challenge when the public does not have experience with related projects.

Funding : General revenue from taxpayers is one of the most common funding sources and the development charges from private properties is also a good choice for communities. Funding from the federal and provincial governments is the most common one. Municipal Natural Assets Initiative (MNAI) and Rural and Northern Communities Infrastructure Stream (RNIS) of the investing in Canada plan are also providing funding to communities. Sometimes the program itself (e.g., Rainwater Rewards Program) also provides funding to the communities.

Image Source: Cameron, K. (2017, October 12). Torrential rainfall causes flooding in Vancouver streets. Daily Hive Vancouver: Latest Stories in Vancity. https://dailyhive.com/vancouver/vancouver-flooding-rainfall-october-12-2017

4 Review Workshops

After the community interviews, the team analyzed three community interviews and created four sample menu items showing four adaptations, two for wildfires, and two for stormwater flooding (see Figure 1). The team invited all past interviewees to two workshop sessions to review the four menu items. Six participants attended the workshops in total: three local government staff, one practitioner, and two project partner members. One session focused on wildfires while the other focused on stormwater flooding.

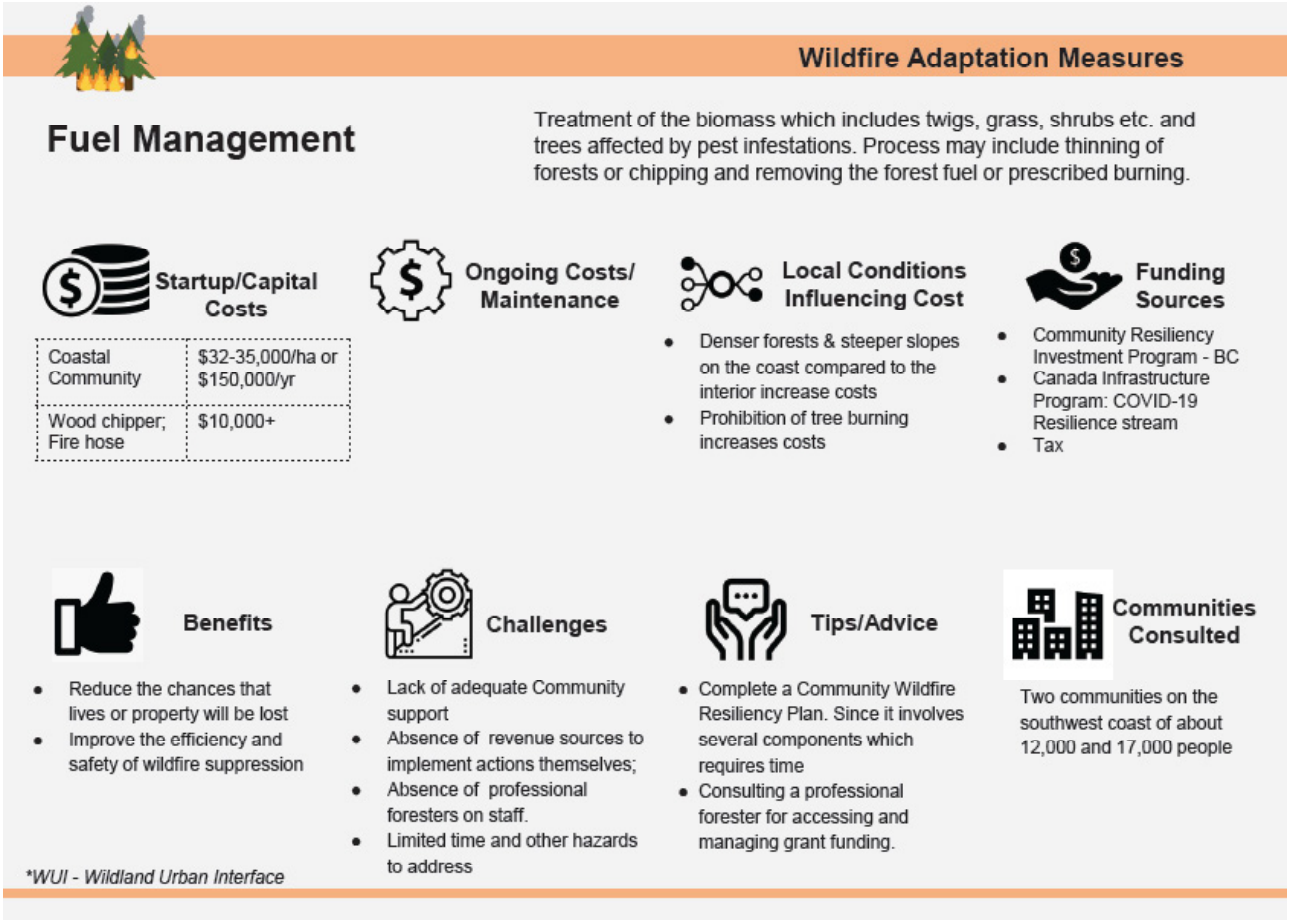


Figure 1. Sample menu item used in a workshop

For more details on how the team carried out this phase of engagement, please see Appendix E.

The feedback we received revealed a few key themes:

Menu framing : Participants discussed how the menu was intended to be used; for example, at what stage of the adaptation planning process, whether standalone or paired with other actions, whether digital or physical, for what purposes (e.g. on a website, in a slide presentation), or how it fits in with broader planning processes (e.g. GHG emissions planning).

Contextualizing costs : Participants felt more clarity was needed around the cost numbers. Seeing the draft menu items list specific numbers, participants wondered where the costs came from and whether the costs captured the full range of differences between communities.

Privacy : Concerned about information privacy, we asked about identifying communities on menu items. Participants find it valuable to see who they can talk to, and while listing the

communities would save users time, much of the information is already available publicly. One participant noted that they would need to check with their manager before associating specific information with their community.

A bigger picture. Participants reminded us of many other factors in climate change adaptation. There are not just benefits in relation to the climate risk but also co-benefits. Users may be in communities in different stages of adaptation. There are other aspects of adaptations (e.g. public acceptability, ease of implementation) as well as of costs (e.g. learning curve, public engagement).

As a response to the feedback, the team made a few changes to the menu (see Figure 2):

- Including introductory pages to make clear where the menu came from, how it's intended to be used, and some limitations of the menu;
- Listing cost components and providing sample costs in the communities we interviewed when we had the numbers;
- Providing the communities consulted at the beginning of each risk instead of on the menu item to save users time in finding contacts to speak with while preserving anonymity of information;
- Changing the category "advantages" to "benefits and co-benefits"; and
- Adding key resources/documents, ownership and use of land affected, and the year the menu item was made.

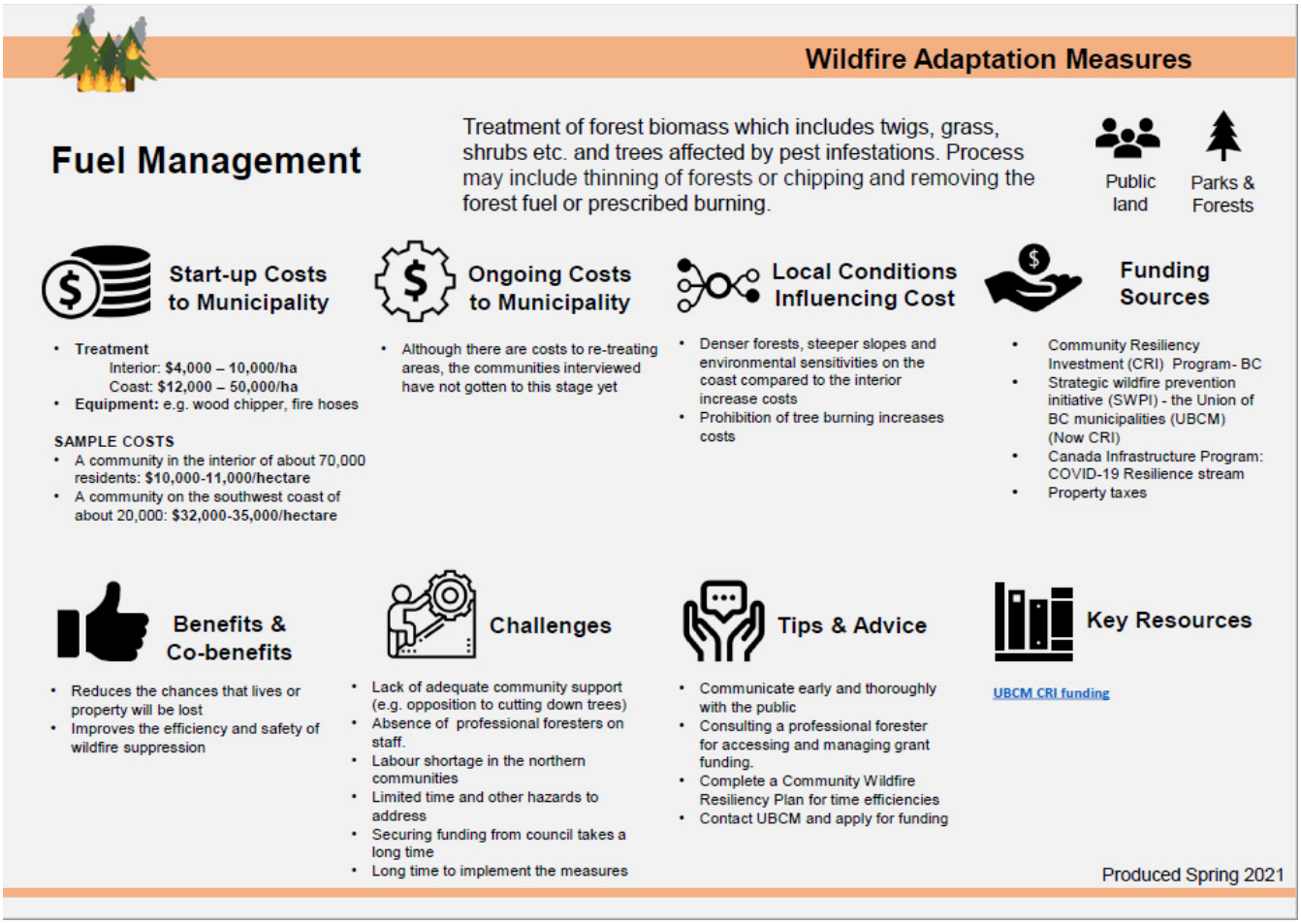


Figure 2. Sample updated menu item after the workshops

5 Menu Creation

With an updated menu design, the team proceeded to extract key information from the rest of the community interviews and turn them into menu items. Although interviewees mentioned many adaptations, the team chose to present the adaptations with relatively more complete content. The team also added a title page, two introductory pages to the menu, an "explainer" page showing how to read a menu item, and two section-level introductory pages to provide background on the climate risks.

The team sent out the draft menu to interviewees, project partners, and a course instructor to verify the information and obtain more feedback on the content and design. A number of interviewees responded with adaptation-specific comments, a course instructor responded with feedback on the presentation of the information, and project partners provided feedback on the same in a meeting with the team.

Taking all the feedback into account, the team made a few more adjustments to the menu, in both design and content. The major changes were:

- Giving each adaptation two pages, with the adaptation name, description, classification, and a picture on the first page and the other details on the second page. This format primarily allows for a longer description.
- Adding a methodology page at the beginning.

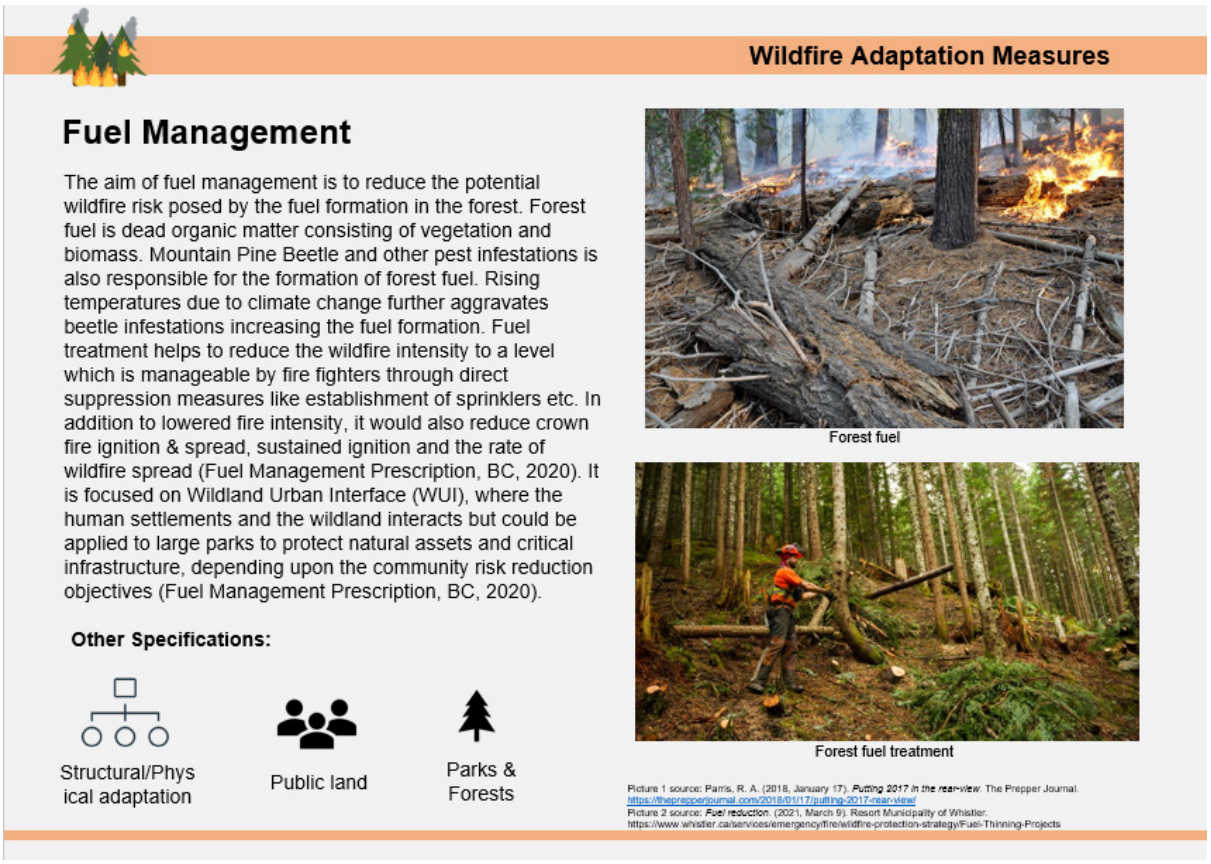
The final menu included the four wildfire adaptations and seven stormwater flooding adaptations (see Figure 3).

Wildfire adaptations:

1. Community Wildfire Protection Plans (CWPPs)
2. Fuel Management
3. FireSmart
4. Development Permit Areas (DPAs)

Stormwater flooding adaptations:

1. Integrated Stormwater Management Plans (ISMPs)
2. Tree trenches
3. Stormwater ponds
4. Prioritizing infrastructure using LIDAR
5. Wetland Enhancement
6. Developing business cases for natural assets
7. Stormwater utility & rewards program



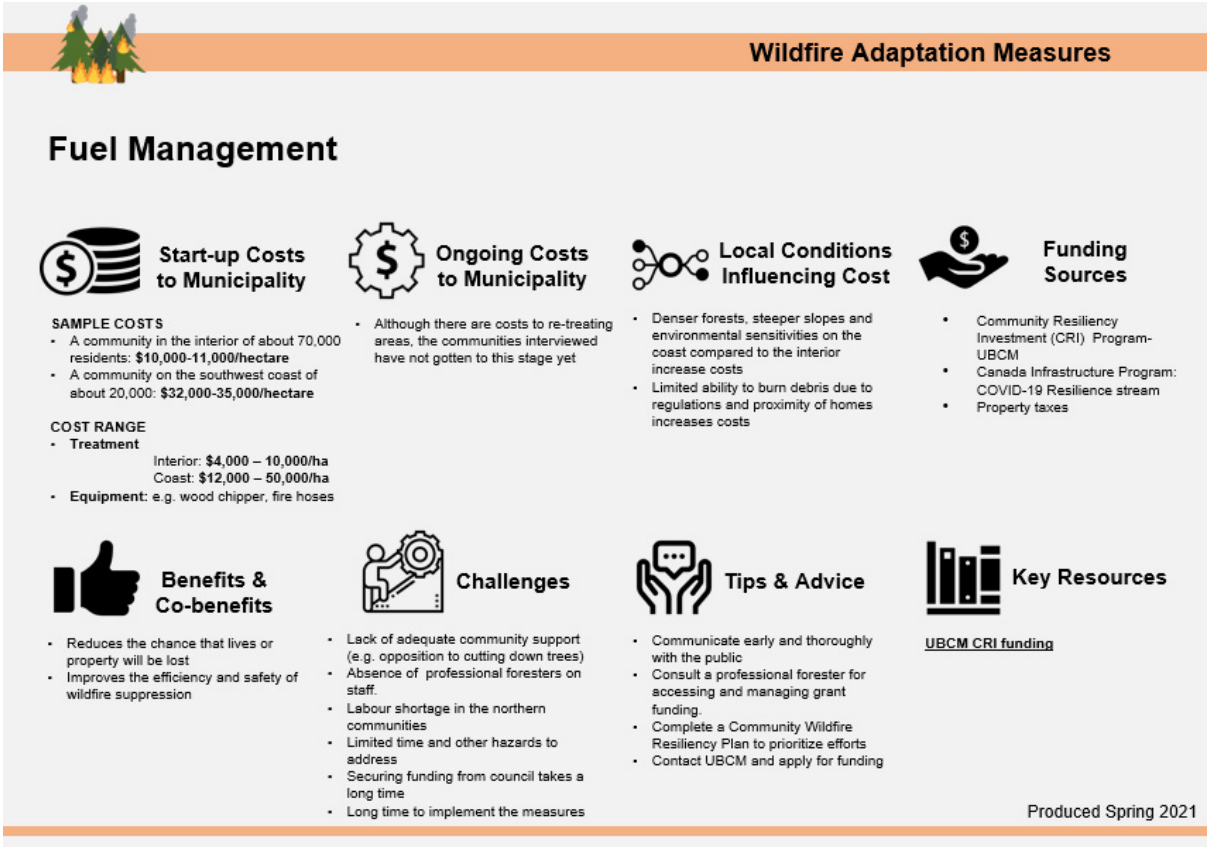


Figure 3. Final menu item design

For the full final menu, please refer Appendix F.

6 Recommendations for future work

There is a clear need to complete the menu by including more adaptations, not only for wildfire and stormwater flooding but also for other climate change risks in BC. However, there are a few other ways that the menu could be expanded upon, which are detailed below. Many of these were highlighted by workshop participants.

Case studies: Participants in both workshops supported the idea of case studies alongside the menu, with one participant in particular feeling strongly about it. Although we have tried to convey some benefits of case studies with sample cost information and listing communities interviewed at the beginning of each section, case studies would still give users a more concrete sense of the magnitude of the adaptations. As this may associate specific information with particular communities, this would require time to have the material reviewed by the featured communities.

Quantifying benefits: Although the current design mentions benefits of adaptations, quantifying the benefits would make it easier for communities to justify the spending on the adaptations. This could put higher-cost adaptations with strong benefits at a more level "playing field" with lower-cost adaptations.

More stakeholders: This project only listed costs borne by the local government. A more complete menu could look also at costs borne by private parties, senior governments, civil groups, non-profits, etc. Benefits, as well, could be broken down into benefits for the public and benefits to private parties.

Publicity: Once the menu is in a ready-to-distribute format, to ensure that it can be used by the most communities possible, it may help to publicize the menu somehow, such as at conferences in the province related to climate change or local government.

Image Source: Kardashian, K. (2018, March 18). Four steps to a perfect presentation. Tuck School of Business. https://www.tuck.dartmouth.edu/news/articles/four-steps-to-a-perfect-presentation

IV. References

References

BC Agriculture & Food Climate Action Initiative. (2018). Regional adaptation strategies update: Cariboo. https://www.bcagclimateaction.ca/wp/wp-content/media/RegionalStrategies-Cariboo-2018-update-report.pdf

BC Wildfire Management Branch. (n.d.). Fire atlas. https://bcfireinfo.for.gov.bc.ca/History/FireAtlas/?year=2011&type=all

BC Wildfire Service. (2020). BCWS Fuel Management Prescription Guidance 2020. Province of British Columbia. https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/wildfire-status/prevention/fire-fuel-management/fuels-management/2020_fuel_management_prescription_guidance_final.pdf

Berke, P. R., & Stevens, M. R. (2016). Land use planning for climate adaptation: Theory and practice. Journal of Planning Education and Research, 36(3), 283-289.

Natural Resources Canada. (2020, July 16). Boreal forest. https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/sustainable-forest-management/boreal-forest/13071

Brandt, J. (2009). The extent of the North American boreal zone. Environmental Reviews 17: 101-161. doi:10.1139/A39-004

Bronkhorst, S., & Bob, U. (2014). Conflict-sensitive adaptation to climate change in Africa.

Burton, I. (1996). The growth of adaptation capacity: Practice and policy. In J. B. Smith, N. Bhatti, G. V. Menzhulin, R. Benioff, M. Campos, B. Jallow, F. Rijsberman, M. I. Budyko, & R. Dixon (Eds.), Adapting to climate change: An international perspective (pp. 55-67). Springer-Verlag.

Canadian Wildland Fire Information System. (n.d.). https://cwfis.cfs.nrcan.gc.ca/report/graphs#gr2

CCEM Strategies Ltd. (2019). Flood risk assessment report. https://www.rdn.bc.ca/sites/default/files/inline-files/RDN%20Flood%20Report%20FINAL_0.pdf

Carlson, D. (2012). Preparing for climate change: An implementation guide for local governments in British Columbia. West Coast Environmental Law. https://www.wcel.org/sites/default/files/publications/WCEL_climate_change_FINAL.pdf

Center for Climate and Energy Solutions. (2020, August 31). Wildfires and climate change. https://www.c2es.org/content/wildfires-and-climate-change/

Church, M. (1988). Floods in cold climates. In V. R. Baker, R. C. Kochel, and P. C. Patton, (Eds.), Flood geomorphology (pp. 205–229). Wiley-Interscience.

Community wildfire protection plans. (2021, March 23). https://www.rdck.ca. https://rdck.ca/EN/main/services/emergency-management/wildfires/community-wildfire-protection-plans.html

City of Kamloops FireSmart Committee. (2008). City of Kamloops Community Wildfire Protection Plan. Kamloops, B.C. Retrieved from www.kamloops.ca/firerescue/pdfs/cwpp.pdf.

City of Kamloops. (1992). Council policy: Development in urban/wildland interface hazards areas (No. EDS-8). Kamloops, B.C. Retrieved from https://kamloops.civicweb.net/Documents/DocumentDisplay.aspx?ID=8299.

City of North Vancouver. (2013). Climate change adaptation plan. https://www.cnv.org/-/media/city-of-north-vancouver/documents/climate-change-adaptation/city-of-north-vancouver-climate-change-adaptation-plan.ashx?la=en

City of North Vancouver. (n.d.). Climate change adaptation. Retrieved December 3, 2020, from https://www.cnv.org/your-government/living-city/climate-action/climate-change-adaptation

City of Vancouver. (2018). Climate change adaptation strategy: 2018 update and action plan. https://vancouver.ca/files/cov/climate-change-adaptation-strategy.pdf

City of Victoria. (2020). Stormwater utility. Retrieved December 2, 2020, from https://www.victoria.ca/EN/main/residents/water-sewer-stormwater/stormwater/stormwater-utility.html

City of Victoria. (n.d.). Rainwater rewards program. Retrieved December 2, 2020, from https://www.victoria.ca/EN/main/residents/water-sewer-stormwater/stormwater/rainwater_rewards_program.html

City of Williams Lake. (2005). Official community plan, Chapter 7 – Development permit areas. http://bc-williamslake.civicplus.com/DocumentCenter/View/291/CHAPTER-7DEVELOPMENT-PERMIT-AREAS?bidId=

Cullington, J., & Gye, J. (2010). Urban forests: A climate adaptation guide. British Columbia. Ministry of Community, Sport and Cultural Development. http://www.toolkit.bc.ca/sites/default/files/Urban_Forests_Guide.pdf

Development permit area guidelines. (n.d.). BC Climate Action Toolkit | climate solutions for BC local governments. https://www.toolkit.bc.ca/dpa

Engineers and Geoscientists British Columbia. (2018). Professional practice guidelines – Legislated flood assessments in a changing climate in BC.

FireSmart. (2021, March 15). FireSmart BC. https://firesmartbc.ca/

Natural Resources Canada. (2020, August 10). Forest fires. https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/wildland-fires-insects-disturban/forest-fires/13143

Georgeson et. al. (2016). Adaptation responses to climate change differ between global megacities. Nature Climate Change volume 6, pages 584–588 (2016). Retrieved from: https://www.nature.com/articles/nclimate2944

Hurlimann, A., & March, A. (2012). The role of spatial planning in adapting to climate change. WILEY Interdisciplinary Reviews - Climate Change, 3(5), 477-488. https://doi.org/10.1002/wcc.183

IPCC. (2007). Climate change 2007: The physical science basis. Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Insurance Bureau of Canada & Federation of Canadian Municipalities. (2020). Investing in Canada's future: The cost of climate adaptation at the local level. Retrieved from: http://assets.ibc.ca/Documents/Disaster/The-Cost-ofClimate-Adaptation-Report-EN.pdf

King-Scobie, C. (2019). Urban flood management and disaster in Canada: incidence, recovery strategy, and environmental resilience [Doctoral dissertation]. https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.0387299

King-Scobie, C. (2020). All floods database. https://open.library.ubc.ca/cIRcle/collections/ubctheses/33426/items/1.0388502

Kirchmeier-Young, M. C., & Zhang, X. (2020). Human influence has intensified extreme precipitation in North America. Proceedings of the National Academy of Sciences, 117(24), 13308-13313. https://doi.org/10.1073/pnas.1921628117

Krishnaswamy, A., Simmons, E., & Joseph, L. 2012. Increasing the resilience of British Columbia's rural communities to natural disturbances and climate change. BC Journal of Ecosystems and Management 13(1):1–15. Published by FORREX Forum for Research and Extension in Natural Resources.http://jem.forrex.org/index.php/jem/article/viewFile/164/115

Martinez-Diaz, L. (2018). Investing in resilience today to prepare for tomorrow's climate change. Bulletin of the Atomic Scientists, 74:22, pp. 66-72.

Matthews, T., & Baker, D. (2019). Advancing responses to climate change through improved interplay between planning theory and practice. International Planning Studies, 1-14. https://doi.org/10.1080/13563475.2019.1674640

McMahon, Tamsin. 2018. "In wildfire-prone B.C. and California, urban sprawl and bad planning are fuelling future infernos. What can we do?" The Globe and Mail. 24 February 2018. https://www.theglobeandmail.com/world/article-in-wildfire-prone-bc-and-california-urban-sprawl-and-bad-planning/

Ministry of Environment and Climate Change Strategy (2019). Preliminary Strategic Climate Risk Assessment for British Columbia. Report prepared for the Government of British Columbia, Victoria, BC. Accessible at: https://www2.gov.bc.ca/gov/content/environment/climate-change/adaptation/riskassessment

Ministry of Forests, Lands, Natural Resource Operations and Rural Development. (2019). Impacts of 2018 Fires on Forests and Timber Supply in British Columbia. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/stewardship/forest-analysis-inventory/impacts_of_2018_fires.pdf

National Institute of Building Sciences. (2018). Natural hazard mitigation saves: 2018 interim report. Retrieved from: https://www.nibs.org/page/mitigationsaves

National Round Table on the Environment and the Economy. (2011). Paying the price: The economic impacts of climate change for Canada. Ottawa (ON): NRT.

Noble, I.R., S. Huq, Y.A. Anokhin, J. Carmin, D. Goudou, F.P. Lansigan, B. Osman-Elasha, & A. Villamizar. (2014). Adaptation needs and options. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and L. L.White (Eds.), Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the Intergovernmental Panel on Climate Change (pp. 833-868). Cambridge University Press. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap14_FINAL.pdf

Parry, M., Arnell, N., Berry, P., Dodman, D., Fankhauser, S., Hope, H., Kovats, Sari., Nicholls, R., Satterthwaite, D., Tiffin, R., Wheeler, T. (2009). Assessing the costs of adaptation to climate change - A review of the UNFCCC and other recent estimates. Retrieved from: https://pubs.iied.org/pdfs/11501IIED.pdf
Perkins, D., & Eade, G. (2015). British Columbia wildfire fuel typing and fuel type layer description. Ministry of Forests, Lands, and Natural Resource Operations. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/wildfire-management/fire-fuel-management/bcws_bc_provincial_fuel_type_layer_overview_2015_report.pdf

Picketts, I., & Coady, C. (2012). Implementing climate change adaptation in Prince George BC (Volume 3: Forests). Natural Resources Canada. https://princegeorge.ca/City%20Services/Documents/Environment/Climate%20Action/Adaptation_ImplementingClimateChangeAdaptation_Vol3.pdf

Picketts, I., & Dyer, D. (2012). Implementing climate change adaptation in Prince George, BC; Volume 4: Flooding. City of Prince George. https://www.princegeorge.ca/City%20Services/Documents/Environment/Climate%20Action/Adaptation_ImplementingClimateChangeAdaptation_Vol2.pdf

Richardson, G.R.A. and Otero, J. (2012). Land use planning tools for local adaptation to climate change. Ottawa, Ont.: Government of Canada, 38 p.

Samson, R., Arnold, J., Ness, R., & Clark, D. (2020). Enhancing Community Resilience as Wildfire Risk Increases. Canadian Institute for Climate Choices. https://climatechoices.ca/publications/enhancing-community-resilience-as-wildfire-risk-increases/

The Council of Canadian Academies. (2019). Canada's top climate change risks. Retrieved from: https://cca-reports.ca/wp-content/uploads/2019/07/Report-Canada-top-climate-change-risks.pdf

The Resort Municipality of Whistler. (2016). Community energy and climate action plan. https://www.whistler.ca/sites/default/files/2020/Jun/related/26399/cecap_draft_7_0_final.pdf

Town of Gibsons. (2017). Advancing municipal natural asset management: The town of Gibsons' experience in financial planning & reporting. https://gibsons.ca/wp-content/uploads/2018/01/GibsonsFinancialPlanningReportJan2018-PRINT.pdf

Town of Gibsons. (2020a). Gibsons' natural asset management journey. Retrieved December 2, 2020, from https://gibsons.ca/sustainability/natural-assets/gibsons-natural-asset-management-journey/

Town of Gibsons. (2020b). White Tower Park stormwater ponds. Retrieved December 2, 2020, from https://gibsons.ca/sustainability/natural-assets/white-tower-park-stormwater-ponds/

Understanding FireSmart. (2019, November 6). FireSmart. https://firesmartcanada.ca/what-is-firesmart/understanding-firesmart/

United States Government Accountability Office. (2016). Climate change: Selected governments have approached adaptation through laws and long-term plans. https://www.gao.gov/assets/680/677075.pdf
University of Maryland, Center for Disaster Resilience, & Texas A&M University, Galveston Campus, Center for Texas Beaches and Shores. (2018). The growing threat of urban flooding: A national challenge. College Park: A. James Clark School of Engineering. https://cdr.umd.edu/sites/cdr.umd.edu/files/resource_documents/COMPRESSEDurban-flooding-report-online-compressed-0319.pdf

Water sustainability act. (2014). https://www.bclaws.ca/civix/document/id/complete/statreg/14015
Weber, A. (2019, January 15). What is urban flooding? NRDC. https://www.nrdc.org/experts/anna-weber/what-urban-flooding

Wildfire glossary. (n.d.). Province of British Columbia. https://www2.gov.bc.ca/gov/content/safety/wildfire-status/about-bcws/glossary#W

Wildfire service. (2020). Province of British Columbia. https://www2.gov.bc.ca/gov/content/safety/wildfire-status

Zerbe, J. (2015). Paying for urban infrastructure adaptation in Canada: An analysis of existing and potential economic instruments for local governments, Simon Fraser University. Retrieved from: https://act-adapt.org/wp-content/uploads/2020/04/ACT-Update-Paying-for-Urban-Infrastructure.pdf

APPENDIX A - Workplan

A Work Plan

	November				December					January (2021)				Feburary				March				Mar/April
Week	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4	1
Important Dates			17th		4th			Scheduled Break	Scheduled Break									2nd		16th		30th
Deliverables																						
Partner Meetings																						
Project Updates																						
Proposal																						
Interim Report/Mid-Project Presentation																						
Draft Report																						
Poster																						
Final Report and Presentation																						
Phase 1: Literature Review																						
Review Planning Theories & Frameworks																						
Define Climate Risk Categories (wildfire & urban flooding)																						
Review Climate Change Actions Reports for BC Communities																						
Examine Existing Methods for Costs of Climate Change Actions																						
Do Internet search for BC communities that have done wildfire and urban flooding adaptations																						
Create two lists of selected BC Communities facing the selected risks																						
Examine Existing Categories of Costs for Selected BC Communities																						
Review climate change adaptation cost information from other provinces and west coast US																						
Ask partners for other reports																						
Review reports sent by partners																						
Summarize findings of literature review into interim report																						
Phase 2: Engagement																						
Ask partners for list of practitioners (consultants) to speak with & create interview guide for them																						
Reach out to people for contacts																						
Check guides with partners																						
Adjust guides																						
Reach out to practitioners & arrange sessions																						
Conduct interviews with practitioners																						
Create list of municipal contacts (and FN if possible) to speak with & create interview guide for them																						
Check list of municipal contacts (and FN if possible) & guides with partners																						
Adjust guides																						
Reach out to municipal contacts (and FN if possible) & arrange sessions																						
Conduct interviews with municipal contacts (and FN if possible)																						
Determine workshop structure (to review menu) & create guide																						
Check workshop structure & guide with partners																						
Adjust guides																						
Invite all contacts to review workshop(s)																						
Conduct review workshop(s)																						
Phase 3: Data Processing																						
Collate Data in Excel																						
Normalisation of Cost for Comparison																						
Listing pros and cons of adaptation measures for each risk type																						
Phase 4: Data Presentation																						
Brainstorm ways to visualize information / create menu																						
Include info into the menu template																						

APPENDIX B -
Full Literature Review

1 Introduction

This section details the findings from the grey literature pertaining to wildfire, stormwater flooding, and costing strategies for adaptation measures. This literature review will help guide our stakeholder engagement process in terms of the data to be collected and the communities to speak with.

For wildfires and stormwater flooding, we first include background information, such as definitions, its occurrence, and its impacts, before highlighting a few communities who have implemented adaptations to those risks. We have included more information about wildfires than stormwater flooding because wildfire can occur at a larger scale and involves more levels of jurisdiction compared to stormwater flooding which occurs primarily at a local level. We felt more background information was necessary to understand the context of wildfires.

In our search for adaptations in BC communities, we encountered and addressed a few issues:

Completion: We are interested in measures that have completed implementation. It is not always easy to tell from documents that have been published years ago whether the measures have been implemented at this point. There are sometimes clues in the document, such as a timeline of implementation. In vague cases, we tended to include them, as more information could be revealed through interviews.

Multiple risks: One adaptation may moderate the effects of multiple risks. It could apply to one of our chosen risks but be listed under a different risk in documents. For example, Prince George, in their 2012 report Implementing Climate Change Adaptation, has a volume on flooding generally, without naming a specific type of flooding (Picketts & Dyer, 2012). We have tried to exercise our best judgment in these cases, again expecting more information from interviews.

Timeframe: Our partners are interested in short- and medium-term actions, which we understand to be actions that could finish implementation within 1 to 15 years. If documents have not included key dates, it is difficult to tell how long implementation took. We again err on the side of including too many adaptations, awaiting further clarification from interviews.

Climate change? While we have framed these actions as climate change adaptations, we recognise that wildfires and stormwater flooding occur even in the absence of climate change. However, it is difficult to distinguish between naturally-occurring risk and climate change-induced risk, so as long as an action helps moderate the effects of wildfires or stormwater flooding, we consider that within our scope.

Communities: By communities, we include municipalities, First Nations, as well as regional districts. As the situation of First Nations is quite different, they will not be a primary focus, but we will attempt to interview one First Nation in the second round of engagement. Their participation would be helpful in gaining an indigenous perspective. We would find it especially helpful if the contact(s) from the First Nation chooses to participate in the review workshop. Regional districts are relevant since they carry out actions on the ground.

2 Approaches: Theories and Frameworks

This project will employ a combination of rational-comprehensive and communicative theories. Following the rational-comprehensive approach, members of our team have been trusted to be qualified to define problems and find optimal solutions (Berke & Stevens, 2016), and this is what we demonstrate in this proposal. However, we will also be following the communicative approach as we will conduct interviews and workshops with related stakeholders and BC communities. We hope that these multiple sources of knowledge will uncover less tangible aspects, such as politics, which could be neglected by a purely rational-comprehensive approach (Berke & Stevens, 2016).

Our approach draws on three main frameworks. First, for the selection of risks, we have relied upon the Government of BC's Preliminary Strategic Climate Risk Assessment for British Columbia (Ministry of Environment and Climate Change Strategy, 2019) which provides a list of hazards considered particularly relevant to the provincial context. Informed by this list and in discussion with our project partners, we have selected two risks to focus on: wildfires and urban/stormwater flooding.

Wildfire adaptation has seen a surge of interest in BC given wildfires in recent years on both sides of the national border, yet not much research has been done on them in BC. While there is a good amount of research on flooding in BC, there still is not a cost menu of adaptations developed for it. Urban flooding is particularly interesting since it can affect all communities in BC, regardless of where they are, and appears to be particularly influenced by local community action.

Second, for the scope of the term "adaptation", we draw on the United States Government Accountability Office (GAO)'s framework for risks, resilience, hazard mitigation, and climate change adaptation (see Figure 1).

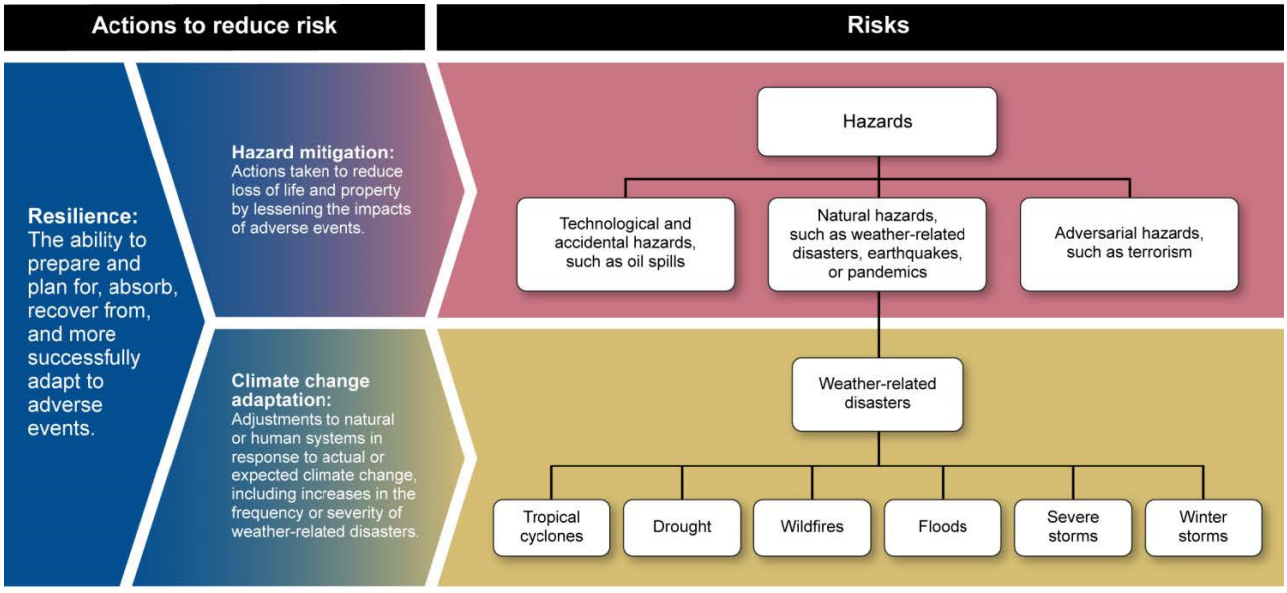


Figure 1. Relationship among risks, resilience, hazard mitigation, and climate change adaptation (Source: United States Government Accountability Office, 2016)

This framework is useful for clarifying the relationships between risks, hazards, resilience, mitigation, and adaptation. In our project, we use "adaptation" loosely to include all three ways GAO outlines for reducing risk:

- **Adaptation:** "Adjustments to natural or human systems in response to actual or expected climate change"
- **Mitigation:** "Actions taken to reduce loss of life and property and lessening the impacts of adverse events."
- **Resilience:** "The ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events" (United States Government Accountability Office, 2016).

The GAO framework also reminds us that natural hazards, such as the ones we are examining, are one of many types of hazards that could be exacerbated by climate change. A complete climate change adaptation plan might also examine other hazards potentially exacerbated by climate change, such as technological/accidental hazards such as oil spills and adversarial hazards such as wars.

Third, for the types of adaptations, we will rely on a framework by the Intergovernmental Panel on Climate Change (IPCC). They categorize adaptations as:

- **structural/physical options**
  - engineering and built environment options, such as sea walls
  - technological options, such as new crop varieties
  - ecosystem-based options, such as floodplain conservation
  - services, such as food banks
- **social options**, which include:
  - educational options, such as awareness raising
  - informational options, such as early warning and response systems
  - behavioural options, such as household preparation
- **institutional options**, which include:
  - economic options, such as taxes and subsidies
  - laws and regulations, such as building standards
  - government policies and programs, such as adaptation plans (Noble et al., 2014).

While there are many ways to categorize adaptations (Burton, 1996), we have chosen IPCC's categorization due to its international and thus, we hope, more comprehensive, scope. We will incorporate this categorization into data collection template and interview/workshop questions to ensure that we capture a more comprehensive range of adaptation options.

While not a framework, we recognise that adaptation measures may play a role in race/ethnic, class, gender, and other conflicts and inequalities (e.g. Bronkhorst & Bob, 2014). Therefore, we plan to include a note on this in the menu, perhaps with suggestions for avoiding this, such as more participatory decision-making processes.

3 Wildfires

Definition

*'**Wildfire:** An unplanned fire - including unauthorized human-caused fires - occurring on forest or range lands, burning forest vegetation, grass, brush, scrub, peat lands, or a prescribed fire set under regulation which spreads beyond the area authorized for burning.'* (Wildfire Service BC, n.d.)

Wildfires or wildland fires should not be confused with the prescribed fires in the forest which are done under supervision, to renew and maintain the health of the forests, and to reduce excessive fuel build up (Natural Resources Canada, 2020). Wildfires are a natural part of the forest ecosystem since these help maintain the diversity in the forest. It is the duty of the forest agencies to control the intensity of the fires and manage the potential damage and costs.

Wildfires in Canada and BC

Wildfires have engulfed an average of 2.5 million hectares per year in Canada (Natural Resources Canada, 2020). In the past decade, Canada has spent $800 million to $1.5 billion suppressing such fires (Natural Resources Canada, 2020). The wildfire season spans from April to October with most of the serious ones occurring between June to August (Farmzone, 2020). Wildfires subside with the onset of winter (Natural Resources Canada, 2020).

British Columbia ranks first in the 10-year average record of number of wildfires amongst other provinces of Canada (Figure 2). Over the past 10 years (2011-2020), an average of 1358 fires have burnt an average of approximately 365,000 hectares in BC (Canadian Wildland Fire Information System, 2020). From April 1 to September 9, 2020, BC experienced 610 wildfires burning 13,458 hectares (Canadian Wildland Fire Information System, 2020). In the past decade, BC experienced particularly severe wildfires in 2018, 2017, and 2014 (Table 1 and 2). The severity of wildfires varies from year to year (Map 1).

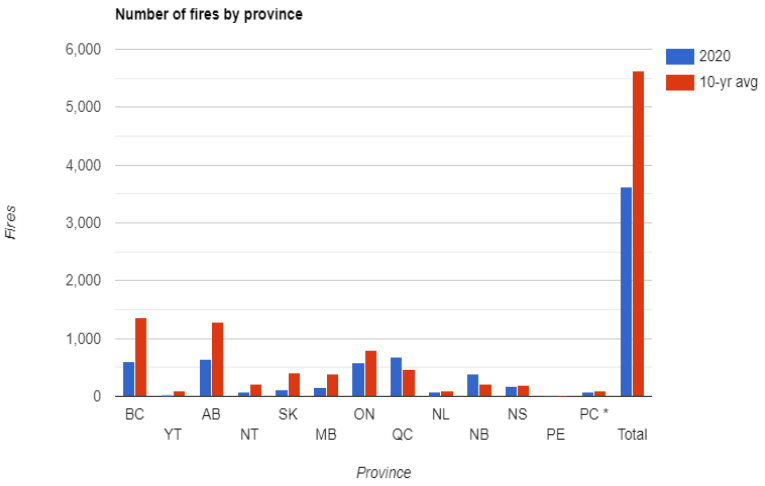


Fig 2: Number of Fires by Provinces
Source: National Wildland Fire Situation Report, Canadian Wildland Fire Information System 2020

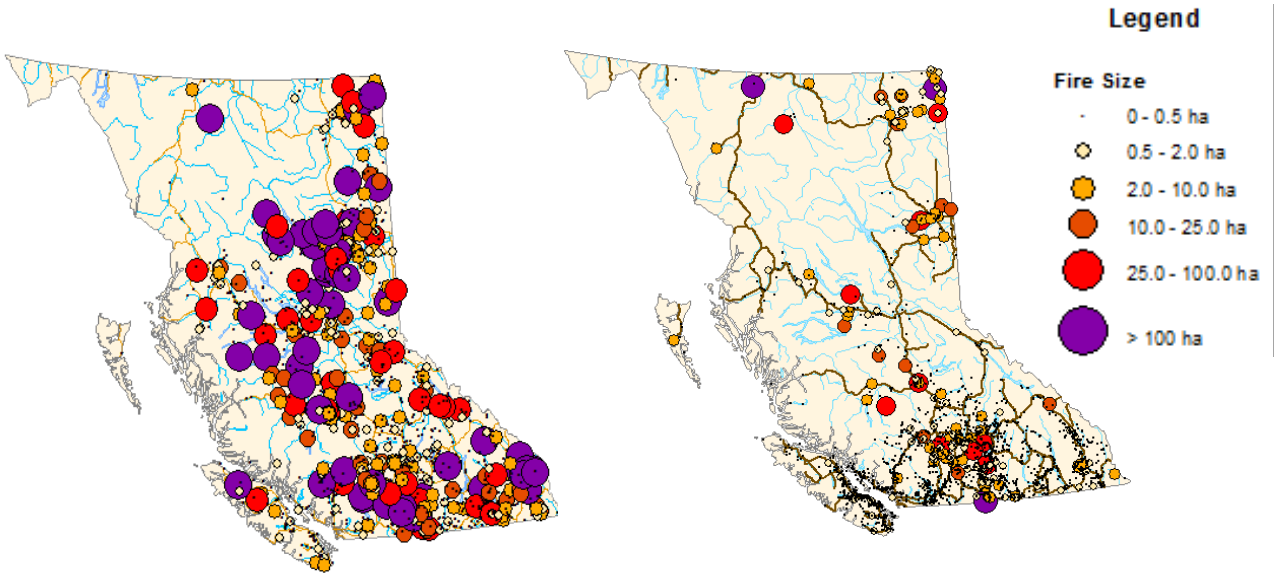
Year	Total Fires	Total Area Burnt	Cost to Province
2018	2117	1,354,284	$ 615 million
2017	1353	1,216,053	$ 649 million
2014	1481	369,168	$ 297.9 million

Table 1: Major Historical Wildfire Seasons of BC
Source: Wildfire Service BC 2019

Year	Notable Fires	Area Burnt
2018	Nadina Lake	86,767 ha
	Shovel Lake	92,412 ha
	Ramsey Creek	79,394 ha
2014	Chelaslie River Wildfire	133,098 hectares
	Tenakihi-Mesilinka Complex	64,576 hectares
	Red Deer Creek Wildfire	33,547 hectares

Table 2: Notable Fires in the Province of BC for the Major Wildfire Seasons
Source: Wildfire Service BC 2019

Note: Notable wildfires are wildfires that were highly visible and, in some cases, posed a threat to public safety.



Map 1: Wildfires in 2014 (left) and Wildfires in 2011 (right) depicting areas burned
Source: Wildfire Service BC 2019

Factors Influencing Wildfire

Several factors are at play in the initiation and spread of wildfires.

Lightning: Lightning strikes are one of two factors that start fires. In Canada, although lightning strikes initiate less than 50% of the total fires, the area burnt and affected by these fires account for more than 67% of the total area burnt by wildfires (Natural Resources Canada, 2020). In BC, lightning has generally accounted for a higher proportion of wildfires (Table 3). In 2014, thunderstorms helped start at least 190 new fires, with most of these in Cariboo (Wildfire Service BC, 2020).

Year	Causal Factors	
	Person	Lightning
2018	25.3%	70.3%
2017	40.8%	57.1%
2014	44.8%	55.2%

Table 3: Causal Factors of Major Historical Wildfire Seasons of BC
Source: Wildfire Service BC 2019

Human intervention: Humans are the second factor that start fires (Natural Resources Canada, 2020).

Warmer climates/climate change: Warmer climates create drought-like conditions--less and more sporadic rainfall and higher temperatures for a longer duration--that are favorable to wildfires. In Canada, the annual area burned by wildfires could increase by 4% by 2050, surpassing 9 million hectares (Ministry of Environment and Climate Change Strategy, 2019). In BC, the major historical wildfire seasons were caused by very hot and dry conditions, leading to 'high' to 'extreme' Fire Danger Ratings in several areas across the province (Wildfire Service BC, 2017). A similar observation was observed in the Cariboo region in the year 2014, which experienced abnormally high temperatures and dry conditions. This led to a high Built Up Index (BUI) in the region (Wildfire Service BC, 2020). In western USA, a 1-degree rise in temperature accounts for an increase of 600% in the median area burned by wildfires for certain forest types (Center for Climate and Energy Solutions, 2020).

Forest fuel: Forest fuel is dead organic matter consisting of vegetation and biomass. The ignition temperature of the forest fuel, that is, the flammability and its susceptibility of catching fire, depends upon the dominant tree species, forest floor, soil moisture, and forest health (e.g. outbreaks of mountain pine beetles) (Perkins & Eade, 2015). The boreal forests in northern, interior BC are more susceptible to wildfires than the moist forests of the west coast (Map 2; Brandt, J. 2009).

Mountain Pine Beetles (MPB): The mountain pine beetle is also accomplice in wildfires, as it helps form forest fuel. The beetle infestation is aggravated by rising temperatures and could be directly correlated to climate change. The major forest fires of 2017 were found to be concentrated in areas with high to very high levels of pine killed by the beetle since 1999 (Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2019).

Map 2: Boreal Forests, BC
Source: Brandt, J. 2009

Topography. The topography of the landscape, along with weather and fuels, affect the spread of wildfire (Countryman, 1966, as cited in Perkins & Eade, 2015).

Impacts of Wildfire

Wildfires have far-reaching impacts on the communities, biodiversity and other components of the environment.

Human health: Air pollution from wildfires can adversely impact human health.

Mental health: The displacement of people could impact the mental health and well being of individuals. Moreover, some groups may have cultural ties to the forests.

Economy: The displacement of people, the loss of livelihood, and the loss of possessions can cause economic loss to the individuals in the long term. The loss of valuable ecosystem and forest resources can also cause economic loss.

Some of the most adversely and visibly affected economic sectors are ones related to biodiversity, tourism and recreation, transportation, and forest areas and related industries (Carlson, 2012). Other economic impacts also include effects on physical infrastructure including water supply, sewerage, electricity and others (Ministry of Environment and Climate Change Strategy, 2019).

Environment: Frequent fire occurrence in forests may force wildlife to relocate. Ash and debris from wildfires could be mixed with fresh water sources like lakes and rivers, causing water pollution (Ministry of Environment and Climate Change Strategy, 2019).

Vulnerable Communities

While the impacts of wildfires depend partly upon the extent and intensity of the wildfire, there are a few groups in BC that are particularly vulnerable.

Communities beside forests: The effects of wildfires are more direct and prevalent in areas where the human settlements and the wildland interacts/intermingles (Ministry of Environment and Climate Change Strategy, 2019). These areas are termed as the wildland urban interface (WUI). The effects of air pollution on human health are far more intense in these areas as compared to areas further away (Ministry of Environment and Climate Change Strategy, 2019). Wildfires in WUI also cause displacement of people, loss of livelihood, and possessions especially in settlements in direct contact with the wildfire (Ministry of Environment and Climate Change Strategy, 2019).

At Williams lake, Princeton, Clearwater, Quesnel and other communities, fires have started close to the settlements (Wildfire Service BC, 2020). Almost all the notable wildfires in the major wildfire season years prompted an evacuation notice to the people living in communities affected by wildfire (Wildfire Service BC, 2020). During the major wildfire season of 2014, more than 4,500 people affected by the Smith Creek fire in West Kelowna and by the Mt. McAllister fire at Hudson's Hop were forced to evacuate their homes. It was the largest ever recorded evacuation; however, there was no major loss to infrastructure (Wildfire Service BC, 2020).

Communities dependent upon forestry: In the historical wildfire seasons of 2017 and 2018, more than 73% and 80% of the total area affected by wildfire fell under timber supply areas respectively (Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2019). Areas affected in 2018 are Cassiar, Lakes, Great Bear Rainforest North, Prince George, Fort Nelson, and Morice Timber Supply Areas (TSAs) and in 2017 Quesnel, Williams Lake, and 100 Mile House TSAs. Not only the TSAs but the Timber Harvesting Land Bases (THLBs) were also gravely affected by the wildfire in these years (Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2019). Besides sustenance, these communities also have direct social, economic and cultural ties with the forests (Pearce & Callihoo, 2011, as cited in Krishnaswamy et al., 2012).

First Nations. Many First Nations have a subsistence-based economy and depend profoundly on natural resources such as forests. Further, they also depend on the forest for the preservation of their culture. Cultural sites such as ceremonial burial, food gathering, hunting, medicinal plant collection and others connected to the forest are vulnerable to damage by wildfires (Krishnaswamy et al., 2012). Permanent damage caused by the wildfire could have an immense impact on the First Nation Identity (Krishnaswamy et al., 2012).

Case Study: Fort McMurray in Alberta

Fort McMurray in Alberta experienced one of the worst wildfire incidents in the year 2016. The wildfire affected the WUI areas and as a consequence displaced more than 85,000 people and destroyed more than 2,400 structures (Westhaver, 2017, as cited in Samson et al., 2020). It is also considered one of the largest evacuations in the Canadian history. Approximately 9 billion dollars were spent to manage the after impacts of the wildfire including impacts on infrastructure, health and environmental impacts (Snowdon, 2017, as cited in Samson et al., 2020). This wildfire had a profound impact on the mental health of people especially the students living in the area (Brown et al., 2019, as cited in Samson et al., 2020)

Adaptation Measures

The history of wildfires in BC have prompted multiple communities, and especially those at the wild-land urban interface or by forests with poor health, to pursue adaptations. While adaptations have been introduced at multiple levels of government, we focus on those adopted by communities.

Covenants and Easement Tools used by Kamloops

The City of Kamloops located in the Thompson River Valley in Southern British Columbia, due to its dry climate is susceptible to wildfires. This risk has further been accentuated by Climate Change. The city experienced three major wildfires in the year 2003, which breached the city boundary. Being a WUI, there was grave threat to the inhabitants and the city infrastructure (Richardson & Otero, 2012)

In order to tackle the risks posed by the wildfires on the community, the city uses **covenants**, a type of land use planning tool (City of Kamloops, 2008, as cited in Richardson & Otero, 2012). The tool has been in force since 1992. It has been implemented as a condition for subdivision approval. A restrictive covenant must be registered by people whose new subdivisions fall under the hazardous zones (City of Kamloops, 1992, as cited in Richardson & Otero, 2012). This covenant mandates the home owners and developers to undertake measures to reduce the risk posed by Wildfires. It includes appropriate roofing material, fuel buffer zones, screening of decks and attics and installing approved spark ar-resters (Richardson & Otero, 2012). According to the Land Use Planning Tools document by Natural Resources Canada, Kamloops is revising the covenants to enhance the conformity to the up – to -date hazard assessment mapping of the city.

Adaptation Measures Undertaken by Prince George

Prince George is located in Northern British Columbia. Being surrounded by forests, natural and land-scaped, the area is particularly vulnerable to wildfires and the impacts of climate change. The term urban forest is used for the both natural and landscaped forests (Picketts & Coady, 2012). The forests are managed by separate City divisions. Mountain Pine Beetle (MPB) infestation has killed lodgepole pine trees and is one of the most pronounced implication of the climate change on Prince George (Picketts & Coady, 2012). This has accentuated the risks of wildfires by increasing the fuel load in the forest.

In order to tackle the risks posed by Wildfires due to Climate Change the city has adopted various strategies, these include **Development of a Community Wildfire Protection Plan, Fuel Management Program in and Community Forest Future Opportunities.**

Since, MPB infestation is responsible for increasing the risk of wildfires in Prince George, the city decided to harvest the MPB affected pine and other fire fuels in the area (Picketts & Coady, 2012). About 1.3 million cubic metres of forest, present within the municipal boundary of Prince George is vulnerable to it (Picketts & Coady, 2012).

First, Prince George was one of the first communities in BC to adopt a **Community Wildfire Protection Plan (CWPP).** The CWPP was responsible for carving out strategies to reduce the long-term impact of the wildfires in the city (Picketts & Coady, 2012). Strategies such as public awareness pertaining to reducing wildfire hazards on private properties and implementation of the FireSmart guidelines for new properties and WUI, since 70% of the land with the municipal boundary is privately owned, were included in the plan (Picketts & Coady, 2012).

Another important observation pertaining to the adaptation measures adopted by Prince George is the development of **Community Forest Agreement (CFA)** Plan in 2006 (Picketts & Coady, 2012). It allowed the city to manage the forests as per the objectives defined by them in consultation with the stakeholders including, the Regional District, the Province, the Lheidli T'enneh Nation. However, the plan was not financially sustainable, the value earned by selling the salvaged trees destroyed by MPB infestation is less than the cost accrued to clear the forest fuel. Hence, the value is only used to reduce the cost and does not add to the profit of the city.

Further, the city also considered larger community benefits while planning for adaptation measures. The development of agroforestry, converting the forest areas vulnerable to forest fires to agricultural areas and offer support required for the conversion into agricultural land. Second, using the dead lodgepole pine for generating bio energy (Picketts & Coady, 2012). The University of Northern British Columbia (UNBC) in Prince George is utilising the dead timber for generating energy and using it for heating needs (Picketts & Coady, 2012). Using this at the community level would help diversify the economy and would also help in reducing the forest fuel thereby reducing the risk of wildfires (Picketts & Coady, 2012).

In addition to the above forest areas, the city is also implicitly looking after the management of the landscaped areas. These areas are also affected by climate change and its effects. In the past, these trees have been affected by MPB infestation and pose wildfire hazard to the residents of the city. The city government uses grants such as the 'Trees for Tomorrow' grant it received in 2009, to fund initiatives including replanting of trees in neighbourhood parks, to diversify plant species. (Ward, 2011, as cited in Picketts & Coady, 2012).

Prince George and has funded these activities through grants from NRCAN and UBCM (Carlson, 2012). Prince George is also taking the initiative of public awareness and education pertaining to wildfires under the CWPP (Carlson, 2012).

Similar to Prince George other communities in British Columbia which have adapted the CWPP include Kamloops, Maple Ridge, Revelstoke and the regional district of Okanagan-Similkameen and Nanaimo (Cullington & Gye, 2010).

Climate Adaptation in Whistler

The **Community Energy and Climate Action Plan (CECAP)** for the Resort Municipality of Whistler (RMOW) was drafted in the year 2016 and aims to reduce the impacts of the projected climate change impacts. It includes risk assessment and vulnerability mapping of the projected climate change impacts, lists objectives to strategically approach the possible impacts and key adaptation measures for each objective. The responsibility for the implementation of the measures is distributed across several departments of the municipality (RMOW, 2016).

The CECAP lists three climate change effects projected for Whistler, which includes - longer, hotter and drier summers, with temperature increasing by three degrees by the year 2050. The maximum length of the dry spells is projected to increase by 15% (RMOW, 2016). The risk assessment and vulnerability mapping in the CECAP helped addressing the potential impacts of climate change. There are two impacts related to wildfire that have been identified using the risk assessment. First, wildfire threat to WUI i.e., threat to inhabitants, infrastructure and property is the highest among other climate change impacts identified and poses a 'Medium High-Risk' (RMOW, 2016). Second is the wildfire threat to biodiversity, which is ranked fourteenth and poses a 'Medium-Low' risk rating (RMOW, 2016).

Several actions along with the resources like cost, time for initiation and organisation responsible for leading the implementation of the action have been recommended (Figure 3).

Objective 1	Potential Impacts Addressed by this Objective: Primary	Secondary
Minimize the threats posed by **wildfire and interface fire** to human health and safety, private property, infrastructure, wildlife, habitat and biodiversity.	1. Increased wildfire and interface fire threats to property, infrastructure, and human health and safety 14. Wildfire threats to species, habitat and biodiversity	n/a

	Recommended Action	Resources	Timing	Lead
8.5.1.1	Continue to implement the Community Wildfire Protection Plan, including emphasis on public education and engagement.	$$$	short	RMOW CCS RMOW CAO RMOW COM
8.5.1.2	Prioritize the implementation of the landscape-level wildfire management plan for the Cheakamus Community Forest area.	$$$	short	RMOW CAO
8.5.1.3	Increase municipal and collaborative efforts around wildfire prevention with key corridor partners (i.e. MFLNRO, Sea to Sky fire rescue services, SLRD, Vancouver Coastal Health).	$$	short	RMOW CCS VCH
8.5.1.4	Continue to review and update pre-incident and emergency response plans and communication protocols for wildfire situations.	①	short	RMOW IS RMOW CCS
8.5.1.5	Develop private property wildfire risk reduction guidelines and implement through municipal policy and/or procedures.	$	short	RMOW CCS

Phasing and Resource Legend

Lead	The organization identified to 'lead' the execution of the associated action. All acronyms used in the following tables are outlined in Appendix A. *Note that other organizations will often need to be involved in project design, support and delivery in order to successfully execute on many of the recommended action opportunities.*
Timing	Short: Initiate within 2 years Med: Initiate within 2-5 years Long: Initiate in 5 years or later
Resources	① primarily time $-$$$ relative expenditure level $ < $25,000 $$ $25,000 - $100,000 $$$ > $100,000

Fig 3: Adaptation Measures for Wildfires, CECAP RMOW 2016
Source: The Resort Municipality of Whistler (RMOW), 2016

The layout and the representation of recommended action and the related resources, time duration, organisation could be used as an example to help guide our template design for the menu.

Climate Adaptation in Cariboo

The **Cariboo Adaptation Strategies Update** (BC Agriculture & Food Climate Action Initiative, 2018) identifies wildfire as one of the impacts on the community and suggests strategies and actions for reducing the risk of wildfires. Further, it also recommends strategies and actions that could be applied to more than one risk areas. For example, Changing Hydrology is also identified as an area that would be impacted by climate change and one of the strategies under it is the 'Maintaining and Enhancing the Agriculturally Significant Dams'. One of the actions under it is to 'gauge the shared benefits and collaborative maintenance models for Cariboo agricultural dams' (BC Agriculture & Food Climate Action Initiative, 2018). A shared use of these dams highlighted in the report is the use of water stored in these dams for firefighting during extreme wildfire events (BC Agriculture & Food Climate Action Initiative, 2018). There are six activities listed under this action that help achieve the over arching objective. The estimated cost that could be accrued on implementing this action ranges from $50,000-$100,000 and the action falls under the short-term timeframe category (less than two years) (BC Agriculture & Food Climate Action Initiative, 2018).

Several other actions that could be used for wildfire indirectly have also been included. One such area impacted by climate change is 'Changes to wildlife and ecological systems' and the strategy defined under it is the 'Collaborative management of changing wildlife impacts', which has been prioritised of the two strategies under the above impact area (BC Agriculture & Food Climate Action Initiative, 2018). The action under this strategy also looks after the effects of the wildfire, however, here the effects listed is caused post the hazard. Action is 'Consolidate and summarize information on damage and losses to agriculture from wildlife with a focus on post-wildfire impacts (BC Agriculture & Food Climate Action Initiative, 2018). The people involved in Agricultural practices were concerned that wildfire could cause the wildlife to enter and destroy the fields and such concern arised especially after the 2017 wildfire (BC Agriculture & Food Climate Action Initiative, 2018). The estimated cost that could be accrued on implementing this action is less than $50,000 and the action falls under the short-term timeframe category (less than two years) (BC Agriculture & Food Climate Action Initiative, 2018).

Infrastructure

Adaptation measures could also include the planning and developing infrastructure that is resilient to the risk posed by the wildfires due to the changing climate. From the literature above it was evident that wildfires could lead to power cuts by affecting the electricity supply infrastructure in an area. Energy Cogeneration is an example of energy infrastructure that could enhance the resilience of energy infrastructure against wildfires. It is also known as 'Recycled Energy' and is used to generate energy using heat at the point of consumption itself (Richardson & Otero, 2012). Although the aim of the energy infrastructure is to shift towards renewable sources of energy, in order to reduce the GHG emissions, this could also help build resilience of energy infrastructure. These measures provide more than one community benefit at a time. It is being used in the South False Creek neighbourhood of City of Vancouver.

It provides heating and hot water to residential, institutional and commercial buildings in the area and at the same time provides resilience during power outages caused by extreme weather and accentuated by climate change impacts (Richardson & Otero, 2012). Further, this infrastructure is financially self sustaining, as the energy generated is sold to the consumers of the area. (Richardson & Otero, 2012)

Capital investment for infrastructure was financed using climate/green bonds and Grants provided by the federal government. Green bonds were utilised by the City of Vancouver to fund 85 million dollars to expand this heating infrastructure among other projects in 2018 (Richardson & Otero, 2012). The federal grants include Green Municipal Fund (GMF), Environmental and Climate Change Canada (ECCC), Municipalities for Climate Innovation Program (MCIP) and others (Richardson & Otero, 2012).

Climate Adaptation in District of Elkford

Integrated OCPs and Climate Strategies

Wildfire is one the three identified risks, others include flooding/stormwater management and shortage of water supply, that poses threat to the District. The District of Elkford developed an integrated climate adaptation strategy and OCP. The plan was introduced in the year 2010. The project was funded by the Columbian Basin Trust under the initiative name Communities Adapting to Climate Change (CCAC).

Development Permit Areas and **Subdivision and Servicing Bylaws** were also adopted by District of Elkford to tackle the risks posed by Wildfires. These act as development controls which prescribe certain measures to regulate the development of the area. Similar to the district of Elkford, the **City of Williams** also has a 'Wildfire Interface' Development Permit Area.

Other Adaptation Measures

Firebreaks - One of the First Nations located west of Kamloops, known as the **Neskonlith Indian Band** community has also used firebreaks around the community as well as pest resistant firs to reduce the risk of pest infestation (Cullington & Gye, 2010).

Image Source: Ministry of Lands, Forest and Natural Resources. (2017). https://www.focusonvictoria.ca/focus-magazine-july-august-2019/not-your-grandpas-wildfires-r7/

4 Stormwater Flooding

Flooding could be classified in a variety of ways, such as by the physical conditions generating a flood event (e.g. Church, 1988) or by the source of water creating the event (e.g. Engineers and Geoscientists British Columbia [EGBC], 2018). We have chosen the latter approach as it is consistent with the Province of BC's approach (Ministry of Environment and Climate Change Strategy, 2019). Under this approach, there could be coastal, lake, riverine, sewage/infrastructure, groundwater, and pluvial flooding (King-Scobie, 2019).

While we are interested in pluvial flooding, and it is used in some documents in BC (e.g. CCEM Strategies Ltd., 2019), we are concerned that the term pluvial flooding may not be understood by interviewees. Some organizations use the term urban flooding to describe the same thing (e.g. University of Maryland, Center for Disaster Resilience & Texas A&M University, Galveston Campus, Center for Texas Beaches and Shores, 2018), but we are concerned that there could be confusion with that term, as flooding in cities could also come from other sources like rivers and lakes. We will instead use the term stormwater flooding in our reports and communications.

While pluvial flooding can include snowmelt, to focus our scope we will focus on rainfall only. In this respect, it may be useful to take as a working definition the definition from the U.S. Federal Emergency Management Agency (FEMA):

"the inundation of property in a built environment, particularly in more densely populated areas, caused by rain falling on increased amounts of impervious surfaces and overwhelming the capacity of drainage systems." (University of Maryland, Center for Disaster Resilience & Texas A&M University, Galveston Campus, Center for Texas Beaches and Shores, 2018).

As Anna Weber of the US-based Natural Resources Defense Council (NRDC) notes, this definition can be broken down into three components:

1) "caused by rain that
2) falls on impervious surfaces and
3) overwhelms local stormwater drainage capacity" (2019),

with each involving three separate processes:

1) increased rainfall due to climate change,
2) increased impervious surfaces due to urbanization, and
3) insufficient stormwater infrastructure (2019).

Note, while sewer systems take care of both stormwater and wastewater, we are only concerned with stormwater.

Image Source: Foster J. https://esemag.com/stormwater/sustainable-and-equitable-stormwater-funding/

Why Stormwater Flooding?

While all types of flooding are important, pluvial flooding is particularly interesting for the menu for a few reasons.

Common occurrence. Firstly, by one account, it is the most common form of flooding in Canadian municipalities (King-Scobie, 2020). As an example, the City of North Vancouver experienced floods caused by heavy rainfall in 2018 and considers that "[t]he greatest threat to both developed and undeveloped lands [in the City] will be more frequent and severe flooding due to more intense precipitation, and to a lesser extent, sea level rise and increased storm surge" (City of North Vancouver, 2013).

Municipal jurisdiction. Secondly, stormwater flooding is primarily under the jurisdiction of municipalities, at least in BC. In contrast, rivers for example are governed by the provincial-level Water Sustainability Act (cite the act). The municipal-level governance of stormwater flooding renders it more relevant to community-decision making, which the menu is intended to facilitate.

Worsening conditions. Thirdly, more frequent pluvial flooding can be expected in BC. More frequent extreme precipitation events are expected for North America in the future, due to human-caused climate change (Kirchmeier-Young & Zhang, 2020). Vancouver expects "heavy rain events [to] become 35 per cent more intense... by 2050" (City of Vancouver, 2018)

Impacts

stormwater flooding may cause a variety of negative impacts, including:

- economic (e.g. spoiled crops, lost customers, out-migration, lost employee hours, damage to streets, damage to buildings),
- human health (e.g. deaths, sickness, injuries),
- mental health (e.g. lowered sense of place, lowered sense of security, lowered sense of pride in the community, the province, or Canada),
- environmental (e.g. pollution, damaged natural habitats), and
- political (e.g. weakened confidence in the municipal, provincial, or federal government).

By the same token, there may be adaptations to moderate different impacts. It is difficult to narrow our scope to one or more types of impacts without knowing what information exists, so we will look for adaptations for all types of impacts for now and narrow our scope as needed later on.

Adaptations in BC

As our project is concerned with creating a menu based on past experiences of BC communities, we looked online for communities in BC that have completed implementation of one or more adaptations to moderate the effects of more frequent and severe stormwater flooding events.

As we are currently more interested in identifying communities rather than the adaptations themselves, we present our search results by community rather than adaptation. We may revisit the source documents here later on to gather more detailed information about the adaptations in preparation for interviews with selected communities.

City of Vancouver

The City of Vancouver has implemented a number of adaptations to stormwater flooding:

- making "changes to the City's sewer design" (City of Vancouver, 2018),
- creating and implementing the Rain City Strategy that will "implement sustainable rainwater management
- with a goal of using rainwater as a resource rather than a waste product" (Ibid.),
- integrating "climate change projections into the intensity, duration, frequency (IDF) curves used to design stormwater management systems" (Ibid.),
- launching "the Adopt a Catch Basin Program" in which Vancouver residents adopted over one thousand catch basins and committed to "keeping it free of leaves and debris" (Ibid.), and
- adopting "the Urban Forest Strategy" which extended "conditions which required permits for tree removal on private property" (Ibid.). Trees can absorb rain water.

City of North Vancouver

The City of North Vancouver has taken the following adaptation measures:

- following Integrated Stormwater Management Planning (ISMP) to allow more rainwater to seep into the ground,
- raising the flood construction levels to provide enhanced protection from floods,
- adopting Hazard Lands Development Permit Areas, which are "lands within the two hundred-year flood plain and areas near steep slopes" which require "that landowners obtain a Development Permit before proceeding with any development or alteration" (City of North Vancouver, 2020), and
- amending "the City's Zoning Bylaw to support the construction of greener buildings," which includes introducing "new incentives and requirements for all new construction" and allows more opportunities to include water diversion (Ibid.).

Town of Gibsons

The Town of Gibsons has implemented the following measures:

- passing "a municipal asset management policy that:
- "Explicitly defines and recognizes natural assets as an asset class; and
- "Creates specific obligations to operate, maintain and replace natural assets alongside traditional capital assets. These obligations include having well-defined natural asset management strategies in place, as well as the financial resources to maintain them" (Town of Gibsons, 2020a).
- conducting general maintenance in White Tower Park and "dredging the ponds every three or four years at a cost of about $10,000 per dredging" (Town of Gibsons, 2020b). The creeks and ponds in the Park convey and treat rainwater run-off, providing the same service as $4 million dollars of engineered infrastructure (Ibid.).

The Town of Gibsons is particularly interesting as it "was North America's first community to experiment with strategies to integrate natural assets into asset management and financial planning" (Town of Gibsons, 2020a). We could gather more details from Advancing Municipal Natural Asset Management (Town of Gibsons, 2017), a major document sharing their experience of developing their strategy.

Stormwater Flooding in Metro Vancouver

City of Victoria

The City of Victoria has taken the following adaptation measures:

- charging for stormwater utility separate from property taxes and charging more for properties that:
  - have more impervious areas, as "measured "through building plans, aerial photography and GIS mapping technology" (City of Victoria, 2020),
  - have more street frontage,
  - are on a more major street, and
  - have higher-intensity land uses (City of Victoria, 2020).
- providing rebates and credits under the Rainwater Rewards Program for properties to install or that use "an approved rainwater management method," which include:
  - rain barrels and cisterns,
  - infiltration chambers,
  - permeable paving,
  - rain gardens,
  - bioswales, and
  - green roofs (City of Victoria, n.d.)

Image Source: MacKichan, S. (2018). https://www.cbc.ca/news/canada/british-columbia/pouring-rain-caused-flooding-traffic-disruptions-across-b-c-s-south-coast-1.4941791

5 Costing

Why invest in climate change adaptations?

As the risk of more frequent severe weather events increases because of climate change, many regions across Canada are becoming riskier. Municipalities are on the front lines of climate change and significant investments are needed to protect the public, properties and businesses from the devastating effects of climate change (Insurance Bureau of Canada [IBC] & Federation of Canadian Municipalities [FCM], 2020). While a number of studies show that investments in climate change adaptations will help communities to increase their resilience to the impacts from climate change, it is critical for communities to identify the costs of adaptation actions (IBC & FCM, 2020). Research has shown a return on investment of adaptations is around 6:1, which means that for every dollar spent on adaptation actions, $6 will be saved in future disaster costs (National Institute of Building Sciences, 2018). These investments are critical to helping communities adapt to and reduce risks from extreme weather events.

Most impacts of climate change are projected to increase non-linearly with climate change, and the costs of adaptations are similar to impacts (IPCC, 2007). Therefore, it will probably be very inexpensive to avoid some impacts, but extremely expensive to avoid others. Some impacts cannot even be avoided even if investments were unlimited, because the technologies are not advanced enough (Parry et al., 2009).

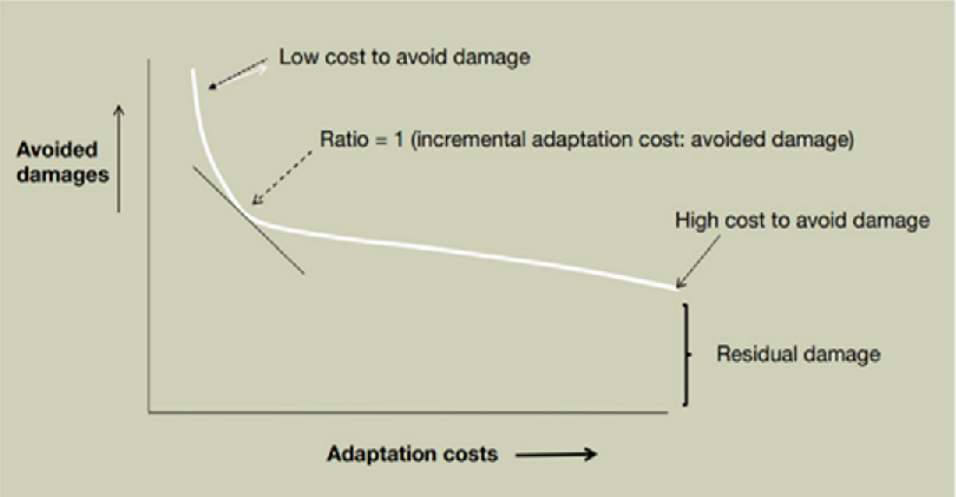


Fig. 4: Schematic of adaptation costs at a point in time
Source: Parry et al., 2009

However, the costs of ad aptations are often significantly lower than the costs of inaction (NRT, 2011). A simple schema of a general adaptation cost curve is shown in Figure 4. The curve varies widely between different sectors and locations, but in most cases, the cost of adaptations to the first 10% of damage will be disproportionately lower than the cost of adaptations to 90% of damage (Parry et al., 2009).

However, before implementing the adaptations, communities need to be clear how much they are willing to invest for adaptations to avoid damages. To further illustrate this point, and to some extent reduce the costs, communities might aim to adapt to: (i) the impacts that reduce human welfare, or (ii) the impacts that are economically feasible (i.e. cheaper to adapt to than to be borne), or (iii) the impacts that are affordable within a given budget constraint (Parry et al., 2009).

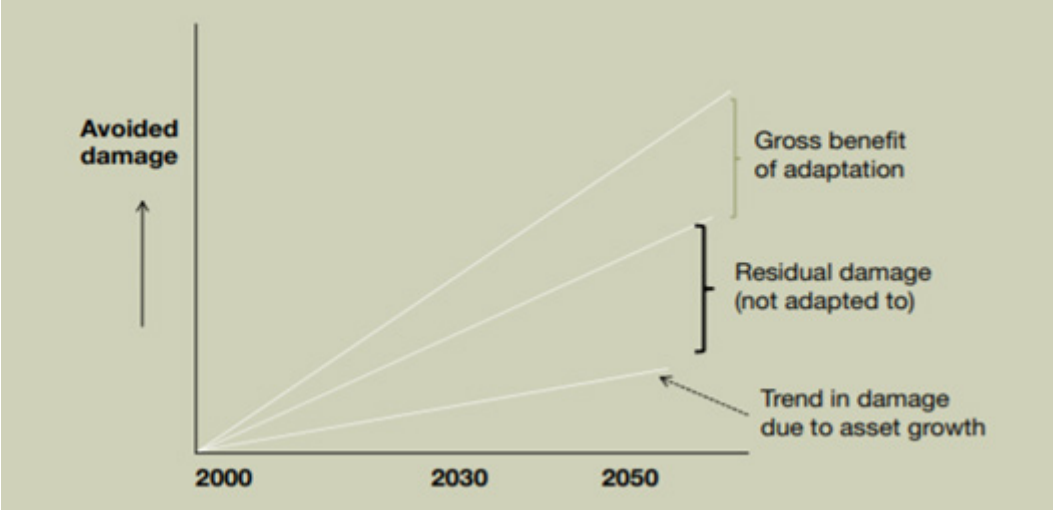


Fig 5: Schematic of adaptation costs over time
Source: Parry et al., 2009

If communities have limited funding, these three choices might help them to prioritize their investments on adaptations. Residual damage is also a critical element needs to be considered during the investments on adaptations (Parry et al., 2009). Residual damage refers to the damage remaining after the implementations of adaptations (Parry et al., 2009). Weak adaptation actions increase the residual damages which will remain at all levels of adaptation and is unavoidable (Parry et al., 2009). Though the United Nations did not specify how much residual damage might be expected, the number might be significant and is likely to increase over time as shown in Figure 5 (Parry et al., 2009). Communities need to consider whether they can accept the residual damage after implementing some adaptations as inefficient adaptations will increase residual damages.

Approaches to quantify adaptation costs:

Though numerous studies confirm that investments in adaptations provide a payback in decreasing climate change costs in the future, a limited number of studies have quantified the cost of climate change adaptations (IBC & FCM, 2020). Most of the studies that have been completed are at a global scale, for example the estimated annual adaptation costs is approximately $40 billion in Asia and the Pacific over 2010-2050 (Adaptation to Climate Change Team, 2015). Similarly, the 2010 World Bank study estimated the global annual cost of adaptation at between $70-$100 billion up to 2050 (IBC & FCM, 2020). International studies of investments in adaptations in the United States, United Kingdom and the European Union conduct that national governments need to invest 0.66%-1.25% of GDP in adaptations to minimize the worst effects of climate change (Martinez-Diaz, 2018). Figure 6 presents adaptation as a percentage of GDP for some major cities in the world, showing the investment range from a high of 0.33% in Beijing to a low of 0.14% in Addis Ababa (Georgeson et. al., 2016).

Figure 7 shows an overall approach, which was completed by IBC & FCM to assess the costs of adaptations in Canada (2020). The approach begins with collecting studies that have quantified the cost of adaptation at the community level across Canada, the objective of this step is to obtain the costs of adaptations from a range of locations, population and climate risks (IBC & FCM, 2020). Then, the estimates of adaptation cost and related details (e.g., adaptation measures and study timeframe) will be extracted from the studies and enter into a database (IBC & FCM, 202). For the study areas corresponding to the cost estimates, the estimated GDP then can be obtained from Statistics Canada or through an equation (IBC & FCM, 2020). The percent of GDP then can be calculated by using cost estimates and obtained GDP.

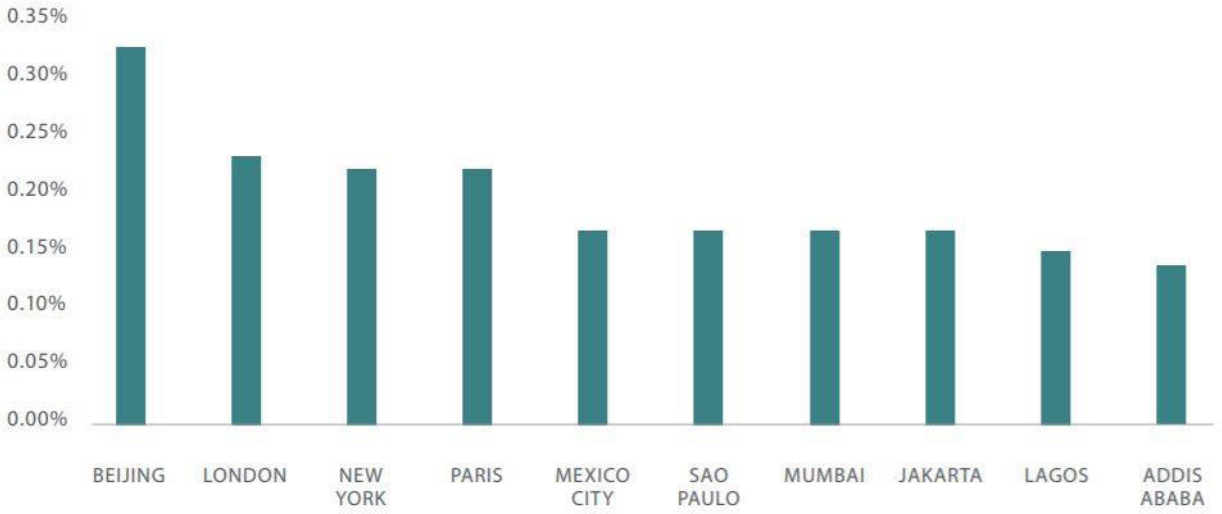


Fig. 6: Costs of climate change adaptations as a percentage of city's GDP, 2015
Source: Georgeson et. al., 2016

The next step is to examine the average percentage of GDP by combining the percentages of GDP calculated in last step, and percentages are also grouped by region (West, East, North, Central Canada), adaptation type, climate risk, and population (IBC & FCM, 2020). As shown in Table 4, these average regional cost of adaptation (i.e., GDP percent) are then combined to give an estimate of the annual national level of investment in adaptation at the local level (IBC & FCM, 2020).

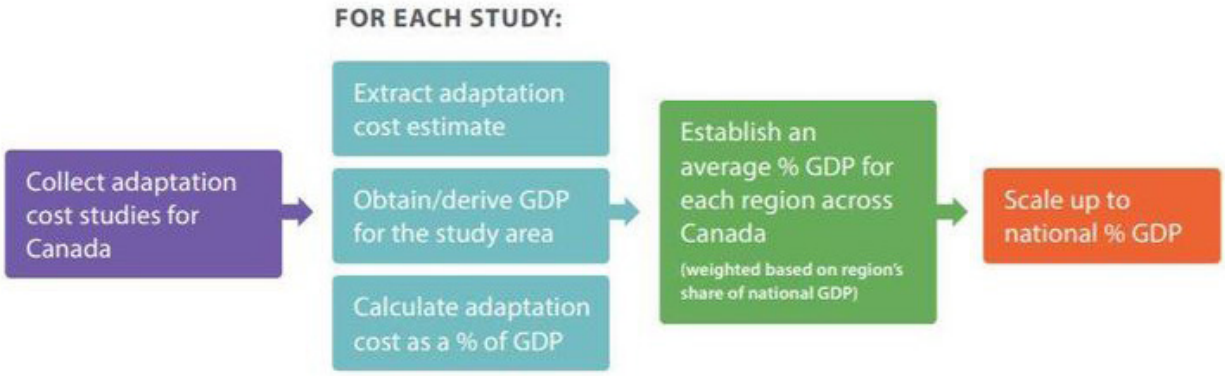


Fig. 7: Approach for assessment of costs of climate change adaptations
Source: IBC & FCM, 2020

CITY	SPENDING 2014/2015	SPENDING AS A % OF GDP	PER CAPITA SPENDING
New York, USA	$2,779 million	0.22%	$270
London England, UK	$1,696 million	0.23%	$167
Paris, France	$1,543 million	0.22%	$563

Table 4: Estimate of cost of adaptation by regions
Source: IBC & FCM, 2020

Consequently, to avoid the worst impacts of climate change at the local level will cost an estimated 0.26% of Canada's GDP, which equivalents to $5.3 billion annually (IBC & FCM, 2020). Though, this study considers the impact of population, communities, locations, climate risks and infrastructure types on the costs of adaptations, this figure (i.e., $5.3 billion) only represents adaptation investments in local public infrastructure, which means the actual costs of adaptations in Canada will exceed $5.3 billion per year.

Though it is obvious that there is a lack of studies that have quantified costs of adaptations for communities in Canada, Canadian governments already recognized the importance of quantifying the adaptation costs and they have had an idea of what governments need to spend on local adaptations to reduce the impacts of climate change. The quantification of costs of climate change adaptation will be improved as more data on adaptation costs becomes available.

6 Communities to Engage

6.1 Potential Communities to Engage

Our literature review of wildfires and stormwater flooding revealed a few promising communities that we could consider interviewing in phase 2 of our engagement. Note that this is a preliminary and incomplete list. Our interviews with practitioners, as well as potential further documents they point us to, could add to or alter this list.

Wildfire	Stormwater Flooding
City of Kamloops	City of Vancouver
Resort Municipality of Whistler	City of North Vancouver
City of Prince George	Town of Gibsons
Regional District of Cariboo	City of Victoria
District of Elkford	

Table 5: Potential Communities for Engagement

Map 5: Potential Communities for Engagement

6.2 Selection of Communities

For the phase 2 of our engagement plan, we will create two lists of potential communities to contact, one for wildfire adaptation and one for stormwater flooding. The same community could feature on both lists. We do not consider this a problem, as it is possible that we would interview different staff members on the two types of adaptations.

Given our project aims/objectives and informed by our literature review, we propose that communities first meet the following criteria to feature on our lists, along with our rationale:

- Given our project aims/objectives and informed by our literature review, we will add communities that have completed the implementation of (not just planned or in the process) at least 1 adaptation measure to one of our selected risks, in order to base our menu on past experience rather than plans or forecasts. Note that communities do not have to have realized benefits from their adaptation to qualify for an interview, as that may take decades.
- Secondly, we will rank communities on our lists by the number of adaptation measures they have implemented, according to the information we found, in order to maximize the number of adaptation measures with the interviews we conduct.
- Thirdly, we will then select communities from the top down, skipping some communities with similar characteristics to ensure our menu is relevant to different communities in BC. Specifically, we will look in our final list of communities a fair representation of different factors, as listed in Table 6. This step will involve gathering demographic information on these communities, which we plan to obtain from census data available from Statistics Canada.

Criteria	Rationale
A diversity of population sizes (aiming to have half of communities above median municipal population and half under)	To ensure our menu is relevant to communities of different population sizes
A diversity in geographic location (aiming to have at least one community each from the Lower Mainland, Vancouver Island, the interior, and northern BC)	To ensure our menu is relevant to communities of different geographic locations and climates
A diversity of median household income (aiming to have half of communities above median provincial income and half under)	To ensure our menu is relevant to communities of different economic means, and possibly of different economic bases (e.g. agricultural)
A diversity of racial composition (aiming to have at least one community with a majority visible minority population)	To ensure our menu is relevant to communities of different racial compositions
The inclusion of a First Nation if possible	To take into account First Nations' particular situation and to hopefully gain an indigenous perspective on the menu at the review workshop

Table 6: Criteria for selection of final list of communities.

We will wait until we have completed phase 1 of our engagement before deciding on the number of communities to engage, as information from practitioners may influence our decision. We will check our final list of communities with our partners before starting phase 2 of engagement.

APPENDIX C -
PHASE I - Practitioner Engagement Plan

Phase I - Practitioner Engagement Plan

This section details the phase 1 of the engagement process, which will include interviews with practitioners. This plan includes details on the objectives, stakeholders, engagement method, engagement material, and engagement timeline.

1. Why: Objectives

The general purpose of this first phase of engagement is to familiarize ourselves with the field of wildfire and urban flooding adaptations in BC from the perspective of practitioners. Specific objectives, as well as how the information obtained will be used, are:

1. to identify case study communities, including ones that have more potential (e.g. have done more adaptations to risks in question)
    a. How this will be used: This will help us decide which communities to reach out to in phase 2 of our engagement.
2. to identify which climate change adaptations to wildfires and urban flooding have been implemented in BC, including more popular ones.
    a. How this will be used: This will give us a better sense of how many adaptations to include in the menu, how to treat potential adaptations that haven't yet been undertaken in BC, and to ascertain the level of detail to go into for each adaptation.
3. To understand if and how practitioners make the distinction between climate change adaptation measures and general management measures.
4. to identify what information and factors have influenced communities to choose certain adaptations over others and the challenges attached with each
    a. How this will be used: This will help us decide on the fields to include in the menu, the questions to ask communities, as well as identify the adaptations more suitable to certain types of communities.
5. to identify, from the perspectives of practitioners, the things that communities should consider when selecting adaptations to wildfires and urban flooding
    a. How this will be used: This can uncover fields that should be included in the menu
6. to identify documents (e.g. reports, articles) on wildfire and urban flooding adaptations in BC, preferably documenting actions that have been implemented already (but may not yet have yielded results).
    a. How this will be used: This will provide us resources for our literature review and thus focus our questions to communities.
7. to identify factors that have caused similar/same adaptations to cost different amounts across communities
    a. How this will be used: This will help us in normalizing costs (e.g. does it depend on population size? number of certain facilities? amount of rainfall?)
8. to understand funding for adaptations to wildfires and urban flooding in BC
    a. How this will be used: This will help fill in potential gaps in this information gained from communities.
9. to identify blind spots in our approach (a.k.a. anything we are overlooking)
    a. How this will be used: This will help uncover "what we don't know we don't know."

10. To get feedback on how practitioners might use an adaptation menu like this and what elements would be most useful.
    a. How this will be used: This will shape what we include in our menu.

2. Who: Stakeholders

We would like to speak with practitioners who have worked with communities in some way in the planning and/or implementation of climate change adaptations to wildfires and urban flooding. This will primarily include consultants (in businesses or non-profits) but may also include provincial/federal government staff such as those administering grants.

We plan to conduct at least 3 interviews for wildfires and 3 interviews for urban flooding. Given these numbers, and the contacts that our partners have in the field, we will be primarily relying on introductions by our partners. We will also reach out to SCARP faculty working in the climate adaptation field.

As we find contacts, we will input them into the following tables to facilitate communication and documentation.

Organization	Contact Name and Title	Email	WCEL/KWL Attendance?
Blackwell Associates	Bruce Blackwell	bablackwell@bablackwell.com	Yes
WSP formerly Metro Vancouver	Francis J Reid	Francis.Ries@wsp.com	Yes
Diamond Head Consulting	Conor Corbett	conor@diamondheadconsulting.com	No

Table 1: Practitioners in wildfire adaptation

Image Source: People Meeting Seminar Office Concept. https://www.shutterstock.com/search/community+meeting

Organization	Contact Name and Title	Email	WCEL/KWL Attendance?
Engineers and Geoscientists British Columbia	Harshan Radhakrishnan	hradhakrishnan@egbc.ca	No
Kerr Wood Liedal	Laurel Morgan	LMorgan@kwl.ca	No
GHD	Gemma Dunn	Gemma.Dunn@ghd.com	Yes
Lanarc Consultants	David Reid	David.reid@lanarcconsultants.ca	No

Table 2: Practitioners in stormwater flooding adaptation

3. How: Engagement Method

We plan to conduct semi-structured interviews with practitioners on Zoom.

Before interviews

After interviewees have been introduced to the team via email (with Charles as the contact person), We will introduce ourselves and the project with an introductory email (see next section) and ask if they might be available for an interview the week of December 7. If that week doesn't work, then we will propose the following week, etc.

At the same time, we will check with our partners as to whether they want to attend. Once a date and time is set (preferably earlier in the period to allow for potential rescheduling),we will send out an event invite with a Zoom link to all participants.

Before each interview, the team will review the interviewee's background info on the Internet, such as the communities they've worked with and the reports they've written, and consider adjustments or additional interview questions as needed.

As soon as the time is confirmed, compile the interview questions into a pdf document, without prompts, and send them to the interviewees in advance of the interview. This allows people to be better prepared for the interview.

We will decide on the role of each team member beforehand, and rotate roles as beneficial for different interviews.

During interviews

We will aim to have at least two members of the project team in attendance at each interview, preferably three. We will each take on one of the following roles:

- **Interviewer:** Ask the starting questions and make sure we're on track with time
- **Facilitator:** Ask follow-up questions to ensure we understand the answers.
- **Note-taker:** Take notes and record the meeting (with approval).

We will introduce ourselves as well as give a short description of the project (see the introductory email), we will ask pre-determined questions as starting points (see next section) and ask follow-up questions as conversations proceed. The last question will be informing them about the review workshop and asking them how they want to participate.

After interviews

Within 24 hours after interviews, we will send a follow-up email as drafted with adjustments as needed.

The engagment material has been included in the Annexures section.

4. When: Engagement Timeline

Below is the engagement timeline for phase 1 and the beginning of phase 2.

Timeline	Tasks
ASAP	Reach out to interviewees
Nov 24	Finish engagement plan phase 1 draft #1, send to Clare for review
by Nov 27	Finish revising engagement plan phase 1, send draft #2 to partners for review
by Dec 4	Finish revising engagement plan phase 1, send final version in interim report to instructors and partners
Week of Dec 7	Meet with partners to discuss interim report
Dec 7 to Mid January	Conduct interviews with practitioners
by Dec 21	Finish community engagement plan draft #1, send to Clare and partners for review
Second week of Jan	Meet with partners to review experience of phase 1 and go over community engagement plan (especially interview guide)
Jan 18 onwards	Reach out to communities

Table 3: Tasks and Timeline for Engagement Phase 1

5. What: Engagement Material

Introductory Email

Subject: Availability for Interview: Dec. 7-11?

Hello [insert first name of interviewee],

Thanks so much for being willing to speak with us. As [insert name of referee] mentioned, we are Charles, Emma, and Pulkit. We're 2nd year students in the Master of Community and Regional Planning planning at the School of Community and Regional Planning (SCARP) at UBC. As part of a course, we have partnered with West Coast Environmental Law (WCEL) and Kerr Wood Leidal (KWL) to draft a cost menu of climate change adaptation measures for communities across British Columbia.

The Cost of Climate Change Adaptation Menu (the "Menu") will be a written and electronic publication outlining options available to BC communities to address the most critical climate change hazards facing BC communities and providing high-level cost ranges for each option. The Menu is intended to make climate adaptation action tangible and provide a foundation for decision-making to start the conversation with community leaders and the public. The Menu could also help communities think proactively about opportunities for funding adaptation action and regional collaboration.

For the purpose of our study, considering the resources available at hand, we have decided to focus on two climate risks and their related adaptation measures and costs: wildfires and urban flooding. We have conducted literature reviews and would be engaging with communities which have adopted Climate Change Adaptation measures to tackle the risk posed by Wildfire and Stormwater Flooding. For each adaptation, we are looking for information such as capital costs, maintenance costs, and human resource requirements.

Considering that you have experience working with multiple communities on adapting to [insert relevant risk/risks], we were hoping you could share with us background information about communities' adaptation experiences, such as what influenced them to choose certain adaptations over others, challenges they experienced in selecting adaptations, and how they funded the adaptations. We can send you a detailed list of our questions before our meeting. Your input will help us select communities to speak with, shape our engagement with them, select adaptations to include in the menu, and decide what information to include about each adaptation.

You will also have the opportunity to review a draft of the menu in February in a workshop if you are available then. We will provide more information about that later if you are interested.
Would you be free sometime during the week of Dec 7 for a Zoom call? We are generally free at 9 am and after 4 pm but can make ourselves available for other times as well. We were hoping for an hour-long call, but we understand you may be quite busy and would appreciate a shorter call as well! Let us know what works for you.

Looking forward to speaking with you,
Charles
On behalf of the team

Interview Guide - Practitioner Engagement

Interviewer: Hello, thanks so much for speaking with us. We are Charles, Emma, and Pulkit. We're all 2nd year students in a community and regional planning program at UBC. As you know, we're trying to create a menu of adaptations that communities can take against wildfires and stormwater flooding, using the experiences of communities in BC that have already undertaken adaptations already. We're specifically interested in the cost of different measures. We hope this interview won't take more than an hour. Me and [facilitator] will be speaking with you, and [note taker] will be taking notes.

Before we start, would you be comfortable if we recorded this conversation so we could check things later? We won't be sharing the recordings.

Do you have any questions before we start?

Interviewer: (asks questions below)
Facilitator: (intersperses follow-up questions throughout)

1. Can you tell us about your experience working with communities on adaptations to wildfire/stormwater flooding?
2. What are some adaptations that communities in BC have done towards wildfire/stormwater flooding?
3. Of those adaptations, which types of adaptations or which specific ones have been more popular?
   Prompts:
   a. Infrastructure ones
   b. Policy ones
4. Can you tell us examples of when adaptations haven't succeeded in providing the intended benefits, and ones where the adaptations have?
5. Which other communities are you aware of that have completed some adaptations to wildfire/stormwater flooding?
6. Among those communities, which ones do you think would be particularly valuable to speak with?
   Prompts:
   a. done a lot of work in this area
   b. have an easy-to-contact contact person
7. What do you think would be useful to communities in a menu?
8. In your experience working with communities, what sort of information about adaptations have you noticed caused them to choose certain adaptations over others?
   Prompts:
   a. capital costs
   b. maintenance costs
   c. timeline
   d. staff requirements

9. Have you noticed that certain communities tend to choose certain adaptations over others?
   Prompts:
   a. coastal vs. interior
   b. larger population vs. smaller
   c. larger land area vs. smaller
   d. wealthier vs. less well off
   e. urban vs. rural
   f. sizeable indigenous population vs. not
   g. sizeable visible minority population vs. not
10. What challenges do communities face in choosing between adaptations?
    Prompts:
    a. unknown costs
    b. unknown timeline
    c. unknown funding sources
11. What challenges have you seen communities face in implementing adaptations?
    Prompts:
    a. costs higher than expected
    b. taking longer than expected
    c. loss of public/political interest
    d. loss of funding
12. What would you suggest for communities to keep in mind when choosing adaptations?
13. Have you written reports/documents or do you know of any that include the experience of BC communities that have implemented adaptations for wildfires/stormwater flooding?
    Prompts:
    a. the capital/maintenance/operations costs they spent
    b. the staff time they spent
    c. their funding sources
    d. the benefits they realized
14. When the same adaptation costs differently in different communities, what makes the difference, according to your view?
    Prompts:
    a. population size
    b. land size
    c. length of streets, pipelines, etc
    d. climate - dry/wet
15. Have you provided costs of adaptations to communities before? If so, how have you gone about getting that information?
16. How have communities gotten funding for adaptations to wildfire/stormwater flooding?
    Prompts:
    a. local property tax
    b. provincial grants
    c. federal grants
    d. private donations
    e. corporate sponsorships/donations
    f. non-profit funding organizations
17. Are there specific funding sources/grants for wildfire/stormwater flooding adaptations at the provincial and federal level? From other sources?
18. We'd like to get your thoughts on our approach. After speaking with practitioners, we plan to speak with communities, create a draft menu, invite interviewees to review the menu, and come up with a final version. What do you think about our approach?
    Prompts:
    a. Is there something we might be missing?
    b. Is there anything we should keep in mind as we go about this?
19. Any other thoughts?

APPENDIX D -
PHASE II - Municipal Staff/Planners Engagement PLan

Phase II - Municipal Staff/Planners Engagement Plan

1. Why: Objectives

The general purpose of the second phase of engagement is to collect more information about wildfire and stormwater flooding adaptations in BC from the perspectives of communities. specific objectives and how the information obtained will be used, are:

1. to identify which approaches communities are using and why they have chosen certain approaches over others.
    a. How this will be used: This will help us finalize the pros and cons of the adaptations in the menu, and understand which factors affect communities.
2. to identify how communities differentiate between climate change adaptations and general management measures
    a. How this will be used: This will help us list climate change adaptations in the menus instead of the mixed measures.
3. to identify how well are the adaptations being implemented by communities and any positive/negative results have shown after the implementation
    a. How this will be used: This will help us get more information about the results after implementing the adaptations, and identify the adaptations more suitable to certain types of communities.
4. to identify challenges that communities have had in choosing adaptations and in implementing them
    a. How this will be used: This will help us decide on the fields to include in the menu, as well as identify the adaptations more suitable to certain types of communities
5. to identify documents (e.g. reports, articles) on wildfire and stormwater flooding adaptations in BC, preferably documenting completed actions.
    a. How this will be used: This will provide us resources for our literature review and thus focus our questions to communities.
6. to understand what different adaptations have cost (Including upfront planning, capital costs and ongoing maintenance), and factors that caused similar/same adaptations to cost different amounts across communities
    a. How this will be used: This will help us in normalizing costs (e.g. does it depend on population size? number of certain facilities? frequency of hazards?)
7. to identify funding sources used by communities for adaptations to wildfires and stormwater flooding for communities
    a. How this will be used: This will help fill in potential gaps in this information gained from communities.
8. To get feedback on how practitioners might use an adaptation menu like this and what elements would be most useful.
    a. How this will be used: This will shape what we include in our menu.

2. Who: Stakeholders

Community	Contact Name and Title	Email	Reference
Resort Municipality of Whistler (RMOW)	Heather Beresford - Manager, Environmental Stewardship	HBeresford@whistler.ca	Recommended by Bruce Blackwell
District of North Vancouver	Guy Exley - Urban Forester	exleyg@dnv.org	Recommended by Bruce Blackwell
District of Squamish	Megan Latimer	mlatimer@squamish.ca	Recommended by Bruce Blackwell
District of West Vancouver	Heather Keith - Manager of Environmental Protection	hkeith@westvancouver	
City of Prince George	Andrea Byrne	Andrea.Byrne@princegeorge.ca	From Literature Study
City of Kelowna	Tara Bergeson	TBergeson@kelowna.ca	Recommended by Bruce Blackwell

Table 1: Communitiy Representatives Interviewed for Wildfire Adaptations

Community	Contact Name and Title	Email	Reference
City of Vancouver	Melina	HBeresford@whistler.ca	
City of Victoria	Brianne Czypyha	Stormwater@victoria.ca	
Town of Gibsons	Emanuel Machado	emachado@gibsons.ca	
City of North Vancouver	Dave Matsubara	dmatsubara@cnv.org	
City of Vernon	Geoff Mulligan	GMulligan@vernon.ca	

Table 2: Communitiy Representatives Interviewed for Stormwater Flooding Adaptations

3. How: Interviews

Similar to phase 1 - practitioner engagement, 45 min - 1 hour long semi structured interviews were conducted with the municipal staff/planners. The interviews were transcribed and the data from the interviews was used for drafting the menu items, which were displayed during phase 3 engagement - workshops, to invite feedback on the preliminary design of the menu.

4. When: Engagement Timeline

Below is a tentative engagement timeline for phase 2.

Timeline	Tasks
2nd week of Jan	Meet with partners to review experience of phase 1 and go over community engagement plan (especially interview guide)
3rd week of Jan	Select communities to speak to (apply criteria)
4rd week of Jan - 3rd week of Feb (before reading break)	Reach out to communities
3rd-4th week of Feb	Draft structure of the menu (after 1st interview)

Table 3: Tasks and Timeline for Engagement Phase 2

5. What: Engagement Material

Introductory Email

Dear (Name),

Greetings for the day!

We are Emma, Pulkit and Charles, second year community planning students at School of Community and Regional Planning (SCARP), UBC. We are working on the project 'Cost of Climate Adaptation Menu' with West Coast Environmental Law (WCEL) and Kerr Wood Leidal as part of our studio course.

The project focuses on developing a Climate Adaptation Menu to help BC local governments better understand the costs of climate action. The Menu is focused specifically on adaptation to wildfire and stormwater flooding.

As a part of the project, we are in the process of conducting interviews with community representatives, who could provide insights into the adaptation measures undertaken by their community. We interviewed (Name of Practitioner), who referred you, since (Name of Community) has undertaken adaptation measures pertaining to (wildfire/stormwaterflooding).

We'd appreciate it if you have time for a 1 hour interview in the coming weeks (Feb 1st - 12th) to share information about (Community's Name) (wildfire/stormwater flooding) adaptation measure(s), cost of planning and implementing the adaptation measure(s) and challenges in selecting and implementing them.

Looking forward to hearing from you soon.

(Name of Student)
On behalf of the team
Master of Community and Regional Planning
SCARP, UBC

Interview Guide - Municipal Staff/Planner Engagement

Intro:

- Hello XXX, thanks so much for speaking with us.
- Maybe before we start it would be helpful to give a bit more background to this project?
- We're interested in creating a menu of adaptation options for climate change risks like wildfire, and have costs associated with each option to aid communities in deciding which option to explore further.
- We are specifically interested in measures targeting the extra risk from climate change as compared to conventional management.
- Before we start, would you be comfortable if we recorded this conversation so we could check things later? We won't be sharing the recordings.

1. What are some adaptations that the community have done towards wildfire/stormwater flooding?
   Follow up: What were those types of adaptations?
   Prompts:
   a. Infrastructure ones
   b. Policy ones
2. Why did your community choose these adaptations over other options? What were the disadvantages of the others?
   Prompt:
   What other adaptations did you consider, but ultimately not implement?
3. How much did the adaptation actions you implemented cost at a general scale, in terms of up front planning/capital costs and ongoing maintenance ?
   Prompts:
   a. the capital cost
   b. the maintenance/operations costs
   c. the staff time they spent
   d. planning costs
   e. contractor costs
4. Are there any other cost components to this project (e.g. equipment, construction material, contractors, etc)?
5. What are the key factors contributing to the cost of implementation of this adaptation measure?
   - local context?
   i. coastal vs. interior
   ii. larger population vs. smaller
   iii. larger land area vs. smaller
   iv. wealthier vs. less well off
   v. urban vs. rural
   vi. sizeable indigenous population vs. not
   vii. sizeable visible minority population vs. not

6. What challenges and success did the communities encounter while planning and implementing the adaptation measure(s)?
   Prompts:
   a. capital costs
   b. maintenance costs
   c. timeline
   d. staff requirements
   e. unknown costs
   f. unknown timeline
   g. unknown funding sources
7. How did you get the funding for your adaptations?
   Prompts:
   a. local property tax
   b. provincial grants
   c. federal grants
   d. private donations
   e. corporate sponsorships/donations
   f. non-profit funding organizations
8. What would have been useful to your community in a menu?
9. Are there other contacts whom you could recommend to us? Either professionals or in communities.
10. Any other thoughts?

Optional Questions:

1. Does your community make a distinction between climate change adaptation measures and general management measures? If so, how?
2. What information about adaptations has helped your community decide on which adaptations to undertake?
3. Are there other communities that you think would be valuable to speak with? Do you have contacts you could recommend or introduce to us?
   Prompts:
   a. done a lot of work in this area
   b. have an easy-to-contact contact person

Interviewer: Thanks again for speaking with us! We will be using this information to create a draft menu, and we'll keep you updated about the review workshop, which we hope to have in February. Bye!

APPENDIX E -
PHASE III - Review Workshops

Phase III - Review Workshops

The third phase of engagement consists of workshop with stakeholders i.e., with practitioners and community representatives whom we had interviewed in the first and second phase of engagement, to invite feedback on the design of the menu.

1. Why: Objectives

1. To seek feedback and recommendations on the draft menu including the components, graphic design, content, and organization of material.
   a. How this will be used: This information will be used to develop and improve the menu for use and application by BC communities.

2. Who: Stakeholders

For inviting feedback we invited practitioners, municipal staff/planners and partners. The list has been provided below:

Contact Name	Organsiation	Email	Risk	Invited	Attendance/ Other Remarks
Bruce Blackwell	Blackwell Associates	bablackwell@blackwell.com	Wildfire	Yes	Waiting for reply
Francis J Reid	WSP formerly Metro Vancouver	Francis.Ries@wsp.com	Wildfire	Yes	Feedback through email
Conor Corbett	Diamond Head Consulting	conor@diamondheadconsulting.com	Wildfire	Yes	Waiting for reply
Harshan Radhakrishnan	Engineers and Geoscientists British Columbia	hradhakrishnan@egbc.ca	Stormwater Flooding	Yes	Yes
Laurel Morgan	Kerr Wood Liedal	LMorgan@kwl.ca	Stormwater Flooding	Yes	Waiting for reply
Gemma Dunn	GHD	Gemma.Dunn@ghd.com	Stormwater Flooding	Yes	
David Reid	Lanarc Consultants	David.reid@lanarcconsultants.ca	Stormwater Flooding	Yes	No

Table 1: Practitioners in wildfire and stormwater flooding adaptation

Contact Name	Organsiation	Email	Risk	Invited	RSVP (Yes/No)
Heather Beresford - Manager, Environmental Stewardship	Resort Municipality of Whistler (RMOW)	HBeresford@whistler.ca	Wildfire	Yes	Yes

Contact Name	Organsiation	Email	Risk	Invited	Attendance/ Other Remarks
Guy Exley - Urban Forester	District of North Vancouver	exleyg@dnv.org	Wildfire	Yes	Feedback through email
Megan Latimer	District of Squamish	mlatimer@squamish.ca	Wildfire	Yes	Waiting
Heather Keith - Manager of Environmental Protection	District of West Vancouver	hkeith@westvancouver	Wildfire	Yes	Yes
Andrea Byrne	City of Prince George	Andrea.Byrne@princegeorge.ca	Wildfire	Yes	Waiting
Tara Bergeson	City of Kelowna	TBergeson@kelowna.ca	Wildfire	Yes	Feedback through email
Melina	City of Vancouver	HBeresford@whistler.ca	Stormwater Flooding	Yes	Wating
Brianne Czypyha	City of Victoria	Stormwater@victoria.ca	Stormwater Flooding	Yes	Yes
Emanuel Machado	Town of Gibsons	emachado@gibsons.ca	Stormwater Flooding	Yes	-
Dave Matsubara	City of North Vancouver	dmatsubara@cnv.org	Stormwater Flooding	Yes	Waiting
Geoff Mulligan	City of Vernon	GMulligan@vernon.ca	Stormwater Flooding	Yes	Interview after Workshop

Table 2: Communitiy Representatives Interviewed for Wildfire and Stormwater Flooding Adaptations (contd.)

Contact Name	Organsiation	Email	Invited	Attendance/ Other Remarks
Andrew Gage	West Coast Environmental Law	Andrew_Gage@wcel.org	Yes	Yes
Silvie Harder	West Coast Environmental Law	sharder@wcel.org	Yes	No
Robin Hawker	Kerr Wood Leidal	robin@hawker.red	Yes	Yes
Patrick Lilley	Kerr Wood Leidal	plilley@kwl.ca	No	No

Table 3: Partner Contact Information

3. How: Workshops

Before workshop:

- We will send individual emails to our interviewees,
- inviting them to attend a workshop, providing them options to choose from two sessions depending upon the sc
- if they cannot attend or prefer to send responses via email, we can send them the design for review.
- the discussion topics - aspects of the menu we are looking to get feedback on

During workshop:

- We will hold two workshops:
- Tue, March 2, 3-4 pm
- Wed, March 3, 4-5 pm
- Each workshop will last 1 hour.
- During the workshop, we will show them a few menu items and note some aspects we're looking to get feedback on. We won't ask questions one by one or direct people to speak one after another. We will let anyone who wants to say something speak. These questions/ topics will help us guide the discussion. To make it convenient for the participants to refer to the discussion questions, so that they don't have to shuffle between screens we will add the discussion topics in the chat box.
- We won't do breakout sessions to facilitate recording (request permission before recording). Just one person needs to record if we're all in one room, but if we split out we'll need multiple people to record.

After workshop:

We will send an email to:

- thank them
- a survey to get feedback on the interviews and workshop sessions
- For practitioners, we will send a gift card, with double the amount for those who attended both an interview and a workshop.

4. When: Timeline

Below is a tentative engagement timeline for phase III.

Timeline	Tasks
11th February - 19th February	Reach out to practitioners and municipal staff/planners
Mid February	Finish draft engagement plan phase III and send to instructors and partners
Last Week of February	Finish revising engagement plan phase III
March 2 and March 3	Workshops
March 5	Send Menu items for feedback through emails
TBD	Feedback survey for participants

Table 4: Tasks and Timeline for Engagement Phase III

5. What: Engagement Material

Email Invitation for Workshop

Dear (Name)

Thank you for attending the interview and providing valuable insights into the initiatives undertaken by the (Name of Community). Also, thanks for sharing the resources.

Also, we are conducting 1 hour workshops on February 23rd (3:30 PM) and February 24th (4 PM) to invite suggestions and feedback on the design of the cost menu. If you are free, we would really appreciate your input. You could attend either of the session. If you're not free during those times but would still like to review the draft menu, we could send it to you by email.

Regards
Name
On behalf of team
Master of Community and Regional Planning
SCARP, UBC

Email for Feedback through Email

Dear (Name),

As discussed please find attached the preliminary draft of the menu items for your reference. We are seeking feedback on the preliminary design of the menu including the components of the menu item, information included in the item, layout of the menu item etc.

The primary audience of the menu is municipal staff and planners. These menu items would be presented as cards to the communities and would have 2 sides. Only the front side of the card was presented during the workshop. The back of each card would show the supporting information like definition of the components of the menu items - Capital Cost, Maintenance cost etc.

I have also attached the discussion questions (used during the workshop) which includes the major topics around which you could structure your feedback.

Any feedback would be greatly appreciated!

Regards
(Name)
On behalf of team
Master of Community and Regional Planning
SCARP, UBC

Interview Guide - Review Workshop

5 mins - Introductions & Opening

- Thanks so much for speaking with us before and for coming out to this workshop session.
- So we're currently processing the information you gave us in the interviews and we've come up with a few draft menu items. We would like to get your thoughts on them.
- (Charles arrange people in order and make everyone see the same order)
- I'll pass it to the partners to introduce themselves and speak a bit about the menu
- (partner intros and Andrew)
- Maybe it would be helpful for practitioners and local government representatives to introduce themselves as well? Maybe we can start with...
- (other intros)
- We'll first show you what we've prepared and ask a few questions about things like the level of detail, the presentation, and organization.
- Before we start, is everyone comfortable with us recording this session? It's just so we can refer back to the discussion later on. If you're not comfortable, just send a message to Pulkit and we'll take notes on this discussion instead of recording.

5 min - Show & Tell

- Intended audience & use: The primary audience of this menu are municipal staff
- Speak how the menu was made
- Speak what goes into each category
- Show draft adaptations (tailor to participants)
- ***Send menu items as pdf in chat so participants can flip through them on their own

40 min - Some aspects that we'd like to get feedback on include:

Information and Level of Detail (20 mins):

1. Is this information too detailed? Or not detailed enough?
2. Is this enough information on the costs?
3. Is it clear how we came to these cost estimates from the interviews?
4. Do the cost ranges make sense? Do they fit with your experience?
5. Are any of these categories not useful? (Do these categories make sense for both wildfire and stormwater flooding? (only ask in 2nd workshop))
6. Is there other information that you think should be here?
7. How comfortable would you be associating your community with cost information and challenges?
8. Are there any other thoughts about any of the questions so far?

Presentation and Organisation (20 mins):

1. Does this organization of material appear good? Should anything be rearranged?
2. Do the graphics effectively convey the topic?
3. Is there too much text? Or too little?

Additional questions in case conversation stops:

1. Would this have been helpful to your community if it was just starting to consider adaptations?
2. How do you see communities using a menu like this?

Any other thoughts/comments about anything? Or other suggestions?

5 min - Closing:

- This discussion has been very helpful, but we don't want to take too much of your time. We will consider these comments and send you a draft menu with all the adaptation options later on for you to ground truth.
- Thank you so much.

APPENDIX F

COST MENU

for Climate Change Adaptation Measures

Background

BC communities have made admirable progress in adapting to climate change however, many other communities in the province are still in the early stages of climate change adaptation. While lists of adaptation options exist, oftentimes these lists leave out costs, making it more challenging for communities to weigh the options.

West Coast Environmental Law (WCEL) and Kerr Wood Leidal (KWL) identified this need, and from the fall of 2020 to the spring of 2021, they engaged a team of three master's students in the School of Community and Regional Planning as part of a studio course.

The project aims to create a "menu" of climate change adaptation options with associated costs, based on the actual experiences of communities that have implemented the adaptations. The team narrowed the scope of the menu to wildfires and stormwater flooding, based on the team's interests and partners' assessment of community needs.

While processing interviews, the team chose to present the adaptations with relatively more complete content. They also made an effort to include a range of adaptations, including structural ones and policy ones.

The team conducted a five-stage process:

1.  **Literature Review:** Reviewing the grey literature in BC on these risks
2.  **Practitioner Interviews:** Interviewing seven practitioners in the field
3.  **Community Interviews:** Interviewed staff from 11 local governments in BC
4.  **Review Workshops:** Conducting two workshops to review sample menu items
5.  **Menu Creation:** Using the information from interviews to create a full menu

User Information

This cost menu provides high-level and sample community costs for various adaptations to climate change risk events in BC. Cost figures are indicative and not definitive.

Who is this menu for?

- The primary audience are planners and staff in local government in BC
- Residents may find it a useful reference for participating in municipal conversations

What can this menu be used for?

- Exploring climate change adaptations other communities in BC have undertaken
- As a foundation or starting point in deciding which adaptations to pursue
- Learning about the experiences other communities in implementing those adaptations
- Identifying other communities to speak with (see introductory pages for each risk)

When should this menu be used?

- The menu may be more useful once your community knows the climate change risks it faces or wants to adapt to
- Ideally, detailed studies/analyses would follow the selection of adaptations before taking action

Limitations of this menu

- There is an overlap in climate change adaptations and general management practices it is not easy to distinguish between them
- Adapting to climate change involves more than local government actions, such as political will or public awareness
- There are more aspects to adaptations than those we have listed, such as costs to other parties or ease of implementation
- The adaptations shown are not exhaustive, nor is the information complete or definitive. In fact, your community may have lessons to share.

Potential Next Steps

- Expanding the menu to include other risk events.
- Obtaining more cost information from communities to obtain cost ranges for more adaptations
- Providing more detail and breakdown of costs and benefits per adaptation
- Adding case studies

Glossary of Key Terms

Risk event: “Occurrence or change of a particular set of circumstances that could occur, due at least in part to climate change, and would have a significant impact on provincial objectives.”

> *Source:* Ministry of Environment and Climate Change Strategy, 2019. *Preliminary Strategic Climate Risk Assessment for British Columbia.*

Adaptations: “Adjustments to natural or human systems in response to actual or expected climate change.” This menu focuses on adaptations that local governments can do.

> *Source:* United States Government Accountability Office, 2016. “Climate change: Selected governments have approached adaptation through laws and long-term plans.”

For the purpose of this menu we have grouped adaptations into two broad categories:

Structural Adaptations: Adaptations involving changes to the built or natural environment done by local government staff or its contractors. Example: fuel management.

Policy Adaptations: All other adaptations, including regulatory changes, price structuring, running activities/programs, making plans, etc, which do not involve local government staff or contractors making direct changes to the environment. Example: Community Wildfire Protection Plans.

Co-benefits: Positive effects of an adaptation besides adapting to the risk event. Example: Stormwater ponds adding recreational space in an local area.

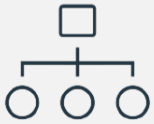
Reading a Menu Item

The risk event the adaptation is for

Name of adaptation

Description of adaptation

Picture(s) related to the adaptation



The broad “type” of adaptation, whether structural or policy

Whether the adaptation applies to public or private land

The land uses that this adaptation applies to

Reading a Menu Item

The risk event the adaptation is for

Adaptation Name

Start-up Costs to Municipality

- These are initial costs to implementing the adaptation.
- These costs are to the municipality and do not include costs to private actors, senior governments, etc.
- Sample community costs are provided to serve as reference figures. Communities are not named, but the region and population are provided.
- We attempt to list cost components to account for differing costs of good/services throughout the province.
- Where available, cost ranges are provided, but these are general estimates, not hard limits.

Ongoing Costs to Municipality

- These are ongoing costs to maintain the adaptation.
- These costs are to the municipality and do not include costs to private actors, senior governments, etc.
- Sample community costs are provided to serve as reference figures.

Local Conditions Influencing Cost

- These are factors that can increase or decrease costs, either for start-up or ongoing costs.

Funding Sources

- Here are funding sources used by at least one community towards this adaptation.
- Amounts are omitted because they can vary by community and year.
- Funding sources change frequently. Note the date the menu was produced (on bottom-right of page)

Benefits & Co-benefits

- Here are benefits and co-benefits experienced or expected from the adaptation.

Challenges

- Here are challenges communities we interviewed faced in implementing the adaptation.

Tips & Advice

- Here are tips and advice interviewed communities gave to other communities considering this adaptation.

Key Resources

- Here are documents or webpages where you can get more information.

Year the menu item was produced

Wildfire Adaptation Measures

Wildfire Definition

'An unplanned fire - including unauthorized human-caused fires - occurring on forest or range lands, burning forest vegetation, grass, brush, scrub, peat lands, or a prescribed fire set under regulation which spreads beyond the area authorized for burning.' (Wildfire Service BC, n.d.)

Wildfire in British Columbia

- Wildfire is a naturally occurring event in BC, however climate change has exacerbated the frequency of wildfires.
- Wildfires have engulfed an average of 2.5 million hectares per year in Canada (NRCAN,2020).
- In the past decade, BC experienced particularly severe wildfires in 2018, 2017, and 2014. Reasons for wildfire include lightening, human intervention, warmer climates, mountain pine beetle infestation, accumulation of forest fuel etc.
- In 2018, 2117 fires were recorded in BC, which burnt 1,354,284 hectares of area and costed the province $ 615 million

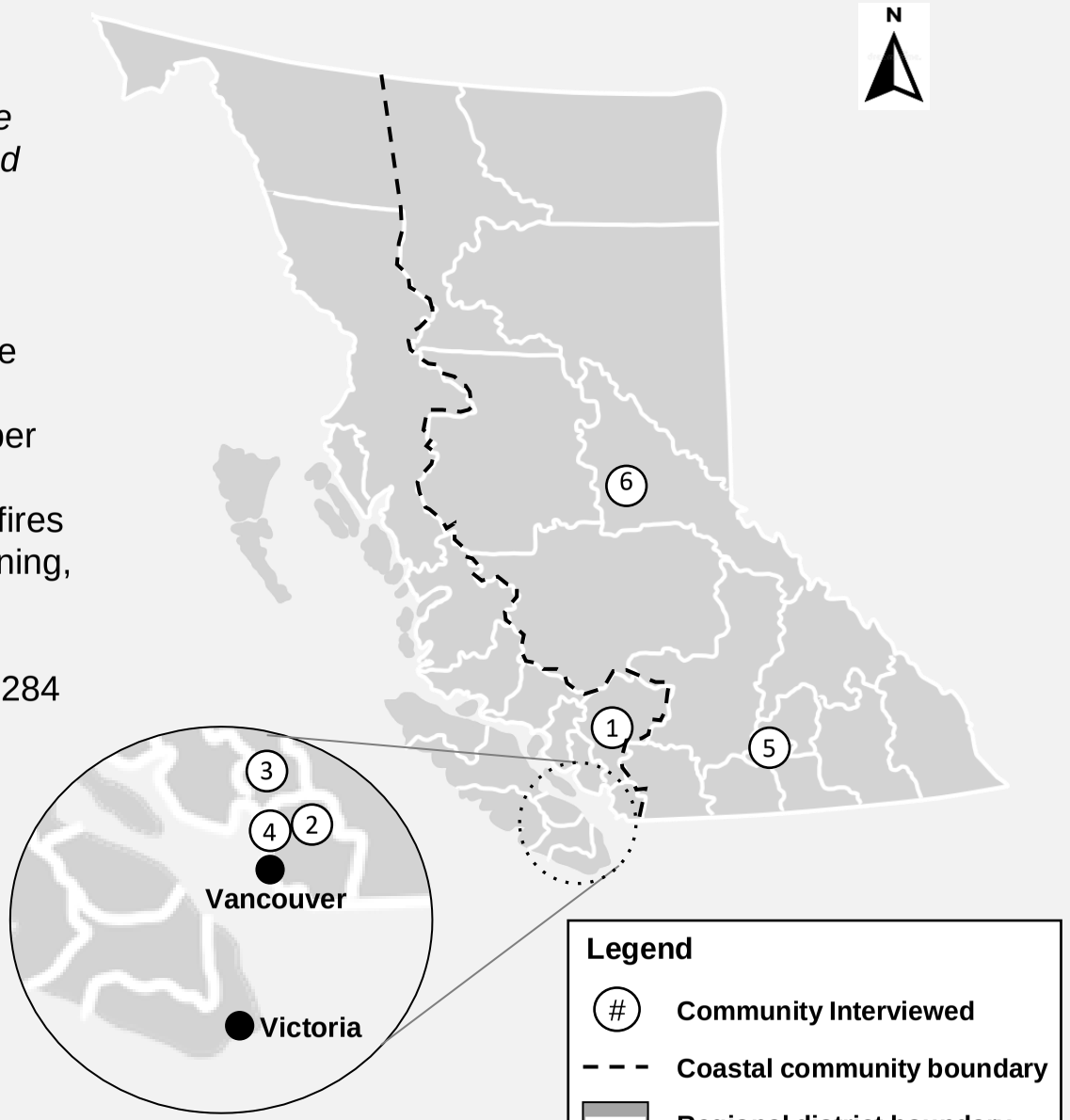
Communities interviewed

1. Resort Municipality of Whistler
2. Corporation of the District of North Vancouver
3. District of Squamish
4. District of West Vancouver
5. City of Kelowna
6. City of Prince George

Note: Regional Districts having a coast line are assumed as coastal communities

**NRCAN – Natural Resources Canada*

Communities Interviewed



Refer the list for community numbers

Community Wildfire Protection Plans (CWPPs)

It helps local governments identify wildfire risk within and surrounding the community and the opportunities available to reduce and mitigate the risk. Community Resiliency Investment program of the BC government which is responsible for funding wildfire adaptations, provides a template for the CWPP, which consists of the mandatory content and structure. As per the template the 4 risk reduction strategies that should be addressed by municipalities include,

- **Fuel Management:** identifies and prioritize actions
- **Community Education:** engagement for community support and education & outreach
- **FireSmart Planning:** current FireSmart implementation and future scenario
- **Other measures:** local strategies and actions to reduce risk

This is a **policy** adaptation

This adaptation applies to **public & private land**

This adaptation applies to **many land uses**

Trees infected by Mountain Pine Beetle infestation

Picture Source: *Mountain pine beetle*. (n.d.). https://wiki.bugwood.org/HPIPM:Mountain_Pine_Beetle

Community Wildfire Protection Plans (CWPPs)

Start-up Costs to Municipality

SAMPLE COST

- A community in the interior of about 70,000 residents and 300 sq. km. spent **$67,000** on a consultant and around **200 hours** by the staff person leading the project

COST RANGE

- **Plan:** prepared by a consultant, **$20,000 – 70,000** is usual, depending on the community size.
- **Staff Time:** Engaging with community and other departments of municipality including Planning, Fire, Parks etc.

Ongoing Costs to Municipality

- Updating the CWPP carries a cost we did not obtain a figure for this.

Local Conditions Influencing Cost

- A larger population size of the community would require more outreach and hence increase the cost

Funding Sources

- Community Resiliency Investment (CRI) Program- UBCM
- Community tax revenue

Benefits & Co-benefits

- Helps identify and prioritise potential risks within and around the community as well.
- Helps strategize actions.
- Provides opportunity to establish the Wildland Urban Interface (WUI) boundary using local knowledge

Challenges

- Co-ordination between internal departments of municipality
- Implementation can be time-consuming

Tips & Advice

- No specific advice was provided for this adaptation measure by practitioners and municipal staff

Key Resources

Example CWPPs

City of Kelowna

City of Prince George

Fuel Management

The aim of fuel management is to reduce the potential wildfire risk posed by the fuel formation in the forest. Forest fuel is dead organic matter consisting of vegetation and biomass. Mountain Pine Beetle and other pest infestations is also responsible for the formation of forest fuel. Rising temperatures due to climate change further aggravates beetle infestations increasing the fuel formation.

Fuel treatment helps to reduce the wildfire intensity to a level which is manageable by fire fighters through direct suppression measures like establishment of sprinklers etc. In addition to lowered fire intensity, it would also reduce crown fire ignition & spread, sustained ignition and the rate of wildfire spread (Fuel Management Prescription, BC, 2020). It is focused on Wildland Urban Interface (WUI), where the human settlements and the wildland interacts but could be applied to large parks to protect natural assets and critical infrastructure, depending upon the community risk reduction objectives (Fuel Management Prescription, BC, 2020).

This is a **structural** adaptation

This adaptation applies to **public land**

This adaptation applies to **parks & forests**

Forest fuel

Forest fuel treatment

Picture 1 source: Parris, R. A. (2018, January 17). *Putting 2017 in the rear-view.* The Prepper Journal. https://theprepperjournal.com/2018/01/17/putting-2017-rear-view/
Picture 2 source: *Fuel reduction*. (2021, March 9). Resort Municipality of Whistler. https://www.whistler.ca/services/emergency/fire/wildfire-protection-strategy/Fuel-Thinning-Projects

Fuel Management

Start-up Costs to Municipality

SAMPLE COSTS

- A community in the interior of about 70,000 residents: **$10,000-11,000/hectare**
- A community on the southwest coast of about 20,000: **$32,000-35,000/hectare**

COST RANGE

- **Treatment**
  Interior: **$4,000 – 11,000/ha** is usual
  Coast: **$12,000 – 50,000/ha** is usual
- **Equipment:** e.g. wood chipper, fire hoses

Ongoing Costs to Municipality

- Although there are costs to re-treating areas, the communities interviewed have not gotten to this stage yet

Local Conditions Influencing Cost

- Denser forests, steeper slopes and environmental sensitivities on the coast compared to the interior increase costs
- Limited ability to burn debris due to regulations and proximity of homes increases costs

Funding Sources

- Community Resiliency Investment (CRI) Program- UBCM
- Canada Infrastructure Program: COVID-19 Resilience stream
- Community tax revenue

Benefits & Co-benefits

- Reduces the chance that lives or property will be lost
- Improves the efficiency and safety of wildfire suppression

Challenges

- Lack of adequate community support (e.g. opposition to cutting down trees)
- Absence of professional foresters on staff.
- Labour shortage in the northern communities
- Limited time and other hazards to address
- Securing funding from council takes a long time
- Long time to implement the measures

Tips & Advice

- Communicate early and thoroughly with the public
- Consult a professional forester for accessing and managing grant funding.
- Complete a Community Wildfire Resiliency Plan to prioritize efforts
- Contact UBCM and apply for funding

Key Resources

UBCM CRI funding

FireSmart

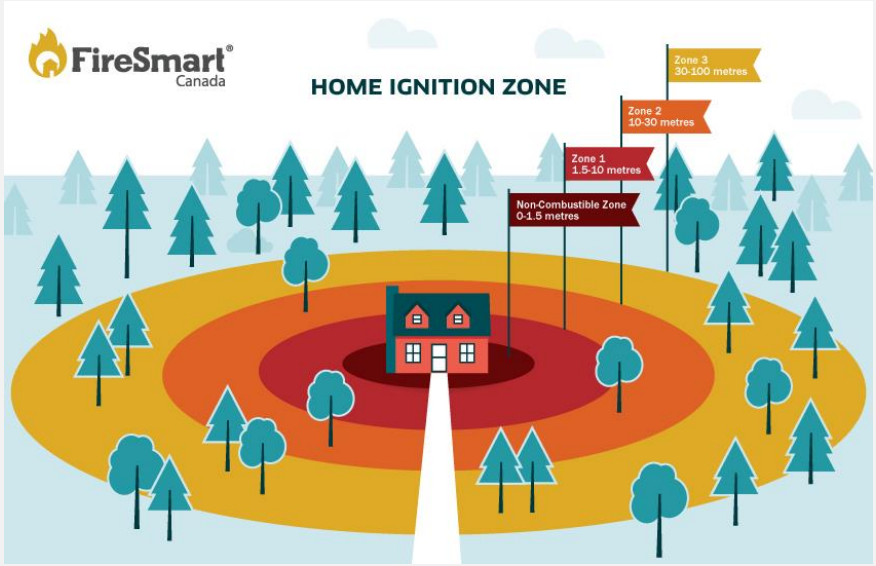
FireSmart is a multi-faceted program aiming to reduce the risk of property damage in the Wildfire Urban Interface areas. It comprises seven disciplines:

1. **Education:** spreading awareness amongst community members
2. **Vegetation Management:** managing type and location of vegetation in fire prone areas to reduce vulnerability
3. **Legislation & Planning:** development of policies and legislation on forestry management practices integrated land use planning compliance and enforcement programs and legal orders.
4. **Development Considerations:** at design /construction/renovation stages to reduce the vulnerability to wildfire
5. **Interagency Cooperation:** encouraging partnership at different levels of government
6. **Cross-training:** structural and wildfire firefighters for improved emergency response performance
7. **Emergency Planning:** combing local knowledge and wildfire management techniques for better emergency response

This is a **social - educational** adaptation

This adaptation applies to **private land**

This adaptation applies to **residential**



FireSmart Home Ignition Zone prescription

Vegetation around properties

Picture 1 Source: *Home ignition zone*. (2019, October 23). FireSmart. https://firesmartcanada.ca/what-is-firesmart/understanding-firesmart/home-ignition-zone/
Picture 2 Source: Ferrell, R. (2020, January 7). *The wildland-urban interface: Wildfire risk at your doorstep | WSRB blog*. WSRB. https://www1.wsrb.com/blog/wildland-urban-interface-washington-state

FireSmart

Start-up Costs to Municipality

- **Equipment/Materials -** depends on the specific measures, but could include information handouts, door hangers, a free-to-use community wood chipper, etc.

Ongoing Costs to Municipality

- **Staff time:** Time spent by the members in the emergency program, the fire department, and local community volunteers (e.g. public presentations and Q&As, door-knocking)

SAMPLE:
- A community located on the coast of about 80,000 residents involves 10 to 20 staff members at a time

Local Conditions Influencing Cost

- A larger population size of the community would require more outreach and hence increase the cost

Funding Sources

- UBCM Union of BC municipalities (UBCM) Community Resiliency Investment program
- Community tax revenue

Benefits & Co-benefits

- Increases public understanding and awareness of wildfire risks
- Allows firefighters to concentrate on fighting wildfires (rather than town fires)
- Stops the domino effect - fire spreading from one house to another
- Reduces the risk of houses being ignited by embers/ burning debris from other houses or the forest

Challenges

- Community support required since onus on community to implement
- Communication issues, such as conflicting FireSmart and subdivision rules

Tips & Advice

- It's difficult for the community to continually fund this, so it's important residents come on board
- Provide incentives like free chipping where possible

Key Resources

Resources from FireSmart BC

FireSmart Community Funding & Supports, Union of BC Municipalities

Development Permit Areas (DPAs)

It is a set of development standards for regulating development in an area demarcated as DPA under the Official Community Plan (OCP). DPA implementation regulations are set out under the Local Government Act, Sections 919.1 and 920. These areas are met with special treatment as compared to other areas for certain purpose. The purpose of Wildfire DPAs is to protect development and other natural assets from wildfire hazards. DPAs could be implemented through OCP and neighbourhood plans. It is implemented in alignment with the zoning bylaw when applied on a development site (BC Climate Action Toolkit, n.d.). A property owner needs to apply for a DPA for site when they are constructing/ renovating a building or subdividing.

This is a **institutional - Laws and regulation** adaptation

This adaptation applies to **private land**

This adaptation applies to **residential**

Vegetation and Development

Wildland Urban Interface (WUI)

Picture 1 source: District of West Vancouver. (n.d.). *Development permits*. https://westvancouver.ca/home-building-property/development-applications/other-development/development-permits
Picture 2 source: *Not your grandpa's wildfires*. (2019, July 4). Focus on Victoria. https://www.focusonvictoria.ca/focus-magazine-july-august-2019/not-your-grandpas-wildfires-r7/

Development Permit Areas (DPAs)

Start-up Costs to Municipality

SAMPLE COST for a community on the southwest coast of about 40,000 residents over 90 sq km:

- **Mapping –** done by staff otherwise outsourced to consultants which costs **$11-12,000**
- **Staff time –** Initial public outreach to gauge community sentiment to the change. Reproducing the mapping done by consultant for distribution to internal departments took the GIS team of 2 people 2 weeks.

Ongoing Costs to Municipality

- **Staff time** – to process DPA applications

Local Conditions Influencing Cost

- A larger population size of the community would require more outreach and hence increase the cost

Funding Sources

- Community tax revenue
- Application fees charged by municipalities

SAMPLE FEE

- a community on the southwest coast of about 40,000 residents over 90 sq km charges **$2500 per DPA application.**

Benefits & Co-benefits

- Prevents domino effect, fire spreading from one house to another
- Minimize threat of post-wildfire erosion and landslide
- Addresses environmental issues along with reducing wildfire impacts
- Costs borne by property owners instead of municipality

Challenges

- Difficulty for the public to understand DPA rules
- Conflicting DPA areas (natural hazards, creek, wildfire).
- Co-ordination between internal departments of municipality
- Public could be reluctant since onus on property owners

Tips & Advice

- Make DPAs easy to understand to reduce confusion and thereby staff time in revising applications
- Allocate appropriate staff time to review applications
- Align DPA areas
- Hire a consultant to streamline the process
- Learn from other municipalities and don't hesitate to ask for information.

Key Resources

Example communities:

DPA Portal District Corporation of North Vancouver

DPA Guide for District of North Vancouver

References for Wildfire Adaptations

- **CWPP Description:**

  Community wildfire protection plans. (2021, March 23). https://rdck.ca/EN/main/services/emergency-management/wildfires/community-wildfire-protection-plans.html

- **Fuel Management Description:**

  BC Wildfire Service. (2020). *BCWS Fuel Management Prescription Guidance 2020*. Province of British Columbia. https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/wildfire-status/prevention/fire-fuel-management/fuels-management/2020_fuel_management_prescription_guidance_final.pdf

- **Fire Smart Description:**

  FireSmart. (2021, March 15). FireSmart BC. https://firesmartbc.ca/

  Understanding FireSmart. (2019, November 6). FireSmart. https://firesmartcanada.ca/what-is-firesmart/understanding-firesmart/

- **DPA Description:**

  Development permit area guidelines. (n.d.). BC Climate Action Toolkit | climate solutions for BC local governments. https://www.toolkit.bc.ca/dpa

Stormwater Flooding Adaptation Measures

Stormwater Flooding Definition

"The inundation of property in a built environment, particularly in more densely populated areas, caused by rain falling on increased amounts of impervious surfaces and overwhelming the capacity of drainage systems." (University of Maryland, Center for Disaster Resilience & Texas A&M University, Galveston Campus, Center for Texas Beaches and Shores, 2018).

Stormwater Flooding in British Columbia

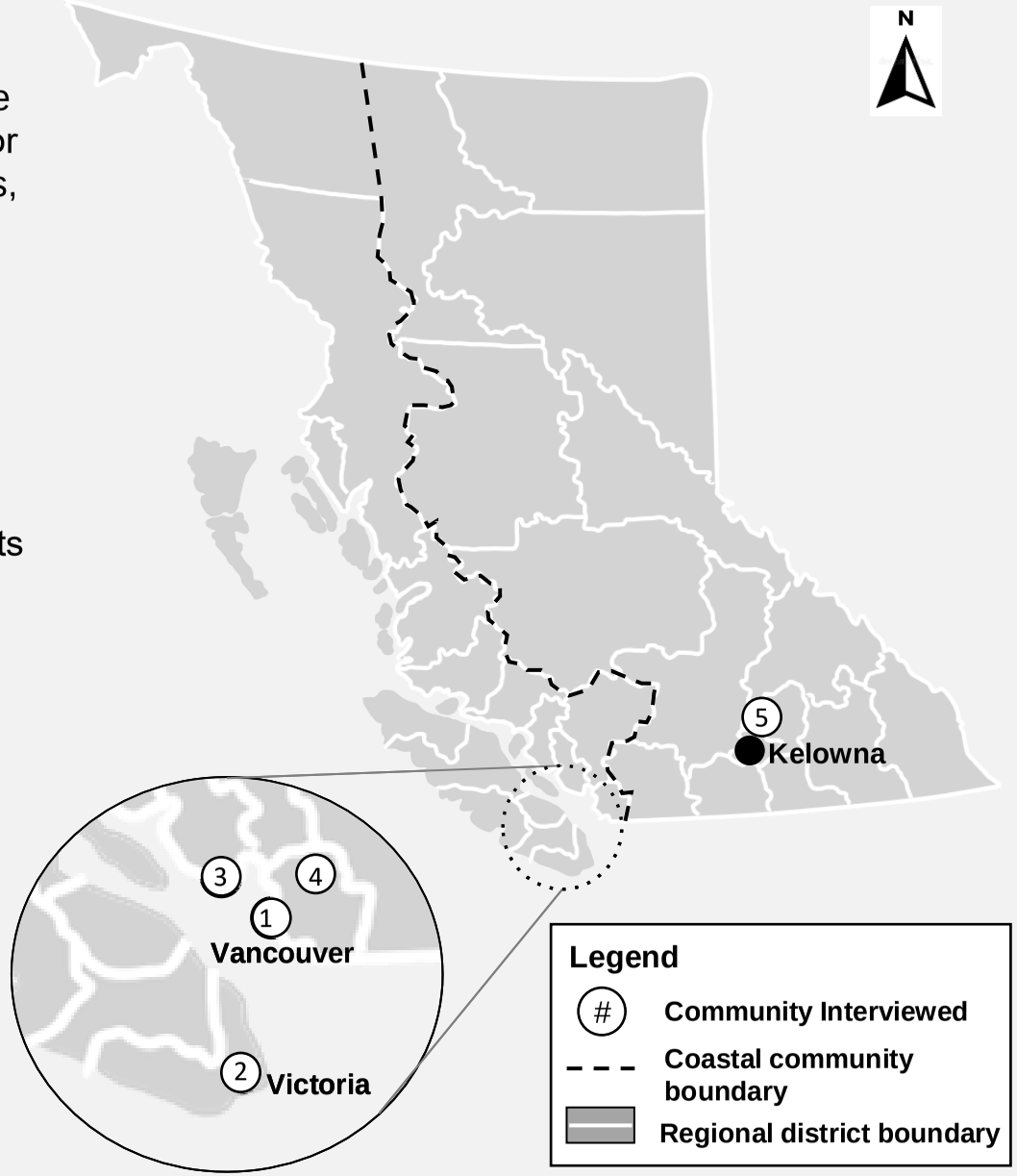
- Stormwater flooding is most common form of flooding in Canadian municipalities (King-Scobie, 2020).
- In case of BC, more frequent flooding can be expected in the future due to human-caused climate change (Kirchmeier-Young & Zhang, 2020). Vancouver expects "heavy rain events [to] become 35 per cent more intense by 2050" (City of Vancouver, 2018)
- Stormwater flooding has impacts on economy (e.g. spoiled crops, damage to streets, loss of employer hours etc. human health (e.g. deaths, sickness, injuries), environmental (e.g. pollution, damaged natural habitats), and political.

Communities Interviewed

1. City of Vancouver
2. City of Victoria
3. Town of Gibsons
4. City of North Vancouver
5. City of Vernon

Note: Regional Districts having a coast line are assumed as coastal communities

Communities Interviewed



Refer the list for community numbers

Integrated Stormwater Management Plans (ISMPs)

An Integrated Stormwater Management Plan (ISMP) identifies a set of stormwater management strategies to operate together in an integrated way. ISMPs often include a combination of strategies, including traditional "hard infrastructure" structural approaches such as ditches and culverts, green infrastructure structural approaches such as rain gardens and tree trenches, and policy and planning approaches such as stormwater management bylaws.

This is a **policy** adaptation

This adaptation applies to **public & private land**

This adaptation applies to **all land uses**

Integrated Stormwater Management Plan Example

source： https://vancouver.ca/files/cov/rain-city-strategy.pdf

Integrated Stormwater Management Plan (ISMPs)

Start-up Costs to Municipality

SAMPLE COSTS for a community in the southwest coast of about 700,000 residents:

- Wastewater treatment plant: **$4 billion**
- Replace subsurface pipe infrastructure: **$350 per meter** with 2200 metres in total
- Long range strategic planning related to infrastructure systems (includes modeling and monitoring): **$10 million**

Ongoing Costs to Municipality

- Ongoing costs of the adaptation were not obtained

Local Conditions Influencing Cost

- Size of community
- Extent of the stormwater system
- Form or condition of existing stormwater infrastructure
- Desired level of community engagement

Funding Sources

- Property tax

Benefits & Co-benefits

- Improve the quality of the treatment of stormwater
- Monitor pipe system helps to handle a certain volume of water
- Improve water quality, resilience, and livability through creating healthy urban ecosystems
- Cost savings by managing water closer to where it falls rather than further away

Challenges

- Challenges with cross-connections within their system that result in combined sewage connections from private properties being connected to the city's separated storm pipe system and eventually the city's receiving waters

Tips & Advice

- Have infrastructure that's easier to change over time, and has a shorter lifespan so that we can replace it with updated infrastructure
- Think differently and do more effective long term financial planning for the full lifecycle and service outcomes

Key Resources

- Integrated Stormwater Management Plan
- Rain City Strategy, City of Vancouver, 2019

Green Stormwater Infrastructure: Tree Trenches

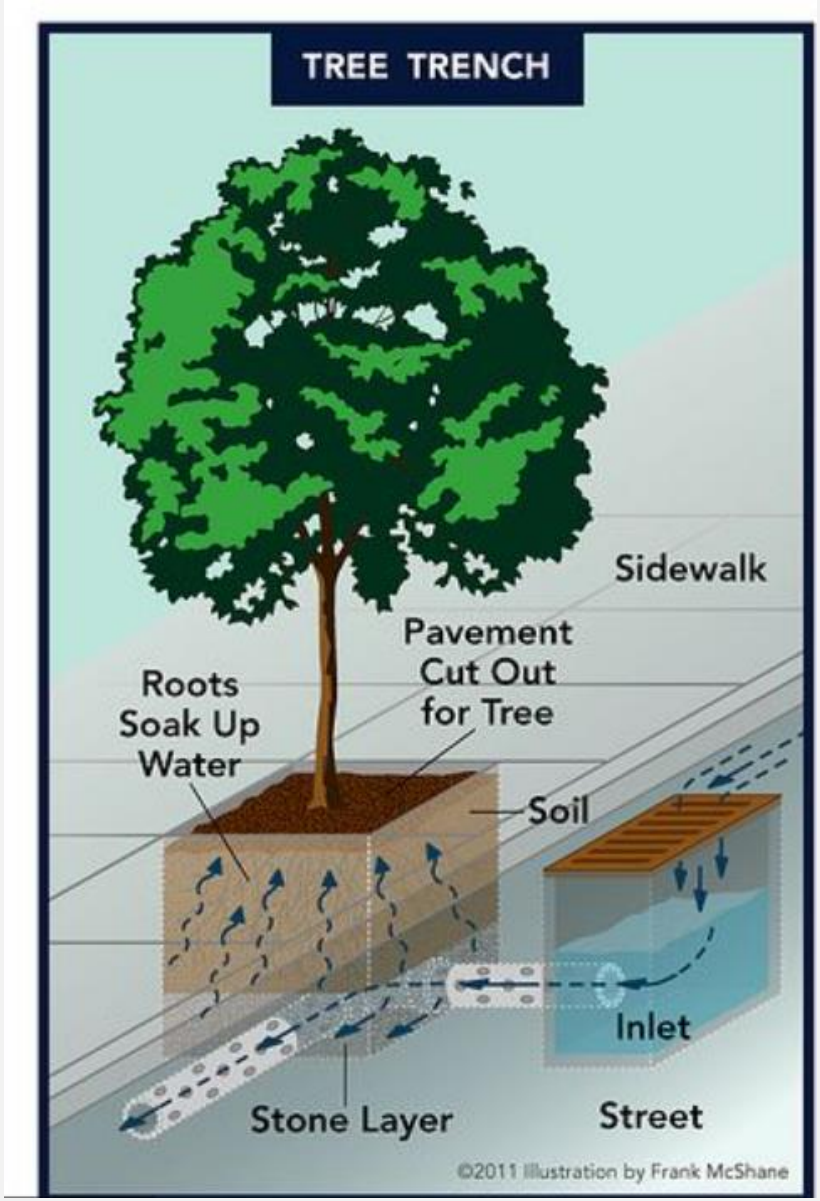
Green stormwater infrastructure (GSI) mimics natural water processes. It works with plants, soils, trees, and buildings to capture and clean stormwater before releasing it into pipes or nature.

Tree trenches are versatile GSI that are well suited for dense urban environment. Trees absorb rainwater through their roots and carry it to the sewer system. The rainwater runoff collected on streets is redirected into the tree trench through inlets and permeable pavers. Then, infiltration into the soil helps clean the runoff and reduces the amount of water into the sewers.

This is a **structural** adaptation

This adaptation applies to **public land**

This adaptation applies to **rights-of-way**



Tree Trench Model

Source: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.pinterest.com%2Fpin%2F428123508301653868%2F&psig=AOvVaw0MCZ-kbnTq1Y1bzhXl6X7L&ust=1617790251827000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCNiaiuOw6e8CFQAAAAAdAAAAABAD

Green Stormwater Infrastructure: Tree Trenches

Start-up Costs to Municipality

SAMPLE COSTS for a community on the southwest coast of about 700,000 residents:

- Tree trenches: **$1.7 million each**
- Tree trenches on both sides of a local residential street: **$100,000-150,000**
- Tree trenches of complex types of systems:**$200,000-300,000 per block**
- **Total cost: $25 million** over 4 years

Ongoing Costs to Municipality

- Maintenance: roughly half a day a year of staff time per facility/infrastructure
- Without proactive maintenance, every 5-8 years, will need to spend around 50% of the initial capital costs to get things back in working order

SAMPLE COSTS for a community on the southwest coast of about 50,000 residents and about 100 facilities (not all trenches):

- minimum **150 hours/year**
- If it had 100% source controls: **$200,000-400,000/year**

Local Conditions Influencing Cost

- Dirtier streets or streets with more stores/population will carry higher maintenance costs
- If need to close down a lane or hire special equipment to build or maintain, will cost more

Funding Sources

- Property tax
- Developer financed through community benefit agreements

Benefits & Co-benefits

- Holds stormwater at the source and slows down the impact on pipes
- Protects some of the environmental function in the streams
- Collects and drop outs sediment and contaminants to help infiltrate runoff

Challenges

- Not making it clear and getting agreement from the beginning on who will maintain the facilities

Tips & Advice

- Have a long term plan
- Understand what kind of facilities are the best fit for the community, scale the level of effort to that
- Pick the adaptations that will pay off in the long term, because communities don't have the ability to rebuild these facilities every 10 years if they want to implement them everywhere

Key Resources

- International Stormwater Best Management Practices (BMP) Database
- Economic Framework and Tools for Quantifying and Monetizing the Triple Bottom Line Benefits of Green Stormwater Infrastructure, Water Research Foundation, 2020

Produced Spring 2021

Stormwater Ponds

Build a stormwater pond along an existing creek can be planted to help settle out sediments and remove pollutants from stormwater.

Stormwater runoff flow into a catch basin, and the mixture of stormwater and pollutants flows from catch basins to storm sewers that lead to stormwater ponds. As the pond fills, sediment and pollutants settle down to the bottom. Then, treated stormwater from the pond is then slowly released into local waterways.

Stormwater Pond Model

This is a **structural** adaptation

This adaptation applies to **public land**

This adaptation applies to **parks & undeveloped areas**

Source: https://www.youtube.com/watch?v=850SUu0YQMQ

Stormwater Ponds

Start-up Costs to Municipality

- Land
- Design
- Construction
- Communications/Coordination

SAMPLE COSTS:

- A community in southwest coast of about 5,000 residents: **$1 million** for 1 pond
- A community in southern interior of about 40,000 residents: **$1.9 million** for 1 pond

Ongoing Costs to Municipality

- Dredging ponds / cleaning out sediment

SAMPLE COSTS:

- A community in southwest coast of about 4,500 residents: **$30,000 every 3 years**
- A community in southern interior of about 40,000 residents: **$50,000/year**

Local Conditions Influencing Cost

- More limited storage capacity in local streams/ponds and steeper channel gradients will allow for more sediment transport and can thereby reduce costs of dredging

Funding Sources

- Province of BC & Government of Canada - Rural and Northern Communities Infrastructure Stream (RNIS) of the Investing in Canada Plan
- Community Emergency Preparedness Fund
- Property tax

Benefits & Co-benefits

- Maybe adapts better than pipes to future increased rainfall
- Addresses long-term erosion and water quality impacts of past development
- Present a learning opportunity and the potential for involvement by a First Nation
- Provide access for sediment removal areas (maintenance)
- New sediment pond protects community from large-scale debris flow

Challenges

- Continual culvert dredging is costly and constrained highly by fish windows
- Emergency creek dredging is very expensive
- Requires regulatory approval

Tips & Advice

- Re-use existing designs when appropriate - a different design costs about twice as much
- Allow lead time for permitting
- Make agreements with the regional district

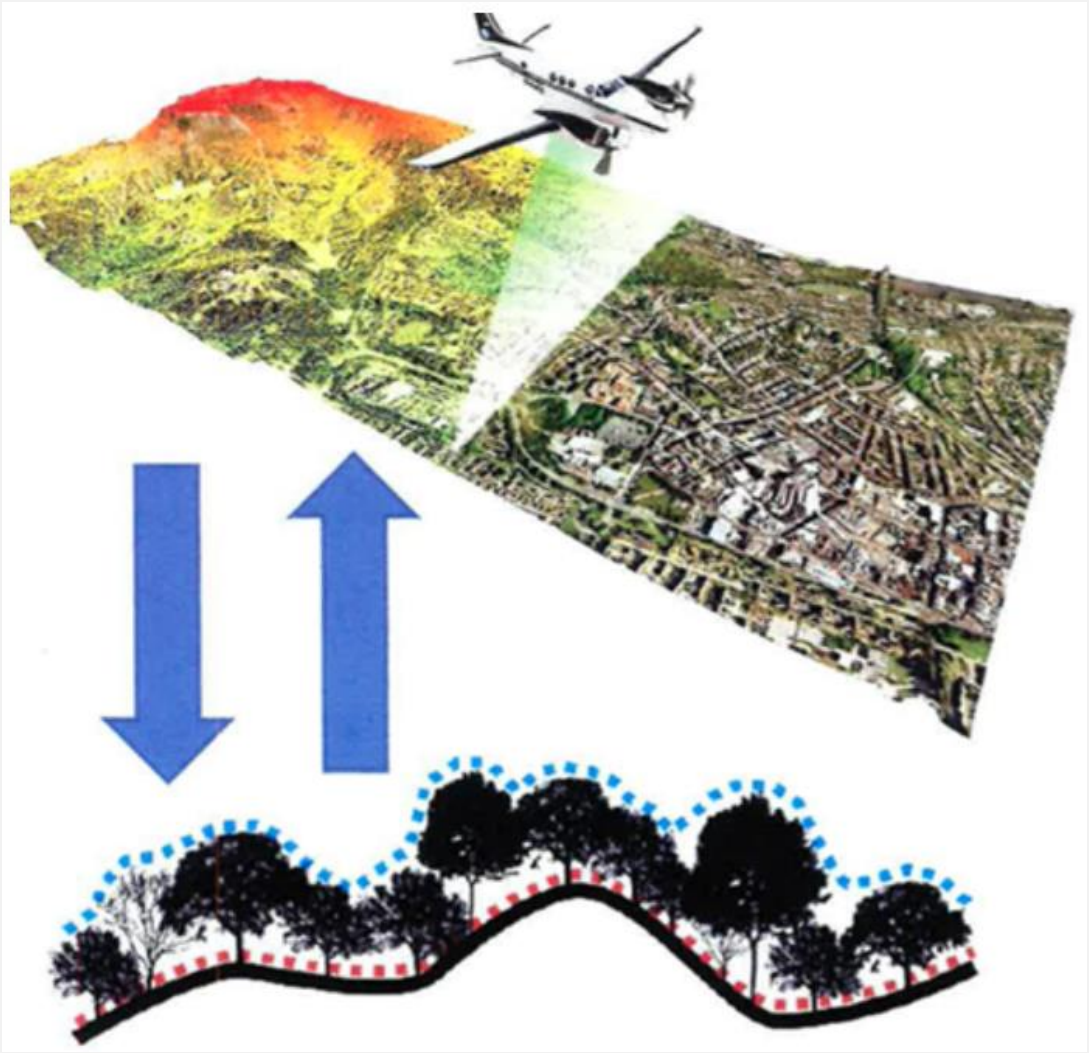
Key Resources

- Stormwater Pond

Produced Spring 2021

Prioritizing Drainage Infrastructure Using LiDAR

Fly a plane or drone over an area and bathe it in light beams. LiDAR is used to help calculate the path falling water would travel through the community, determine overland flow routes and community vulnerabilities. So, the collected LiDAR data shows where overland drainage would happen, which changes where buildings might be located.



LiDAR Scanning

Source: https://vernonmatters.ca/2021/02/07/vernon-storm-water-plan-is-the-envy-of-the-okanagan/

This is a **policy** adaptation

This adaptation applies to **public & private land**

This adaptation applies to **all land uses**

Prioritizing Drainage Infrastructure Using LiDAR

Start-up Costs to Municipality

- Quote for high density (30 points/sq.m) LIDAR is about **$500/km²**

SAMPLE COSTS for a community in southern interior of about 40,000 residents:

- LiDAR flight paths: **$17,000** onto a federal project of $1.5 million for the watershed (1% of which is the community in land area)
- Data analysis and report by consultant: **$110,000**
- Drainage infrastructure project afterwards: **$70,000 (**included **$12,000-15,000** if LIDAR**)**

Ongoing Costs to Municipality

- Ongoing maintenance is still unknown by the community, but one suggestion is to fly LIDAR every 5 years to update drainage routes

Local Conditions Influencing Cost

- Limited human resources to decrease cost (so have to do some open houses with some workshops bringing people)
- If didn't get LiDAR high resolution data then wouldn't be able to model the data and then make additional costs
- Capital cost depends on the number of the flight paths and the number of going back and forth

Funding Sources

- Federal Gas Tax
- Strategic Priorities Fund
- Property tax

Benefits & Co-benefits

- Guide future development - possible to use zoning, OCP designations, statutory right of ways
- Complete flood mapping studies and hazard assessments to help change the way that the community plan to put buildings and set bylaws related to construction levels

Challenges

- Managing large amounts of LiDAR data
- Finding topographic data that covered the study area

Tips & Advice

- Have to invest in high quality Lidar data, have the skills, have a skillful consultant to process the data into the overland flow routes

Key Resources

- *Okanagan Valley Receives $1.45M for Floodplain Mapping*. Okanagan Basin Water Board. April 10, 2018
- Understanding climate change impacts key to prioritizing drainage infrastructure projects

Produced Spring 2021

Flood Protection and Enhancement Projects

Flood protection and wetland enhancement projects are usually carried out in the lower reaches of the community's creek drainage basin. It can include the construction of culverts, flow diversion structures, channel like rip-rap channels, sedimentation/detention basins, and wetland areas for flow attenuation and bio-treatment.

Engineered wetlands in particular can increase the higher level of treatment of water (such as filtering out metals) in the basin.

Stormwater Flooding

This is a **structural** adaptation

This adaptation applies to **public land**

This adaptation applies to **parks & undeveloped areas**

Source: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwater.unl.edu%2Farticle%2Fdrinking-water-wells%2Ffloodwater-and-stormwaters-can-contaminate-your-water-well&psig=AOvVaw2PP5THMrMXY2hhxweHwYJg&ust=1617460805048000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCICa-sbl3-8CFQAAAAAdAAAAABAD

Flood Protection and Enhancement Projects

Start-up Costs to Municipality

SAMPLE COSTS for a community in southern interior of about 40,000 residents:

- Capital Costs: **$960,000**

Ongoing Costs to Municipality

- Ongoing Maintenance is still unknown by the community

Local Conditions Influencing Cost

- Land acquisition
- Presence of species at risk
- Archaeological site

Funding Sources

- Building Canada Fund
- Development Cost Charges
- Property tax

Benefits & Co-benefits

- Improve flood protection and design to stormwater events
- Filter stormwater to improve water
- Provide varying water levels to support a variety of wetland and riparian species
- Address soil erosion concerns along the drainage channel
- Adds native plants to enhance local upland and aquatic habitats

Challenges

- Require parcel subdivision and purchase of land
- Require decommissioning existing weir upstream
- Regulatory approval
- Construction needs to be completed in fish window

Tips & Advice

- Lead time for permitting, archaeological findings, potential for grants, risk assessment, prioritization and studies prerequisites

Key Resources

OKANAGAN VALLEY RECEIVES $1.45 MILLION FOR FLOODPLAIN MAPPING, Okanagan Basin Water Board, 2018

Natural Asset Plans

Create a plan that accounts for the jurisdiction's natural assets such as parks and streams can include comparisons of alternatives, such as building pipes versus maintaining creeks. The plan also helps the community make strategic and operational decisions about municipal assets over their entire lifecycle to ensure that assets are maintained, repaired and replaced at appropriate times. Natural assets provide stormwater management services equivalent to engineered alternatives instead of only focusing on the engineering fields.

Natural Asset

This is a **policy** adaptation

This adaptation applies to **public land**

This adaptation applies to **parks & undeveloped areas**

source: https://davidsuzuki.org/expert-article/natural-asset-management-is-proving-its-value-in-the-field/

Natural Asset Plans

Start-up Costs to Municipality

SAMPLE COSTS for a community in southwest coast of about 5,000 residents:

- Comparative analysis between concrete pipe vs restoring and expanding an existing park area and ponds: **$45,000**

Ongoing Costs to Municipality

- Variable: May involve hiring staff to collect data on natural assets and plan for the maintenance and monitoring of these assets
- Primarily to cover monitoring and the dredging of road sediment that accumulates in the ponds

Local Conditions Influencing Cost

- Communities with a larger area may take more resources to create a plan
- Communities with more natural assets may have more opportunities for cost savings

Funding Sources

- Municipal natural Assets Initiative (MNAI)
- Property tax

Benefits & Co-benefits

- Reveals more cost-effective options than traditional grey infrastructure
- Helps prioritize which assets to maintain first
- Cheaper to operate and maintain, if not degraded
- Does not depreciate if properly managed
- Carbon neutral or even carbon positive (carbon sequestration, carbon storage)
- Provides slope stabilization, water filtration, coastal protection

Challenges

- Lack of precedents (few examples of plans by BC communities)
- Limited funding options
- Culture of bias towards engineered option to address climate impacts
- Legislative and policy tools are needed to support nature-based solutions at a watershed scale

Tips & Advice

- Input your own GIS data for localized results
- Recognize dependencies & manage the whole system (e.g. creeks recharge aquifers)
- Have proper financial plan
- Consider nature-based solutions as an alternative to an engineered option, where possible
- Nature-based solutions have substantial financial advantages

Key Resources

- Natural Asset Management
- MNAI Land Awards Video, October 2018

Stormwater Utility & Rewards Program

Stormwater utility charges are based on the impervious area, street cleaning, intensity, and codes of practice program (a program to clean stormwater before it leaves a property) of the property.

Rainwater rewards credits and rebates (i.e., financial incentives) to properties to incorporate stormwater infrastructure practices (e.g., rain gardens, cisterns and permeable paved areas).

Stormwater Infrastructure Practice - Rain Garden

This is a **policy** adaptation

This adaptation applies to **private land**

This adaptation applies to **all land uses**

source: https://www.victoria.ca/EN/main/residents/water-sewer-stormwater/stormwater/rainwater_rewards_program.html

Stormwater Utility & Rewards Program

Start-up Costs to Municipality

SAMPLE COSTS for a community on the Island of about 85,000 residents:

- Community budget for infrastructure: **$6 million** and annually, increases about 2% per year
- Grants: **$8 million** annually

Ongoing Costs to Municipality

- Regular maintenance: clean up catch basin, replace the pipes

SAMPLE COSTS for a community on the Island of about 400,000 residents:

- **$300,000** or more per year, including staff positions etc.
- **Staff time** in engineering: one stormwater management specialist, junior stuff, and additional stuff depending on the type of needed work

Local Conditions Influencing Cost

- If all of the stormwater drains to a common point, there's a higher cost.

Funding Sources

- Stormwater utility generates revenue
- Property tax

Benefits & Co-benefits

- Encourages properties to incorporate green stormwater infrastructure on their buildings and landscapes, also to reduce footprint of impervious areas
- Addresses biodiversity, traffic etc.
- Financially sustainable

Challenges

- Limited green space and many competing priorities (the use of the space - roads, bike lanes, etc.)
- Difficulty in commuting a new and complex program to get public and political support
- In the beginning, public had trouble understanding the program staff got many questions
- Old data comes in different forms and are not consistent

Tips & Advice

- Ensure that the model of stormwater utility works well for the municipality, many attributes can be considered (flat fees, property size, property type, impervious area, or a combination)
- Be clear about the purpose of the stormwater utility
- Input and coordination from many departments across a municipality
- Have a database where the stormwater connections are identified properly

Key Resources

- Stormwater Utility
- Rainwater Rewards Program

Produced Spring 2021

References for Stormwater Adaptations

- **ISMP Description:**

  Rain City Strategy. (2019, Nov 5). City of Vancouver https://vancouver.ca/files/cov/rain-city-strategy.pdf

- **GSI - Tree Trenches:**

  Richards St. Blue-Green Network, Green Infrastructure Implementation. (n.d.). City of Vancouver.

- **Stormwater Pond:**

  Land Development Guidelines. (n.d.). http://www.rainwatermanagement.ca/wp-content/uploads/2014/04/Draft-BC-Land-Development-Guidelines-Section-4.pdf

- **Prioritize Drainage Infrastructure Using LiDAR Description:**

  Land Development Guidelines. (n.d.). https://vernonmatters.ca/2021/02/07/vernon-storm-water-plan-is-the-envy-of-the-okanagan/

References for Stormwater Adaptations

- **Flood Protection and Enhancement Description:**

  Vernon Stormwater Plan is the Envy of the Okanagan. (2021, Feb 7). Kevin Rothwell http://www.rainwatermanagement.ca/wp-content/uploads/2014/04/Draft-BC-Land-Development-Guidelines-Section-4.pdf

- **Natural Asset Plan Description:**

  Natural Asset Management. (n.d.). Town of Gibsons https://gibsons.ca/sustainability/natural-assets/#:~:text=GIBSONS%27%20NATURAL%20ASSETS&text=The%20Gibsons%20Aquifer%2C%20for%20example,acts%20as%20a%20natural%20seawall

- **Stormwater Utility & Rewards Program Description:**

  Stormwater Utility. (n.d.). City of Victoria http://www.rainwatermanagement.ca/wp-content/uploads/2014/04/Draft-BC-Land-Development-Guidelines-Section-4.pdf

APPENDIX G - Project Poster

Cost of Climate Change Adaptation Menu

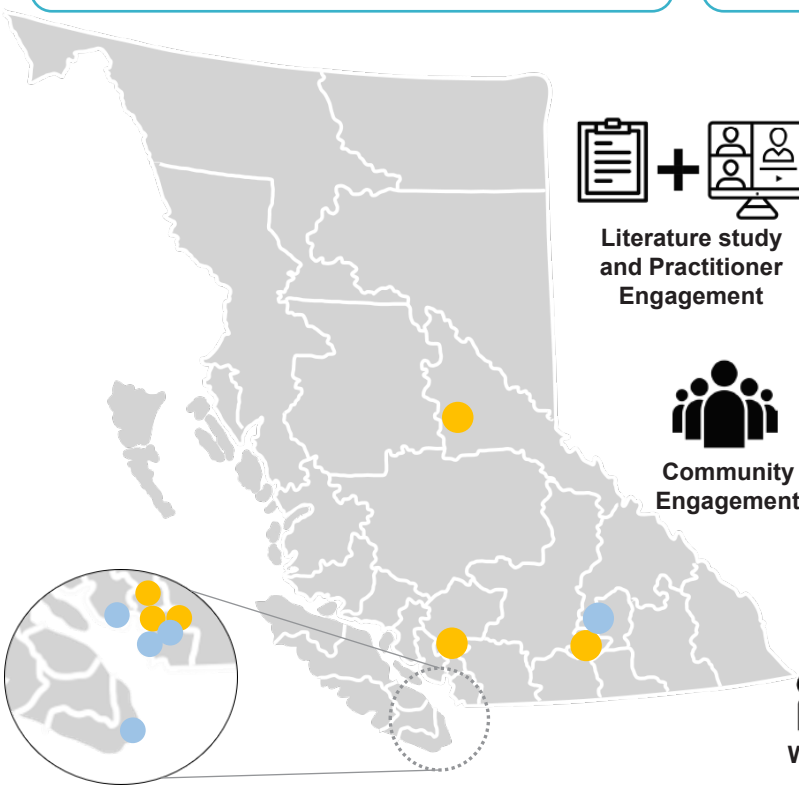
Helping Communities Adapt to Wildfire and Stormwater Flooding

Question

What has it cost BC communities to implement different adaptations to wildfires and stormwater flooding?

Context

We aimed to create a menu to be used by local government staff in BC to explore possible adaptations to wildfire and stormwater flooding.



Communities Interviewed for:

Wildfire Stormwater Flooding

Literature study and Practitioner Engagement

Community Engagement

Workshops

Phase I

- We interviewed **7 practitioners** from wildfire and stormwater management who provided overview on adaptation measures and related costs
- Identified communities undertaking adaptation measures

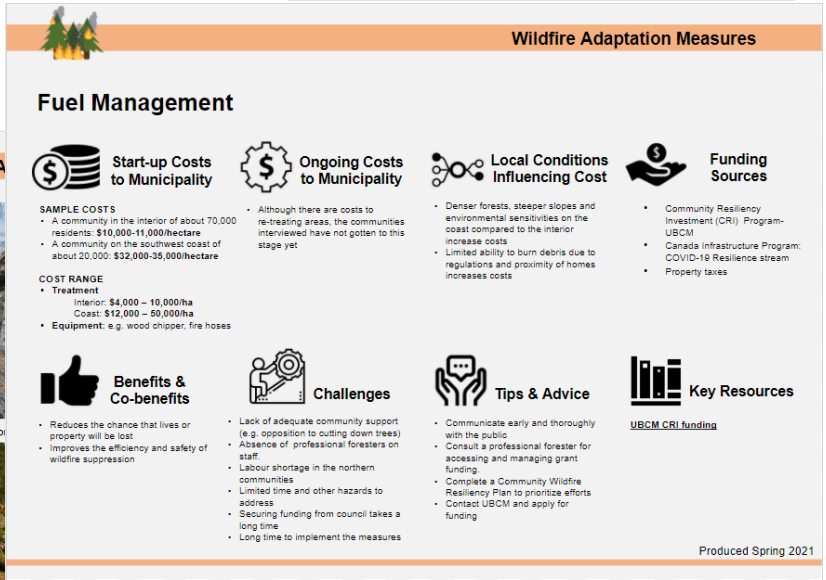
Phase II

- We interviewed **11 municipal staff/planners**. **6** for **wildfire** and **5** for **stormwater flooding (map)**.
- The information collected formed the base and provided structure to the menu.

Phase III

- We conducted **2 workshops** to invite feedback from practitioners & municipal staff on draft menu created using the data collected from earlier engagement phases.

SAMPLE COST MENU ITEM



Wildfire Adaptation Measures

Fuel Management

Start-up Costs to Municipality

SAMPLE COSTS
- A community in the interior of about 70,000 residents: **$10,000-11,000/hectare**
- A community on the southwest coast of about 20,000: **$32,000-35,000/hectare**

COST RANGE
- **Treatment**
  - Interior: **$4,000 – 10,000/ha**
  - Coast: **$12,000 – 50,000/ha**
- **Equipment**: e.g. wood chipper, fire hoses

Ongoing Costs to Municipality

- Although there are costs to re-treating areas, the communities interviewed have not gotten to this stage yet

Local Conditions Influencing Cost

- Denser forests, steeper slopes and environmental sensitivities on the coast compared to the interior increase costs
- Limited ability to burn debris due to regulations and proximity of homes increases costs

Funding Sources

- Community Resiliency Investment (CRI) Program-UBCM
- Canada Infrastructure Program: COVID-19 Resilience stream
- Property taxes

Benefits & Co-benefits

- Reduces the chance that lives or property will be lost
- Improves the efficiency and safety of wildfire suppression

Challenges

- Lack of adequate community support (e.g. opposition to cutting down trees)
- Absence of professional foresters on staff.
- Labour shortage in the northern communities
- Limited time and other hazards to address
- Securing funding from council takes a long time
- Long time to implement the measures

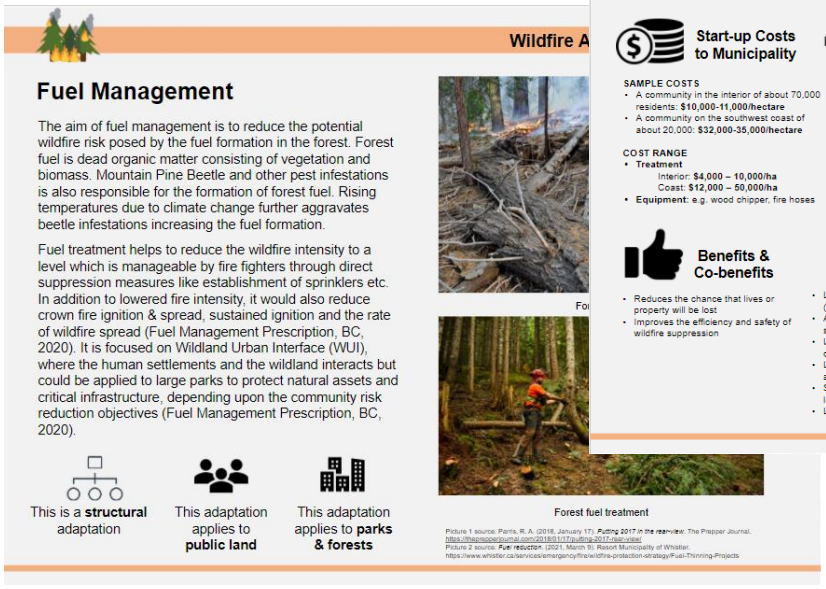
Tips & Advice

- Communicate early and thoroughly with the public
- Consult a professional forester for accessing and managing grant funding.
- Complete a Community Wildfire Resiliency Plan to prioritize efforts
- Contact UBCM and apply for funding

Key Resources

UBCM CRI funding

Produced Spring 2021



Wildfire A

Fuel Management

The aim of fuel management is to reduce the potential wildfire risk posed by the fuel formation in the forest. Forest fuel is dead organic matter consisting of vegetation and biomass. Mountain Pine Beetle and other pest infestations is also responsible for the formation of forest fuel. Rising temperatures due to climate change further aggravates beetle infestations increasing the fuel formation.

Fuel treatment helps to reduce the wildfire intensity to a level which is manageable by fire fighters through direct suppression measures like establishment of sprinklers etc. In addition to lowered fire intensity, it would also reduce crown fire ignition & spread, sustained ignition and the rate of wildfire spread (Fuel Management Prescription, BC, 2020). It is focused on Wildland Urban Interface (WUI), where the human settlements and the wildland interacts but could be applied to large parks to protect natural assets and critical infrastructure, depending upon the community risk reduction objectives (Fuel Management Prescription, BC, 2020).

This is a **structural** adaptation

This adaptation applies to **public land**

This adaptation applies to **parks & forests**

Forest fuel treatment

Picture 1 source: Parris, R. A. (2018, January 17). *Putting 2017 in the rear-view*. The Prepper Journal. https://theprepperjournal.com/2018/01/17/putting-2017-rear-view/

Picture 2 source: *Fuel reduction*. (2021, March 9). Resort Municipality of Whistler. https://www.whistler.ca/services/emergency/fire/wildfire-protection-strategy/Fuel-Thinning-Projects

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