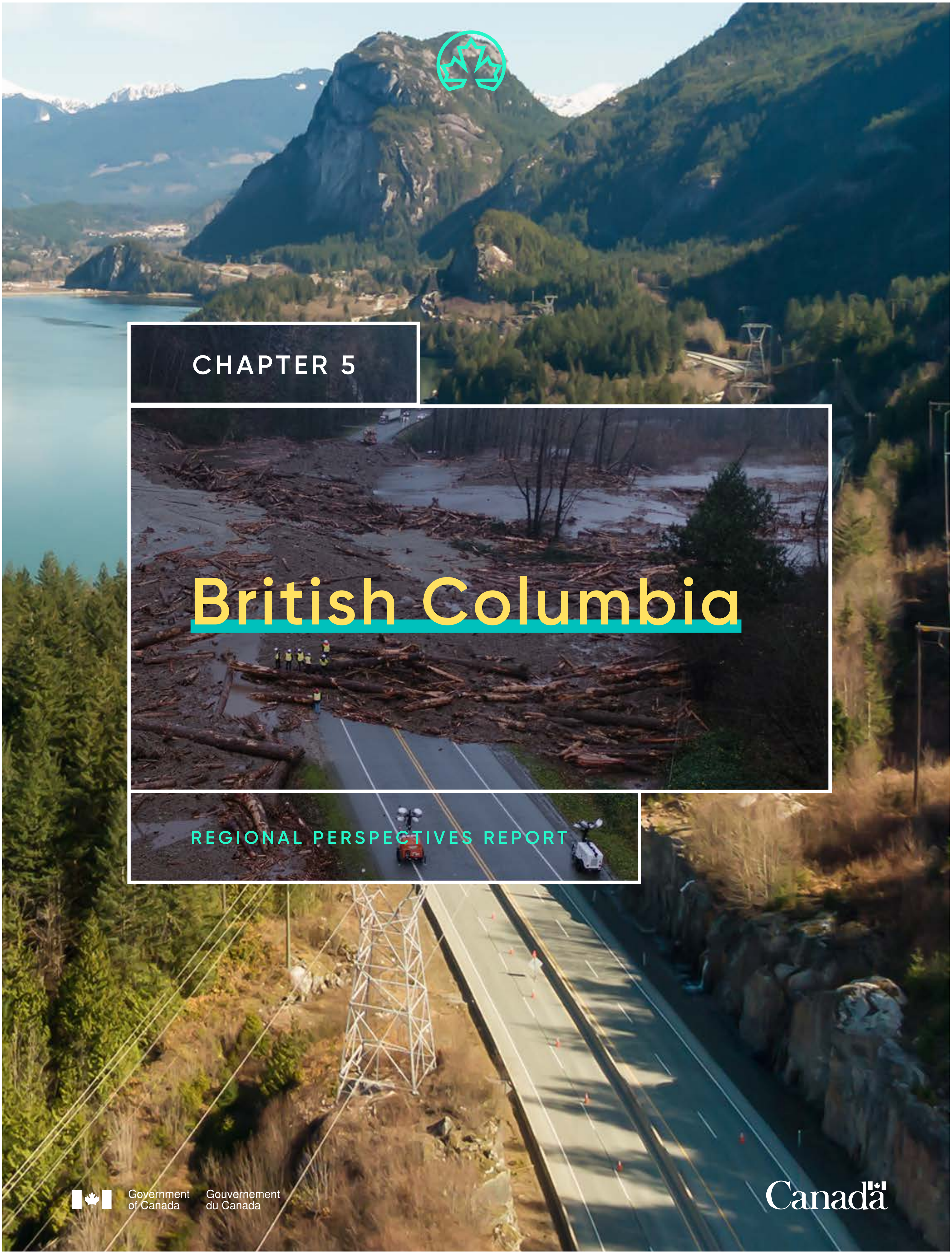

CHAPTER 5

British Columbia

REGIONAL PERSPECTIVES REPORT

Government of Canada Gouvernement du Canada

Canada

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Key messages

Indigenous Peoples in B.C. are experiencing and adapting to climate change (*see* section 5.2)

Indigenous Peoples are uniquely impacted by climate change, and are also uniquely resilient as a result of Indigenous Knowledge Systems. Successful adaptation is more likely when co-created with Indigenous Peoples in ways that protect and strengthen Title, Rights, and jurisdiction, and when Indigenous Knowledge and unique connections to territories are respectfully acknowledged and thoroughly incorporated in all aspects of climate change related planning and action. Indigenous-led adaptation efforts are emerging across many traditional territories in what is today known as British Columbia, and often consider climate change adaptation alongside strengthening Indigenous governance and environmental stewardship.

Climate change brings increasing flood risks (*see* section 5.3)

British Columbia's water resources will see significant changes as the climate warms, with flooding causing some of the most damaging and costly impacts. Many communities in British Columbia are reducing the risks by proactively planning, designing and implementing flood adaptation projects, but increased action across all scales is needed.

Climate change is impacting British Columbia's forests (*see* section 5.4)

Climate change is profoundly affecting British Columbia's forests, as well as communities and infrastructure located in forested regions. The risk of disturbance from fire and pests is increasing due to climate change, affecting forest productivity, wildlife habitat, biodiversity and ecosystem services. Action to enhance forest resilience is still in the early stages, as policy, operational guidance and the necessary tools are being developed.

Building a climate-ready agriculture sector is critical (*see* section 5.5)

Climate change is already impacting food production in British Columbia. Continued collaborative efforts across B.C. are needed to help advance adaptation in the agriculture sector.

Adaptation continues to advance in B.C. (*see* section 5.6)

Climate change adaptation activities—including efforts focused on implementation—are present across most sectors and settings in B.C. This work continues to mature, supported by improved access to climate data, decision-support tools, funding, supportive institutions and collaboration. However, significant gaps remain and it is unclear whether current and proposed efforts will be sufficient given the extent of the risks faced and the costs of implementation.

5.1 Introduction

5.1.1 Provincial overview

British Columbia (B.C.) is characterized by its climatic and physiographic diversity (*see* Figure 5.1). The Pacific Ocean produces an immense amount of precipitation that is trapped in the western part of the province by the Coast and Cascade Mountains, rendering the B.C. west coast the wettest region in Canada. The ecosystems and landscapes of B.C. include temperate rainforests, semi-arid deserts, boreal forests and alpine tundras. Depending on the approach used to calculate gross domestic product (GDP), natural resource industries represent about 51.4% of B.C.'s GDP (Government of B.C., 2020c).

The population of B.C. was estimated at about 5.25 million as of October 2021 (B.C. Stats, 2021) and is growing by approximately 1% annually (Government of B.C., 2020f). Although most of the province's population is concentrated in urban areas in the Lower Mainland and on Vancouver Island, there are communities found across the province. Immigrants comprise almost 30% of the population—a proportion that has been steadily increasing since 2001—and about 18% of the province's population in 2016 consisted of senior citizens (age 65+), a proportion that is expected to grow to 26% by 2040 (B.C. Statistics, Ministry of Jobs, Trade and Technology, 2018).

Of the total number of Indigenous people in B.C. (270,585 in the 2016 census), about two thirds (63.8%) are First Nations people who reside both on and off reserve, with about one third (33.0%) being Métis and less than 1% being Inuit (Statistics Canada, 2017). The Indigenous population—both the on-reserve and the urban and away-from-home population—has been steadily growing over the past decade at a faster rate than the non-Indigenous population in B.C. (First Nations Health Authority, 2020a). The Province of B.C. recently introduced legislation to ensure that its laws are brought into line with the principles of the United Nations Declaration on the Rights of Indigenous Peoples (Government of B.C., 2020d), and over 50% of B.C.'s 200 Bands as identified in the *Indian Act* are participating in treaty negotiations processes, or have concluded treaties through such processes (B.C. Treaty Commission, 2020).

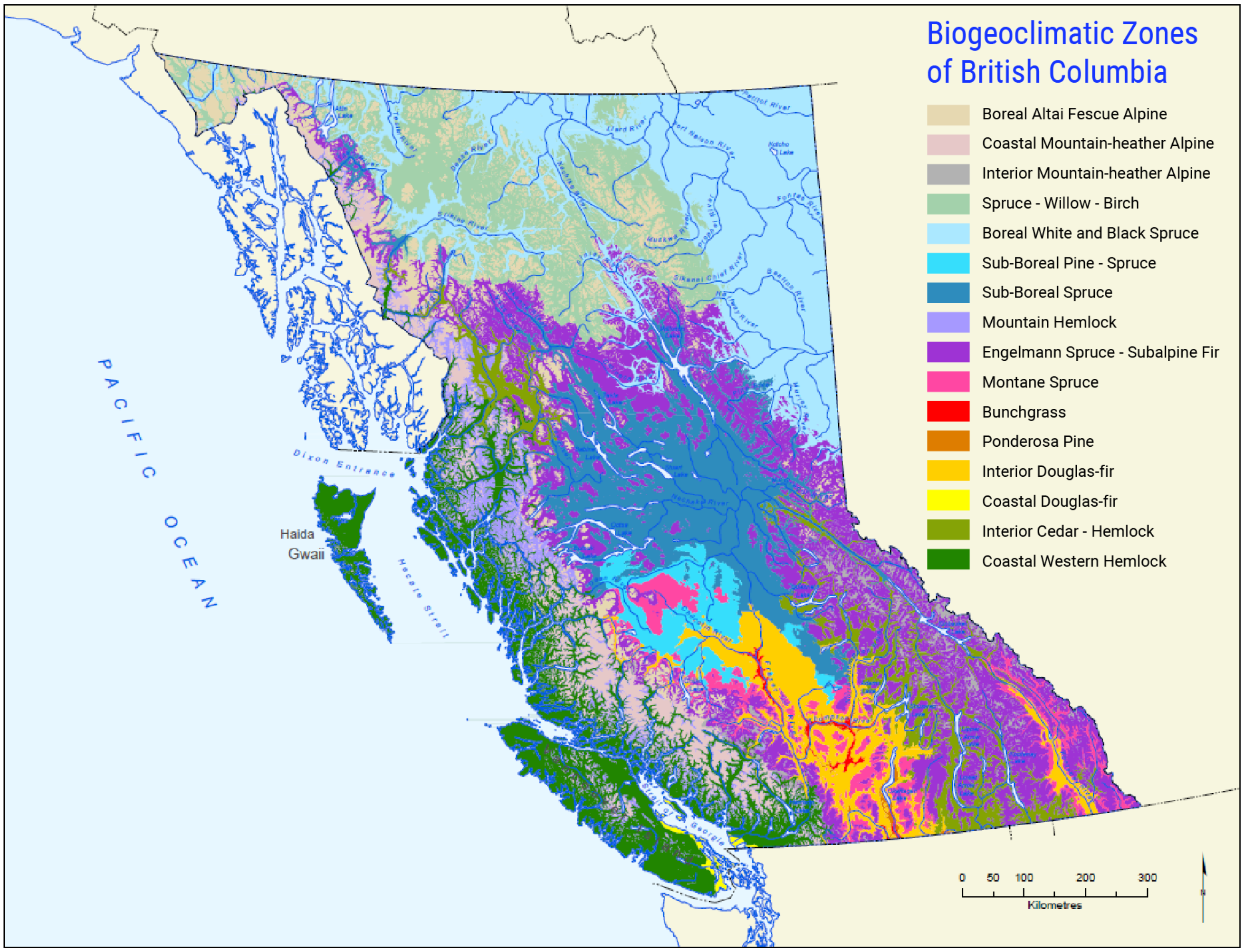

Figure 5.1: Biogeoclimatic zones of British Columbia. Source: B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2018a.

Extreme weather events are having significant impacts on B.C.'s economy and on the health and well-being of its population. Recent extreme weather events in B.C. include the following:

- An atmospheric river event in November 2021 brought record precipitation to many areas of southern B.C., leading to destructive flooding in many communities (Schmunk, 2021), and extreme precipitation-triggered landslides, leading to mortalities and the failure of several highways in B.C. (Schmunk, 2021). Early estimates suggest that this atmospheric river event led to at least $450M in damage in the province (Charlebois, 2021).

- Between June 25 and July 1, 2021, peaking on June 27 and 28, much of B.C. experienced an unprecedented heat event. This event included record-breaking day-time and night-time temperatures, and led to 526 heat-related deaths between June 25 and July 1, 2021, with 96% of these deaths occurring in a residential setting (B.C. Coroners Service, 2021). A rapid attribution study determined that this event would not have occurred without climate change (Philip et al., 2021).
- In 2017, 2018, 2020 and 2021, smoke from fires in B.C., as well as fires from the United States, contributed to poor air quality in communities across the province. During the 2018 wildfire season, the air quality monitoring stations that recorded the most days during which air quality posed high health risks were the stations in Prince George (32 days), Castlegar (30 days), Quesnel (26 days), Williams Lake (20 days), Fort St. John (18 days), and in the Central Okanagan (18 days) and the South Okanagan (18 days) (Statistics Canada, 2019);
- A severe windstorm on December 20, 2018, battered B.C.'s south coast, and was the most damaging in B.C. Hydro's history (B.C. Hydro, 2019a). The event was unprecedented, with strong winds coming from multiple directions, sometimes exceeding 100 kilometres per hour, and with more than 400 millimetres of rain falling in some areas leading up to the storm, which destabilized trees. The storm left more than 750,000 customers without power—some for over a week—and thousands of damaged pieces of equipment (B.C. Hydro, 2019a); and
- A well-documented ocean warming event that started offshore of the west coast of B.C. in 2013 was evident in coastal waters by the summer of 2015, with an increase in water temperatures of 3 ˚C above normal (Ross, 2017). This warming of coastal waters was accompanied by harmful algal blooms, record-high levels of large gelatinous zooplankton, and invasion by warm-water species (*see* Sector Impacts and Adaptation chapter; Chandler et al., 2016).

Between 1948 and 2016, British Columbia experienced 1.9 °C of warming, as well as increases in daily minimum temperature, which is an important driver of change (Zhang et al., 2019). Warming has been more pronounced in northern parts of the province (*see* Figure 5.2). As described further below, these trends are projected to continue (*see* Figure 5.2).

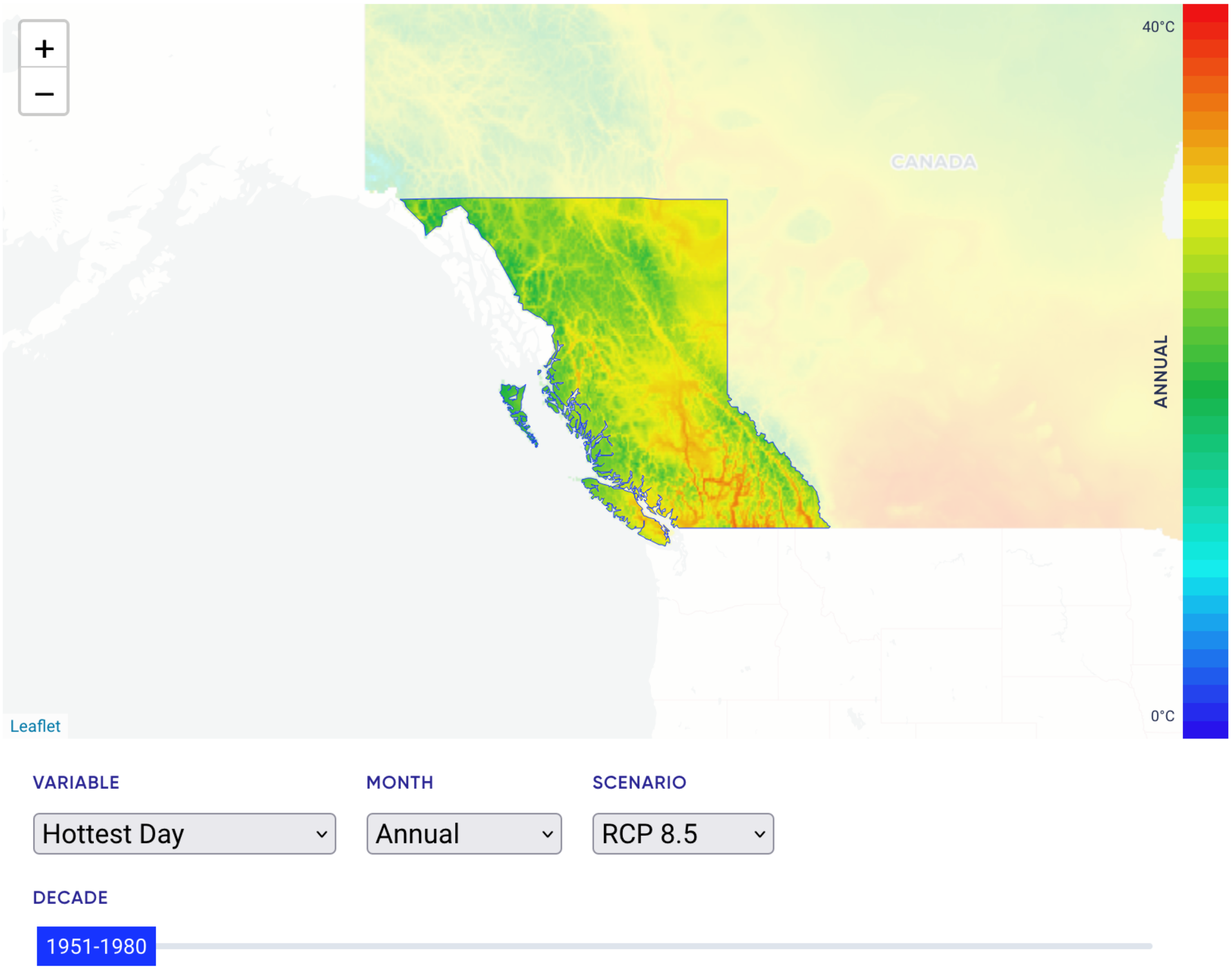

Figure 5.2: Interactive regional map of British Columbia that draws from climatedata.ca and visualizes various climate variables from 1980 to 2100 using a high emissions RCP8.5 scenario. On the interactive site, users can also explore the influence of different emissions scenarios on the projections.

Warming trends will drive a number of climate changes for B.C., including:

- **Warmer temperatures** in all seasons, leading to more extreme heat events and longer growing seasons (*see* Canada's Changing Climate Report). The annual average temperature in B.C. would increase by over 5°C by 2100, under the high emissions scenario, with warming most pronounced in the winter (Zhang et al., 2019). The number of days below 0°C will also decrease, leading to impacts on ecosystems, freeze-thaw cycles, the design of building heating systems, etc.;

- **Annual precipitation** increasing by 5.7% by 2050, and by 13.8% by 2100 under the high emissions scenario (RCP 8.5; Zhang et al., 2019). Changes in seasonal precipitation—including longer summer droughts—will pose a threat to current patterns of water accumulation (e.g., decreased snowpack, glacier mass loss) and discharge, and will lead to water scarcity issues in the summer, challenging B.C.'s ecosystems, agriculture and forestry industries, and communities (B.C. Ministry of Environment, 2016);
- **Extreme precipitation** events becoming more frequent and intense (Zhang et al., 2019), and increased frequency of atmospheric river events (Curry et al., 2019; Vadeboncoeur, 2016; Pinna Sustainability, 2014). These events will exacerbate the impacts associated with changes to seasonal precipitation: for example, by contributing to faster runoff, thus increasing the risk of flooding, landslides, and sediment and pollutant loading in drinking-water reservoirs and aquatic ecosystems;
- **Changes in streamflow**, including the timing of spring freshet, timing and duration of summer-autumn low flow, and higher water temperatures during low-flow periods (Bonsal et al., 2019), leading to increased flood risks and changes to aquatic ecosystems;
- **Changes to ocean conditions**, including stronger storm surges, rising sea levels and increasing acidification (Greenan et al., 2019; Vadeboncoeur, 2016), leading to increased flood risks and changes to marine ecosystems;
- **Increased wildfire risk** resulting from changing precipitation and temperature, along with changes to wind patterns (Bush and Lemmen, 2019) and shifts in ranges of pests such as the Mountain Pine Beetle (*Dendroctonus ponderosae*), leading to ecosystem changes and impacts on infrastructure and health; and
- **Changing forest conditions, and changes in plant and animal distributions** (Government of B.C., 2020e), leading to impacts on economic productivity, ecosystem health, and Indigenous health and wellness, etc.

5.1.2 Previous assessments and scope

The B.C. chapter in the previous national assessment (Walker and Sydneysmith, 2008) highlighted a general trend from research on climate change impacts towards adaptation action. The present chapter builds on these findings by assessing current knowledge to provide examples of observed and projected impacts from climate change in the province, examples of successful adaptation, as well as actions that can facilitate future adaptation. It focuses on five priority areas: Indigenous Peoples; water resources and flood management; forestry; agriculture; and adaptation planning and action. These areas were determined through an iterative process based on prior knowledge and targeted engagement with experts.

Focusing on key messages allows authors to address questions of greatest importance to adaptation decision making in B.C., rather than assessing all possible issues. The chapter has been supplemented by recently completed assessments—namely, by the B.C. chapters in the coastal assessment (Vadeboncoeur, 2016) and the transportation assessment (Nyland and Nodelman, 2017), the *Preliminary strategic climate risk assessment for British Columbia* (*see* Section 5.6; B.C. Ministry of Environment and Climate Change Strategy, 2019), *Canada's Changing Climate Report* (Bush and Lemmen, 2019), the *Health of Canadians in a Changing*

Climate: Advancing Our Knowledge for Action report (Berry and Schnitter, 2022), as well as by several chapters in the *Canada in a Changing Climate: National Issues Report* (Warren and Lulham, 2021) of this assessment (e.g., Sector Impacts and Adaptation, Water Resources, and Ecosystem Services).

5.2 Indigenous Peoples in B.C. are experiencing and adapting to climate change

Indigenous Peoples are uniquely impacted by climate change, and are also uniquely resilient as a result of Indigenous Knowledge Systems. Successful adaptation is more likely when co-created with Indigenous Peoples in ways that protect and strengthen Title, Rights, and jurisdiction, and when Indigenous Knowledge and unique connections to territories are respectfully acknowledged and thoroughly incorporated in all aspects of climate change related planning and action. Indigenous-led adaptation efforts are emerging across many traditional territories in what is today known as British Columbia, and often consider climate change adaptation alongside strengthening Indigenous governance and environmental stewardship.

First Nations are already experiencing impacts of climate change, including warmer temperatures, shifting precipitation, heat waves, wildfires and floods. These impacts also include loss of access to cultural sites and traditional foods and medicines, often exacerbated by the location of reserves, and by the legacy of colonization and systemic racism. Indigenous communities in B.C. are at various stages in addressing climate change; several communities have developed adaptation plans, and many of the initiatives are community-led. Critical to the development of these plans are the multigenerational, land-based Indigenous Knowledge Systems that date back thousands of years and continue to develop and evolve. Each community has a unique history, experience and distinct perspective on B.C.'s changing climate, yet Indigenous knowledge and experiences have been under-represented in climate change initiatives to date.

5.2.1 Introduction

Approximately one third of all First Nations communities in Canada—more than 203 communities—are located in B.C. (Government of Canada, 2010). There are seven language families comprising 34 distinct First Nations languages in B.C. and this high level of language diversity is unique in Canada (First Peoples' Cultural Council, 2018). First Nations territories in B.C. span diverse lands, water and marine ecosystems. This section focuses mainly on B.C. First Nations people living on reserve because of their defined geographical land connection and limited governing rights, as defined by the *Indian Act*, R.S.C. 1985, c. I-5.

Indigenous leaders have been actively bringing attention to the changing climate and finding ways to adapt to new conditions (Indigenous and Northern Affairs Canada, 2019; Wilson, 2019; Sanderson et al., 2015). This critical depth of understanding is often based on Indigenous Knowledge Systems, which are intrinsically interconnected with the territories from which they emerge and have been passed down from generation to generation since time immemorial (Belfer et al., 2017). Globally, lands held or managed by Indigenous peoples and local communities are under increasing pressure from human activity including climate change, but are generally deteriorating less rapidly than other lands (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019a). Based on the findings of the Global Assessment Report on Biodiversity and Ecosystem Services (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019b), the United Nations is calling for Indigenous leadership and guidance to help address human-caused environmental destruction and climate change that threatens the survival of species worldwide.

First Nations communities in B.C. are closely connected to their territories, which are an important source of resilience; however, climate change exacerbates existing inequities resulting from colonization (Weatherdon et al., 2016; Downing and Cuerrier, 2011; Jacob et al., 2010; Turner and Clifton, 2009). Because of colonial violence and injustices, and ongoing systemic levels of discrimination, many Indigenous communities tend to be socioeconomically marginalized, and more susceptible to negative climate-related impacts. Despite the innate resilience of Indigenous Peoples, who have thrived through extreme variations in climate for millennia, their ability to address climate-related challenges has been profoundly affected by the historic inequitable relationship between Indigenous peoples in B.C. and the Government of Canada (Yumagulova, 2020). These challenges have been exacerbated by the provisions of the *Indian Act*. Despite the critical importance in informing climate change adaptation, Indigenous perspectives and values have been largely excluded from much of the contemporary climate discourse, resulting in further inequities and marginalization (Yumagulova, 2020).

The location of many reserves was arbitrarily established, breaking down pre-existing governance structures and rights, and disrupting cultural identities. Furthermore, the designated reserve lands included only a small portion of the First Nations' traditional territories and were often established in areas that were deemed economically uninteresting for the settler governments due to their vulnerability or unsuitability (e.g., their location in floodplains, downstream or downwind, and the downgrade of major industrial developments) (Yumagulova, 2020; Mascarenhas, 2007). The size and location of reserves also often make effective climate change adaptation planning challenging. Moreover, First Nations that are not self-governing are dependent on federal assistance with installing and maintaining their infrastructure, which is often inadequate, as seen in multi-year boil water advisories (Yumagulova, 2020).

5.2.2 Valuing Indigenous Knowledge Systems

Indigenous Knowledge and experiences have been under-represented in climate change assessments, policies and laws to date. The limited inclusion of Indigenous Knowledge Systems in climate change assessments to date has been acknowledged, but much more work is needed to develop processes for meaningful engagement with Indigenous Peoples and provide opportunities for them to define climate change related planning processes, to foreground their values and needs in the context of climate change adaptation, and to improve respectful inclusion of Indigenous Knowledge in these processes (Ford et al., 2016).

Under the umbrella of CleanBC, the province held 10 regional sessions in 2019 and 2020 to discuss issues related to climate change, and to work towards co-producing the provincial adaptation strategy (Government of B.C., 2020a; Indigenuity Consulting Group Inc., 2020). This effort was made after significant shortcomings were identified in the *Preliminary Strategic Climate Risk Assessment for British Columbia*, and indicates an important step in building effective nation-to-nation relationships and true co-production. (B.C. Ministry of Environment and Climate Change Strategy, 2019).

The failure to recognize, include and respect Indigenous Knowledge Systems can result in adaptation efforts being less effective, especially for Indigenous Peoples (Nakashima et al., 2012). For instance, a study of 92 newspaper articles published from 1995 to 2015 focusing on Indigenous peoples in a climate change context across Canada, the USA, Australia and New Zealand (Belfer et al., 2017) revealed that Indigenous Knowledge Systems had identified almost twice as many climate change impacts as Western or scientific knowledge had done. The study also demonstrated that Indigenous Knowledge Systems tend to provide observations about sociocultural, health and safety impacts that otherwise often go unnoticed. This highlights the critical importance of working with Indigenous Peoples and seeking their leadership on these issues, as well as foregrounding the Indigenous Knowledge Systems that have developed over time and that have enabled place-specific sustainable living for millennia.

Acknowledging the value of the knowledge and rights of the Indigenous peoples, who have successfully stewarded their territories for thousands of years, holds the potential to create a solid foundation for innovative knowledge co-production and mutual learning for effective climate action. For example, a study of climate change and water at Stellat'en First Nation in B.C. combined knowledge from Western science and local Elders, and led to a series of recommended actions formulated by the First Nation (Sanderson et al., 2015). Implementation of these actions, including the creation of a community food garden and a ride-sharing hotline, has improved policy making and increased climate action in the community.

5.2.3 Climate change impacts for Indigenous communities in B.C.

Indigenous communities in B.C. are already experiencing substantial impacts associated with extreme weather events, many of which will increase in frequency and intensity as the climate continues to change (Government of B.C., 2020a; Indigenuity Consulting Group Inc., 2020). In addition, Indigenous peoples are noticing more gradual climate-related changes, such as the melting of glaciers, ocean acidification, rising sea levels, and changes in traditional food harvesting (Turner and Clifton, 2009). Climate change impacts present distinct challenges to Indigenous communities because of their unique worldviews that acknowledge the intrinsic interdependency with—and spiritual relationship to—their natural environment, and deeply rooted connection to their respective territories (Castleden et al., 2009; Lewis and Sheppard, 2005). This was reflected in the artwork done by youth Indigenous artists for a 2019 art contest (*see* Box 5.1). Traditional food sources, such as salmon, are not only an important nutritional source in many Indigenous communities in B.C., but they also play a significant part in cultural identity and social cohesion. Similarly, sharing traditional harvests with relatives, neighbours and those who are in need is one of the foundational elements of Indigenous community resilience.

Box 5.1: Fraser Basin Indigenous Youth Climate Art Contest

The Indigenous Youth Climate Art Contest was launched in 2019 by the Fraser Basin Council and invited Indigenous youth who live in B.C. to submit proposals to create visual stories about their perspectives on B.C.'s changing climate. Artwork from the winning artists is featured below (*see* Figure 5.3) in order to promote better understanding and representation of, and respect for, Indigenous youth perspectives in Canada's national assessment on climate change.

Youth from all over B.C. submitted proposals, and five of these proposals were chosen by the contest judges Tsēmā Igharas and Sheldon Pierre Louis. The winners of the art contest were:

- Leah Anthony, Nak'azdli Band, with the piece "UNEVEN GROUND: laying down complex root systems"
- Adrian Rain Flinn, James Bay Cree, Mistissini, with the collection "ᐅᑲᓇ·ᐁᔨᒧ·ᐁᐤ/ukanaweyimuweu"
- Sarah Jim, Tseycum First Nation, W_SÁNEĆ, with the piece "Saltwater Ways"
- Coralee Miller, Sylix, Okanagan Nation, with the piece "Red Woman," and
- Veronica Rose Waechter, Gitxsan Nation, with the piece "Legends of the Blue Sky."

More details about the contest, the winners and judges can be found [here](#).

Figure 5.3: Samples of the artwork from the winners of the Fraser Basin Indigenous Youth Climate Art Contest

Seasonal cycles also play an important role in the lives of Indigenous peoples. For example, the presence of snow on mountains or the presence of specific plants can signal significant times for gathering, travelling, practicing specific ceremonies, and harvesting foods and medicines. Climate change is impacting all of these activities. Although Indigenous peoples often have limitations in accessing human, financial and political resources to address climate change, their commitment to uphold their roles as stewards and guardians of their territories is steadfast. The strong sense of responsibility and stewardship is demonstrated, for instance, through Indigenous Guardian Programs (Coastal First Nations, 2017; Indigenous Leadership Initiative, n.d.), Haida Marine Planning (Jones et al., 2010), and the Syilx Nations Stewardship Project to reduce wildfires (Forest Enhancement Society of British Columbia, 2019). As they have done for thousands of years, Indigenous people rely on their values of stewardship, laws and covenants with their territories.

Indigenous communities are at various stages in addressing climate change; some have produced and are implementing climate change adaptation plans, such as the following: the Ahousaht, Hesquiaht, and Tla-o-qui-aht Community-based Climate Change Adaptation Plan (Lerner, 2011); Gitgaa'at value-based climate change adaptation planning (Reid et al., 2014); Tsleil-Waututh's climate change planning (*see* Case Story 2.5 in Cities and Towns chapter); and the Toquaht Nation's Coastal Adaptation Plan (Toquaht Nation, 2018). Some communities are aware of climate change impacts, but are either unable or unsure of how to act due to long-term political, social and economic marginalization (Jacob et al., 2010). The support of the BC First Nations Leadership Council (FNLC) for the Assembly of First Nations Global Climate Emergency Declaration demonstrates that climate change is an increasingly important issue for First Nations in B.C. (First Nations Leadership Council, 2019). At the provincial level, the Chiefs-in-Assembly of the BC Assembly of First Nations and the Union of British Columbia Indian Chiefs have passed resolutions instructing these organizations to develop a First Nations Climate Change Strategy and Action Plan identifying actions that will lower greenhouse gas (GHG) emissions, reduce vulnerability to the impacts, and build capacity and resilience, as well as identifying low-carbon economic opportunities arising from adaptation (*see* Box 5.2). Funding programs are becoming more common, including the First Nations Adapt Program (Government of Canada, 2021) and the health-focused Indigenous Climate Health Action Program (First Nations Health Authority, 2021a).

Box 5.2: BC First Nations Climate Change Strategy and Action Plan

The First Nations Leadership Council (FNLC), made up of the BC Assembly of First Nations, the First Nations Summit and the Union of BC Indian Chiefs, as mandated by the Chiefs in BC, is developing a First Nations Climate Change Strategy and Action Plan (the Strategy) that will be informed by First Nation priorities and knowledge. The objective of the Strategy is to identify strategies and actions to reduce greenhouse gas emissions, to strengthen Indigenous climate leadership in B.C., to reduce vulnerability to impacts, and to build capacity, understanding and resilience in First Nation communities. The Strategy is intended to help guide climate responses while also communicating to governments and partners of priority areas. This will, in turn, remind governments and partners that successful climate action is possible only when co-created with First Nations in ways that protect and strengthen Title, Rights, and jurisdiction, and when Indigenous Knowledge and unique connections to territories are respectfully acknowledged and thoroughly incorporated in all aspects of climate planning and action.

The following subsections discuss Indigenous perspectives on climate change adaptation within the framework of four natural elements: water, land, fire and air.

5.2.3.1 Water

For many Indigenous communities, “water is life”—from the protection of glaciers and flowing waters into the ocean to the fluid in our mother’s prenatal womb. Indigenous Knowledge connects individuals and communities to these waters and ignites their birth responsibilities to steward waters and land. With climate change, Indigenous peoples are experiencing changes in these water cycles, including receding glaciers, decreased snowfall, drought, and emergency situations such as flooding, leading to problems such as loss of access to clean drinking water, and interrupted or reduced access to traditional food sources and medicines, and impacts on mental health (*see* Video 5.1; Kitsumkalum Communications, 2018; Cave and McKay, 2016). Many of these impacts are exacerbated by systemic issues like federal inaction on boil water advisories resulting from inadequate infrastructure.

Many First Nations have reserve lands located in areas that experience recurring flood events, but lack adequate resources to address the issues (Partners for Action, 2019). Many First Nations, however, are attempting to collaborate with others to take action. For example, a Memorandum of Understanding between the Cowichan Tribes, Cowichan Valley Regional District, the City of Duncan and the Municipality of North Cowichan on Vancouver Island came into effect in 2010 to guide integrated flood management for the Lower Cowichan/Koksilah River (Government of B.C., 2020a; The Cowichan Tribes et al., 2010; Northwest Hydraulic Consultants, 2009). Dykes have been constructed on Cowichan Tribe lands to protect the community and divert flood waters, including from the Koksilah River. Like Cowichan Tribes, other Indigenous communities are also beginning to prepare for and adapt to extreme events, including through uptake of floodplain mapping technologies such as LiDAR.

Video 5.1: The connections between climate change and people’s mental health in the Quw’utsun (Cowichan) River Valley. Source: https://www.youtube.com/watch?v=pCraV8ahpYo

In the Cowichan Region, severe recurring seasonal drought is threatening to reduce river flow to the extent that salmon runs will not be able to take place unless adaptive actions are taken (Cowichan Watershed Board, 2018). This is a significant change to the way that things used to be for First Nations: "The elders talk about salmon runs being so numerous that there were runs all year round and you could fish all year round" (Tim Kulchyski, Cowichan Tribes Fisheries Consultant). The knowledge of Elders is well-aligned with findings of the B.C. Wild Salmon Advisory Council, whose review found that salmon levels across all regions and species had declined since the 1950s (B.C. Wild Salmon Advisory Council, 2018). For example, in southern B.C., the sockeye population was reduced by 43% between 1954 and 2016 (B.C. Wild Salmon Advisory Council, 2018), making these salmon—an important cultural and spiritual animal as well as essential food source for Indigenous peoples in B.C.—particularly vulnerable to climate change. Salmon are also sensitive to several different climate impacts in different seasons, which further increases their sensitivity (e.g., increased winter precipitation can lead to earlier spring melt and higher temperatures during spawning) (Vadeboncoeur, 2016) (*see* Case Story 5.1).

B.C. First Nations are often excluded from government decision-making and management frameworks related to freshwater (Simms et al., 2016). However, evidence of collaborations and Indigenous-led initiatives suggests some progress. For example, the Cowichan Tribes co-chair the Cowichan Watershed Board together with the Cowichan Valley Regional District (CVRD). This process fosters a co-management opportunity between First Nations and local governments (Cowichan Watershed Board, 2018). While collaborative management of natural resources is challenging—especially when bringing together different worldviews in a culturally diverse partnership—the work of the Cowichan Watershed Board demonstrates the benefits of Indigenous co-governance.

A study that interviewed 50 community members and leaders from coastal First Nations in B.C. found that adaptation actions relating to governance and social capital emerged as strategies critical for climate change adaptation while infrastructure upgrades and natural resource management were not prioritized (Whitney et al., 2020). Results from this study were presented by the Coastal First Nations Great Bear Initiative and Fraser Basin Council (Coastal First Nations, 2020), and showed that the management of climate impacts cannot be separated from reconciliation and self-governance. The study also identified a number of salient climate impacts for coastal communities (Whitney et al., 2020). Studies such as this one are supplemented by initiatives at other scales. For example, Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) put in place the First Nation Adapt Program (FNAP), which provides funding to First Nation communities to address climate change impacts on community infrastructure and emergency management. The FNAP has funded many projects across B.C., including a project with Skidegate First Nation that is developing models to map sea-level rise and storm surge, and to identify impacts on coastal First Nation communities in B.C. (Government of Canada, 2020).

Case Story 5.1: What becomes of "Salmon People" without Salmon? The Stó:lō and Indigenous organizations' role in a changing climate

The Stó:lō—a word meaning "river" or "the Fraser River" in Halq'eméylem—have inhabited the Lower Fraser River watershed since time immemorial. Stó:lō people comprise a supra-tribal collective of Halq'eméylem-speaking peoples whose traditional territory extends from Yale to Langley, B.C. For the Stó:lō, this place is *S'ólh Téméxw* ("Our World" or "Our Land"). Their connection to the territory is expressed in their self-identification as "People of the River" (Schaepe, 2007; Carlson, 2001).

The Stó:lō Research and Resource Management Centre (SRRMC), based in Chilliwack, B.C, is a branch of Stó:lō Nation: the political amalgamation of eleven Stó:lō communities. The SRRMC provides land and water stewardship support, and investigative stewardship support, for the collective Stó:lō community. Its mandate is to protect, preserve and manage Stó:lō heritage according to the principles of Stó:lō stewardship.

The Stó:lō were historically deprived of their right to self-govern and to determine the use of their traditional lands and resources, which have been fundamentally altered since pre-contact time (Duffield, 2001; Woods, 2001; Thom and Cameron, 1997). Notwithstanding current procedures for consultation and accommodation, development and resource extraction continue to exert pressure upon the Stó:lō people's traditional lands, resources and waterways (Brady, 2014). This pressure is compounded by climatic changes, which ultimately impact resources that are essential for Stó:lō subsistence, cultural practices, spiritual connections to ancestors, and cultural survival.

Semi-structured interviews with SRRMC staff and Stó:lō community members indicate that climatic and climate-induced impacts, along with other drivers of cumulative effects, are contributing to shifts in the availability, seasonal patterns and geographical distribution of traditional resources. These shifts exacerbate the Stó:lō people's already restricted access to traditional resources, which include traditional plants and medicines (e.g., Western red cedar, berries), wildlife and, most notably, Fraser River salmon (McHalsie, 2007). The Fraser River salmon are an integral aspect of Stó:lō history, ecology and identity. The salmon are regarded as ancestors and compose the primary staple in Stó:lō traditional diet (McHalsie, 2007; Smith, 2001; Deur, 1999; Cameron, 1997). The shifts described above are affecting the Stó:lō fisheries and food security, the timing and conduct of Stó:lō ceremonies, access to Stó:lō traditional foods, and the ability of the Stó:lō to exercise cultural practices and teachings. Overall, these changes exert multiple impacts on Stó:lō health and emotional well-being. Climate-induced changes are projected to increasingly affect Stó:lō traditional territory through declines in snowfall, changes to the Fraser River's hydrology and temperature, and reductions in Fraser River salmon availability (Shrestha et al., 2012; Healey, 2011; Ferrari et al. 2007; Morrison et al. 2002). Figure 5.4 summarizes the results regarding climate-induced and cumulative effects to Fraser River salmon.

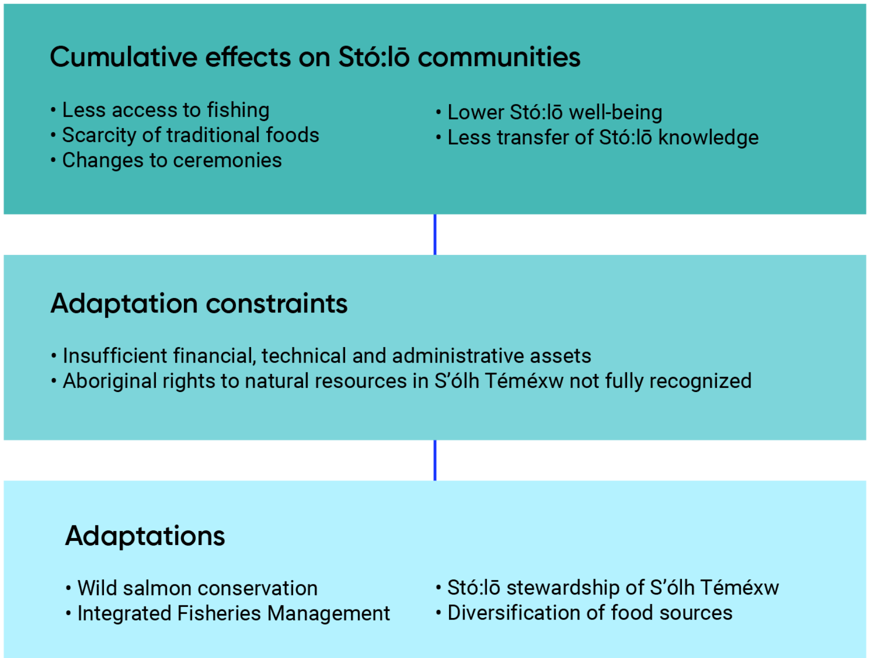

Figure 5.4: Summary of Fraser River salmon-related results.

Stó:lō community members have reported barriers in adapting to such effects, with special reference to financial and capacity constraints. Another major constraint lies in the lack of recognition of Stó:lō Aboriginal rights to manage traditional territories. In addition, consultation processes in B.C. often overburden First Nations' technical and administrative capacities, and fail to lead to meaningful reconciliation (Booth and Skelton, 2011; Marsden, 2006; Baker and McLelland, 2003). Nonetheless, the Stó:lō are actively coping with changes and exerting adaptive capacity. Stó:lō community members are identifying environmental changes and adapting accordingly to maintain continuity in their cultural practices and identity. For example, Stó:lō communities and organizations are involved in wild salmon conservation advocacy and integrated fisheries management, practicing Stó:lō stewardship of wild salmon and of *S'ólh Téméxw*—the Stó:lō traditional territory—as a whole.

The Stó:lō Research and Resource Management Centre supports Stó:lo adaptive capacity by filling technical and research capacity gaps, preserving Stó:lo culture and knowledge, and supporting Aboriginal rights and title. The SRRMC is also involved in adaptation planning with Stó:lō communities. Academic engagement with the SRRMC highlights the primary role that Indigenous organizations can play in facing the challenge of adaptation, as this organization is unique in that it combines technical capacity and expertise with cultural values and community knowledge.

In conclusion, advancing reconciliation in a changing climate entails the recognition and support of existing Indigenous adaptive capacity, including the capacity embedded in Indigenous organizations. Furthermore, the recognition of Indigenous rights, such as through meaningful consultation processes, is paramount for communities to be able to exercise stewardship of threatened traditional resources.

5.2.3.2 Land

The unique relationships that Indigenous people have with their territories and lands have developed through careful stewardship over thousands of years and are reflected in the profound sense of relational connection (LaDuke, 1999). Indigenous-managed lands in Canada have been found to have slightly greater levels of vertebrate biodiversity than do protected areas, while also supporting a greater number of threatened vertebrate species; partnerships between Indigenous communities and other government agencies could enhance biodiversity conservation efforts (Schuster et al., 2019). The impacts of climate change are manifested in various ways and affect Indigenous communities both environmentally and socially (Turner and Clifton, 2009). One example is that less severe winters have contributed to devastating outbreaks of the Mountain Pine Beetle, reducing overall forest health (Parkins, 2008). Indigenous livelihoods have been impacted because many communities have economic interests in both timber and non-timber products retrieved from forests. Changes in traditional food availability, ranging from caribou to saskatoon berries, as well as access to medicinal and ceremonial plants such as salal or cedar, have significant social, health and cultural implications for First Nations (Marushka et al., 2019).

Landscapes are changing rapidly, and the cumulative impacts of industrial resource extraction and climate change make cultural and livelihood retention challenging in Indigenous communities (Turner and Clifton, 2009). Mainstream land management practices rarely align with Indigenous Knowledge Systems, and communities seldom have authority in how they would like the lands to be governed (Simms et al., 2016).

Despite enormous challenges, there are some promising examples of effective Indigenous climate change adaptation projects on the land, such as caribou conservation. Caribou herds of critical importance to Indigenous peoples in northern B.C. are at extremely high levels of risk (Booth and Skelton, 2011). The cumulative impacts of forestry, roads, mining, and oil and gas industries have destroyed almost two thirds of the caribou habitat in B.C. (Johnson et al., 2015). Climate change poses another significant threat to caribou and their habitat (Masood et al., 2017). According to Roland Willson, Chief of the West Moberly First Nations in northeast B.C., the decline in the caribou population has transformed his traditional way of life (Huffington Post, 2015). Studies conducted by the First Nation document community losses due to the inability to harvest caribou. This crisis led to a partnership between the West Moberly First Nation and Saulteau First Nation to develop caribou management plans for the surviving caribou herds, resulting in restoration efforts that have effectively regenerated one herd from 16 to 70 animals in the span of four years (Newton, 2018). Key actions included implementing maternity pens, applying a self-determined ban on hunting caribou, using a traditional predator management program, and systematically monitoring and mapping the caribou habitat. The First Nations also negotiated a draft Caribou Recovery Partnership Agreement with both the Government of British Columbia and the Government of Canada (B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2019a), which outlines areas of protection, restoration and conservation, including predator management measures and an Indigenous Guardianship program.

5.2.3.3 Fire

Many communities in B.C. are experiencing increases in the length of the forest fire season and the severity of wildfires. These wildfires continue to devastate Indigenous communities, resulting in displacement from homes and homelands, serious physical and mental health impacts, economic impacts and threats to community infrastructure (Abbott and Chapman, 2018), as well as impacts to cultural heritage and cultural rights. Indigenous communities face inequities in situations of wildfire crisis in terms of preparedness, response and recovery (Abbott and Chapman, 2018). The First Nations Leadership Council (FNLC) issued a news release outlining the issue of jurisdiction between federal and provincial governments in managing the wildfire crisis that is affecting First Nations communities, underscoring the urgent need for emergency planning and implementation assistance, training, funding and collaboration with all levels of government (First Nations Leadership Council, 2018). Addressing the gaps in emergency response is an important priority for First Nations in B.C.

People living on First Nations reserves in Canada are 33 times more likely to experience evacuations due to wildfire than those living off reserve (Yumagulova, 2018). An online engagement survey, launched in 2018 as part of the B.C. Flood and Wildfire Review following the 2017 and 2018 wildfire events that affected many Indigenous communities, yielded the following results: two-thirds of the respondents focused solely on the wildfires; half thought that their community was unprepared for wildfire events; over three-quarters supported prescribed burning; and one third considered that they had received unclear information regarding evacuation (Abbott and Chapman, 2018).

Many First Nations communities are proactively addressing and preparing for wildfire. ʔaq̓am, a Ktunaxa Nation community, needed to evacuate 110 people from 37 homes due to a 2017 wildfire. The fire damage was extensive, but could have been much worse had relationships not been built with the Regional District of East Kootenay and the City of Cranbrook prior to the wildfire. ʔaq̓am hosted a community celebration to express gratitude to its neighbours for their support. As Chief Joe Pierre reminds us, “Relationships need to be worked on all the time. Neighbours that know each other, help each other” (Abbott and Chapman, 2018). Indigenous communities such as the ʔaq̓am Community are utilizing Indigenous Knowledge Systems along with Western science to address, prepare for and manage forest fire risk, including through prescribed burning. These efforts are supported by programs like the Union of BC Municipalities’ (UBCM) Community to Community (C2C) Forum, which was designed specifically to help First Nations and local governments connect (Union of BC Municipalities, 2021).

Many Indigenous communities in B.C. used burning practices to enhance landscapes and manage the land. Prior to colonization, these traditional fire uses were practiced on a large scale to promote the growth of important foods, such as berries, and to support animal migration (Turner, 1999). Current fire suppression policies have meant that these practices are not being used to the same degree anymore. Oral tradition has documented these practices, and some Indigenous elders have recollection of these practices. Fire practices are still in use today, though on a smaller scale and with the primary purpose of hazard management and reducing wildfire risks to nearby communities (Lewis, et al. 2018). Indigenous Knowledge Systems include knowledge of how to burn safely, and about the interconnections between fuels, fire behaviour and weather. An example of a community-led effort to manage wildfire is the Revitalizing Cultural Burning project coordinated by the First Nations Emergency Services Society (FNESS), in collaboration with three First Nations in B.C.: the Shackan Indian Band; Xwisten (Bridge River) First Nation; and Yunesit’in Government (First Nations Emergency Services Society, 2022). According to FNESS, the project broadens learning opportunities about cultural burning revitalization to strategic partners such as the provincial and federal governments, and through stories/case studies on (i) advancing cultural burning revitalization in relation to reconciliation, wildfire prevention and risk reduction, and climate change adaptation; and (ii) enhancing holistic knowledge and observations of wildfire management to inform climate change adaptation planning for First Nations communities of similar scale and needs (British Columbia Assembly of First Nations, 2020, 4–5).

Fire management practices are also part of stewardship, and fire suppression is related to the ability to be good stewards (Forney, 2016).

5.2.3.4 Air

The elements of water, earth and fire are visually easier to conceptualize than air. The space that we occupy as humans is generally through the atmosphere that supports our ability to breathe and to exist, which is based on good air quality. Our symbiotic interdependence with oxygen-producing plants is one example of what Indigenous Knowledge Systems refer to as interconnection and as an interdependent relationship with the natural world (Caverley, 2011).

Climate change affects the air in multiple ways, including through higher temperatures—leading to drought and evaporation—and through poor air quality stemming from wildfire smoke, resulting in a range of social, health and cultural impacts on Indigenous Peoples. Knowledge holders in the Clayoquot Sound area have noted an increase in storm severity and a decrease in storm frequency (Lerner, 2011). Through a collaborative climate adaptation planning process, the Ahousaht Nation, Hesquiaht Nation and Tla-o-qui-aht Nation identified approaches for responding to more severe storms. One of the adaptation responses identified in this plan is to upgrade key community assets to better perform during storm surges, flooding and rain, wind and windthrow (Lerner, 2011). The Ahousaht, Hesquiaht and Tla-o-qui-aht Community-based Climate Change Adaptation Plan outlines many adaptation strategies that interconnect to support the overall community vision. An example of these resilience-enhancing strategies is the effort to promote cultural self-reliance and continual learning about climate change.

5.2.3.5 Indigenous Food Systems

Indigenous Knowledge Systems related to harvesting plant foods involve taking into account many complex variables, including elevation, season and preferred growing climates (e.g., dryness, shade, proximity of trees). Climate change has, and will continue to have, greater impacts on food sovereignty for Indigenous peoples than for non-Indigenous people. Climate change impacts (e.g., increased air temperature) will affect the growing season of plant foods and medicines. Shifting climate patterns negatively impact traditional food harvesting and result in food that is harder to locate, less abundant, and changed in consistency or taste. Indigenous peoples rely on traditional foods for their health, culture, identity, stewardship and political roles. Work is needed, including through Indigenous-led study, to find the best ways to adapt traditional foods in response to climate change. For instance, there is a relative lack of research on the effect that climate change will have on berry harvesting.

Indigenous Knowledge Systems include sustainable harvesting practices, such as the “first harvest practices.” For instance, huckleberries are an important food for the Ktunaxa people; Ktunaxa elders shared a practice whereby women carry the responsibility for picking the first huckleberries of the season for their family, followed by praying for a good harvest that year (Forney, 2016; Williams and Clarricoates, 2002). These berries are used in important ceremonies throughout the year, including at important times in one's life. Berry pickers play a role in the health of huckleberry patches. Values such as respect for and reciprocity with the plants themselves are part of the good stewardship that Indigenous people practice. Other impacts to food systems arise as a result of changing ocean conditions. These issues too are being address by Indigenous-led efforts. For example, the First Nation Health Authority's Health Canada-funded project *We All Take Care of the Harvest (WATCH)* focuses on Indigenous seafood safety, security and sovereignty in the context of climate change (First Nations Health Authority, 2021a).

5.2.4 Conclusions

Indigenous Knowledge and experiences are often under-represented in climate change discourse and initiatives. Failing to appropriately make space for Indigenous Knowledge Systems in climate change adaptation initiatives has consequences for Indigenous peoples, including the repeat of maladaptive adaptation policies. Acknowledgement of the relative lack of engagement of Indigenous Knowledge Systems is needed to understand how meaningful inclusion can be achieved (Ford, et al. 2016).

Making space for these Indigenous Knowledge Systems promotes relationship building based on respect and understanding for Indigenous values, histories and worldviews. Treating Indigenous People and their Knowledge Systems on an equal footing with Western systems will empower Indigenous Peoples to develop their own climate adaptation programs. It will also help to promote collaboration at all levels of government, leading to true, long-term partnerships that enable climate change adaptation planning developed by Indigenous Peoples and Nations for Indigenous Peoples. Emerging evidence indicates that collaborative efforts to bring together Indigenous Knowledge Systems and scientific approaches, based on culturally appropriate and responsive strategies, would be actively supported and would help to ensure ongoing engagement in climate change adaptation plans (Wildcat, 2013).

The lack of autonomy to govern and make decisions regarding Indigenous lands and territories is a barrier for many successful adaptation efforts. Historic and current colonization efforts have systematically separated Indigenous peoples from their lands, as well as dismantled Indigenous Knowledge Systems in myriad ways, including through residential schools (Greenwood and Lindsay, 2019). Climate change has in some ways intensified the effects of colonization: "A central theme is that anthropogenic climate change is intimately connected to the ideologies, systems and practices of colonialism, and that the impacts on Indigenous peoples can be conceptualized as an intensification of the process of colonization (Jones, 2019, 73)." Indigenous rights and self-determination are an important aspect of the health and survival of Indigenous peoples. Indigenous-led climate change adaptation initiatives that address inequities, support reclamation of self-determination and are grounded in Indigenous ways of knowing can help to repair and restore the health of the land and to ensure collective survival and well-being (Greenwood and Lindsay, 2019).

5.3 Climate change brings increasing flood risks

British Columbia's water resources will see significant changes as the climate warms, with flooding causing some of the most damaging and costly impacts. Many communities in British Columbia are reducing the risks by proactively planning, designing and implementing flood adaptation projects, but increased action across all scales is needed.

British Columbia faces significant risks from coastal, riverine, and urban flooding. These flood events negatively impact critical infrastructure and services, ecosystems, and health and well-being. While there are many useful resources (e.g., floodplain mapping), and examples of planning and action at different scales, challenges remain, including complex and often overlapping jurisdictional mandates, long-term uncertainty and trade-offs, and limited human and financial resources. Opportunities exist to mainstream flood risk management into existing municipal practices (e.g., integrated storm water master plans, asset management), and research continues to build a strong economic case for action.

5.3.1 Introduction

Climate change is altering and will continue to alter hydrological regimes in B.C., negatively impacting riverine ecosystems and marine ecology (B.C. Ministry of Environment, 2016; Vadeboncoeur, 2016). In addition to high-flow events, changes in streamflow will very likely impact the timing and duration of summer-autumn low flow, and lead to higher water temperatures during low-flow periods (Bonsal et al., 2019). These periods of low flow represent decreased water availability, and can impact aquatic ecosystems and drinking-water supply (Bonsal et al., 2019). For example, the Cowichan Valley Regional District's 16 watersheds are impacted by increasing water use and a changing climate, requiring adaptation to deal with lower water levels in the Cowichan River (Watershed Governance Dispatch, 2019) (*see* Cities and Towns chapter for a discussion of adaptation options pursued). Changes to hydrological regimes also have the potential to affect hydroelectricity, B.C.'s primary source of electricity (Canada Energy Regulator, 2020).

5.3.2 Flood hazards

5.3.2.1 Riverine flooding

Riverine flooding is widespread in B.C. (*see* Figure 5.5) and occurs when forces such as excessive rains or rapid snowmelt exceed the capacity of a river channel or stream bank (Abbott and Chapman, 2018). An atmospheric river event in November 2021 brought record precipitation to many communities in southern B.C., leading to destructive flooding in many communities (*see* Box 5.3; Schmunk, 2021).

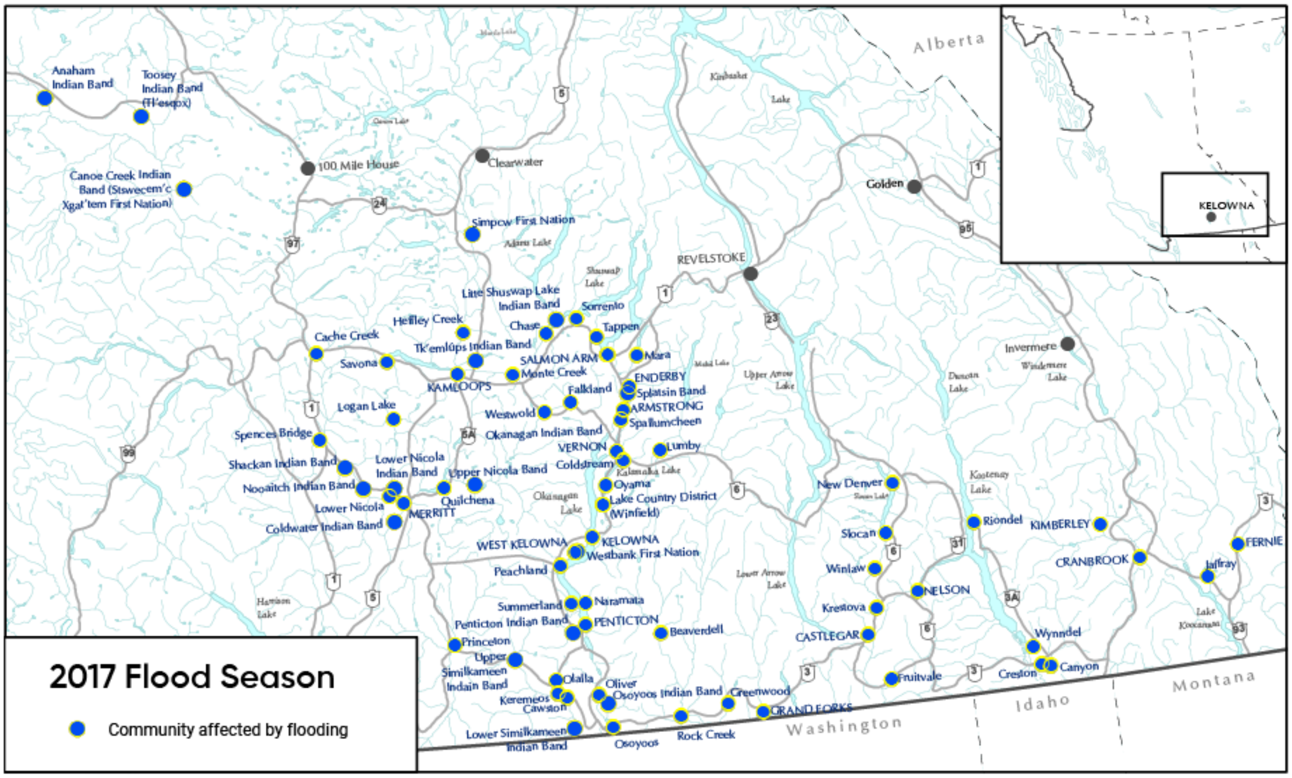

Figure 5.5: Map showing communities located in inland British Columbia that were affected by flooding during the 2017 flood season. Source: Abbott and Chapman, 2018.

Increasing temperatures and changes in seasonal precipitation will alter current patterns of water accumulation (e.g., decreased snowpack, glacier mass loss) and discharge, including the timing of spring thaw, timing and duration of summer-autumn low flow, higher water temperatures during low-flow periods (Bonsal et al., 2019), and increased strength and frequency of atmospheric river events (*see* Box 5.3) (Curry et al., 2019). These changes will be influenced by natural climate variability associated with El Niño–Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) (Vadeboncoeur, 2016).

Box 5.3: Atmospheric Rivers

Atmospheric rivers are narrow bands of concentrated moisture in the atmosphere that enter western Canada from the Pacific Ocean and can lead to extreme precipitation events such as those witnessed in November 2021 (Bonsal et al., 2019). Such atmospheric rivers can be up to 1,600 km long and more than 640 km wide and, on average, carry an amount of water equivalent to 25 Mississippi Rivers (CBC Radio, 2021).

Climate change is likely to increase the strength and frequency of these events in British Columbia's Fraser River Basin (Curry et al., 2019).

Although there is uncertainty regarding how higher temperatures and reductions in snow cover will combine to affect the frequency and magnitude of future snowmelt-related flooding (Bonsal et al., 2019), available research indicates that riverine flood risk will increase in many parts of the province (B.C. Ministry of Environment and Climate Change Strategy, 2019; Engineers and Geoscientists British Columbia, 2018). Flood hazards in the Fraser River Basin, for example, would increase substantially under RCP 8.5 as a result of the increased strength and frequency of atmospheric river events (Curry et al., 2019).

As part of the Lower Mainland Flood Management Strategy, the Fraser Basin Council led the creation of a set of maps that show the extent of flooding in the Lower Mainland under various climate scenarios. These maps indicate a substantial increased risk of large flood events for much of the region (Auditor General of British Columbia, 2018).

5.3.2.2 Coastal flooding

B.C.'s coastline extends for more than 26,000 km and is a zone of considerable vulnerability to flooding resulting from rising sea levels and storm surges, especially in low-lying areas (Vadeboncoeur, 2016). B.C.'s coast will face increased flood risk as sea levels rise and high-water events become more common. Relative sea-level rise under a high-emissions scenario is projected to exceed 50 cm by 2100 for Prince Rupert, Haida Gwaii, and the Vancouver area (Cohen et al., 2019; *see* also Figure 7.16 in Greenan et al., 2019 for more locations). There is also the potential for much greater sea-level rise due to the melting of Antarctic ice (Greenan et al., 2019). For Vancouver, this would result in sea-level rise of approximately 135 cm by 2100 (Greenan et al., 2019). The frequency and magnitude of extreme high water-level events will also increase where the sea level is rising (Greenan et al., 2019). These events are typically associated with storm surges that coincide with high tide levels (Greenan et al., 2019).

5.3.2.3 Urban flooding

Urban flooding occurs when extreme precipitation events overwhelm municipal storm water infrastructure, leading to localized flooding that can create widespread impacts to property values, service provision, and health and safety (*see* Cities and Towns chapter for more information). Although local governments often understand the historical occurrences of urban flooding events in their communities, no research exists that characterizes this risk across the province. Similarly, local planning exercises often assess the future likelihood and consequences of urban flooding events (e.g., City of Prince George, 2021), but to date these results have been difficult to summarize at the provincial scale. Given the projected increases in extreme precipitation, and the challenges of ageing infrastructure and intensive development, it is likely that urban flood risk will increase alongside riverine and coastal risks (Auditor General of British Columbia, 2018).

5.3.3 Observed and projected impacts

Flooding affects infrastructure, natural systems and assets, health and well-being, and requires significant local, provincial and federal resources (B.C. Ministry of Environment and Climate Change Strategy, 2019). For example, it is estimated that the widespread flooding in November 2021 caused $515M in insured damages in B.C. (Insurance Bureau of Canada, 2022). Wildfires often lead to hydrophobic soils, and it is likely that the significant 2021 wildfire season exacerbated the volume and speed of runoff during the November 2021 atmospheric river event (Clague, 2021).

Extreme precipitation events can trigger landslides, as was seen in November 2021 when landslides led to mortalities and the failure of several highways in B.C. (Schmunk, 2021). For a discussion of the impacts of flooding on air and marine transport infrastructure (e.g., Vancouver International Airport, Port of Metro Vancouver), see Vadeboncoeur et al. (2016) and Nyland and Nodelman (2017).

Flooding also negatively impacts human health as well as the health system itself (*see* also Health of Canadians in a Changing Climate; Burton et al., 2016; Du et al., 2010). For example, extreme precipitation events can lead to an increase in the cloudiness of water with mud and silt, as well as enteric diseases (e.g., cryptosporidiosis, giardiasis) in drinking water systems (Chhetri et al., 2019).

Coastal communities face impacts to their coastal infrastructure, ecosystem damage and coastline erosion (Greenan et al., 2019; Vadeboncoeur, 2016). The risks associated with these events are expected to increase as the sea level rises and as storm surge events become more frequent and intense. Flooding also creates unique challenges for Indigenous communities, some of which are discussed above (*see* Section 5.2). Agricultural land and freshwater sources may also be affected by salinization, through a build-up of salt in the soil (B.C. Agriculture and Food Climate Action Initiative, 2013).

As part of Phase 1 of its Lower Mainland Flood Management Strategy, the Fraser Basin Council projected the damage and direct and indirect economic losses in Lower Mainland floodplain areas that would result under different flood scenarios (*see* Table 5.1; Fraser Basin Council, 2016). This represents the most detailed study of the future economic impacts of flooding available in B.C.

Table 5.1: Economic loss projections for coastal and riverine systems in the Lower Mainland flood area (Fraser Basin Council, 2016)

FLOOD SCENARIO	RESIDENTIAL[1]	COMMERCIAL[1]	INDUSTRIAL[1]	PUBLIC/ INSTITUTIONAL BUILDINGS[1]	INTERRUPTED CARGO SHIPMENTS[2]	INFRASTRUCTURE[3]	AGRICULTURE[4]	TOTAL
A | Coastal (Present Day)	$5.6 B	$6.3 B	$1.6 B	$720 M	$3.6 B	$1.4 B	$100 M	$19.3 Billion
B | Coastal (Year 2100)	$7.1 B	$8.6 B	$2.6 B	$910 M	$3.6 B	$1.8 B	$200 M	$24.7 Billion

FLOOD SCENARIO	RESIDENTIAL[1]	COMMERCIAL[1]	INDUSTRIAL[1]	PUBLIC/ INSTITUTIONAL BUILDINGS[1]	INTERRUPTED CARGO SHIPMENTS[2]	INFRASTRUCTURE[3]	AGRICULTURE[4]	TOTAL
C | River (Present Day)	$2.6 B	$3.8 B	$1.6 B	$880 M	$7.7 B	$4.6 B	$1.6 B	$22.9 Billion
D | River (Year 2100)	$6.6 B	$7.6 B	$2.9 B	$1.2 M	$7.7 B	$5.0 B	$1.6 B	$32.7 Billion

Table 5.1 summarizes economic loss projections for all types of loss included in this vulnerability assessment, across the entire region, based on longer-duration flood: a two-week coastal flood (Scenarios A and B) or four-week Fraser River Flood (Scenarios C and D).

Notes

[1] Building-related loss projections encompass the cost of repair or replacement of residential, commercial, industrial and public/institutional buildings damaged or destroyed by flood, and include losses relating to inventory, relocation and wages.

[2] These are revenues from delays and cancellations in cargo shipping.

[3] Included in infrastructure are electrical substations.

[4] These losses include agricultural buildings and equipment damaged or destroyed, lost farm gate sales and replanting costs.

5.3.4 Flood risk reduction strategies

Flood risk management in B.C. occurs across the four pillars of disaster management, namely i) planning and preparedness, ii) prevention and mitigation, iii) response, and iv) recovery (Abbott and Chapman, 2018), and involves a multitude of actors, including federal, provincial and local governments, First Nations, non-government organizations, utilities, educational institutions and the private sector (Government of B.C., 2021a). Municipalities are often primary drivers of flood risk management (Auditor General of British Columbia, 2018). For example, land-use decisions—which are essential for risk prevention and reduction—generally fall within the jurisdiction of municipalities, regional districts and/or First Nations, as does the creation of storm water master plans, which were an early example of adaptation in the province. Efforts to manage flood risks are supported by researchers across the country (e.g., design guidelines being prepared by the Canadian Standards Association and the National Research Council of Canada, and the Pacific Institute for Climate Solutions' large-scale research projects aimed at creating a strategic approach to coastal adaptation in B.C.) (Pacific Institute for Climate Solutions, 2021). See Table 4.2 in the Water Resources chapter for a list of national and provincial resources relating to flood risk management.

5.3.4.1 Riverine

B.C.'s Lower Mainland contains 600 km of dyking and 100 pump stations (Government of B.C., 2018b). This infrastructure has been designed to reduce flooding associated with the Fraser River and coastal areas, but it is not sufficient in all cases (Northwest Hydraulic Consultants, 2016a). The Lower Mainland Flood Management Strategy (Fraser Basin Council, 2016) resulted in the creation of several maps that are designed to support planning and preparedness in the Lower Mainland (Fraser Basin Council, 2019).

The B.C. River Forecast Centre monitors riverine flood risk in the province and issues advisories, watches and warnings as appropriate (B.C. River Forecast Centre, 2021). These early warning mechanisms are supplemented by emergency response mechanisms like GeoBC and Emergency Management BC's Emergency Management Common Operating Picture (COP) Portal. These provincial resources provide emergency GIS information and are the primary mechanism for displaying real-time emergency response data for emergency management personnel across B.C., and they have been used during both wildfire and flood events (Emergency Management B.C., 2019).

In 2018, the Auditor General of B.C. concluded that the provincial government may not be able to effectively manage the increasing flood risk posed by climate change (Auditor General of British Columbia, 2018). There is no existing research that assesses the adaptation gap across all levels of government for flooding in B.C.

5.3.4.2 Coastal

Many municipal and regional governments are engaged in planning activities that seek to manage coastal flood risk (Chang et al., 2020). Protection, accommodation and retreat are the general adaptation approaches used to reduce the risks of sea-level rise (*see* Figure 5.6). There is an increased understanding of these approaches, as can be seen in the compendium produced during the development of the North Shore Sea Level Rise Adaptive Management Strategy (Kerr Wood Leidal, 2020). Managed retreat via voluntary buyout is an important strategy that is often politically and emotionally charged (Rutledge, 2017; Gibbs, 2016), and that must consider efficiency, social acceptability and political feasibility in order to be effective (Thistlethwaite et al., 2020). The most prominent example in B.C. comes from Grand Forks, which was awarded funding from Infrastructure Canada's Disaster Mitigation and Adaptation Fund, in part to purchase properties located in floodplains (Government of Canada, 2019).

Land-use planning can prevent development in areas that are vulnerable to sea-level rise. An example of this is the City of Surrey's policy to regulate development within the Serpentine and Nicomekl River Floodplains, which restricts subdivision within the floodplain in order to limit the number of exposed businesses and residences. Combined with the City's Hazard Area Development Permit requirement (City of Surrey, 2022), the policy ensures that those living in or reconstructing a building in the floodplain will have buildings constructed to safe elevations. An understanding of flood risks and subsequent land-use planning are the foundations of this strategy (*see* Case Story 5.2).

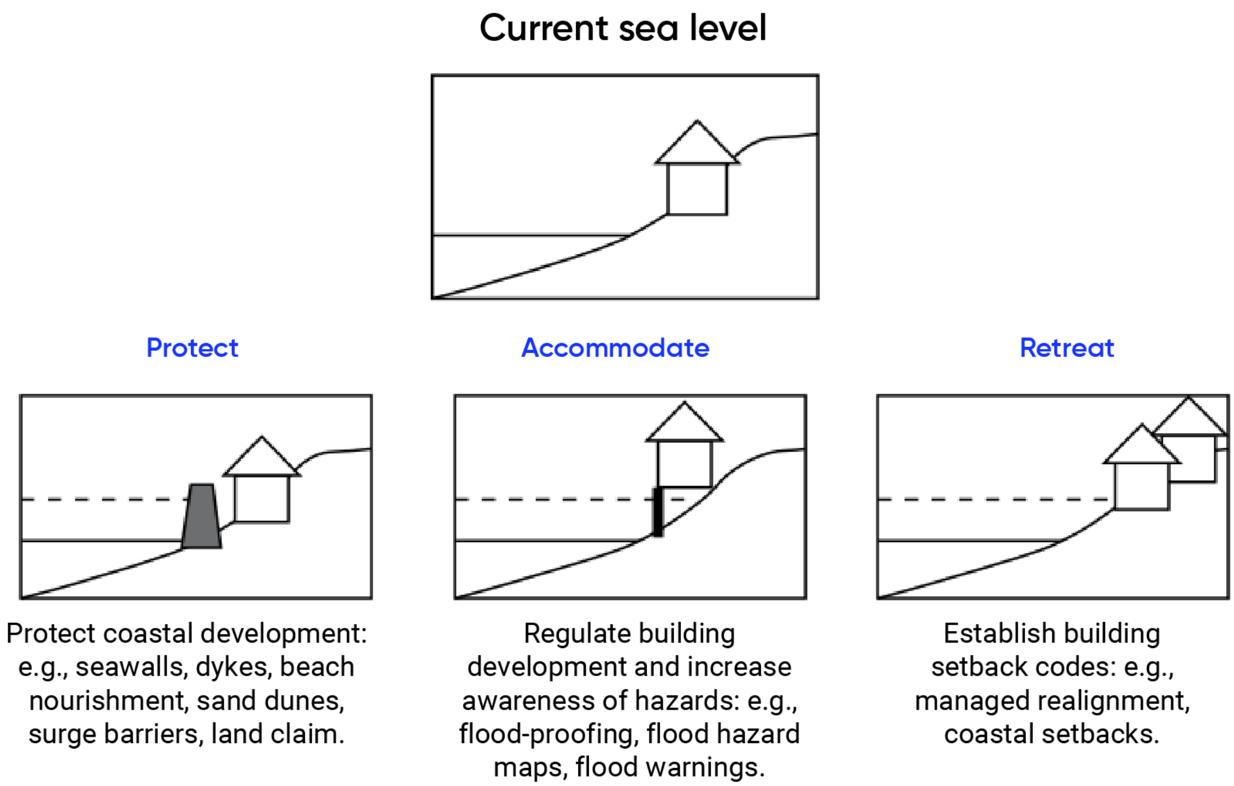

Figure 5.6: Schematic representation of protection, accommodation and retreat responses to sea-level rise.
Source: Mercer Clarke et al, 2016, as modified from Linham and Nicholls, 2010, based on IPCC, 1990.

In 2019, the Government of British Columbia updated its Flood Hazard Land Use Management Guidelines to specify that all lots created through subdivision must have viable building sites on natural ground that are above the year 2100 flood construction level (considering 1.0 m of sea-level rise). An example of this can be seen in North Vancouver's Harbourside development, which was required to raise the entire site by 1.5 metres and to stabilize the foreshore (Richter, 2020).

Although engineered defences (e.g., dykes, tidal gates and pump stations) are often essential to protect people, property and infrastructure (Doberstein et al., 2019), planners are also considering the use of nature-based solutions that can be adapted to local conditions, in part due to their potential cost-effectiveness and for the co-benefits that they deliver (*see* also Ecosystem Services Chapter; Reguero et al., 2018). Many of the most populated coastal communities in the Salish Sea region have had asssessments conducted regarding their local potential for green infrastructure—as well as the vulnerability of the green infrastructure itself. Findings indicate that coastal green infrastructure can provide high coastal protection benefits (Conger and Chang, 2019). These approaches are sometimes augmented by solutions that rely on Indigenous Knowledge. For example, researchers are currently exploring the many co-benefits of clam gardens for coastal adaptation (e.g., through wave attenuation) (Lokman and Tomkins, 2020).

Coastal adaptation decisions often require collaboration between different levels of government and First Nations. Waterfronts, for example, are within the jurisdiction of the Government of British Columbia to administer Crown land approvals, and within the jurisdiction of the Government of Canada for the evaluation of impacts on fisheries and navigable waters (West Coast Environmental Law, 2018). The City of Vancouver's sea-level rise plan is informed by traditional Musqueam canoe landing protocols and requirements, a process that required a great deal of investment in trust building and collaboration.

The capacity of local governments to respond to changing coastal conditions varies greatly, as does the level of funding and support for coastal adaptation and vulnerability reduction. Larger municipalities like Vancouver, Surrey and Victoria have been able to source or leverage funding, while smaller communities often rely on support from higher levels of government when available (Chang et al., 2020). Furthermore, municipal governments do not have jurisdiction over the placement of certain types of critical infrastructure, such as railways, ports, airports, hydro infrastructure, pipelines, ferry terminals and highways. This infrastructure is often located in floodplains, placing it at risk to flooding, which requires collaborative adaptation efforts (Nyland and Nodelman, 2017).

5.3.4.3 Urban

Municipal governments have been managing storm water for many decades, and generally have a sense of their vulnerabilities and priorities, usually through storm water master plans. Much of this work is supported by guidance and funding from others level of government and has resulted in integrated storm water master plans, and various infrastructure upgrades (City of Surrey, 2022).

Low-impact development practices (LIDs) can significantly improve storm water management (*see* Cities and Towns chapter). Where LID features are applied in a neighbourhood, storm flows are reduced, water quality is improved, and base flows to creeks are sustained or improved over conventional storm water treatments (Dagenais et al., 2014). Some typical LIDs being used in B.C. communities include rain gardens, green roofs, infiltration galleries, bioswales, soil augmentation, downspout disconnections, lot grading, and on-lot cisterns/ retention systems. The Municipal Natural Assets Initiative increasingly supports municipalities in developing resilient, long-term infrastructure alternatives at substantial savings compared with engineered adaptation options (*see* Case Story 2.2 in the Cities and Towns chapter; *see* also Ecosystem Services chapter).

5.3.5 Key challenges and opportunities

In 2018, the Auditor General of B.C. found that local governments require more financial support, more reliable data and knowledge, stronger policies and plans from the federal and provincial levels, and additional human resources to improve flood risk management (Auditor General of British Columbia, 2018). A case study in Vancouver and Surrey identified the following five barriers to effective adaptation: inadequate collaboration, absence of senior-level political leadership, lack of public awareness, insufficient financial and staff capacity, and misalignment of policies within and between levels of government (Oulahen et al., 2018).

Some additional challenges faced by communities as they manage increasing flood risk include:

- **Governance:** A now-prominent report released before the flooding in November 2021 proposed a new model for flood risk governance in B.C. (Ebbwater Consulting, 2021), and the November 2021 floods have created a significant level of activity across all levels of government. However, at the time of writing, the outcomes of these activities are not known.
- **Data availability**: Many adaptation measures, particularly those involving engineering solutions, require high-quality data and rigorous options analysis. A survey of 72 B.C. communities indicated that only 31% had access to floodplain maps created using LiDAR (B.C. Real Estate Association, 2015). The Columbia Basin Trust recently accessed $2 million in funding to perform LiDAR mapping of the region.
- **Controversial trade-offs**: Community efforts to adapt to sea-level rise may focus on one particular community interest, such as the protection of private homes or an important economic resource, such as a port. When exploring options to reduce flood risk, it is important to balance objectives based on a broader understanding of community values (Educating Coastal Communities About Sea Level Rise, 2019; Capital Region District, 2015).
- **Significant financial consequences**: The costs of both action and inaction will be high, and communities generally cannot afford to reduce all aspects of climate risk, nor can they afford to build to the worst-case scenario. The estimated cost of installing a hard seawall can be in the order of $33,000 per lineal metre, whereas a more natural approach to shoreline protection is estimated at $10,000–$14,000 per lineal metre (Lamont et al., 2014). —Although less costly, this amount is still high for a small community's budget. For example, the Town of Qualicum Beach on Vancouver Island has approximately three km of coastline in its central waterfront, which would cost at least $30 million to protect using natural approaches. Implementing such measures therefore usually requires contributions from higher levels of government or external funding (including from organizations such as the Federation of Canadian Municipalities) to assist with planning, design and construction.
- **Short- and long-term implementation**: Adaptation is a continuous process. Assets are designed with lifespans of many decades, and it is important to recognize that the climate will continue to change throughout that timeframe, thereby posing risks to asset performance. An emerging practice is the incorporation of climate risk into formal asset management planning, a process for which guidance exists (*see* Water Resources Chapter; Asset Management B.C., 2018). In other situations, it may be possible to design for a less distant climate future, where uncertainty is minimized and the asset can be modified as part of planned maintenance or upgrading, if needed.

Case Story 5.2: Surrey's Coastal Flood Adaptation Strategy

As a coastal community, the City of Surrey, B.C., is expected to experience more flooding in the future as a result of climate change (e.g., sea-level rise and changes in precipitation patterns) and due to the region's low-lying topography (*see* Figure 5.7). Approximately 20% of Surrey's land lies within a coastal floodplain. Several sectors are at risk from flooding, including agriculture, recreation and transportation (*see* Case Story 7.8 in the Sector Impacts and Adaptation Chapter), as well as infrastructure, communities, and local and regional economies. The city was in need of a comprehensive adaptation strategy that considered climate change impacts to different sectors and stakeholders, examined different adaptation options and solutions, and identified long-term strategic directions, as well as shorter-term actions that could be used by multiple stakeholders to collectively manage and adapt to climate change impacts. To proactively address these needs, the city has developed a Coastal Flood Adaptation Strategy (CFAS) (City of Surrey, 2019).

Figure 5.7: Coastal area of Surrey, B.C. Photo courtesy of the City of Surrey.

The CFAS project team included experts from multiple disciplines; the process was guided by a multi-departmental steering committee, and partnerships with external organizations played a key role throughout the project's five phases. The collaborative work was grounded in rigorous technical analyses—including modelling of current and future flood extent, depth and velocity—and infrastructure vulnerability assessments.

Aside from designing complex engineered coastal flood resilience solutions, coastal adaptation planning often involves making difficult decisions about valuable assets, public funds and the future of existing communities. To balance these trade-offs, the CFAS challenged the long-held practice of keeping flood management decisions solely within the domain of professional engineers, and instead sought to bring community and stakeholder voices into the decision-making process. To achieve meaningful public engagement, the process incorporated structured decision making and impact-scenario planning (City of Surrey, 2019). This approach helped to integrate shared community values into the development of an inclusive plan that was publicly and politically supported. Over the three-year planning process, more than 30 organizations, agencies and governments, including First Nations, participated in the project. Over 2,000 residents and other stakeholders attended workshops, open houses, focus groups, project surveys and other engagement events. Communications related to the CFAS generated over 250,000 social media impressions, major national media coverage and almost 4,000 views of project videos.

Strategic directions on adaptation were developed through an iterative adaptive design process. Initially, over 20 adaptation concepts were co-developed with the community, professional stakeholders and academic partners. These concepts were assessed for feasibility, evaluated using community-identified values as criteria, and presented to stakeholders for further feedback and prioritization (*see* Figure 5.8; City of Surrey, 2018a). The selected long-term strategic directions subsequently guided the identification of 46 actions to be implemented over the next 80 years.

Implementation of the CFAS actions will involve numerous departments within the City of Surrey, outside agencies, senior levels of government and community-based organizations. The Strategy is an example of how a proactive, community-focused planning approach was successful in developing the partnerships and buy-in necessary to advance 13 major infrastructure projects valued at $187 million, which includes $76.6 million of Government of Canada funding through the Disaster Mitigation and Adaptation Fund. These projects address priority needs within the community and include the use of innovative approaches, such as nature-based solutions.

Values criteria	Baseline – no adaptation	Current conventions	Mud Bay barrier	Highway 99 realignment	Managed retreat
Residents *People permanently displaced*	Far worse	Slightly worse	No change	Slightly worse	Far worse
Agriculture *Permanent loss of agriculture land*	Far worse	Slightly worse	No change	Slightly worse	Far worse
Environment *Impacts to wetland habitats, freshwater fish habitat and riparian areas*	Moderately worse	Far worse	Far worse	Slightly better	Far better
Infrastructure *Percent of service/transportation infrastructure made vulnerable*	Far worse	No change	No change	No change	Slightly worse
Economy *Revenue*	Far worse	Slightly worse	No change	Slightly worse	Moderately worse
Recreation *Diversity of recreational opportunities*	Far worse	No change	Slightly worse	Slightly better	Moderately better
Culture *Opportunities for traditional practices*	Slightly worse	No change	Moderately worse	No change	No change
Impact and risk of failure					
Overall risk	Very high	Very high	Very high	Medium	Very low
Cost criteria					
Capital cost	–	$100m – $1b	More than $4b	$1b – $4b	$1b – $4b
Operation and maintenance cost	More than $10m	More than $10m	$1m – $10m	$1m – $10m	Less than $1m
Other infrastructure cost	More than $100m	$10m – $100m	Less than $10m	$10m – $100m	More than $100m
Future adaptation cost	$1b – $4b	$1b – $4b	$1b – $4b	$1b – $4b	Less than $100m

Risk assessment heat map

Likelihood \ Impact	Very low	Low	Medium	High	Very high
Very high				Current conventions	
High					Mud Bay barrier
Medium			Highway 99 realignment		
Low					
Very low		Managed retreat			

Figure 5.8: The City of Surrey's Coastal Flood Adaptation Strategy was developed using graphics that distilled complex technical information and facilitated meaningful public and stakeholder engagement. Featured here is an example of an evaluation matrix for the shortlisted adaptation options for Mud Bay, one of the three CFAS study areas. Source: City of Surrey, 2018b.

5.3.6 Conclusions

A changing climate means increased flood risk for much of British Columbia. In addition to high flow events, changes to the timing and duration of summer-autumn low flow and higher water temperatures will likely impact ecosystems negatively. B.C. experiences hazards from riverine, coastal and urban flooding, and some strategies, adaptation responses and governance processes are in place to reduce these risks. However, a number of key challenges are present that represent urgent areas of action given the level of risk faced. The flood events in November 2021 highlighted the importance of improving flood risk governance in B.C.

5.4 Climate change is impacting British Columbia's forests

Climate change is profoundly affecting British Columbia's forests, as well as communities and infrastructure located in forested regions. The risk of disturbance from fire and pests is increasing due to climate change, affecting forest productivity, wildlife habitat, biodiversity and ecosystem services. Action to enhance forest resilience is still in the early stages, as policy, operational guidance and the necessary tools are being developed.

Forests are important economic, recreational and cultural resources for the people of British Columbia, as well as home to a wide range of species. Key climate change impacts in forested regions include increased incidence of wildfire, pest outbreaks, water stress and the introduction of new diseases. Changes in forest disturbances and productivity lead to changes in wildlife habitat, biodiversity, and ecosystem services, such as water supply, provision of timber and carbon storage. Adapting forest management practices is critical and involves understanding the climate change information needs of different users, as well as their capabilities to apply this information in decision making, and in the development and implementation of tools, such as FireSmart.

5.4.1 Introduction

B.C.'s forest resources provide the basis for the forestry industry, which makes a significant contribution to the provincial and local economies. In 2018, the total value of B.C. forest sector manufacturing shipments was just under $18.4 billion, with nearly $14.9 billion in exports (forestry is the leading export sector in B.C.) (Forestry Innovation Investment, 2019). Over 52,000 people are employed in the sector, which, in 2018, contributed 2.9% to the province's GDP and just under $1 billion to provincial revenues (Forestry Innovation Investment, 2019).

The diversity of ecosystems and species reflects the diversity of climates in B.C., which can vary substantially over relatively narrow ranges in elevation and horizontal distances (Moore et al., 2010; Meidinger and Pojar, 1991). These ecosystems provide a wide range of services to society. A changing climate could result in species at any given location being maladapted to their new climate (Wang et al., 2012; Aitken et al., 2008; O'Neill et al., 2008). At the stand and landscape levels, climate change could result in increased risk of disturbance by drought stress, fire, insects, disease and loss of productivity (*see* Sector Impacts and Adaptation Chapter; Dymond et al., 2016; Haughian et al., 2012; Sturrock et al., 2011; Woods et al., 2010), and changes to hydrological regimes and aquatic resources (Pike et al., 2010).

Climate change will have substantial social, cultural and economic consequences for the province (Abbott and Chapman, 2018). Adapting forest management practices will minimize the negative impacts of climate change and take advantage of potential benefits (Auditor General of British Columbia, 2018; Spittlehouse, 2005). However, challenges exist in translating knowledge into action (Shannon et al., 2019).

5.4.2 Biophysical impacts

Forestry needs to deal with both near-term impacts—largely related to changes in disturbance regimes—and longer-term changes in forest composition, structure and productivity. The net effect will be changes in ecosystem goods and services, such as the provision of timber, water, biodiversity, carbon sequestration, and in the cultural and social values associated with forests. The direction of those changes will depend on many factors, including whether the range of an ecosystem is expanding or contracting, other climate-induced changes that alter forest processes (e.g., regeneration, pest and pathogen susceptibility), and non-climate factors (e.g., management approaches). Not only will there be less predictability, but changes are expected to occur in ecosystem boundaries, forest structure and the incidence of disturbances (Fettig et al., 2013; Haughian et al., 2012).

Increased temperatures and reduced summer precipitation have already increased the length of the forest fire season and the occurrence of high fire-risk conditions in parts of B.C. (Kirchemeier-Young et al., 2019) affecting human health, property values and timber supply (Abbott and Chapman, 2018,). For example, the 2017 and 2018 fire seasons each set records, the first for the most buildings destroyed and people evacuated, and the second for the largest area burnt in a year—exceeding the record from the previous year (Government of British Columbia, 2019a, b). Tens of thousands of people were evacuated and the resulting health issues (e.g., respiratory problems, stress), property damage and expenditures related to fire fighting were widespread (Abbott and Chapman, 2018). The fires also resulted in reductions in estimates of midterm timber supply in the B.C. Cariboo Region (B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2018b). In 2021, a tremendously challenging wildfire season led to a provincial state of emergency being declared on July 21, 2021, and remaining in effect for 56 days until September 14, 2021 (Government of B.C., 2021b).

Increased disturbances from fire, insects, disease and water stress correspond to an increase in salvage logging to recover some timber value. Over a number of years, such disturbances may also result in a reduction in forest productivity and in timber available for harvest (Metsaranta et al., 2011). Existing management practices can have unintended consequences: the protection of timber supply through fire suppression in combination with changing climatic conditions may have set the stage for the Mountain Pine Beetle outbreak in the 2000s that killed approximately 60% of the mature pine forest in the B.C. Interior (Carroll, 2017). This, in turn, resulted in a short-term increase in harvest levels to promote salvage, but projected decreases in longer-term harvest levels (*see* Figure 5.9). Road building associated with the surge in harvesting has changed habitat conditions for wildlife and other species (Bunnell et al., 2011), and this may compound the influence of climate-induced changes on wildlife habitat and migration corridors (Stralberg et al., 2019). A changing climate is also expected to impact operations. For example, a shorter winter season increases costs by reducing the period of time available for road construction and hauling, and when logging can take place on more sensitive soils (Kuloglu et al., 2019). Other insects and diseases that are endemic to

B.C.'s forests may become more prominent in the future (Fettig et al., 2013; Sturrock et al., 2011; Woods et al., 2010), with potentially similar negative consequences for timber productivity and harvest levels.

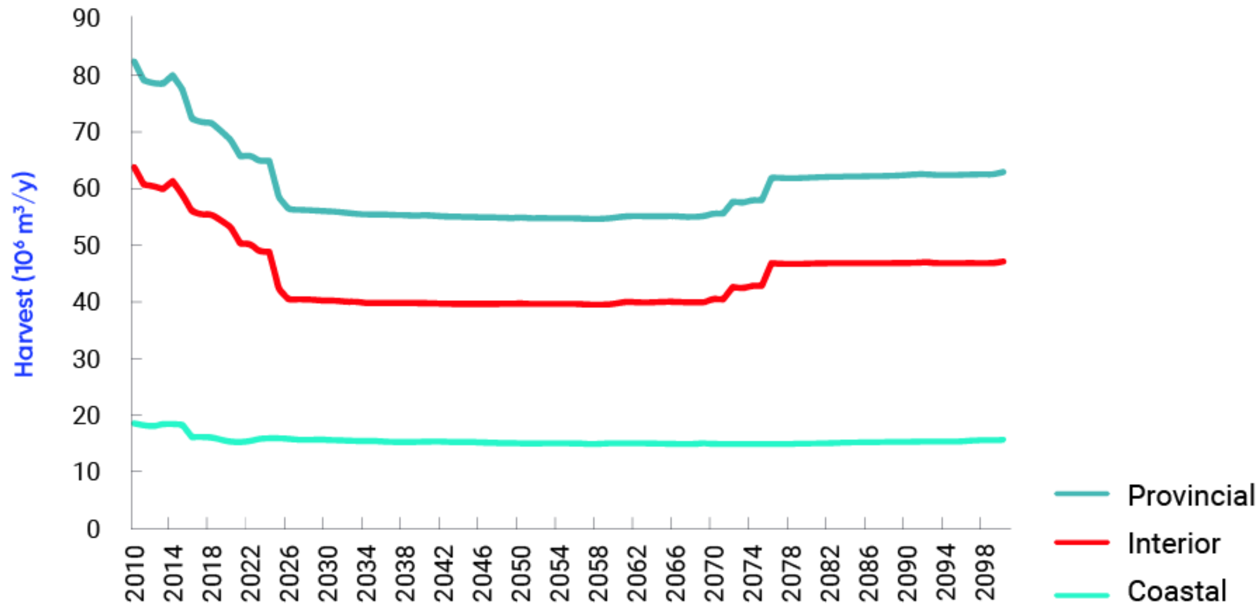

Figure 5.9: Provincial timber supply forecast to 2100, including data specific to B.C.'s interior and coastal regions. This analysis projects decreases in timber supply to about 58 million cubic metres per year by 2025, due to mortality caused by the Mountain Pine Beetle epidemic. The forecasted timber supply increases to 65–70 million cubic metres per year in 2075, although this does not account for potential impacts of climate change on tree survival and growth or for increases in disturbances. Source: Government of B.C., 2018c.

Longer-term changes in forest productivity and structure will arise as the geographic distribution of ecosystems shift in response to changing climate conditions. Changes in temperature, precipitation patterns and other climate variables may mean that plants and animals in any given area are exposed to conditions outside of their optimal climate. By 2050, climates typical of grasslands, dry interior forests and moist continental cedar-hemlock forests will expand substantially; the area of climates that are suitable for coastal rainforests will remain relatively stable; and the area of boreal, subalpine and alpine climates will decrease substantially (*see* Figure 5.10; Wang et al., 2012). Some climate regimes that currently do not occur in B.C. are likely to occur by the end of the century (Mahoney et al., 2018). This complicates the selection of species and provenances that are better suited to the anticipated future climate because there are no examples of desired tree species or provenances growing in such climates in B.C., although there may be examples in other jurisdictions.

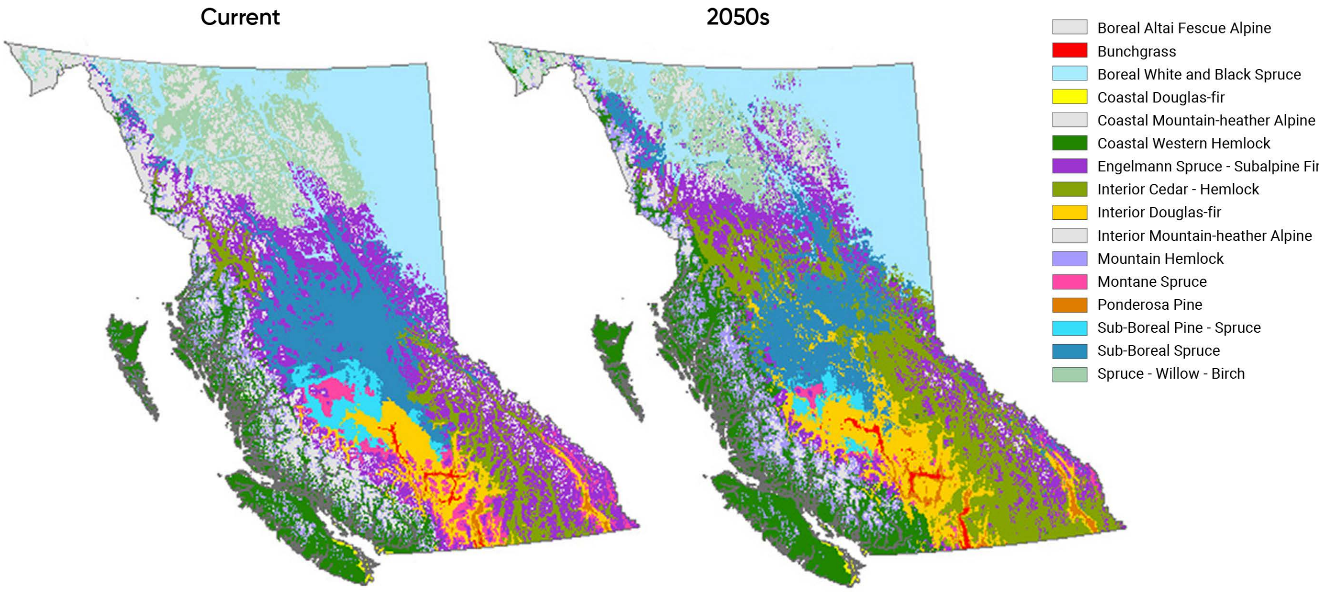

Figure 5.10: Distribution of the 16 biogeoclimatic ecosystem classification zones, for the period 2001–2009 and as projected for the 2050s based on consensus predictions with the best-model agreement among 20 climate change scenarios. Source: The University of British Columbia, 2022; Wang et al., 2012.

Ecosystem changes have significant implications for carbon storage. Increased air temperatures and a longer snow-free season increase the evaporative demand on vegetation and, combined with reduced summer precipitation in the central and southern parts of the province, increase the risk of drought, particularly at drier sites (B.C. Ministry of Forests, Lands and Natural Resource Operations, 2016c; Spittlehouse, 2008). These changes are expected to reduce forest productivity, increase mortality, and increase susceptibility to insects and disease (Fettig et al., 2013). Productivity at cooler, higher elevation sites may benefit from warmer conditions (Dymond et al., 2016; Williamson et al., 2009). Analysis of climate change impacts on the annual forest carbon balance over the next century under multiple climate scenarios indicates that timber growing stock could decline by 26 to 62% over the 21st century, depending on changes in tree growth rates and annual area burned (Metsaranta et al., 2011). This analysis indicated that B.C.'s forests would be sources of greenhouse gases (GHGs) under many climate change scenarios, which could significantly impact the provincial carbon balance. As such, GHG emissions reduction and adaptation strategies would help to minimize climate change impacts on forests.

5.4.3 Enhancing forest resilience

The importance of climate change adaptation and forest resilience in Canada has been recognized for more than three decades (e.g., Wall, 1992; Pollard, 1991; Spittlehouse and Pollard, 1989), and has been a national priority since at least 2008 (Canadian Council of Forest Ministers, 2008). Provincial jurisdiction over forest resources and lands places the Government of British Columbia in a unique role for enabling a framework in which different parties can work together in improving forest resilience to climate change. Addressing management goals and values, while considering the long-term risks associated with climate change at the local level, makes management plans more robust in the face of uncertainty and changing conditions. Proactively increasing species diversity at the time of planting can be a cost-effective climate change adaptation measure (Hoff et al., 2017; Dymond et al., 2015, 2014). Conservation of wildlife requires a vulnerability-adaptation framework based on species' individual vulnerability and exposure to climate change, the protection of refugia, the promotion of geophysical diversity, and habitat connectivity (Stralberg et al., 2019). A major challenge, however, is translating adaptation concepts into specific, tangible actions (Shannon et al., 2019; Hagerman and Pelai, 2018; Halofsky et al., 2018). It is important to include local knowledge as part of that process (Nelson et al., 2016). Examples of actions that enhance the resilience of forests and associated communities and infrastructure are presented in Case Stories 5.3 and 5.4.

Case Story 5.3: Climate-based seed transfer and climate change informed species selection in B.C.

Assisted migration can facilitate forest survival and growth under a changing climate (O'Neill et al., 2017; Pedlar et al., 2012; Peters, 1985). This involves reforesting harvest sites with seedlings of species and provenances that are suitable for survival and growth under a future climate, while still being able to withstand current climatic conditions.

The Climate-based Seed Transfer (CBST) project was initiated in 2012 to modernize the Province of British Columbia's seedlot selection system and to facilitate a wider use of assisted migration to help promote healthy, resilient and productive forests and ecosystems in a changing climate (O'Neill et al., 2017; B.C. Ministry of Forests, Lands and Natural Resource Operations, 2012a). CBST aims to define a target distance and transfer range for species to maintain the acceptable productivity. This seed transfer system takes advantage of genecological research, provenance trial data, fine-scale climate mapping, improved climate projections and genomics tools that assess the ability of a seed to succeed under future climate conditions (O'Neill et al., 2017), and also leverages benefits from strong science-policy connections (Klenk, 2015; Klenk and Larson, 2015). This is one of the first examples anywhere in the world where such a project has been developed and implemented. An example of CBST being implemented is the extension of the planting range for larch in B.C. (Klenk and Larson, 2015; Rehfeldt and Jaquish, 2010).

Another decision-support tool under development is the Climate Change Informed Species Selection (CCISS) tool (Mackenzie and Mahoney, 2020). This tool will project the suitability of different tree species for planting in ecosystem variants and site series, as described in B.C.'s Biogeoclimatic Ecosystem Classification system (Meidinger and Pojar, 1991). It is intended to be used in conjunction with the CBST tool. Whereas the CBST tool is used to determine the appropriate provenance or origin for the tree species, the CCISS tool will assess potential shifts in ecosystem units based on climate projections, which incorporate climate uncertainty. The CCISS tool also makes use of an ecologically derived rule set that summarizes which species are most likely to be suitable under projected future climate conditions.

5.4.4 Wildfire risk reduction

While wildfire is a natural part of the forest ecosystem cycle, climate change is driving increases in the size, frequency and intensity of wildfires, and is posing a threat to human life and infrastructure (*see* Sector Impacts and Adaptation chapter; Abbott and Chapman, 2018). The Preliminary Climate Change Risk Assessment for B.C. indicated with a high degree of confidence that severe wildfire is the highest-level climate risk for B.C. (B.C. Ministry of Environment and Climate Change Strategy, 2019). Wildfire science and policy in Canada are being challenged by the changing behaviour of fires and the need to account for the complex role that fire plays in forest ecosystems (Sankey, 2018). Growing awareness that historical fire suppression in some areas of B.C. is leading to unhealthy forests and ecosystems (Filmon, 2003), and increases in the Wildland Urban Interface and the cost of fire suppression, have resulted in a shift in focus towards prevention activities. Among the factors driving action are the costs associated with fire suppression, which have risen in recent years and are expected to continue increasing over time (Tymstra et al, 2020; Stocks and Martell, 2016).

Wildfire managers in B.C. and elsewhere have expressed a desire to move away from fire suppression and towards an approach that balances the need to rebuild the health and sustainability of forests with the need to reduce negative climate impacts to human lives and quality of life (Tymstra et al. 2020). One example is FireSmart, a longstanding program consisting of sets of practices that reduce risks to structures and surrounding areas, intended mainly for communities, fire regime restoration and targeted fuel treatments (FireSmart, 2018). Despite such guidance, there is relatively little information available to guide and prioritize investment decisions by forest professionals, communities and private land owners regarding wildfire reduction activities outside of private homes and community boundaries. Wildfire managers lack information about the actual costs and benefits of various treatments for reducing wildfire risk to the degree that is necessary for supporting the business case for investment of public funds (Sankey, 2018).

Case Story 5.4: Climate change adaptation and wildfire protection in a community forest

The Harrop-Procter Community Forest consists of 11,300 hectares of Crown Land on the south shore of Kootenay Lake, and has a mandate to practice socially and environmentally progressive forestry. The cooperative has four primary values: 1) protect domestic water; 2) maintain biodiversity; 3) create local jobs; and 4) protect communities from wildfire. The cooperative sells timber products from its mill in Harrop, has Forest Stewardship Council certification, and is actively engaged in community outreach.

Community wildfire protection is being addressed through a risk assessment and through the development of a management plan to reduce risk. Maps of ecosystem units, fuel loading and soil moisture regimes were used to assess the risk of fire to homes, water supply and biodiversity. Climate change scenarios were used to evaluate changes in soil moisture regime and fire risk. This assessment will aid in prioritizing areas for adaptive management. Management questions to consider include:

- How much forest to cut and how much fuel treatment can be done?
- Where to log first (e.g., drought-prone stands, poorly adapted species, wildland-urban interface, etc.)?
- Where to protect (e.g., headwaters, riparian, old growth, wildlife habitat, etc.)?
- How to log (e.g., opening size, use of partial cuts, type of fuel treatment, etc.)? and
- How to regenerate (e.g., which species, what provenance, and at what density)?

Source: Leslie, 2018

5.4.5 Progress on adaptation

There are several recent and ongoing initiatives in B.C. to advance adaptation in the forest sector. The provincial government has played a strong role in setting objectives for resource management and adaptation, developing a climate change strategy (B.C. Ministry of Forests, Lands and Natural Resource Operations, 2015) and facilitating adaptation efforts led by other actors (e.g., licensees, First Nations, community forests, forest professionals). Examples of adaptation programs offered by the province include:

- The Community Resilience Initiative Program, which provides provincial funding for communities to develop community wildfire prevention plans and is administered by the First Nations Emergency Services Society (FNESS) and the Union of BC Municipalities (UBCM) (Government of B.C., 2021c);
- Climate action plans for each business area and forest region and pilot studies on assessing the risk of climate change to built infrastructure in forest regions, led by B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development (B.C. Ministry of Forests, Lands and Natural Resource Operations, 2015);
- The Forest Carbon Initiative, which takes into consideration how activities to enhance forest resilience can also serve to increase biological sinks (Government of B.C., 2021d).

Progress has been significant, but more needs to be done (Auditor General of British Columbia, 2018). Efforts have increased public awareness, supported new research into impacts and adaptation options, and produced information and tools for resource managers. Examples of relevant information and tools include climate summaries and adaptation extension notes for each forest region (*see* Box 5.4), and monthly historic and projected climate data in high spatial resolution. However, this has not yet translated into significant change within the industry, where practices remain largely unchanged and responses to date have been largely reactive (e.g., increased salvage logging following disturbances) (Williamson and Nelson, 2017).

Box 5.4: Adapting resource management to climate change: Tools for forestry practitioners

In 2016, the B.C. Ministry of Ministry of Forests, Lands and Natural Resource Operations produced Regional Extension Notes for each of B.C.'s eight forest regions that "…inform adaptation of natural resource planning and practices to climate change by providing best available information to resource professionals, licensees and Government staff engaged in: operational planning and practices under the *Forest and Range Practices Act* and other natural resource legislation; monitoring effectiveness of adaptation practices; assessing cumulative effects; and, preparing climate change action plans" (B.C. Ministry of Forests, Lands and Natural Resource Operations, 2016a). Each note describes region-specific climate change projections, along with possible impacts on forest resources (e.g., ecosystems, tree productivity, hydrology, wildlife, fisheries). The notes also present adaptation strategies that reflect regionally important and best available information drawn from research and the input provided by regional specialists. The Regional Extension Notes are available here: https://www.for.gov.bc.ca/hfd/pubs/en.htm.

Professional organizations and associations have played an important role in promoting awareness and increasing understanding among their members and the public. For example, the Association of BC Forest Professionals has engaged in activities related to professional development and education, including undertaking province-wide surveys of its members on their needs related to understanding and adapting to climate change (Nelson et al., 2014). Work by non-governmental organizations includes the development of practitioner guides for climate change assessments and other tools to support adaptation planning by local managers (Pearce and Krishnaswamy, 2011). As elsewhere, monitoring and evaluation are key aspects of assessing progress on adaptation. A noteworthy example is the assessment of government responses to B.C. wildfires and floods (Abbott and Chapman, 2018).

5.4.6 Challenges

A key issue limiting progress towards adaptation in British Columbia's forest sector is the availability of information and resources at different scales for the different actors (Price and Daust, 2019), including those related to future timber supplies (*see* Box 5.5), and the capacity to act on that information (Shannon et al., 2019; Williamson and Nelson 2017; Nelson et al., 2016). Other challenges relate to the extent to which adaptation is integrated into policy and policy-making, and the institutional setting in which third parties prepare management plans and carry out activities on public lands.

Resource challenges relate to data and information, tools, as well as human and financial limitations. Issues with data relate both to accessibility and to spatial resolution, because operational decision-making benefits from local-scale data (Nelson et al., 2016). The information that is available through a range of databases and tools is often not in a form that the decision-maker can readily use (Price and Daust 2019; Halofsky et al., 2018). Although many decision-support tools exist, most do not yet fully account for climate change (*see* Box 5.5). Funding to aid provision of information in appropriate formats is a common concern, with solutions likely to involve governments, professional associations and industry to increase the adaptive capacity of the forest management system (Williamson and Nelson, 2017; Nelson et al., 2016).

Box 5.5: Projecting future timber supplies

In British Columbia, the process for determining current harvest levels is largely based upon projections of future timber supply, which are typically modelled over a 100- to 200-year period. Built into those models are estimates of forest land area, inventory, growth and yield, as well as expected losses due to disturbance, all of which can be affected by climate change. To date, however, future climate change impacts are not considered in these models. Implicitly this assumes that these future impacts will remain constant, despite increasing evidence pointing towards greater incidence of disease and disturbance (Brown et al., 2013). The 2021–2025 Climate Change Strategy (in press) aims to addresses this deficiency.

The extent to which adaptation is integrated into policies and policy-making is often influenced by a range of institutional factors including, for example, allocation of rights, availability of public funding to manage risks and public attitudes towards alternative forest management strategies. Formal and informal policies can serve as either enablers or barriers to climate change adaptation. A commonly mentioned barrier is the lack of mandated use of climate change information and specific change scenarios in decision making (Price and Daust, 2019; Halofsky et al., 2018). Without relevant legislation, policies or operating procedures, resource managers cannot be assured that they will be supported in their adaptation decisions (Nelson et al., 2016). In some cases, this may preclude decision-makers from assessing or implementing adaptation strategies.

The traditional siloed approach to resource management reduces the ability to assess systematic risk (Williamson and Nelson, 2017), identify potential trade-offs and plan appropriate adaptation responses. Similar barriers sometimes exist between climate change adaptation and GHG emissions reduction initiatives, preventing or limiting the effectiveness of actions aimed at achieving either of those objectives (Williamson and Nelson, 2017). For example, B.C.'s Forest Carbon Initiative aims to reduce carbon emissions and increase sequestration through forest management. However, unless climate change risk factors are fully considered when assessing the long-term consequences of different GHG emissions reduction strategies, there is potential for proposed solutions to result in increased costs over time.

The roles of government and the forest industry are critical in forest management adaptation, where all industry activities are subject to government approvals, compliance and enforcement. In cases where industry operates on crown land, differences in perspectives between the government and the forest industry can affect how climate-related risk is assessed, and which industry incentives can reduce those risks (Hotte et al., 2016). From an industry perspective, one of the risks associated with climate change is the potential for increased management costs related to adaptation decisions made by government, which could become problematic for industry in the global market place (Williamson and Nelson, 2017).

In terms of economic analysis, fundamental challenges include the short time horizon of decision-makers and the impact of discount rates on evaluating the cost of future impacts (*see* Costs and Benefits of Climate

Change Impacts and Adaptation chapter). Both industry and government typically operate on the assumption of high discount rates and focus on short-term interests. Even where government may apply a lower social discount rate, this can still heavily discount the future, reducing the case for making larger or more proactive investments even where the risks are large and significant (Williamson and Nelson, 2017).

A final important challenge is the fact that the directly managed timber harvest land base is only about one third of the forest land base, which limits the applicability of many adaptation measures. For example, assisted migration in forest management will reduce the vulnerability of commercial tree species at selected sites. On the managed land base, however, less than 1% of land is harvested in a year (Government of B.C., 2018c); consequently, even over the next 50 years, assisted migration can only influence the direction of forest adaptation in a relatively small area of B.C. (Spittlehouse, 2005). Therefore, many forest species will have to adapt autonomously, which will affect ecosystem services and society. Of immediate concern is how to address the near-term risk of disturbance, such as fire, to human health and well-being in all forested regions of B.C. This risk perhaps provides the greatest challenge to management agencies in adapting to our changing climate in the short to medium term.

5.4.7 Conclusions

There is limited evidence of proactive adaptation within the forest industry in the province, suggesting a need for improved understanding of business risks and opportunities related to climate change. As a result of the vastness of B.C.'s forested area and the longevity of tree species, active forest management can influence forest adaptation only in selected areas, and much of the forested land will adapt through natural processes. Society will also have to adapt by adjusting expectations of and demands on forests.

5.5 Building a climate-ready agriculture sector is critical

Climate change is already impacting food production in British Columbia. Continued collaborative efforts across B.C. are needed to help advance adaptation in the agriculture sector.

In B.C., climate change impacts are already affecting the agricultural sector. These changes result from changing hydrological regimes; shifting range and life-cycle of pests, diseases and invasive species; and increasing wildfire frequency and intensity. Impacts occur across the food system, impacting production, processing and distribution. Adaptation programming is occurring to support the province's roughly 17,500 farms and includes efforts to create regional plans, to provide funding and to foster collaboration.

5.5.1 Agricultural climate change risks

B.C.'s agricultural sector employs approximately 63,000 people and produces over 200 commodities (B.C. Ministry of Agriculture, n.d.). In 2017, the sector generated approximately $14.2 billion in annual revenue (B.C. Ministry of Agriculture, 2018). This section discusses key risks for the sector, including flooding, reduced water availability, wildfire, and increases in pests, diseases and invasive species. For further discussion on agriculture and the national scale, *see* the Sector Impacts and Adaptation chapter.

5.5.1.1 Flooding and excess moisture

As described above, climate change is anticipated to intensify the hydrological cycle and increase precipitation variability regionally and seasonally (B.C. Ministry of Environment, 2016). Long-term projections show that these trends are expected to continue (Government of Canada, n.d.), with precipitation clustered temporally and longer drought periods, particularly for southern B.C. (Bonsal et al., 2019; Zhang et al., 2019; B.C. Ministry of Forests, Lands, and Natural Resource Operations, 2016b).

For agriculture, B.C.'s increasing seasonal precipitation presents challenges, such as contributing to spring freshet and winter runoff flooding intensification. Heavy precipitation and rapid snowmelt can cause erosion and nutrient leaching, impairing plant health and productivity (Fraser Valley Regional District, 2017). Following a severe drought or wildfire, increased precipitation may also cause erosion and site-specific flooding, resulting in crop and infrastructure losses (B.C. Ministry of Environment, 2016).

For agriculture, flood risk from winter runoff and spring thaw in the Fraser Valley is of particular concern as the area accounts for 38% of B.C.'s gross annual farm receipts (Government of B.C., 2018a). Within the Fraser Valley Regional District (FVRD), a major spring thaw flood event (1894 flood comparable) is estimated to result in $800 million in damages to producer assets and to have a $1.1 billion impact on the FVRD's agricultural economy (Northwest Hydraulic Consultants, 2016b). Potential agricultural costs in this scenario include damage to agricultural buildings and equipment, livestock mortalities and crop losses (Northwest Hydraulic Consultants, 2016b).

Flooding is also a significant agricultural production risk elsewhere in British Columbia. (B.C. Agriculture and Food Climate Action Initiative, 2019, 2016, 2014). Floods range from larger regional occurrences—e.g., the 2018 flooding of the Kettle and Granby Rivers (Yumagulova, 2019)—to small site-specific instances. Agricultural adaptation strategies range from regional-level action, such as enhancing dyking and natural infrastructure (e.g., forests, riparian areas, floodplains and wetlands), to farm-level action, such as planting riparian buffers, improving drainage systems and adopting flood-tolerant cropping or production systems. The extent to which these measures have been explored or adopted and the degree to which agriculture is represented in risk mitigation efforts vary regionally.

Sea-level rise and storm surges also pose flooding threats to coastal agriculture, through the risk of dyke breaches, soil salinization and farmland inundation (B.C. Agriculture and Food Climate Action Initiative, 2013). For example, in B.C.'s Delta region, most agricultural land is two metres or less above sea level, and existing protection mechanisms—dykes, seawalls and pumping stations—require costly upgrades for sea-level rise protection (Delcan Corporation, 2012). For dykes alone in the wider Metro Vancouver region, the estimated cost is approximately $9.47 billion (Delcan Corporation, 2012) and the lost agricultural land from expanded or enhanced dyke systems is of concern.

Infrastructure and farming system upgrading and adaptation represent only one part of flood adaptation. Emergency response measures—including the Provincial Emergency Program (Government of B.C., 2016)—and recovery measures that emphasize rebuilding infrastructure to be more climate-resilient are important for reducing agricultural vulnerability.

5.5.1.2 Reduced water availability

The shifting seasonal distribution and intensity of precipitation pose additional challenges for B.C. agriculture. The frequency and intensity of extreme precipitation events will likely increase in southern B.C., and will be accompanied by rising summer temperatures and declining precipitation (B.C. Ministry of Environment, 2016). Less seasonal snow accumulation, hot and dry summer conditions, and reduced summer rainfall will influence the duration and frequency of seasonal drought (B.C. Ministry of Forests, Lands and Natural Resource Operations, 2016b). Consequently, agricultural drought—when soil water deficiency causes plant water stress to negatively affect crop yield and productivity—is more likely (Government of B.C., 2018a). This type of drought occurred in southern B.C., with record breaking dryness, particularly in the South Thompson, Nicola, Similkameen and Kettle basins from late August through mid-October of 2017 (Government of B.C., 2018a). Recorded agricultural impacts of this drought include heat stress, accelerated crop maturation, reduced livestock feed, limited irrigation water supply, and reduced crop quality and quantity (Agriculture and Agri-Food Canada, 2017). These conditions also contributed to the severity of the 2017 wildfire season, which caused additional negative agricultural impacts, including losses to livestock, rangeland, forage, fencing and livestock infrastructure (Agriculture and Agri-Food Canada, 2017).

With drought conditions becoming more common across B.C., longer-term water shortages are likely (B.C. Ministry of Environment and Climate Change Strategy, 2019). With increasing shortages, there will be additional demand on relief and business risk management programming (e.g., the AgriStability Program, the AgriRecovery Framework, the Production Insurance Program, the Livestock Tax Deferral Program and the Western Livestock Price Insurance Program; Government of B.C. (2018a)). Governments and industry associations are also promoting preemptive measures to help farmers prepare for drought (e.g., through enhanced on-farm water storage and drought-tolerant cropping) and reduce water demand (e.g., through precision irrigation and regional crop water demand modelling).

5.5.1.3 Wildfire

Extreme warm and dry weather conditions enhanced the severity of B.C.'s recent wildfire seasons (Kirchmeier-Young, et al., 2019). In 2017, 1.22 million hectares burned, causing a $35 to $70 million agriculture capital and revenue loss (B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2018b). Then, in 2018, 1.35 million hectares burned in B.C.'s largest wildfire season on record (B.C. Wildfire Service, 2019). Ranching operations in particular were impacted by these two wildfire seasons, with record wildfire damage and loss of animals, farm buildings, fencing, forage crops and rangeland.

Additional impacts associated with wildfire include:

- the need to manage the logistics of relocating livestock and finding feed resources as the result of evacuation alerts and orders (B.A. Blackwell and Associates Ltd, 2018);
- decreased livestock health and productivity from smoke and evacuation transport (B.C. Agriculture and Food Climate Action Initiative, 2014);
- diminished crop production due to a lack of irrigation over multiple weeks for farm properties under evacuation orders;
- reduction of usable forage and pasture because of fire retardant contamination (B.C. Ministry of Agriculture, 2017);
- agri-tourism decline, particularly for Okanagan region vineyards (Abbott and Chapman, 2018; Government of B.C., 2018b);
- possible smoke taint in wine grapes, making them unfavourable for wine production (Noestheden, et al., 2018); and
- multi-year recovery challenges, such as rapid runoff from the loss of vegetation (Shakesby and Doerr, 2006) and changed soil structure, which can decrease soil productivity (DeBano, 1990) and increase erosion risks (Certini, 2005).

The B.C. wildfire seasons of 2017 and 2018 led to increased interest in reducing wildfire operational risks for agriculture. For example, the BC Cattlemen's Association, along with the Province, is piloting the use of grazing to reduce fine fuels—such as grass, pine needles and tree moss— with the aim of reducing wildfire risk near communities, and to allow ranchers to access new forage (B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2019b). Nevertheless, as hotter and drier summers occur, and as forest susceptibility to climate impacts increases (e.g., due to increasing pest populations), wildfire risk will continue to become more severe, with predictions of up to a 4% increase in annual area burned by 2050 (B.C. Ministry of Environment and Climate Change Strategy, 2019).

5.5.1.4 Pests, disease and invasive species

Climate change is shifting the latitude and altitude range, pervasiveness and frequency of insect pests, diseases and invasive species populations (Scholefield et al., 2017a). The distribution and lifecycles of pests, diseases and invasive species are being influenced by increases in annual temperatures, growing-degree days (GDDs), growing season length, winter/spring precipitation and extreme rain events, as well as drier summer conditions and warmer winters. The introduction of new pests, diseases and invasive species, the changes in number of generations possible in a single season, and the potential for reduced efficacy of management control measures have the potential to affect both crop and livestock producers (Beddington et al., 2012).

An example of a destructive pest identified in B.C.'s Fraser Valley in 2009 is the Spotted Wing Drosophila Fruit Fly (*D. suzukii*) (B.C. Ministry of Agriculture, 2014). This soft-skinned fruit pest lays eggs in ripe fruit (e.g., berries); consequently, high canopy humidity and ripe and over-ripe fruit create infestation risks. While the presence of this pest is not climate change-induced, milder winters and warmer summer conditions likely increase the abundance and range of this pest, placing an elevated risk on small fruit and tree fruit crops in northern latitude regions (Langille et al., 2017). Studies undertaken in the Cariboo Region (i.e., Powell, 2018) and the Fraser Valley region (i.e., Scholefield et al. 2017a) have identified additional pests of concern that may shift in abundance and range as climate conditions change. Responses to these pests to date have been limited as there is opposition to long-term and landscape-level efforts in some jurisdictions (Scholefield et al., 2017a). Monitoring efforts in B.C. have tended to be relatively short-term and location-specific, focusing on select crops, pests, diseases or invasive species (B.C. Agriculture and Food Climate Action Initiative, 2015).

5.5.2 Agricultural adaptation programming

These climate change risks pose a compounding threat to agriculture in B.C. When considering the challenges together, there is unprecedented additional strain on agricultural profitability and existing emergency response and recovery systems (Donahue, 2014). In response to these risks, in 2013, the B.C. Ministry of Agriculture, Food and Fisheries partnered with the industry-led Climate and Agriculture Initiative BC (CAI)—formerly the B.C. Agriculture and Food Climate Action Initiative—to deliver adaptation programming.

CAI's mandate is to develop tools, knowledge and resources to enable adaptation in collaboration with producers, industry leaders, local governments, provincial agencies and academic institutions. For example, CAI developed the BC Agriculture and Climate Change Action Plan (B.C. Agriculture and Food Climate Action Initiative, 2010) and the Adaptation Risk and Opportunity Assessment Report Series in 2012. These publications helped to clarify the importance of collaborative and cross-disciplinary models for strengthening adaptive capacity (*see* Figure 5.11). Over 60 projects had been completed as of April 2020 through CAI's two main programs: the Regional Adaptation Program and the Farm Adaptation Innovator Program (FAIP).

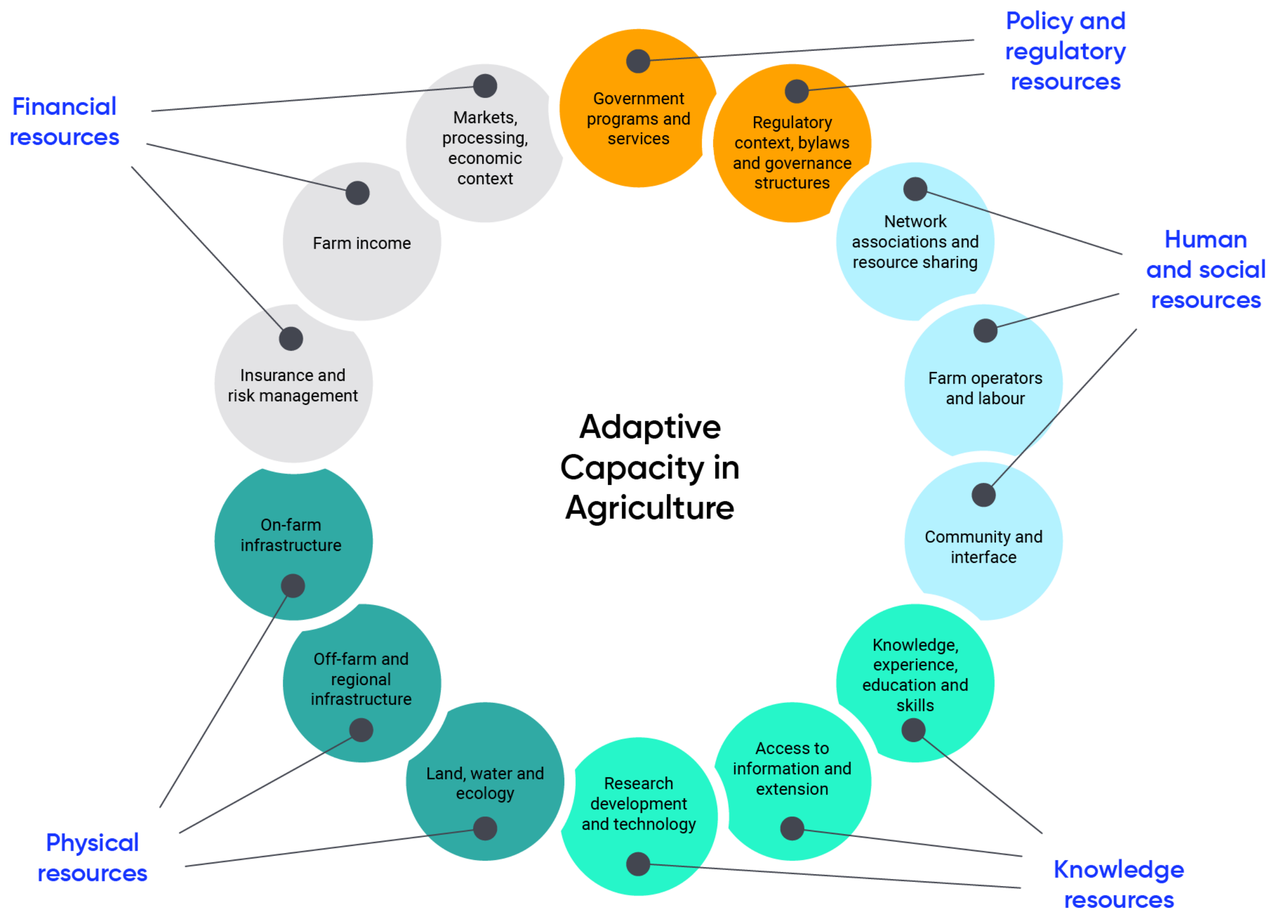

Figure 5.11: Factors influencing B.C.'s agricultural adaptive capacity. Source: Recreated based on B.C. Agriculture and Food Climate Action Initiative, 2012, Crawford and MacNair, 2018.

The Regional Adaptation Program has enabled regional adaptation planning processes that include seed funding and that bring together local governments, provincial agencies, agricultural organizations and producers. Between 2013 and 2020, plans were developed for eight regions of B.C.: Delta, Fraser Valley, Okanagan, Cariboo, Peace, Bulkley-Nechako and Fraser Fort-George, Vancouver Island and Kootenay-Boundary (B.C. Agriculture and Food Climate Action Initiative, 2010). These plans identify impacts, some of which are highly localized, requiring region-specific solutions, tools and resources. Other impacts are similar across regions, allowing projects to build on one another. For example, increasing wildfire risk was prioritized in the Cariboo (2014), the Okanagan (2016), Bulkley-Nechako and Fraser-Fort George (2019), and Kootenay-Boundary (2019) regional plans and a series of regional projects created guides and workbooks to aid farmers and ranchers with developing operational wildfire preparedness plans. The FAIP supports farm-level, multi-year applied research projects examining adaptation-focused farm practices or technologies that reduce weather-related production risks and/or increase new production opportunities (B.C. Agriculture and Food Climate Action Initiative, 2018). Projects range from an evaluation of insect (thrips) damage to potatoes in a changing climate in the Fraser Valley, to the demonstration of adaptation practices for forage production in the Central Interior, to an evaluation of soil and water management practices for Sweetheart Cherry production in shifting climatically suitable growing locations in the Okanagan (*see* Case Story 5.5).

Case Story 5.5: Opportunities and barriers associated with B.C. cherry production

The climate component of crop suitability modelling for Sweetheart cherries (*Prunus avium L.*) over the past five decades in the Okanagan region has shown a significant expansion in northern and higher elevation areas due to decreasing frost (*see* Figure 5.12). Building on this climate suitability modelling, Nelson (2018) investigated whether the soil microbiological conditions were also suitable for establishing Sweetheart cherry orchards in locations that matched climate suitability. The study found that soils in newly established orchards were more biologically suitable than older orchards, highlighting the importance of managing soil health in established orchards (Munro et al., 2020). Building from these findings, the next FAIP project (2019–2023) focuses on cherry water management practices (B.C. Agriculture and Food Climate Action Initiative, n.d.) given increasing regional water scarcity (Neilsen et al., 2018), a potential limitation for orchard expansion. This project primarily investigates whether post-harvest deficit irrigation practices—the reduced application of water following fruit harvest—in the autumn can reduce water demand for cherry orchards, without compromising fruit quality and the long-term health and vigour of the orchard.

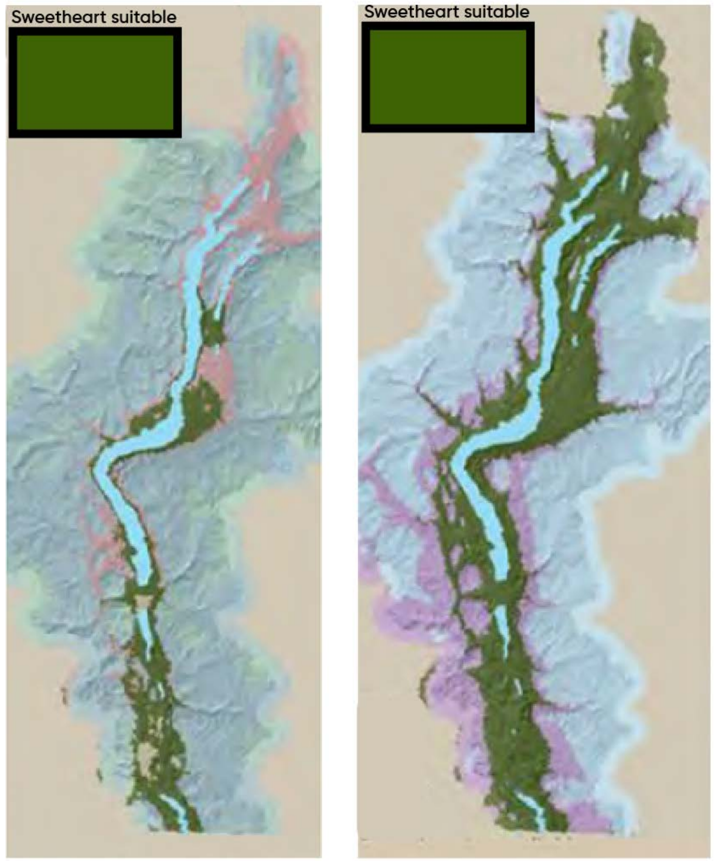

Figure 5.12: Expanding soil suitability for sweet cherry production in the Okanagan Valley comparing data for 1961–1970 (left) with data for 2001–2010 (right). Source: Based on models published in Neilsen et al, 2017.

5.5.2.1 Agricultural Climate Adaptation Research Network (ACARN)

ACARN, launched in 2017, acts as a provincial hub to foster collaborative and strategic agricultural adaptation research and extension in British Columbia (B.C. Agricultural Climate Adaptation Research Network, 2018). Actions include hosting educational programming and annual provincial workshops for knowledge mobilization and collaboration among researchers, producers, government and agriculture professionals. With strong linkages to FAIP and other climate change-focused projects led by its members, ACARN is bringing researchers together to strengthen awareness of current research and to facilitate data-sharing. The long-term success of ACARN depends on strengthening linkages between industry groups and researchers to prioritize research that addresses industry needs, improving the ability of researchers to collaborate across institutions, disciplines and regions, and securing long-term funding (B.C. Agricultural Climate Adaptation Research Network, 2018).

5.5.3 Conclusion

Agricultural adaptation is an emerging provincial priority. Through federal and provincial funding, B.C. has initiated programing to identify climate change risks and to implement priority adaptation actions. Recent wildfires, floods and regional water shortages have accelerated the need for adaptation and emergency management; however, gaps in planning, implementation and evaluation still exist. Limited financial and human resources are allocated to climate change adaptation within governments, and there has not yet been wide-scale adoption of agricultural climate change considerations, planning tools and initiatives by governments and producers (Auditor General of British Columbia, 2018). Continued collaborative efforts at the farm, regional and provincial levels that are multi-temporal and cross-sectoral would help to advance agricultural adaptation in the province.

5.6 Adaptation continues to advance in B.C.

Climate change adaptation activities—including efforts focused on implementation—are present across most sectors and settings in B.C. This work continues to mature, supported by improved access to climate data, decision-support tools, funding, supportive institutions and collaboration. However, significant gaps remain and it is unclear whether current and proposed efforts will be sufficient given the extent of the risks faced and the costs of implementation.

The climate change adaptation field in B.C. has continually progressed, partly due to the impacts of increasingly extreme weather events and a growing understanding of both short- and long-term risks. Local and regional governments play an important role in convening planning processes and implementing projects, but capacity constraints still exist across B.C. The provincial government and public sector organizations are active contributors to climate change adaptation, and significant financial resources are required to drive implementation at the provincial scale. A wide range of B.C. professional practitioners, private sector organizations, NGOs, boundary organizations and academic groups are contributing to adaptation, either explicitly or as part of other initiatives. Although adaptation is advancing, further efforts are needed to deal with the growing risks.

5.6.1 Introduction

This section discusses the important role that various levels of government play in advancing climate change adaptation in B.C. (for an Indigenous-focused discussion, *see* Section 5.2). It also includes a discussion of existing resources and challenges for the adaptation field generally, and the role that non-government actors play in advancing adaptation.

5.6.2 Municipal and regional governments

B.C.'s municipal, regional and Indigenous governments are important drivers of climate change adaptation (Kovacs et al., 2020; Yumagulova, 2020; Auditor General of British Columbia, 2018; Vadeboncoeur, 2016). They are well placed to identify local vulnerabilities and address equity issues (*see* Box 5.6), implement appropriate actions and integrate disaster risk reduction and climate change adaptation (The Expert Panel on Disaster Resilience in a Changing Climate, 2022).

The level of local government adaptation activity varies across B.C. Early adopters at the local government level included the following: the cities of Vancouver (which developed Canada's first official municipal adaptation plan in 2012), Richmond, Prince George, Surrey and Kimberley; the Corporation of Delta; the Districts of Elkford and Saanich; and the Cowichan Valley Regional District, with many more entities now engaged in adaptation. Some include adaptation in existing plans and operations, while others have developed standalone adaptation plans, and some are beginning to advance to implementation. Many local government networks convened by partner organizations are also playing a key role in advancing adaptation in British Columbia. Regional governments, including Metro Vancouver, the Cowichan Valley Regional District and the Capital Regional District, have also developed adaptation planning, with Metro Vancouver developing a comprehensive vision for climate action by 2050 and embedding regional green infrastructure planning as a low-carbon resilience approach into the upcoming Regional Growth Strategy refresh (Metro Vancouver, 2018).

However, local governments still face numerous challenges, including a lack of locally specific data and knowledge, inadequate human and financial capacity, and a need for more supportive policies at the provincial level (Auditor General of British Columbia, 2018) (*see* section 5.2 for a discussion of First Nations challenges). Leadership shown by staff and elected officials, backed up by robust plans, policies and systems (e.g., infrastructure, ecosystems), is essential to motivate planning efforts (Birchall and Bonnett, 2021). Recently, recommendations were co-developed by the Province and the Union of B.C. Municipalities' (UBCM) *Green Communities Committee Adaptation Working Group* to support municipal government climate change adaptation efforts (Government of B.C., 2020a; UBCM, 2020). These included committing to ensuring local governments had the tools and resources needed to complete climate risk assessments and to adopt adaptation plans by 2030.

Box 5.6: Equity

Exposure and susceptibility to hazards are disproportionately skewed towards populations that have been placed at higher risk, resulting in asymmetrical impacts. The cascading nature of these crises and the risks that they pose underscore the intersectional nature of income and health disparities, environmental racism, the legacy of colonization, and other sources of vulnerability in our communities (*see* Health of Canadians in a Changing Climate Report). It is crucial to recognize and identify the compounding impacts of climate change and inequality in public health and other emergencies in order to develop effective, equitable solutions and to identify opportunities for preventative approaches (ACT, 2020a). Acting to address these issues, and to promote equitable outcomes through respectful engagement and resourcing, can help to reduce risk, alleviate pressure on critical systems during and after extreme events, and achieve co-benefits such as improved health and cultural and economic opportunities.

The City of Vancouver's VanPlay Parks and Recreation Services Master Plan models a deliberate focus on equity, inclusion, and access to parks and recreation, with co-benefits for reduced urban heat and flooding, human health and active transportation (Harford and Hunter, 2021). Similarly, engagement conducted by the Climate Action Secretariat sought to ensure that assessments of risk to Indigenous communities were produced by Indigenous community members in a culturally sensitive manner (Indigenuity Consulting Group Inc., 2020).

5.6.3 Provincial government

The Ministry of Environment and Climate Change Strategy's Climate Action Secretariat (CAS) is responsible for coordinating a government-wide approach to adaptation in B.C. (Auditor General of British Columbia, 2018). Their work is complemented by adaptation work in a number of other ministries, including the Ministry of Forests, Lands, Natural Resource Operations and Rural Development, and the Ministry of Agriculture, as well as the Ministry of Transportation and Infrastructure, and Emergency Management B.C. (EMBC), the latter stressing the urgency of addressing climate change in their disaster-mitigation funding offerings (Emergency Management B.C., 2021).

British Columbia was one of the first jurisdictions in Canada to publish a provincial-scale climate change risk assessment (B.C. Ministry of Environment and Climate Change Strategy, 2019). This semi-quantitative analysis was done to help better understand and address the risks the province is facing. It assesses the likelihood and consequences of 15 potential climate risk events across multiple sectors at the provincial scale, considering risk in the context of events that would constitute a level of emergency requiring the provincial government to respond. The province is currently exploring ways to uphold Indigenous values in its climate risk assessments (Government of B.C., 2020b). For a list of completed and planned activities, *see* the *Managing Climate Risk* table in the Government of British Columbia's 2020 Climate Change Accountability Report (Government of B.C., 2020a). Provincial leadership is essential in supporting a harmonized and strategic approach to adaptation across the province, including in coordination with the federal government.

Hazard, Risk and Vulnerability Analyses (HRVA) are mandated by the provincial Local Authority Emergency Management Regulation, cover all hazards and usually have a five-year time horizon (EMBC, 2020). HRVAs in B.C. typically consider extreme weather, but have not rigorously included climate change to date (e.g., Bowen Island Municipality, 2018). An updated HRVA tool being developed by the Province will encourage users from local and regional governments and First Nations to think not only about how the climate will change in the future, but also how today's climate is already different from that of the past— thus cautioning against an overreliance on solely historical climate data.

5.6.3.1 Public sector organizations

The Province provides the mandates for Public Sector Organizations (PSOs)—including school districts, health authorities, post-secondary institutions and Crown corporations—that operate critical infrastructure and large-scale assets throughout B.C. communities, and thus play an important role in managing future climate risks. Impetus for adaptation action across PSOs ranges from internal voluntary measures to research projects and regulatory requirements. For example, amendments to the *Climate Change Accountability Act*, SBC 2007, c. 42, in 2022, enable the Province to establish requirements for PSOs related to reporting on climate risks and for the management of climate risks to public sector buildings, including considerations in the capital planning and approval process, and in climate risk reporting requirements that are comparable to existing public sector reporting on GHG emissions.

Risk assessments, planning, piloting and implementation are occurring across several PSOs; examples include BC Housing's Mobilizing Building Adaptation and Resilience (MBAR) project (B.C. Housing, 2020), which seeks to increase knowledge and capacity among building owners and occupants, and B.C. Hydro's work to understand current and future risks that extreme weather creates for its assets and services (B.C. Hydro, 2019b, 2019c).

5.6.4 Adaptation resources and challenges

Researchers, NGOs, practitioners and professional associations are also advancing adaptation in B.C. These organizations and individuals intervene at multiple points in the adaptation spectrum and have created many adaptation-focused, decision-support planning tools for a variety of sectors (e.g., ACT, 2020b; Government of B.C., 2020a).

Localized historical and projected climate data can be extremely useful to planning, decision making and implementation under a changing climate, across a variety of scales. Various helpful resources now offer modelling and projections for climate change impacts across B.C. under a range of scenarios. Some of these resources have been produced by the Pacific Climate Impacts Consortium (PCIC), a regional climate service centre at the University of Victoria and partner of the new federal Canadian Centre for Climate Services that aggregates historical and projected climate data being produced across the country and offers free online support services (Capital Region District, 2017; Cowichan Valley Regional District, 2017; Pacific Climate Impacts Consortium, 2017a, 2017b; Metro Vancouver, 2016). B.C.-focused data have also been created by provincial government staff (e.g., Foord, 2016), local governments, not-for-profits, and federal initiatives. For example, Living Lakes Canada's Columbia Basin Water Hub, which provides access to open data and research that are useful in the beginning phase of adaptation planning (Columbia Basin Water Hub, 2021). These local resources are supplemented by national resources like www.climatedata.ca and https://climateatlas.ca.

Resources are being developed using this data with the goal of inspiring action and enabling decision making. For example, a 2018 CBC podcast series called 2050: Degrees of Change explored projected climate changes for B.C., and provided examples of adaptation in several sectors (CBC Listen, 2017). Some existing online resources aggregate these new resources for ease of use, including the ReTooling for Climate Change website (BC Regional Adaptation Collaborative, 2022) and an online Climate Adaptation Tools Inventory (Government of B.C., 2021e).

Other organizations are engaged in capacity building for BC professionals. Royal Roads University's Adaptation Learning Network (Adaptation Learning Network, 2020) aims to increase professionals' capacity for climate change adaptation and is supported by B.C.'s Climate Action Secretariat and Natural

Resources Canada. Similarly, Engineers and Geoscientists B.C. provides guidance to its members on how to incorporate climate change adaptation into their practice (Engineers and Geoscientists British Columbia, 2020). To support designers, PCIC has produced a set of future weather files that are useful for designing energy-efficient, climate-resilient infrastructure and buildings (Pacific Climate Impacts Consortium, 2020). The penetration and impact of the above knowledge products and decision-support tools have not been empirically studied in B.C., but the adaptation field is clearly active and working to address the earlier parts of the adaptation spectrum.

Funding is often identified as a barrier to action on adaptation (Bednar et al., 2018), and governments, foundations and non-profits in B.C. are increasingly offering a variety of economic supports to facilitate aspects of action on adaptation. There is a substantial amount of federally funded activity locally, including at the level of regional districts and First Nations governments. However, this funding has primarily supported planning activities, and may not be positioned to allow the sustained level of cross-sectoral collaboration thought to be effective for adaptation planning.

The next steps in the adaptation process, such as implementation and monitoring and evaluation (M&E), are still largely nascent at all scales, partly because M&E tools are not yet well-developed, and partly because the cost of implementation often requires extremely expensive infrastructure upgrades or retrofits. For example, a 2012 study commissioned by the Province found that the cost to upgrade coastal protection to one metre of sea-level rise (SLR) in the Lower Mainland would be $9.5 billion (B.C. Ministry of ForestsLands and Natural Resource Operations, 2012b). It is unlikely that government funding will be sufficient to address the scale of action needed to address climate risk, and public-private partnerships (PPPs) will be required (ACT, 2015); however, there are as yet few examples of adaptation-related PPPs in BC. Recent advances in cost-benefit research could support decision-making efforts, for example by demonstrating to decision-makers that cost-benefit ratios for adaptation actions are very favourable (Boyd and Markandya, 2021).

Those involved in adaptation planning are increasingly motivated to consider the GHG implications (positive and negative) of their proposed actions (Nichol and Harford, 2016). Much of this work is occurring under the banner of low-carbon resilience, which emphasizes the need to reduce both emissions and vulnerability to climate change impacts (Nichol and Harford, 2016). If not strategically planned, these efforts risk increasing emissions and reducing the effectiveness of adaptation, as well as wasting resources and time. A number of pilots are under way that are refining concepts and empirically validating the low-carbon resilience approach, as well as exploring how “multi-solving” plays out in local contexts (ACT, 2020c).

It will be important to refine governance regimes relating to adaptation in the province. This refinement applies between First Nations and all levels of non-Indigenous government, horizontally (e.g., between the Ministry of Health and MOECC), as well as vertically. The B.C. Office of the Auditor General has identified the need for cross-agency coordination in planning for climate change adaptation in British Columbia (Auditor General of British Columbia, 2018). There is likely a role for the federal government to convene provincial, territorial, Indigenous and municipal governments to co-develop a more coordinated approach to governing adaptation (Sawyer et al, 2020).

5.6.5 Conclusions

As the climate change adaptation field matures in B.C., the focus is evolving from assessing risks and developing plans to also implementing adaptation and the beginnings of monitoring and evaluation. Important barriers and challenges still remain across the adaptation spectrum (Auditor General of British Columbia, 2018; Bednar et al., 2018), as most local governments and sectors still do not have a good understanding of all the climate change risks that they face, nor do they have the capacity to respond to them. While a systematic assessment has not been conducted of whether current and proposed levels of adaptation activity are likely to be sufficient for the increasing risks faced in B.C., it appears likely that more effort, collaboration and resources will be required.

5.7 Moving forward

5.7.1 Knowledge gaps

The assessment of current knowledge presented in this chapter reveals knowledge gaps across the adaptation spectrum.

Although B.C. has a history of providing access to climate projections, there is a need to update the networks of data collection instruments that collect climate data in the province (e.g., temperature, precipitation, snow depth). For example, the sparsity of monitoring stations in the northern regions of the province and at high elevations can make locally specific planning more challenging. There are also gaps relating to hydrometric and groundwater monitoring in the province (Auditor General in British Columbia, 2018). There is also a need to better understand shifting ranges of various pests, diseases and invasive species that affect B.C. ecosystems and natural resource sectors (Scholefield et al., 2017a).

Many locations in the province still do not have up-to-date flood maps, and many point to a lack of resources and capacity as primary reasons for lacking these maps (British Columbia Auditor General, 2018; B.C. Real Estate Association and University of British Columbia Okanagan, 2021). The representation of agriculture and prioritization of agricultural values in floodplain planning constitute a current knowledge gap.

There is also a need to better understand compounding hazards and cascading impacts, both of which can be challenging to achieve due to the dynamic interplay between multiple hazards and impacts. For example, a study of the infrastructure costs associated with future projections for B.C. did not examine cascading impacts, and thus potentially underestimated impacts and costs (e.g., Ryan et al., 2021). Similarly, although risk assessments are becoming more common, there is a growing need for after-action reports that summarize impacts (e.g., B.C. Hydro, 2019c) across scales, including communities, regions, and the entire province.

As with other sectors and regions, there is a need for contextual information about costs and benefits, the costs of inaction and expected reasonable returns on investments for adaptation initiatives (*see* Costs and

Benefits of Climate Change Impacts and Adaptation chapter). Although national figures are useful (Sawyer et al., 2020; e.g., Insurance Bureau of Canada and Federation of Canadian Municipalities, 2020) and some provincially relevant costs exist (e.g., for dyke improvements in the lower mainland), more contextualized information is needed. It is also important not to overlook costs that are difficult to quantify in economic terms (Sawyer et al., 2020).

Monitoring and evaluation strategies need to continue to be developed and adopted alongside progress in implementation, especially with activity occurring across sectors and scales. Limited guidance exists for this task (e.g., EPCCARR, 2018), and there is a need to determine appropriate scales, geographies and objectives for M&E in B.C.

5.7.2 Emerging issues

This assessment of the current knowledge of climate change impacts and adaptation in B.C. highlights several emerging issues that will influence the development of the adaptation field.

The atmospheric river event and subsequent floods and landslides in November 2021 demonstrate the tension between emergency management, which is reactive by nature, and proactive adaptation. The financial resources required to rebuild damaged infrastructure are extensive and will very likely diminish—at least in the short term—the resources available to fund various proactive initiatives identified in B.C.'s Climate Preparedness and Adaptation Strategy. The unprecedented nature of this event, along with the heat event in June 2021, is still of concern in that B.C. is experiencing an inability to keep pace with the rate of change. However, it is also possible that these events can provide an impetus for action. For example, there is potential that lessons learned from the November 2021 flooding could inform and help stimulate revisions for improved flood risk management in B.C.

Another emerging issue is innovation in how financing is secured and distributed in order to meet the often large needs across sectors and scales. Examples of areas being explored include how municipal revenue could be decoupled from development charges and property taxes, and how new sources of income could help to alleviate the disproportionate burden of costly climate impacts and responses (ACT, 2015).

B.C. has introduced legislation to ensure that its laws are brought into line with the United Nations Declaration on the Rights of Indigenous Peoples (Government of B.C., 2020d), and that the essential role of Indigenous leadership and knowledge in adaptation is increasingly recognized (The Expert Panel on Disaster Resilience in a Changing Climate, 2022). However, the potential of these efforts are only beginning to be glimpsed. For instance, the Tsleil Waututh Nation is leading a storm water planning process that focuses on the health of Burrard Inlet and is based on their community's values and traditional ways of knowing. This process serves not only to increase climate resilience, but also to strengthen Indigenous rights and self-determination. There is an emerging need for centering Indigenous leadership and creating just and fair adaptation governance regimes in connection with adaptation in B.C.

Reconciliation is imperative across all sectors and settings in B.C. For example, the impact of climate change on Indigenous food security and food sovereignty is being studied by Indigenous organizations (e.g., First

Nations Health Authority, 2022), and the role that agricultural climate adaptation plays in reconciliation is increasingly a topic of focus for the Government of British Columbia.

5.8 Conclusion

British Columbia faces significant challenges as the climate continues to change. These changes impact all regions and multiple sectors of the province, and the longer-term risks to hydrology, forestry, agriculture and communities are significant. Indigenous Peoples and communities are uniquely impacted and are increasingly leading climate change adaptation initiatives at various scales. Centering and supporting Indigenous leadership and knowledge systems are essential, and collaboration with governments and partners is possible only when it is co-created with Indigenous Peoples in ways that protect and strengthen Title, Rights, and jurisdiction.

Managing flood risk in B.C. will continue to be a priority as hazards from riverine, coastal and urban flooding intensify. Although some strategies and governance processes are in place to reduce these risks, a number of key challenges exist that represent urgent areas of action given the level of risk faced.

B.C.'s vast and important forests are exposed to a number of significant climate-sensitive hazards, many of which will likely lead to changes in forest productivity, wildlife habitat and ecosystem services. Although the forest sector has long been adapting to climate change in the province, more proactive adaptation would help to ensure the continued health and productivity of B.C.'s forests.

Agricultural adaptation is an emerging provincial priority in B.C., and recent extreme weather events have accelerated the need for wide-scale adaptation and emergency management, and have highlighted gaps in preparedness. Continued collaborative efforts at farm, regional and provincial levels will likely advance agricultural adaptation in the province.

Local and regional governments and First Nations continue to be important drivers of adaptation implementation. The province and public sector play an important role in leading and supporting adaptation efforts across multiple scales, supported by researchers, practitioners, NGOs and professionals.

Further action is required across multiple sectors and scales to meet the challenges that are likely to emerge as the climate changes. However, accelerating widespread implementation will be challenging. Significant resources will be required to create a level of action that is commensurate with the risks that British Columbia is facing. It will also be difficult, but important, to establish a baseline of risks and vulnerabilities, to evaluate the effectiveness of adaptation efforts, and to monitor improved resilience to the climate risks described throughout this chapter.

5.9 References

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