Pacific Institute for Climate Solutions

Bridging climate research and risk assessments:

a research and knowledge mobilization agenda

June 2025

Authorship team

Alyssa Hill
Project Analyst,
Pacific Institute for Climate Solutions

Dylan Clark
Director of Research Mobilization,
Pacific Institute for Climate Solutions

Dr. Ian Mauro
Executive Director,
Pacific Institute for Climate Solutions

Emily MacNair
Director of Programs and Partnerships,
Pacific Institute for Climate Solutions

Caroline Merner
Project Manager (former),
Pacific Institute for Climate Solutions

Project advisory group

Dr. Diana Allen
Professor,
Department of Earth Sciences,
Simon Fraser University

Dr. Natalie Ban
Professor & President's Chair,
Environmental Studies,
University of Victoria

Dr. Samuel Bartels
Assistant Professor,
Department of Ecosystem Science and Management,
University of Northern British Columbia

Dr. David Bristow
Associate Professor,
Department of Engineering,
University of Victoria

Dr. Craig Brown
Senior Scientist,
Vancouver Coastal Health Authority

Dr. Robin S. Cox
Professor and Director,
Resilience by Design Research Lab,
Royal Roads University

Dr. Emily Dicken
Director, North Shore Emergency Management

Dr. Mike Flannigan
Professor & B.C. Innovation Research Chair for Predictive Services, Emergency Management and Fire Science,
Thompson Rivers University

Dr. Maya Gislason
Associate Professor,
Faculty of Health Science,
Simon Fraser University

Dr. Kira Hoffman
Postdoctoral Fellow and Professional Fire Ecologist,
University of British Columbia

Dr. Maggie Low
Assistant Professor,
School of Community and Regional Planning,
University of British Columbia

Dr. Joseph Shea
Associate Professor,
Department of Geography, Earth, and Environmental Sciences,
University of British Columbia

Rita Steele
Manager of Sustainable Operations,
Simon Fraser University

Dr. Brent Ward
Professor,
Department of Earth Sciences,
Simon Fraser University

We gratefully acknowledge the financial support of the Province of British Columbia through the Ministry of Emergency Management and Climate Readiness.

In addition to the Advisory Group, more than 150 experts graciously provided insights and expertise through interviews and focus groups. We are grateful to each of them for sharing their time, insights, and expertise throughout the project. The depth and richness of this report are a direct result of the participants' dedication to advancing climate resilience across the province. Thank you and we look forward to working together toward a resilient future.

Disclaimer: This report does not necessarily reflect the views of the Advisory Group members, other experts or organizations that provided input throughout the project. Any potential errors or omissions in this report are attributable to the Pacific Institute for Climate Solutions.

Territory acknowledgement

The main office of the Pacific Institute for Climate Solutions (PICS) is located at the University of Victoria. PICS respectfully acknowledges the Lək̓ʷəŋən (Songhees and Xʷsepsəm/Esquimalt) Peoples on whose traditional territory the university stands, and the Lək̓ʷəŋən and WSÁNEĆ Peoples whose historical relationships with the land continue to this day. Throughout this research project, PICS hosted gatherings across British Columbia (B.C.) and researchers, practitioners, and Indigenous Knowledge Holders travelled from different unceded, ancestral, and traditional territories to discuss climate change research and risk assessments.

PICS would like to respectfully acknowledge the territories where we gathered and express gratitude to the Nations whose historical relationships with the land continue to this day. The in-person Advisory Group meeting gathered on the traditional territories of the Lək̓ʷəŋən (Songhees and Xʷsepsəm/Esquimalt) Peoples and WSÁNEĆ Peoples; the wildfire focus group gathered on the unceded and traditional territories of the syilx Okanagan Nation; and the extreme heat and flood focus groups gathered on the unceded and traditional territories of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh Úxwumixw (Squamish), and səl̓ilw̓ətaʔɬ (Tsleil-Waututh) Nations.

Throughout this research project, Indigenous Peoples' stewardship of their territories and leadership in climate change solutions grounded conversations around climate change risks and impacts and the solutions, tools, and pathways forward. At the same time, recognition of the historical and ongoing legacies of colonialism for First Nations in B.C. was a critical reminder that we need ways of working together that are rooted in the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), truth and reconciliation, decolonialization, and cultural safety.

The outcomes of this research project advocate for an approach to climate change research and risk assessment that connects and values both Indigenous Knowledges and western science. Indigenous Knowledges across B.C. are specific and distinct to each First Nation and are inextricably connected to their territories. In pursuit of a resilient and just future, a bridged approach to climate change research and risk assessment must be rooted in place to acknowledge and learn from the histories, Indigenous Knowledges, and relationships that have existed and will continue to exist for generations to come.

Table of contents

Forest fire at night in the Okanagan Valley, unceded territory of the syilx Okanagan people. *iStock photo*

Executive summary

Climate change is having a devastating impact on communities across British Columbia (B.C.). In the past few years alone, wildfires, droughts, extreme heat, and floods have led to considerable impacts to humans, ecosystems, and economic well-being and prosperity. Further, the impacts of climate change are unevenly distributed, with those who are systemically marginalized often experiencing the worst impacts.[1] As disasters and climate risks are likely to increase across B.C. in the years ahead, governments and private sectors need to prepare for current and future climate risks to reduce social, environmental, and economic costs.

Risk assessments are a common tool used by both the public and private sectors to identify, evaluate, and prioritize risks.[2, 3] They are the first step in a broader framework that supports risk reduction and resilience planning, decision-making, and implementation.

In B.C., risk assessments have been used across public and private sectors for more than two decades. In the last 10 years, risk assessments that focus on climate hazards and risks have gained traction through voluntary and mandated mechanisms across B.C., in part due to the increasingly devastating impacts of recent climate events.

However, conducting evidence-informed risk assessments in B.C. remains challenging. Practitioners and decision makers need to be able to integrate the best-available climate change data, research, and information to adequately reduce risks in a changing climate.[2–5]

To support this, the Government of British Columbia's Ministry of Emergency Management and Climate Readiness (EMCR) funded the Pacific Institute for Climate Solutions (PICS) to develop a research agenda that provides recommendations on how to integrate climate change research into risk assessments and identifies research needs to support on-the-ground risk and resilience in B.C. This report summarizes the challenges, needs, and opportunities at the intersection of climate change research and risk assessment. The intended audience is the research community in B.C. and practitioners conducting evidence-informed risk assessments.

This report is a result of a year-long process with data and knowledge from three sources: key informant interviews, four focus group discussions based on priority hazards (wildfires, droughts, extreme heat, and floods), and a literature review. The interviews and focus groups included researchers, practitioners, and Indigenous Knowledge Holders.

The first half of this report is presented around three foci: risk assessments, climate change research, and the intersection of climate change research and risk assessments.

1. **Risk assessments** are a common tool used in B.C. and other jurisdictions for several purposes (e.g., climate change adaptation, emergency management, infrastructure, and asset management). While general risk assessment practice has evolved and improved, risk assessments do not consistently reflect up-to-date climate science. Based on PICS' analysis, risk assessments can better reflect the climate risks and integrate climate change research by strengthening frameworks and processes. The main themes that emerged to support this were: the importance of participatory approaches, mixed methodologies, considering Indigenous Knowledges; the need for more holistic and integrated risk assessments, coordination and consistency; and actionable results.

2. **Climate change research** is growing in B.C. and there is extensive expertise across the province. However, PICS' analysis identified substantial information needs related to wildfire, drought, extreme heat, and flood risks (Tables 3-11). These information needs challenge evidence-informed risk assessments and the ability to plan for emergency response and adaptation. The cross-cutting themes that emerged on how to approach climate change research needs were: addressing geographic data and research inequity; incorporating interdisciplinary and holistic approaches; and learning from Indigenous Knowledges.

3. **Integrating climate change research into risk assessments** is not a consistent practice nor is there a standard approach in B.C. or in other jurisdictions. Based on PICS' analysis, there are challenges with research availability and access; useability and mobilization; and gaps and uncertainty. There is also a general disconnect between practitioners and researchers. The main themes that emerged on how best to address these challenges were: improve research and knowledge mobilization; develop a standard approach to integrate research; and re-imagine research partnerships so that research outputs flow easily into risk assessments.

To better support evidence-informed risk assessments and subsequent emergency management and adaptation, there should be more efficient and effective integration between B.C.'s rapidly evolving risk assessment practices and climate change research.

The second half of this report outlines three resilience pathways to better connect climate change research and risk assessments in ways that are informed by both Indigenous Knowledges and western science:

» **Resilience pathway 1: Improving risk assessment frameworks and good processes**
To assess the true state of climate risks facing B.C. communities, governments and private and public sectors should draw from both quantitative and qualitive sources, including local and Indigenous Knowledges, and consider risk and resilience in integrated and interconnected ways. There are research opportunities to improve the consistency and effectiveness of risk assessments through shared terminology and concepts, similar assumptions and inputs, and stronger connections to risk reduction measures (Table 13).

» **Resilience pathway 2: Improving methods for integrating climate change research**
To better integrate climate change research into risk assessments, academic organizations should increase the availability and useability of research. Practitioners should have easy access to up-to-date climate change research, including journal publications, datasets, and synthesis products. There are research and partnership opportunities to support consistent guidelines, improve data sharing, and understand effective knowledge mobilization and risk communication techniques (Table 14).

» **Resilience pathway 3: Innovative research approaches to address climate change research needs**
To address key climate change information needs, research funders and research coordinating organizations should emphasize interdisciplinary and co-designed research approaches through funding calls. Further, research approaches need to evolve to meet the pace and scale of climate change. There are many research opportunities for each climate hazard related to understanding risk (Tables 3, 6, 8, 10) and improving effective risk reduction, emergency response, and recovery (Tables 4, 5, 7, 9, 11).

Looking down the east-bound lane of the Trans-Canada Highway after a series of atmospheric rivers caused extensive flooding in Sumas Prairie (known as Sumas Lake or Semá:th Xhotsa by Semá:th First Nation). November 17, 2021. *iStock photo*

Introduction

Climate change is having severe consequences on communities across British Columbia. Wildfires, droughts, extreme heat, and floods have led to considerable impacts to people, ecosystems, and economic well-being and prosperity.

Disaster and climate risk arise when vulnerable communities or systems are exposed to hazards. Across B.C., disaster and climate risks are increasing. Climate change is driving more frequent and severe climate hazards, and this trend will likely continue without substantial policy changes to reduce global greenhouse gas emissions. At the same time, communities in B.C. are located in areas where climate hazards are growing quickly. Further, the impacts of climate change are unevenly distributed, with those who are systemically marginalized often experiencing the worst impacts.[1] To increase resilience, governments and the public and private sectors must prepare for current and future climate risks.

Demonstrating its commitment to addressing disaster and climate risks, the Government of B.C. established the Ministry of Emergency Management and Climate Readiness (EMCR) in 2022. The ministry leads provincial emergency and disaster risk management, building collaborative partnerships, advancing reconciliation with Indigenous Peoples, and supporting risk reduction across B.C.[6] To meet their mandate, EMCR has advanced evidence-based approaches to identify and reduce disaster and climate risks through risk assessments.

> *"To increase resilience, governments and the public and private sectors must prepare for current and future climate risks.*

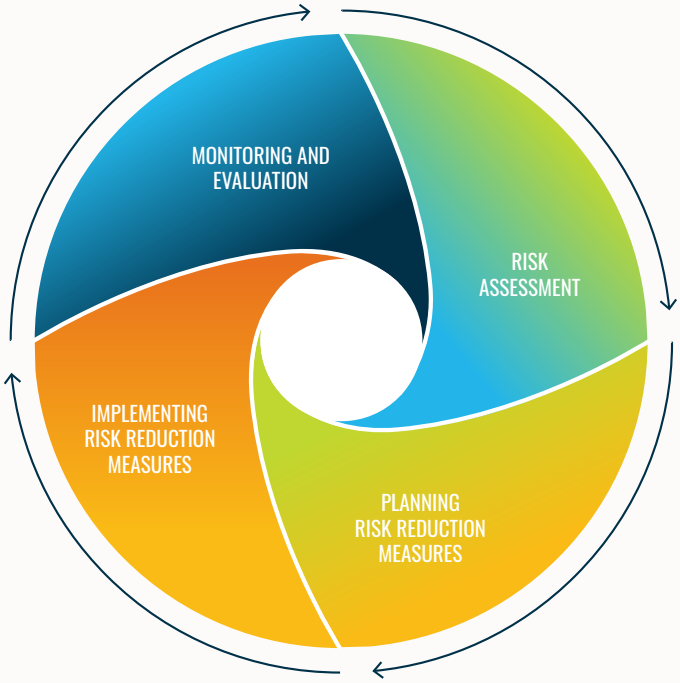
Risk assessments are a common tool used by both the public and private sectors to manage potential threats.[2, 3] The core objective of a risk assessment is to identify, evaluate, and prioritize risks, so practitioners and decision makers can triage risk reduction measures.[7]

What is a risk assessment?

The definitions of "risk" and "risk assessment" vary across many sectors and disciplines. According to the Intergovernmental Panel on Climate Change (IPCC), risk is defined as "the potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems."[8] In the context of climate change, risk "results from the interaction between climate-related hazards and the exposure and vulnerability of human and ecological systems."[8] PICS follows the IPCC concept of "risk assessment" as the practice of identifying and prioritizing risks to a system by considering how likely an event is and the consequences of the event.[8] In practice, risk assessments have many different titles depending on the scope, context, and methods of the assessment, for example, climate risk assessment, risk and vulnerability assessment, risk, and resilience assessment.

Risk assessments are the first part of a broader framework used in risk reduction (Figure 1). This framework has different names depending on the discipline and sector: enterprise risk management, risk management, or the adaptation cycle.[4] After a risk assessment, practitioners and decision makers consider measures to reduce prioritized risks. Next, the most effective risk reduction measures are implemented. Finally, implemented measures are monitored and evaluated. The framework then circles back to risk assessment as risks evolve and ongoing iteration is necessary.

FIGURE 1: GENERAL RISK MANAGEMENT FRAMEWORK



The history of climate risk assessments in B.C.

In 2018, the Auditor General of B.C.[7] recommended that the Government of B.C. undertake a comprehensive "provincial wide risk assessment that integrates existing work and provides an overview of key risks and priorities." In response, in 2019 the Climate Action Secretariat (CAS) led and completed the Preliminary Strategic Climate Risk Assessment or "provincial assessment." At the time, it was among the most advanced risk assessments completed by any Canadian provincial or territorial government and set an important baseline for climate risk and preparedness work.

Despite the groundbreaking nature of the provincial assessment, it focused only on climate-related hazards, siloing climate risks from others, like tsunamis, landslides, and earthquakes. Further, the process to assess risks did not adequately involve and reflect First Nations' perspectives and priorities.[9]

To improve risk assessment processes, the Government of B.C. leveraged lessons from 2019 to inform an updated Disaster and Climate Change Risk and Resilience Assessment (DCRRA). The DCRRA has a renewed focus on both disaster and climate hazards and is being developed in collaboration with First Nations and other experts across various sectors.

Regional, local, and First Nations governments across B.C. have also rapidly scaled up climate risk assessments over the past five years. Many health authorities, municipalities, and large infrastructure owners have voluntarily completed climate risk assessments for adaptation plans or large-scale infrastructure designs or improvements. Local authorities

are mandated by the province to complete Hazard, Risk, and Vulnerability Analyses which consider all hazards (including climate hazards) for their emergency management plans.[10] The Government of B.C. is working to streamline these risk assessment efforts through updated legislation that will require regulated entities to conduct risk assessments and emergency management plans that directly integrate climate change, include Indigenous Knowledges, and consider disproportionate impacts on people, places, and things.[11]

The future of climate risk assessments in B.C.

While risk assessments are a mainstream tool, it remains difficult for practitioners to effectively assess and reduce risks in B.C. A key challenge practitioners face is accessing, using, and integrating climate change research. To effectively reduce risks in a changing climate, practitioners and decision makers need access to the best available climate change research and guidance to integrate climate research* into risk assessments.[2–5] At the same time, the research community needs to address critical knowledge gaps and share research in ways that are easily translatable to risk assessments.

> *To effectively reduce risks in a changing climate, practitioners and decision makers need access to the best available climate change research and guidance to integrate climate research* into risk assessments.*

Acknowledging the critical role that PICS and other research institutes play in supporting evidence-based decision-making, EMCR funded PICS to develop a research agenda that: provides insight to improve the integration of climate change research into risk assessments; furthers the understanding of climate risk; and identifies on-the-ground research needs related to risk and resilience assessments and adaptation. The intended audience is the research community in B.C. and decision makers and practitioners conducting evidence-informed risk assessments.

* In the context of this project, PICS considers climate change research as information related to climate change hazards, impacts, vulnerability produced by an academic or non-academic source.

This research agenda has two main objectives:

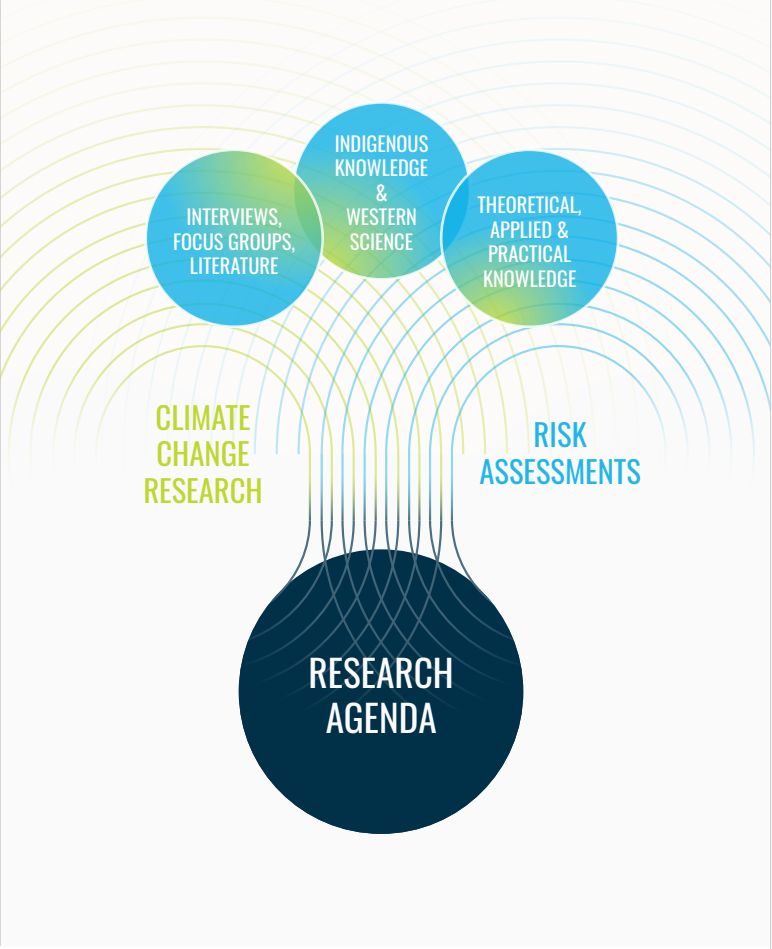
To provide recommendations to improve evidence-informed risk assessments in B.C. by:

1. *collecting up-to-date climate change research for use in risk and resilience assessments; and*
2. *bringing climate change research into risk and resilience assessments.*

To articulate research needs related to risk assessments and climate change research in B.C. by:

1. *documenting important ideas, interconnections, and opportunities for collaboration related to risk assessments for various sectors and scales; and*
2. *articulating actual, on-the-ground needs for knowledge and information related to risk and resilience assessments and adaptation.*

FIGURE 2: PICS' PROCESS FOR DEVELOPING THE RESEARCH AGENDA



To develop the research agenda in an intentional way, PICS designed a research methodology and presented the agenda around three foci: risk assessments, climate change research, and the intersection of climate change research and risk assessments (as represented by the braiding of two strands (Figure 2).

Notably, PICS bridged different knowledge systems (western science and Indigenous Knowledges) and sources of knowledge (theoretical, applied, and practical knowledge). This bridging and weaving—of climate change research and risk assessment and different knowledge systems and sources—informed the research agenda. The process of weaving knowledges helped ensure the final research agenda was collaboratively designed and thus relevant and meaningful for various partners across B.C.

PICS Academic Advisory Group and PICS staff met in March 2024 on the traditional territories of the Lək̓ʷəŋən peoples (Victoria). From left to right; Emily MacNair, Robin Cox, Maya Gislason, Dylan Clark, Emily Dicken, Dave Bristow, Shauna MacKinnon, Alyssa Hill, Ian Mauro, Rita Steele, Craig Brown, Caroline Merner, Kira Hoffman, Samuel Bartels, Janna Wale, and Joseph Shea. (Not pictured: Diana Allen, Natalie Ban, Mike Flannigan, Maggie Low, Brent Ward). *Sunset Labs photo*

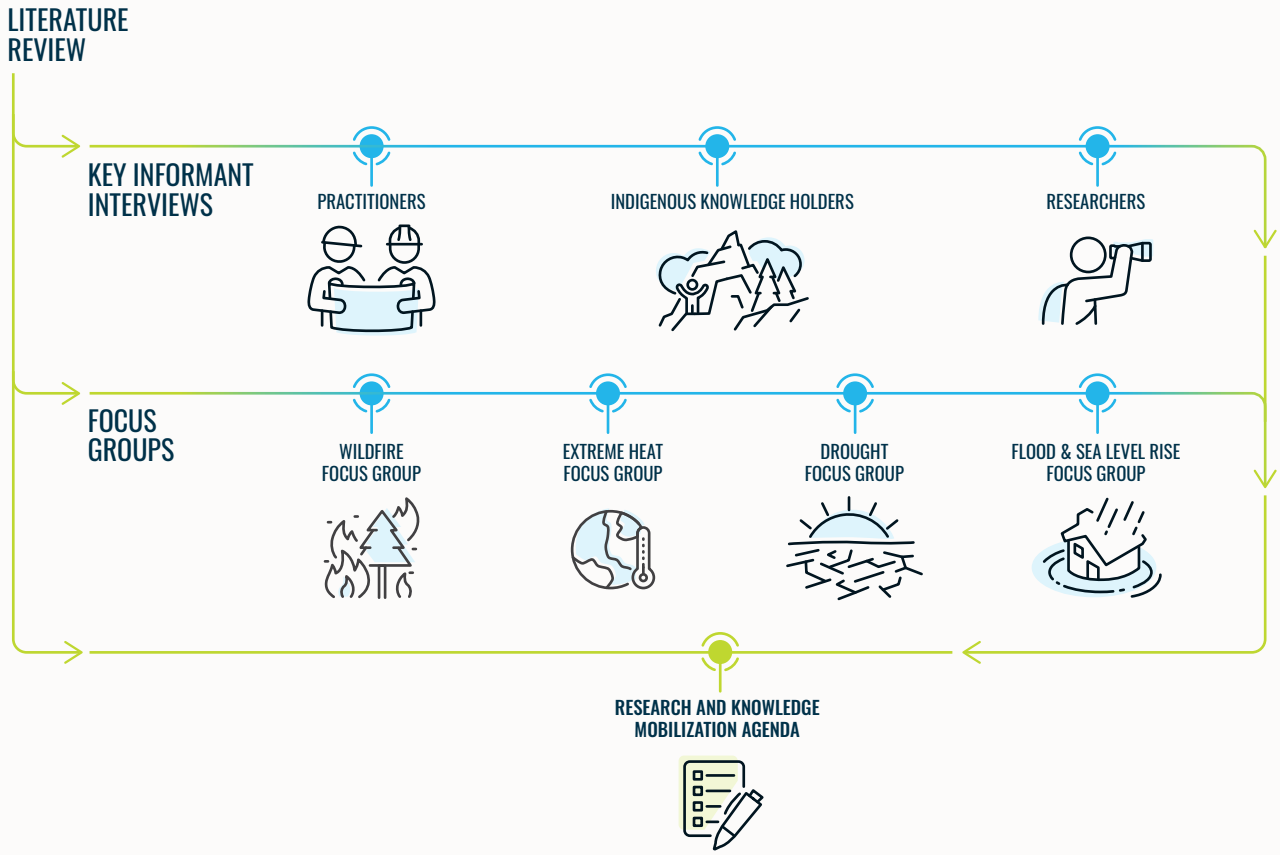
Methods

The research project was guided by a project advisory group with 14 experts from across B.C. Each expert had unique knowledge and experience in the areas of climate science, risk analysis, emergency management, and resilience. They provided high-level guidance and expertise, supported climate hazard focus groups, recommended literature, and offered insights for integrating research into risk assessments.

Design

The research agenda was designed to have multiple data and knowledge inputs from three sources: key informant interviews, four focus group discussions, and a literature review (Figure 3). The interviews and focus groups included researchers, practitioners, and Indigenous Knowledge Holders. Prior to engaging with participants, PICS obtained Research Ethics Board (REB) approval through the University of Victoria (UVic) protocol #24-0140. All interview and focus group participants provided consent (written and verbal) to participate. PICS recorded audio during all key informant interviews; focus group discussions were captured by notetakers.

FIGURE 3: OVERVIEW OF RESEARCH METHODOLOGY



Data collection

Literature review

The literature review occurred throughout the research project to inform the interviews, focus groups, and analysis. It was used to collect up-to-date climate change research in B.C. and triangulate across the other information sources. The literature review was also used to unpack emerging themes related to risk assessments and research in B.C. and other jurisdictions to compare practices.

PICS started by identifying and analyzing literature about the four climate hazards pre-determined for this project by EMCR based on government priority: wildfire, extreme heat, drought, and floods. PICS reviewed all literature suggested by the project advisory group members and key informants, then identified additional sources by searching Scopus, UVic Libraries, Google Scholar, and Google Search Engines, using the search string: "*British Columbia*" AND "*[climate hazard]*" AND *(risk OR resilience)*.

PICS also identified literature about risk assessment processes and the integration of climate change into risk assessments. This search included applications of risk assessments from B.C. as well as other jurisdictions to incorporate a broader understanding of current risk assessment practices. The literature review included academic and grey literature. All sources reviewed were in English and published after 2017.

Interviews

Between February and July 2024, PICS conducted 22 semi-structured interviews with key informants, including researchers, practitioners, and Indigenous Knowledge Holders. Interviewees had experience across scales (local to national) and expertise in climate risk assessments, emergency

Left: Wildfire hazard workshop on the unceded territory of the syilx Okanagan people in June 2024. *Shauna Mckinnon photo.* **Right:** Panelist at the flood hazard workshop on the traditional and unceded territory of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) Nations (Vancouver) in October 2024. From left to right: Tribal Chief Tyrone McNeil, Tarina Colledge, Dr. Kees Lokman, Dr. Maggie Low. *Caroline Merner photo*

management, risk reduction, and community resilience. During key informant interviews, PICS asked participants about their experience assessing climate risk and resilience, integrating research into risk assessments, research and practices, and pathways to adaptation and emergency management.

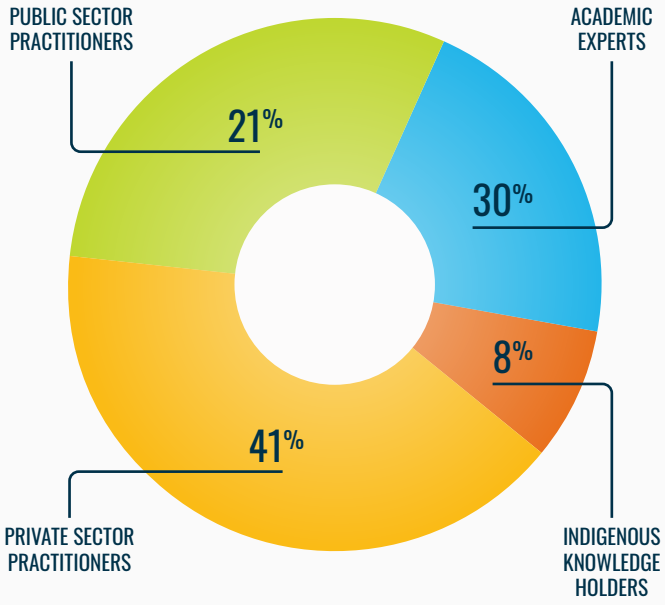
Hazard focus groups

Between June and October 2024, PICS facilitated four focus groups, one per climate hazard: wildfire, extreme heat, drought, and floods. The hazard focus groups were a key deliverable outlined in the Contribution Agreement with EMCR.

Focus group participation was by invitation only. PICS developed the participant list using a snowball method that started with recommendations from the project advisory group. PICS received ongoing recommendations as the project network expanded and aimed to capture a broad cross-section of researchers, practitioners, and Indigenous Knowledge Holders and to have representation from across B.C. Across all four focus groups there were 191 attendees that spanned various geographies, demographics, expertise, and knowledge types (Figure 4).

During each focus group, participants rotated through breakout discussions. This encouraged smaller conversations of six to ten individuals and allowed for mixing of participants. Breakout discussions focused on thematic areas such as health, community, ecosystems, economy, and infrastructure. To integrate themes, participants considered cascading risks, interconnections, vulnerable groups, and justice and equity. For each theme and hazard, PICS asked participants about research needs, knowledge mobilization barriers, and barriers to risk reduction. Following each focus group, PICS collated all notes into a summary document and then shared it with all participants for their written feedback, additions, and comments.

FIGURE 4: TYPE OF FOCUS GROUP ATTENDEES ACROSS ALL FOUR FOCUS GROUPS



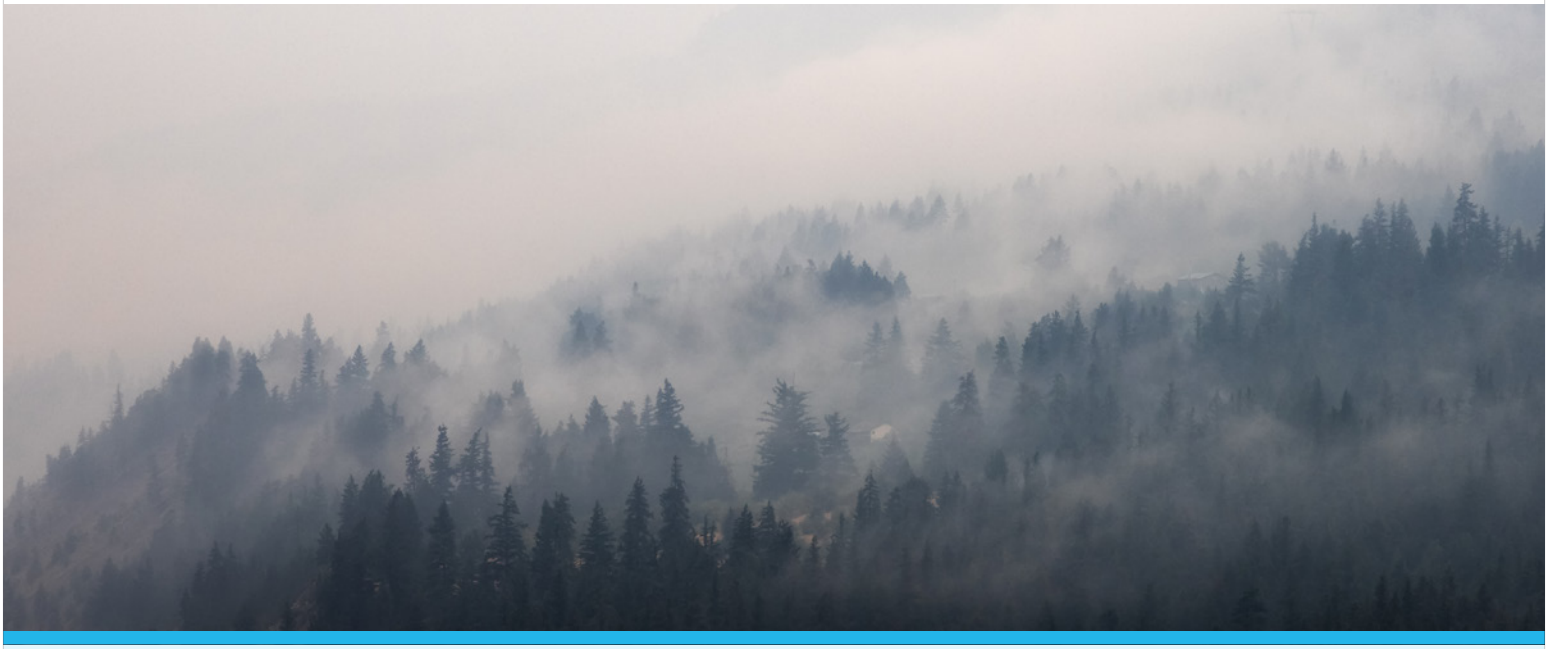
Data processing and analysis

PICS used the qualitative analysis software NVivo version 14 (released 2023) to support thematic analysis of data from key informant interviews. PICS began by coding transcripts based on high-level interview question themes. Transcripts were then coded based on other themes that emerged. PICS summarized these themes in preliminary "What We Heard" documents.

To analyze the qualitative information from the interviews and focus groups, PICS first consolidated the information from all the summary documents into an Excel spreadsheet with each unique idea representing its own cell. PICS then categorized each unique idea as either a research, data, or information need or a process-based challenge, barrier, suggestion, or opportunity.

PICS clustered the challenges, barriers, suggestions, and opportunities around common themes or problems. Themes included: research process, knowledge mobilization, risk assessment, risk reduction and adaptation, risk communication, funding and capacity, governance and policy, and an Indigenized and decolonized approach. PICS grouped the information, research, and data needs based on hazard and their relevance to different components of a risk assessment, response and recovery, or adaptation. The final step was to contextualize these findings and themes within the literature review to validate and expand upon the challenges, needs, and opportunities identified by participants.

The focus group and interview participants contributed to the identification of key themes, ideas, nuances, and opportunities. The PICS team included quotes from the interviews and focus groups, highlighting the challenges and limitations but also the strength, hope, and resilience shown by participants.



Smoke from the wildfire that destroyed the community of Lytton, Nlaka'pamux territory, in June 2021. *iStock photo*

Research and knowledge mobilization agenda part 1:

Challenges, opportunities, and research areas

The objectives of the report are to provide recommendations on how to integrate climate change research into risk assessments and to identify research needs that support on-the-ground risk and resilience in B.C.

The first part of the report articulates the challenges, opportunities, and research areas that were identified in both the literature and the interviews and focus groups. It is presented around three foci: risk assessment practices, climate change research, and integrating climate change research into risk assessments. Each focus area begins with a summary of the literature and then describes findings and insights.

Risk assessment practices

The state of risk assessment practices: a review of the literature

Risk assessments are a globally recognized tool to identify, understand, and evaluate risks to inform decisions.[2,3] Climate change risk assessments and disaster risk assessments that consider climate change mark progress towards understanding and planning for risks in a changing climate. However, there are several challenges across the different risk assessment practices that have been well-documented in the scholarship.

First, risk assessments commonly rely on an approach that simplifies and siloes risk. This approach, known as a "reductive" approach, was designed for familiar and well-defined systems.[2] However, climate change introduces many layers of complexity.

A flooded trailer park in B.C. *iStock photo*

Climate change is challenging for researchers to define and understand as it is complex and dynamic across time and space.[2, 12] Further, the exposure and vulnerability of human and natural systems to climate impacts are shaped by many factors, including socioeconomic drivers and conditions (e.g., colonialism, unequal power distribution, poverty, and food insecurity), past decisions (e.g., land-use policy, industry, hazard management) and responses to a climate hazard.[13–15]

Second, risk assessments are subjective exercises and driven by normative assumptions, despite often being presented as "objective truths."[2, 12, 16, 17] They are also often closed technocratic processes, disconnected from on-the-ground realities and do not consider diverse perspectives or experiences of risk.[12, 13, 16, 18]

> *"The challenges of both the complexity and the disconnect from on-the-ground realities, means risk assessments may misestimate risks or have an incomplete view of the risk landscape.*

The challenges of both the complexity and the disconnect from on-the-ground realities, means risk assessments may misestimate risks or have an incomplete view of the risk landscape. This may lead to less relevant and/or less effective adaptation.[12, 16, 18, 19]

Fortunately, risk assessment scholarship has explored these challenges and there are emerging frameworks that are more holistic and consider complex risks.[17–21] For example, some complex risk assessment frameworks include response to a risk as a factor that drives and influences the level of risk.[19] This new generation of risk assessments also considers the interactions between hazard, vulnerability, exposure, and response and other non-climate-related risk drivers.[19] Indigenous-led frameworks (e.g. Climate rez-ilience: building transformative climate resilience in Indigenous communities[22]) also offer a more holistic and systems-based approach that considers important interconnections and how changes manifest over space and time, while centring Indigenous Peoples' values and priorities.[18, 22] Research also indicates that transparency and engagement with diverse groups that are underrepresented in risk assessments and with those who use risk assessments can build public trust and buy-in, leading to more effective and inclusive adaptation in the face of deep uncertainty and difficult decisions.[2, 4, 16, 17, 23]

In B.C., values-based projects and risk assessments are also emerging. Values-based approaches identify values (e.g., ecosystems, infrastructure, health, economy, culture, and well-being) as the starting point for a risk assessment and then assess how the values are at risk and how to protect them. For example, the City of Surrey Coastal Flood Adaptation Strategy[23], Sumas First Nation: Resilience in Action-Managing Risk and Recovery[24], and Tsleil-Waututh Understanding Our Community's Climate Change Vulnerabilities[25] have identified values first and then connected the values to specific climate risks and risk reduction strategies.

This shift towards more complex, holistic, and participatory risk assessments necessitates different types and sources of information, particularly as there are data and research gaps. Research points to the benefits of mixed methodologies to expand the evidence base and integrate qualitative and quantitative information sources (e.g., integrated risk assessment models, storylines, and scenario planning).[2, 19, 26] These approaches are also more agile in bridging western science and Indigenous Knowledges, accommodating where each knowledge system stands alone and where they can be braided together. For example, researchers from Manaaki Whenua Landcare Research proposed a framework to bring together Mātauranga Māori (Māori Knowledge) with land management scenario modelling to support Māori freshwater decision making.[27]

> *"This shift towards more complex, holistic, and participatory risk assessments necessitates different types and sources of information*

Risk assessments in B.C.: a dialogue on challenges and opportunities

In B.C., the practice of risk assessments has grown rapidly, and they are now a common tool used by governments and public and private sectors. At present, there are a variety of risk assessment frameworks used across the province. They have different objectives and approaches, for example, some take an all-hazards approach to risk assessment; others are specifically focused on climate risks (Table 1).

PICS asked participants about their experience with either all-hazard or climate risk assessments including what is working well and areas for improvement to better integrate climate change research. Across the interviews and wildfire, extreme heat, and flood focus groups, several themes emerged around risk assessment practices including:

- Participatory approaches and mixed methodologies
- Holistic and integrated risk assessments
- Importance of Indigenous Knowledges and working in good ways
- Coordination and consistency
- Actionable results

These themes are presented below and align with challenges and opportunities identified in risk assessment scholarship.

TABLE 1: EXAMPLES OF RISK ASSESSMENT FRAMEWORKS AND APPLICATIONS IN B.C.

Risk assessment objective	Frameworks and applications in B.C.
Climate change risk and/or vulnerability assessments for adaptation plans	» B.C. Preliminary Strategic Climate Risk Assessment [28] » Northeast B.C. Vulnerability Assessment Series [29] » Simon Fraser University Climate Risk Assessment [30] » Vancouver Coastal Health and Fraser Health Climate Change and Health Vulnerability and Capacity Assessment [31] » Kanaka Bar Indian Band Climate Change Vulnerability Assessment [32]
All hazards risk assessments for emergency management and business continuity plans	» Cowichan Region Hazard, Risk, and Vulnerability Analysis [33] » City of Nelson Hazard, Risk, and Vulnerability Analysis [34] » Sumas First Nation: Resilience in Action–Managing Risk and Recovery [24]
Asset management and infrastructure risk assessments	» Xwu'nekw Park Sea Dike Climate Lens Resilient Assessment [35] » St. Paul's Hospital Climate Risk Assessment [36] » Asset Management BC; Sustainable Service Delivery Primer [37] » Asset Management Guide for BC First Nations [38]
Hazard-specific risk assessments	» North Shore Sea Level Rise Risk Assessment and Adaptive Management Strategy [39] » Cowichan Valley Regional District Natural Hazard Risk Assessments [40] » Professional Practice Guidelines – Landslide Assessments in B.C. [41] » Professional Practice Guidelines–Legislated Flood Assessments in a Changing Climate in B.C. [42]

Participatory processes and mixed methodologies

Participants recognized that risk assessments are inherently subjective, driven by values, and some risks, vulnerabilities, and values may be missed depending on who is in the room. Participants suggested that risk assessments should include a participatory process to include risks to diverse and equity-denied populations, consider multiple values, and bring people together from different disciplines, epistemologies, and lived experiences. One participant noted,

> *"A good risk assessment has a fulsome and holistic understanding of the consequences … that means really talking to all of the stakeholder groups and treating them all like experts."*

Relationship building, respect, and trust were noted as being foundational for meaningful processes and partnerships:

> *"Risk assessments don't capture the grit and resilience embedded within vulnerability, which is the most beautiful part, and can only be shared through relationships and experience."*

Participants indicated these collaborative practices were increasingly being used, pointing to examples in B.C.

Participants also suggested that risk assessments are more accurate when they integrate multiple types and sources of information and data (e.g., geospatial data, community-based research, storytelling, and local and Indigenous Knowledges). One participant described that,

> *"In an ideal world, a risk assessment isn't just looking at the numbers but is valuing just as much the narratives, the stories, and the knowledges that western systems have not recognized or valued in the ways that they truly need to be."*

Mixed methodologies can deepen understanding of all the risks or impacts in the absence of adequate data and can bridge different types of knowledges. One participant noted,

> *"There [are] often mixed methods being used in these assessments where there is a weaving or braiding of some aspect of western science or approaches to risk assessment with traditional or Indigenous or local approaches."*

The wildfire focus group highlighted that dialogue and non-colonial approaches (e.g., non-written communication) can bring different types of knowledge together and provide more holistic descriptions of resilience scenarios.

Chum Salmon swimming upstream in the traditional territory of the Qualicum First Nation. *iStock photo*

Holistic and integrated risk assessments

Participants noted that risks are often assessed in siloes, focused on physical assets, and do not include a holistic, integrated, or interconnected understanding of risk and resilience. They also noted that risk assessments are more effective at capturing complex risks when they use an all-hazard approach and assess risks to both tangible and intangible values (e.g., ecosystems, infrastructure, health, economy, culture, and well-being). Participants highlighted there is no framework to consider and integrate equity and justice into risk assessments. Further, a more holistic approach can better consider the values and interconnections that are significant for Indigenous communities:

> *"It's more about understanding that as water temperature goes up, it's a risk to our salmon, it's them being exposed to a risk, which will then put our culture at risk rather than just saying the cultural infrastructure is at risk."*

Participants also noted that risk assessments should account for cumulative effects or factors that drive risk (e.g., the ongoing impacts of colonization, urban development, industry, and sociopolitical dynamics). One participant stated,

> *"What I would like to see is a new generation of … common working frameworks that don't require us to think of hazard and physical assets first but actually think about risks in a more holistic way."*

Indigenous Knowledges and working in good ways

Making space for Indigenous Knowledges and working with Indigenous communities in good ways were strong themes that emerged across the focus groups and interviews. Indigenous Knowledges need to be recognized as inherently valuable and weighted equally with western science. Many participants echoed this sentiment, with one participant stating,

> *"Integrating Indigenous Knowledge into a western framework is not the same as supporting and enabling it to stand on its own as an inherently valuable way of understanding and assessing risk."*

Participants spoke to the importance of grounding Indigenous Knowledges in community and partnerships, with one participant describing,

> *"Indigenous Knowledge is so locally held and there [are] so many protocols and pieces of spirituality and responsibility that are tied into the knowledge, you really have to go and talk to the community and look at what makes sense."*

Participants suggested that cultural safety training should be required for practitioners and decision makers working with Indigenous communities on risk assessments and emergency response.

Participants highlighted that risk assessments could provide opportunities to advance commitments to the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), the B.C. Declaration on the Rights of Indigenous Peoples Act (DRIPA), and truth and reconciliation. Participants stated that First Nations in B.C. should assess risks in ways that are self-determined, culturally appropriate, context specific, and match their priorities, timeline, and capacity. They also noted that guidance is needed to understand how to action reconciliation principles and include First Nations' rights and title in risk assessments.

> *"A risk assessment…that [doesn't] burden any First Nations, but…that recognizes and… actualizes Indigenous jurisdiction and authority are really important."*

Coordination and consistency

Participants described that risk assessment frameworks often lack consistent definitions and approaches. For example, the definitions for vulnerability, disproportionate impacts, and resilience vary across hazards and disciplines. Approaches to risk classification (e.g., risk matrices) and likelihood metrics also vary. Participants from the wildfire focus groups noted that risk assessments should include more intentional and strength-based framing, definitions, and language. Participants from the flood focus group described that guidance, including sector-specific tools, or direction on project type, location, or region may be helpful.

Participants across all focus groups and interviews described a lack of coordination in how the public and private sectors assess risk across the province. Moreover, they described duplication of efforts and inefficiencies. Several participants stated that while risk assessments should be grounded in local context, regional or watershed-level partnerships should be leveraged to share quantitative analyses and collaborate on resilience planning or emergency response:

> *"We've [regional district] created our own [hazard] models, our own worst-case scenarios to build our planning to meet our service levels … the issue there is that we're all going to be duplicating this research."*

Participants noted that research to evaluate the optimal geographic scale for risk assessments may support regional partnerships.

iStock photo

Actionable results

Participants expressed varying sentiments about whether risk assessments are useful and result in effective adaptation and risk reduction. One participant summarized a common concern by saying, "people will look at the assessment as a checkbox.

> *"We're very good at coming up with plans. We're not very good at actioning those plans."*

PICS theorizes that part of the broader challenge in translating risk assessments into action is related to issues with adaptation and emergency management in B.C. For example, across the focus groups and interviews, participants described a severe lack of funding and capacity for implementation and risk reduction. One participant working in emergency management said,

> *"My workload has exploded. We have no downtime between incidents. There's no time for planning and [risk] mitigation. It's drastically diminishing my capacity."*

Participants also spoke to policy barriers, governance challenges, research needs, and opportunities for improved decision support tools for adaptation and emergency response. One participant described the opportunity for,

> *"A menu of [adaptation options] you can use to accomplish this work in different ways depending on what you're looking to do."*

Nonetheless, participants suggested that risk assessments should clearly link to actions for emergency management, adaptation plans, and specific outcomes, such as improved ecological and community resilience. They noted that proper guidance and capacity can support actionable risk assessment practices. They also discussed the need for long-term funding mechanisms to ensure risk assessments are dynamic, relevant, and can incorporate new information. One participant expressed concern with the static nature of these projects:

> *"It feels like we're putting a pin in the [extreme heat] mapping project and it's becoming a static piece of work. And it will give us a benchmark to refer back to and springboard forward from. But it will all change tomorrow, right? And it just continues to change and evolve."*

Climate change research

The state of climate change research in B.C.: a literature review

There is a large academic community that is actively researching climate change across B.C. While many information needs exist and will be explored in later sections, there is a general sense of climate change and hazard trends in B.C. (Table 2).

While climate change research continues to evolve, there are several cross-cutting challenges related to climate change research in B.C. First, there is a well-known geographic research imbalance. Local and regional disaster literature tends to focus on urban centres and densely populated

Water skimmers work the Pigeon Creek wildfire by filling up in Okanagan Lake (known as kłusxnitkʷ, or a "place or body of water that has two long sides," to the syilx Okanagan people). Captured on June 7, 2023 in Peachland, B.C. *iStock*

TABLE 2: CLIMATE CHANGE AND HAZARD TRENDS IDENTIFIED IN THE ACADEMIC LITERATURE

Wildfire	» 2017, 2018, 2021, and 2023 were four of the most severe wildfire seasons in B.C.[43] » Wildfire activity in B.C. increased over the last 20 years due to climate change combined with past and ongoing fire suppression, land use practices, and the disruption of Indigenous fire stewardship.[14, 43–45] » Climate change is likely to increase severe fire weather, wildfire occurrence, intensity, fire season length, and area burned in Canada, especially in the southeast and interior of B.C.[46–49]
Extreme heat	» Research shows that climate change made the 2021 heat dome across the Pacific Northwest 150 times more likely.[50, 51] » Climate change is likely to increase the frequency, intensity, and length of extreme heat events across Canada.[50–53]
Drought	» Climate change is increasing the frequency and severity of droughts, which contribute to water scarcity in B.C.[54, 55] Drier conditions are projected in B.C.'s southern and interior regions.[56] » Warmer temperatures and altered precipitation patterns are stressing water resources. As glaciers and snowpacks melt, water availability will become more unpredictable.[57] » Drier and warmer winters are more likely to produce severe snow drought (lack of snow accumulation). Snow drought can lead to decreased summer streamflow and decreased summer groundwater storage. [58, 59] Snowpack in coastal and southern river basins in B.C. are projected to decline significantly.[60]
Floods	» Climate change is likely to increase temperatures, alter precipitation patterns, and contribute to glacier and snowpack melt which will shift river flow timing and effect flood events.[17, 61, 62] » Atmospheric rivers will likely increase in strength and frequency in the Fraser River Basin by 2100.[63] Sea level rise is projected to exceed 50 centimetres for Prince Rupert, Haida Gwaii, and Vancouver by 2100.[64] » Increased rainfall and storm surges will intensify flood events, with more flash floods in urban areas due to overwhelmed drainage systems.[65–67]

areas leaving rural and remote disaster-prone locations understudied.[68] Researchers tend to focus on locations or specific hazards that have available and accessible datasets (e.g., earthquakes in Metro Vancouver).[68] Northern, rural, and higher elevation regions also have insufficient weather stations, data collection instruments, and datasets.[7, 61] This constrains a baseline understanding of regional climate, weather, and hazards, and may be exacerbating the lack of research and modelling in specific regions. The diversity of ecosystems and landscapes in B.C. also challenges the ability to have high-resolution data and locally specific research.

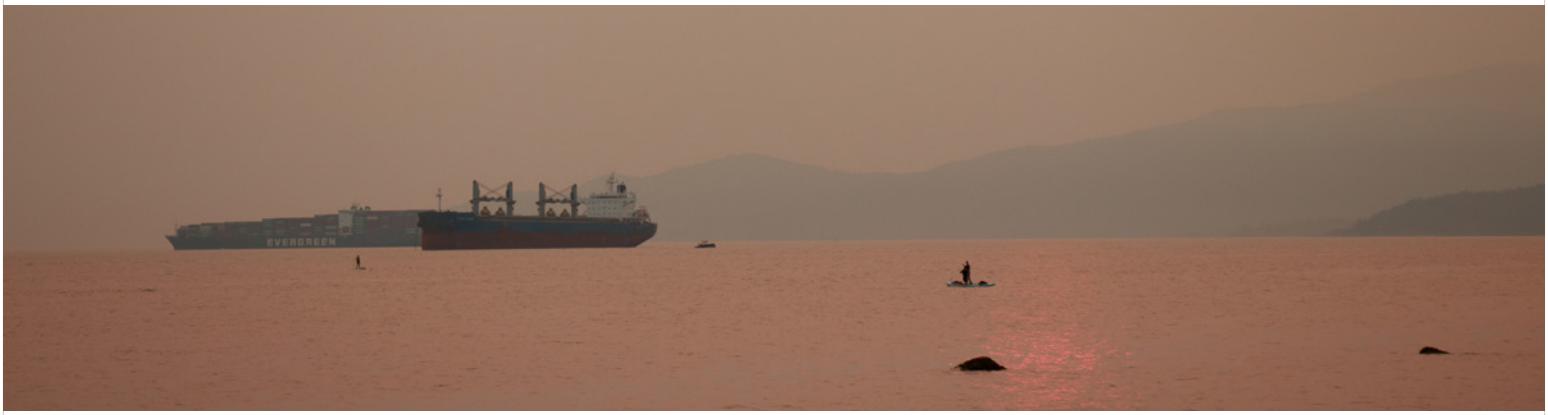
A recent literature review by the University of British Columbia (UBC) Disaster Resilience Research Network noted discrepancies between disaster trends in the literature and actual disaster trends in B.C.[68] For example, hazards such as storms and extreme weather events (including atmospheric rivers, extreme heat, and drought) are understudied, despite the fact that many communities in B.C. are exposed to these hazards and/or have experienced them.[68] This discrepancy is compounded by significant gaps in primary data related to drought risk and hazard mapping related to flood risk.[69, 70] Further, as B.C. is increasingly experiencing cascading and compounding hazards, more research is needed in this area, particularly on the impacts at local and regional levels.[2, 61, 71] Although the research community has an anecdotal understanding of these hazards, modelling them and their related risks remains a global research challenge.[19, 61, 71–73]

Few research methods exist to measure the non-fungible impacts of climate hazards (e.g., impacts to ecosystems, culture, and social cohesion). As a result, climate impacts to social and cultural values are poorly tracked, assessed, and managed.[17, 70] Without clear research to characterize, evaluate, and monitor the impacts to these values, they can be excluded, deprioritized, or inappropriately replaced with economic valuation.[17, 18] Part of the challenge is that disaster research in B.C. is not necessarily interdisciplinary, but instead concentrated in science, technology, engineering, and mathematics fields, specifically, engineering and earth sciences.[68] Siloed research may lead to outputs that are unable to support the complex, cross-sector, and interdisciplinary research needs related to climate change.

Increasingly, there are calls for the recognition and valuing of Indigenous Knowledges in research as well as for Indigenous research led by and for Indigenous communites.[15, 18] Disaster literature in B.C. has not fully acknowledged First Nations and the colonial history and context of disasters.[68] This is an area of opportunity to bring together Indigenous Knowledges with western science and answer key research questions at the intersection of disaster and climate risk and resilience. Notably, the B.C. First Nations Leadership Council* is identifying First Nation specific research and data needs and supporting Nation-led research through the Climate Strategy and Action Plan.[74]

* The First Nations Leadership Council is made up of political executives from the B.C. Assembly of First Nations, First Nations Summit, and Union of B.C. Indian Chiefs.

Aerial view of flooded farmland on southern Vancouver Island. *iStock photo*



Smoky sunset over Vancouver harbor, territory of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) Nations (Vancouver). *iStock*

Climate change research in B.C.: a dialogue on needs and opportunities

Wildfire

Participants identified key information needs related to understanding wildfire risk and strengthening wildfire risk assessments (Table 3). Specific information needs related to understanding forest composition, fuel types, and fire behaviour across B.C.'s diverse ecosystems. One participant noted,

> *"We do have a pretty good handle on fire regimes in our Interior dry forests … we don't know very much about fire and sub-boreal forests and coastal forests. British Columbia is incredibly complex and a fuel treatment that's very successful in one fuel type does not work in another."*

Participants also described information needs related to health and community impacts during and after evacuations and cascading and long-term risks related to wildfires. One participant said that

> *"One of the things we hardly talk about enough is the mental health impact of wildfire smoke and the emotional burden that's taking on society."*

Participants described the inability to access differentiated health data, particularly for northern, rural, and remote communities, as a barrier to understanding wildfire exposure.

TABLE 3: INFORMATION PRIORITIES FOR UNDERSTANDING WILDFIRE RISK

Information needs identified by participants	Connection to understanding wildfire risk
Comprehensive data, inventories, and mapping of surface and canopy fuels	Increase ability to identify where and when wildfires are most likely.
Information on ecosystem-specific fire behaviour (e.g., burn likelihood of different fuel types and the effects of seasonality on fire severity)	Increase ability to identify where and when wildfires are most likely.
Information and synthesis of the health and community impacts of wildfire (e.g., physical and mental health impacts of smoke and the impacts of repeated evacuations)	Enhance knowledge of the potential health consequences of wildfires.
Information and data on the cascading risks of wildfire (e.g., wildfire impacts on soil, hydrology, and water quality)	Increase information about the cascading consequences of wildfires and identify where those impacts are more likely.
Approaches to analyze and articulate the costs and values at risk	Improve ability to identify and assess community-level values at risk due to wildfire.

Participants identified information needs for guiding effective risk reduction and supporting resilience for communities and different sectors (Table 4). Many participants described the importance of learning from deep land-based local and Indigenous Knowledges and implementing cultural and prescribed burning as essential tools for risk reduction. They identified research needs related to the effects, benefits, and good practices for cultural and prescribed burning which could be addressed through co-designed and/or Indigenous-led research and approaches. One participant stated,

> *"When we sit down, and we work together ... we're not only able to prepare and make ourselves ... less vulnerable to the aspects of wildfires ... but we're able to produce a productive, healthy landscape as well."*

Both wildfire risk and response are shaped by governance and policy, which remain complex, colonial, and jurisdictionally challenging. Participants identified information needs related to identifying and evaluating practices for collaborative, decolonial, and multi-governance models. They also spoke to major risk communication challenges, specifically about the critical role of "good" fire in many B.C. landscapes and the impossibility of eliminating all wildfire risk. Highlighting the public's aversion to all wildfires, one participant noted,

> *"Some people don't have a good understanding of real versus perceived risk ... and our public can be disconnected from risk assessment."*

Trees burned in the 2023 MacDougall Creek wildfires (unceded syilx Okanagan territory), captured during the Wildfire Coexistence in B.C. Symposium in June 2024. *Alyssa Hill photo*

TABLE 4: INFORMATION PRIORITIES FOR ADDRESSING WILDFIRE RISK REDUCTION

Information needs identified by participants	Connection to addressing wildfire risk reduction
Indigenous-led approaches and methods for documenting cultural and prescribed burning practices, like ideal timing and practices for safe burning, and outcomes like cultural and social benefits	Improve understanding and use of cultural and prescribed burning.
Scan of forest management policies and forest industry practices to incentivize resilient ecosystems/landscape practices	Increase involvement of the forest sector in wildfire risk reduction practices.
Analysis of forest composition and ecological changes to guide management practices for resilient forests and ecosystem values	Increase management and planting practices for resilient forests and ecosystems.
Decision support tools for risk reduction prioritization and landscape management strategies	Improve practitioners' ability to prioritize and implement effective wildfire risk reduction measures.
Approaches and strategies for communicating wildfire risk with the public	Increase public knowledge about wildfire risk, risk reduction, and improve preparedness.
Approaches and incentives to increase FireSmart BC practices	Increase FireSmart BC activities at the household level.
Information and actions (e.g., educational campaigns and policy decisions) to reduce human-caused ignitions	Reduce human-caused ignition risks.
Scan of housing policies and new development exposure to wildfires	Improve understanding of how housing policies influence exposure to wildfire.
Identify and evaluate collaborative and multi-governance models.	Improve cross-jurisdictional coordination for addressing and reducing wildfire risks.

Finally, participants identified information needs to improve wildfire evacuations, response, and recovery (Table 5). Participants indicated that there is a lack of information to guide recovery, and that resources are more often directed to immediate emergency response with insufficient understanding of how to monitor, assess, and address longer-time impacts and rebuilding efforts. Information needs were identified for both ecological and community recovery efforts, with specific focus on First Nations communities in B.C. that are more likely to be evacuated. Notably, there are many existing post-wildfire response, evacuation, and recovery resources, including documents developed by First Nations, that should be leveraged [75–80]. Participants noted these challenges extend well beyond research, but collaborative or co-designed research could be a valuable contributor in identifying and evolving new approaches to response and recovery.

TABLE 5: INFORMATION PRIORITIES FOR IMPROVING WILDFIRE RESPONSE AND RECOVERY

Information needs identified by participants	Connection to understanding wildfire response and recovery
Guidance on post-disaster recovery such as the barriers and enablers for rebuilding and the appropriate processes, structures, and supports for recovery	Improve policies, decisions, and supports for recovery.
Synthesis and evaluation of economic and social (including mental health) impacts of wildfire evacuations	Improve post-evacuation supports and reduce long-term social and economic impacts of wildfires.
Information on post-wildfire ecosystem impacts, recovery, and rehabilitation	Improve ability to recover and rehabilitate ecosystems post-wildfire.
Explore the implications (financial and ethical) of relocation for communities in high-risk areas, particularly for remote and First Nations communities.	Explore different long-term options for communities facing high risk.

Extreme heat

Participants identified key information needs to improve understanding of extreme heat risk, particularly related to human, ecosystem, and infrastructure vulnerability (Table 6). Participants discussed that additional information, monitoring, and data on the cascading impacts of extreme heat to agriculture, food systems, ecosystems, as well as compounding

TABLE 6: INFORMATION PRIORITIES FOR UNDERSTANDING EXTREME HEAT RISK

Information needs identified by participants	Connection to understanding extreme heat risk
Detailed and disaggregated demographic and health data (including strategies for collecting data)	Increase ability to identify where and when public health impacts are most likely, particularly for vulnerable and equity-denied groups.
Projections and analysis of electricity demand and production capacity during heat events	Increase ability to identify where and when heat impacts on critical infrastructure are most likely.
Assess heat vulnerability of small/medium water systems	Increase ability to identify where and when heat impacts on water systems are most likely.
Information on specific heat risks and safe heat thresholds for vulnerable groups	Improve understanding of specific risk factors to identify most at-risk groups and locations.
Information on the factors and conditions that exacerbate or protect against heat risk in Indigenous communities	Improve understanding of specific risk and resilience factors to support Indigenous communities during heat event.
Information and data on agriculture and food system heat impacts	Increase ability to identify where and when heat impacts on agriculture are most likely.
Monitoring and data for extreme heat impacts on other hazards and ecosystems (e.g., drought, wildfire, flood, vector-borne diseases, water quality)	Improve understanding of heat impacts on ecosystem health.
Information on cascading and compounding risks (e.g., socioeconomic impacts, infrastructure failure, and pressure on health services)	Increase information about cascading consequences of heat and identify where these impacts are more likely.

Freighter spotted off Victoria. *iStock photo*

risks (e.g., heat and smoke) is needed. Lack of data accessibility and data governance were identified as key challenges to accessing detailed demographic and health data, which is needed to identify vulnerable populations. Participants also noted a geographic research imbalance—northern, rural, and remote communities face distinct challenges related to extreme heat which require geographically specific data and research.

Participants identified research needs related to supporting effective healthcare and emergency preparedness and response measures to extreme heat (Table 7). Participants described the need to broaden definitions of risky temperatures beyond extreme heat days to include extreme cold, unseasonal temperature spikes, and ongoing exposure to milder heat waves to provide a more comprehensive and coherent assessment of the risks from climate change-induced temperature changes. They also stated there was a need for more information on the effectiveness of cooling strategies at home and in public settings. Participants recognized that First Nations hold knowledge about historical ways of staying cool. One participant stated,

> *"Communities know what's changing. We have decades of that evidence."*

Participants also noted a need for more research on effective healthcare and emergency services delivery to ensure they are prepared to address the impacts of extreme heat. One participant stated,

> *"There's virtually no clinical research on heat stroke ... we have very little knowledge practically on how to best ... treat these patients ... we think we know how to do it, but there's no randomized trials."*

Additional research could focus on better response protocols for health care systems, medical supply requirements, and cross-agency communication.

TABLE 7: INFORMATION PRIORITIES FOR ADDRESSING EXTREME HEAT RISK REDUCTION AND RESPONSE

Information needs identified by participants	Connection to understanding extreme heat risk reduction and response
Broaden definitions of "risky" temperatures to include extreme cold, unseasonal temperature spikes, and ongoing exposure to milder heat waves	Facilitate risk reduction and response plans for different temperature thresholds.
Strategies for urban tree planting that reduce heat exposure	Understand effectiveness of urban greening in reducing heat island effects and the trade-offs with other policy priorities.
Evidence-based information on temperature thresholds and worker protection protocols	Inform occupational safety regulations and employer policies to reduce heat exposure in workplaces.
Evidence-based information on safe temperature thresholds for vulnerable groups	Inform targeted interventions for most at-risk groups.
Evaluation of cooling strategy options in homes (especially for rental housing)	Improve evidence-based policies to protect public health at the household level.
Evaluation and synthesis of cooling strategy options for public and urban spaces	Improve evidence-based policies to protect public health at the community level.
Evaluation of healthcare and school heat management practices	Inform policy development for heat-resilient infrastructure in essential institutions.
Evidence-based information on healthcare heat response protocols	Support healthcare administrators and emergency planners to develop protocols for patient prioritization, facility cooling, and staff safety during extreme heat events.

Drought

While participants were less familiar with drought risk assessment and did not identify specific risk assessment challenges or opportunities, they did identify information needs related to understanding drought risk and serving the most vulnerable populations and sectors (Table 8). One participant summed up the state of knowledge by saying,

> *"We don't know how much water we use in B.C. I don't know how much water I use in my house .... We just assume that when we turn the tap on that there will be this plentiful supply."*

Participants identified data and research needs related to drought exposure and impacts including understanding regional hydrology, landscape management impacts on hydrology, socioeconomic impacts of drought, and how hydrometeorological shifts may influence hydroelectricity:

> *"The only tools we currently have to be anticipating how bad drought might get in the future are things like global climate models and there's a lot of uncertainty related to those."*

Across the information needs, participants discussed the need to break down disciplinary siloes and increase data accessibility. For example, they said that drought data may exist but is either not accessible, in a usable format, or available at the right scale.

TABLE 8: INFORMATION PRIORITIES FOR ADDRESSING EXTREME HEAT RISK REDUCTION AND RESPONSE

Information needs identified by participants	Connection to understanding drought risk
Hydrological and watershed monitoring and drought outlook data and forecasting	Increase ability to identify where, when, and how consequential a drought may be.
Data and monitoring of snowpack	Increase ability to identify where, when, and how consequential a drought may be.
Data and monitoring of water supply and demand from households to large scale users	Increase ability to identify where, when, and how consequential a drought may be.
Data on agricultural and crop water demand	Improve understanding of agricultural water use.
Data and monitoring of water quality	Increase ability to monitor where, when, and how consequential a drought may be.
Regional and watershed specific hydrogeology and hydrology models and information	Increase understanding of regional hydrology and ability to monitor where, when, and how consequential a drought may be.
Assessment of the effects of landscape management (e.g., development, industry) and water use practices on hydrology	Increase understanding of factors that increase drought risk.
Assessment of socio-economic impacts of drought (e.g., productivity and economic impacts for agriculture, traditional and community food systems, and ecosystem health, specifically salmon)	Increase information about the potential consequences of drought.
Evaluation of systemic and disproportionate impacts of drought (e.g., communities with small water systems, small agricultural producers, marginalized communities, specifically First Nations and remote communities)	Improve understanding of the disproportionate impacts of drought and factors that increase vulnerability to drought.
Analysis of how snowpack-to-rain hydrological transitions will impact hydroelectricity generation	Increase information about the potential consequences of drought on hydroelectricity.
Assessment of cumulative and multi-year drought on landscapes and communities	Increase information about the effects of different types of droughts.
Identify the relationship between drought, wildfire, and flood risks and assess the cascading impacts of drought on ecosystem health (e.g., soil and forests).	Increase information about cascading consequences of drought and identify where those impacts are more likely.

An organic winery vineyard in Okanagan Falls, traditional and unceded territory of the syilx Okanagan people. *iStock photo*

Participants identified the need for evidence-based guidance and decision support tools for water management, water infrastructure investment, and drought risk reduction planning (Table 9). One example discussed was the need for analysis of regulatory barriers and opportunities surrounding water use in the province. Participants also identified that learning from Indigenous Knowledges and Indigenous water stewardship is an important starting point to improve drought resilience. Some participants suggested that Indigenous-led processes and collaborative water governance models may support risk reduction while protecting multiple values. One participant noted that,

> *"Water security isn't something we achieve but a relationship we maintain."*

Participants discussed the need for swift action to reduce water scarcity impacts from drought, aridification, and land use stressors on watershed resilience, and the importance of adaptive management to accommodate uncertainties. They noted applied research was needed to evaluate different drought risk reduction measures including managed aquifer recharge and water storage for agricultural purposes.

TABLE 9: INFORMATION PRIORITIES FOR ADDRESSING DROUGHT RISK REDUCTION

Information needs identified by participants	Connection to addressing drought risk reduction
Evidence-based guidance for environmental flow management (e.g., water curtailment, reservoir management, and environmental flow protections)	Improve guidance for managing flows under drought conditions.
Evaluation of water infrastructure investments, including cost-benefit data and "business cases" to support proactive investments in resilient and nature-based infrastructure	Improve investments in water infrastructure that support drought resilience.
Explore the role of DRIPA in water/resource management, as well as the use of Indigenous-led tools and guidance materials for water management.	Increase Indigenous-led water stewardship.
Evaluation of how growing communities meet housing demands while balancing water security concerns	Evidence and guidance to balance urban growth with drought risk
Evaluation of regulatory constraints and incentives for adaptive water management practices (e.g., grey water reuse and rainwater harvesting)	Evidence to support adaptative water management practices
Evaluation of lessons learned from existing drought resilience planning, evaluation of community drought emergency response and contingency plans, and investigation barriers and opportunities for water storage	Improve community-level water management and drought planning.
Evaluation of where managed aquifer recharge is possible	Improve opportunities for water security.
Information and guidance on water storage for agriculture	Improve opportunities for water security.
Information and strategies on reforestation to reduce drought vulnerability and improve soil moisture retention and ecosystem health	Improve resilient reforestation practices.

Floods

Participants identified research and data needs related to understanding flood risk and strengthening flood risk assessments (Table 10). Participants discussed research needs related to the direct impacts of flood events (e.g., agroeconomic and socioeconomic impacts) and longer-term impacts of floods on communities and ecosystems. Participants stated that the methods for measuring risk associated with assets that are uninsured or difficult to quantify (e.g., private assets, land, nature, and ecosystems) need to be improved. The challenge of measuring and incorporating multiple (often intangible) values was expressed by one participant:

> *"How do we move forward with projects and evaluate them in a much broader way so that other types of values are included in the way that we're evaluating them."*

Participants identified research needs related to how flood impacts cascade, for example, to supply chains and the economy. They also stated more research was needed on cascading hazards that drive flood (e.g., drought and wildfire) and the compounding impacts of different types of flood events.

> *"We have to think about not just flooding, but flooding in context with forestry, in context with droughts, in context with all sorts of other hazards, earthquakes .... I think a lot of research needs to go into understanding these interconnected issues related to flood management."*

Devastating flooding of Sumas Prairie, Abbotsford, in 2021, known as Sumas Lake or Semá:th Xhotsa by Semá:th First Nation. *iStock photo*

TABLE 10: INFORMATION PRIORITIES FOR UNDERSTANDING FLOOD RISK

Information needs identified by participants	Connection to understanding flood risk
Flood models aligned with near real-time monitoring frameworks	Increase ability to identify where and when a flood event may occur.
Local and sub-local watershed data and flood models	Increase ability to identify where and when a flood event may occur.
Considerations of how water flows in floods	Improve understanding of how a flood event may occur.
Evaluate flood impacts to the agricultural sector (e.g., agronomic and economic impacts).	Improve evidence on the potential consequences of flood.
Socio-economic flood impact studies (e.g., how community demographics relate to flood risk and flood effects on health, public services, and economic production)	Improve evidence on the potential consequences of flood.
Evaluate psychosocial and physiological effects of flood.	Improve evidence on the potential mental health effects of flood.
Improve understanding of cascading impacts of floods (e.g., supply chains, utilities, and critical services).	Increase information about cascading consequences of flood and identify where those impacts are more likely.
Cascading impacts of different types of flood events and the relationship between drought, wildfire, and flood risk	Increase information about cascading consequences of flood.

Participants noted that more evidence was needed to support effective flood preparedness and implementation of more complex adaptation actions (Table 11). They identified that frameworks and guidelines to support decision-making for flood adaptation options and asset management may be helpful.

Emergency response workers and community members pile sandbags in preparation for a flood in Kelowna, traditional and unceded syilx Okanagan territory. *iStock photo*

Finally, participants identified governance and policy limitations associated with flood management and complex jurisdictional roles and responsibilities. Research may help understand how risk and responsibility are held across the system and help answer the question of "who is responsible for what." Many participants noted that stronger governance, new policies, and social license are required to address flood risk in many places across B.C.:

> *"When we start to implement much more complex solutions, like managed retreat … we just don't have the regulations or the funding to actually support these types of [decisions]."*

TABLE 11: INFORMATION PRIORITIES FOR ADDRESSING FLOOD RISK REDUCTION AND RECOVERY

Information needs identified by participants	Connection to understanding flood risk
Guidance for integrating sea level rise information in inland planning and risk management	Improve ability to consider sea level rise in land-use planning.
Review dike management best practices, including devolution to local governments.	Improve governance and coordination of dike management.
Develop tools and supports for return on investment for "build back better" strategies.	Improve understanding of "build back better" strategies.
Evaluate flood mitigation authority and accountability to generate recommendations and guidance for improved collaboration across jurisdictions, agencies, and entities	Improve governance and coordination of flood mitigation.
Evaluate the distribution of flood risk and responsibility across the current asset management system.	Improve accountability and coordination of flood mitigation.
Evaluate flood adaptation drivers including drivers for household and community preparedness.	Improve preparedness for flood risk and optimize opportunities for flood adaptation.
Develop cost-benefit analysis of different flood mitigation options for the agricultural sector.	Improve understanding of different options for effective flood mitigation.
Comparative research on different flood adaptation strategies (e.g., accommodate, protect values, managed retreat)	Improve understanding of different options for effective flood adaptation.
Identify and leverage existing local government mechanisms for climate resilient practices	Improve implementation of effective flood adaptation through existing land-use planning and urban design policy levers.
Guidelines for advanced asset management, including best practices from other jurisdictions to prioritize repairable infrastructure and improve resilience	Evidence-based guidance for asset management
Information on relocation patterns and impacts, particularly for remote and First Nations communities	Improve understanding of implications of relocation.

TABLE 12: EXAMPLES OF HOW CLIMATE CHANGE INFORMATION IS INTEGRATED INTO RISK ASSESSMENTS

Type of risk assessment	Example assessments	Approach used to integrate climate change information
Disaster risk assessments	» Canada's National Risk Profile [70] » Australia's National Emergency Risk Assessment Guidelines [81] » Calgary Disaster Risk Report [82] » Washington State Enhanced Hazard Mitigation Plan [83]	» Climate change is considered one of many risk drivers for hazards. » Climate change research is usually referenced in relation to the impacts of past disasters and the likelihood and potential consequences of hazards in the future. » An increasing or decreasing trend of the climate hazard is included as part of the future likelihood score or future hazard trend. » More advanced disaster risk assessments leverage both climate projections and climate research to assess the likelihood and consequence of future hazards (see Washington Enhanced Hazard Mitigation Plan).
Climate change risk assessments	» European Climate Risk Assessment [84] » Arotakenga Huringa Āhuarangi: A Framework for the National Climate Change Risk Assessment for Aotearoa New Zealand [85] » Ontario Provincial Climate Change Impact Assessment Technical Report [86] » NWT Climate Change Risks and Opportunities Assessment [87]	» Climate change hazards and impacts drive the risk assessment scope. » Climate change research is usually collated through a literature review. » Climate projections and research are integrated throughout the assessment; climate projections are used to inform past, current, and future likelihood scores. » Climate change research informs the selection of risk scenarios, the characterization of exposure, vulnerability, adaptive capacity, likelihood, and consequence. » More advanced assessments include a characterization and evaluation of the evidence base and areas of uncertainty.

Integrating climate research into risk assessments

A review of practices

Integrating up-to-date climate change research is essential to developing risk assessments that are effective, evidence-based, and support decision-making. To understand good practices for integrating climate change research into risk assessments, PICS reviewed more than 20 unique risk assessments from both Canadian and international jurisdictions as well as risk assessment guidance documents and academic literature on risk assessment practices. Although PICS focused on climate change research, each risk assessment included many types and sources of both qualitative and quantitative information (e.g., geospatial data, census data, local, community, and Indigenous Knowledges, grey literature, media articles, and technical studies).

While good practice for risk assessments is to use the most up-to-date information, the range of risk assessment objectives and applications means there is no standard approach to integrating climate change research.[2–5]

> *"The range of risk assessment objectives and applications means there is no standard approach to integrating climate change research.*

One of the strongest indicators for how climate change research is considered is the type of risk assessment (Table 12).

iStock photo

For example, disaster risk assessments usually consider climate change as one of many risk drivers. As such, they sometimes integrate climate change projections and research, but only in specific ways or in part of the assessment, for example, when considering the future likelihood or trend of hazards. Alternatively, in climate change risk assessments, climate change drives the scope of the assessment including which risks and impacts are considered.

The review determined that the type of climate change research most often included in risk assessments was on the relationship between climate change and a climate variable or hazard (e.g., current or future changes of flood or extreme heat risk due to climate change). Other research that was included focused on current or future impacts of climate change to areas of value, sectors, or populations (e.g., impact of climate change on health, ecosystems, critical infrastructure, etc.). Where location-specific research was not available, risk assessments did integrate general climate research or climate research from other jurisdictions.

There was also a trend between the scale of a risk assessment and the depth of climate change research integrated. Risk assessments at provincial, national, and multi-national scales conducted comprehensive literature reviews, included or even developed climate projections for the assessment, and brought in academic and technical expertise. Risk assessments at local and regional levels included climate change projections but varied in the extent to which academic literature was considered. For example, ICLEI's Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation has no instructions to include academic literature or conduct a literature review[88]. This may be because larger scale risk assessments (and their budgets) support top-down processes conducted by consultants. Conversely, local and regional risk assessments do not have the budget, capacity, or expertise for academic literature reviews and rely on other information sources such as historical event data, census data, internal and external studies, and community engagement.

> *"Risk assessments at local and regional levels included climate change projections but varied in the extent to which academic literature was considered."*

The review also revealed that every risk assessment dealt with uncertainty, information gaps, and limitations. A common practice across the advanced risk assessments was to include the level of confidence in the evidence considering the amount, quality, and consensus of evidence integrated. This is good practice and can provide transparency and clarity on data uncertainty, gaps, and limitations to reduce misuse or misinterpretation.[12] The New Zealand Framework for the National Climate Change Risk Assessment[85] labelled the topics with "low confidence" as research priorities that need to be addressed before the next risk assessment.

A dialogue on challenges and opportunities

PICS asked participants how to better integrate climate research into a risk assessment and identified four themes: research availability and access; research useability and knowledge mobilization; research gaps and uncertainty; and reimagining research partnerships.

Research availability and access

One of the challenges that participants identified related to research was the lack of data availability and access. Across the focus groups, participants noted that several datasets that should inform risk assessments are not widely shared including data on flood risk, health, critical infrastructure

and assets, and water scarcity. In some cases, participants described the reasons why data is inaccessible:

> *"... [There are] still a lot of challenges with either proprietary data or confidential data ... like electricity usage data and critical infrastructure [data] from BC Hydro, for understandable reasons, is pretty lock and key ... and there's not much data sharing with other infrastructure owners."*

Another barrier was lack of access to academic articles, research, and general climate risk knowledge and information. Practitioners and decision makers frequently mentioned that paywalls blocked them from accessing publicly funded research. Participants also noted that they may not know research exists or where to find the information:

> *"... It might be this great piece of research, [but] there [are] so many libraries and climate tool websites and ... it's not easy to find them."*

Participants in each focus group stated that partnerships could improve research and data access, for example:

- Partnerships with health authorities may reduce data privacy concerns and open access to data on how extreme heat impacts health outcomes
- Partnerships with unions and business organizations may help mobilize information on occupational heat risk
- Partnerships with water users may support increased understanding of water sources, drought types, and build capacity for water management
- Partnerships with the insurance industry may support access to flood risk data and improve risk research

Participants in the wildfire and drought focus groups noted that data collection and sharing must uphold Indigenous data sovereignty through First Nations principles of ownership, control, access, and possession (OCAP®)[89] and Métis principles of ownership, control, access, and stewardship (OCAS). They suggested the use of data stewards and data sharing protocols, and thoughtful cooperation related to data governance. Understanding who is negatively impacted by data being shared or not being shared will be critical as data sharing is addressed. One participant described the importance of First Nations data:

iStock photo

> *"We're starting to collect our own data ... and what that means to our communities, because those that have the information have the authority."*

Research usability and knowledge mobilization

Another challenge that participants identified was research usability and knowledge mobilization (i.e., connecting research findings to real-world applications and decision-making). Participants described that research is often not at the right scale to assess risks or determine priorities. For example, participants in the drought focus group stated that data on water use for a large region is not at a useful scale for small communities, farmers, or organizations in the public and private sectors. Participants also noted that even when hazard exposure data was at the appropriate scale, it was not always reflective of the local context:

> *"I think one of the trickiest things that we found is how do we take the research and apply it into action at the community level. The data itself, we realized, didn't tell the story of our community."*

iStock photo

In terms of information format, PICS heard many research and risk-related reports were not available in the appropriate format to inform decisions. Some participants also noted they do not have the subject matter expertise to interpret technical or highly specific information and jargon. One participant summarized this frustration as,

> *"If I don't have that subject matter knowledge and I don't know the language in those risks reports, how can I possibly conceptualize what they're telling me?"*

Participants also expressed that they do not have time to review multiple articles or extensive documents to draw out the most important details for their risk work:

> *"One of my biggest challenges is wading through 200 pages ... [when] I need to write a response plan that has value."*

Another participant noted,

> *"As a consultant ... we don't have enough time to read all of the [literature], our clients aren't paying us to read all of these review materials."*

The need for concise and comprehensive information was also expressed:

> *"The information must be easy to understand. It must be concise in order for emergency managers to actually be able to find the information useful and to apply it."*

Opportunities to improve knowledge mobilization were discussed across the interviews and focus groups. Participants described activities like summarizing existing information (e.g., key climate change research), developing case studies from other jurisdictions, and creating guidance or good practice documents. Participants stated that general information or data that can be broadly applicable should be made available in a useable format:

> *"We don't need to invent the information that should already be readily available and is blanketed across the province or regionally within a health authority or regionally within a climate model."*

Participants also identified a role that can operate between practitioners and decision makers and academia to support knowledge mobilization. One participant described this concept as,

> *"... [a] role that might sometimes be called knowledge broker ... that helps to link science and policy where somebody is in a position where they can take scientific papers or reports and then understands what would be useful to decision makers and is able to create some of those summaries."*

Finally, participants discussed fit-for-purpose tools to support knowledge mobilization and increase the impact of research. There was strong consensus from the wildfire focus group on the utility of a platform or common interface to share fuel data, fuel treatment information, and interdisciplinary research related to climate risks. The flood focus group participants described the need for accurate and highly local datasets and suggested that these datasets could be hosted on the ClimateReadyBC website.

Research needs, limitations, and uncertainty

As described in the Climate change research section, there is a wide range of information needs and uncertainties related to climate hazards and the risks they pose to B.C. communities. While some of these needs can constrain risk assessments, adaptation, and emergency response, there was strong consensus that insufficient research is not an excuse for inaction. One participant described this sentiment as,

> *"Making a roughly right decision is possible and doesn't have to be a source of inaction."*

Another participant from the research community cautioned that even when research delivers additional insights, uncertainty persists:

> *"If we were making decisions about heat waves based on the data that could have been produced before the 2021 heat dome, we likely wouldn't have prepared any better. Instead, the conversation might need to focus on how we should make decisions in light of climate uncertainty."*

Several participants noted that guidance on how to consider uncertainty in risk assessments and decision-making would be helpful:

> *"... Uncertainty is a tough one to tackle, but yet I think that's really high on the priority list because inaction is not an option. We need to be acting now, but we need to do so carefully and strategically with limited resources."*

Reimagining research partnerships

Across the focus groups and interviews, there was agreement that to leverage research effectively and in more meaningful ways, communities, practitioners, and governments need stronger connections with researchers and opportunities for research projects, partnerships, and long-term dialogue:

> *"Researchers could fill a gap as long as it was informed directly by a need and not just the researchers saying, 'I think there's a need.'"*

Participants spoke to co-designed and co-produced research which can support communities to define their own research questions, guide quantitative and qualitative research, and produce highly relevant and actionable outputs. One participant described this approach:

> *"We're trying to come in from the bottom and talk to communities ... to see what they want to know, what they're concerned about ... it sort of changes the type of research you do but it's much more community centred."*

Participants in the flood focus group specifically noted the importance of bottom-up research approaches that include both local knowledge and Indigenous Knowledges.

Participants described that this research approach requires reciprocity and building relationships:

> *"The relationships persist. And that felt like one of the more important outcomes of the research process for you all was those relationships."*

Participants in both the flood and wildfire focus groups described the importance of culturally safe and trauma-informed research.

Participants across the focus groups and interviews discussed the benefits of interdisciplinary research and dialogue to improve information flow between (often) siloed groups (e.g., community members, practitioners, Indigenous Knowledge Holders, government, and academics):

> *"Having teams that bring together people that are producing the evidence with the people that need to use that or integrate that evidence into processes is important."*

Finally, participants stated that communities of practice or collaborative round tables (across hazards, disciplines, and practices in B.C.) could be beneficial models to help inform risk assessments and support more collaborative approaches. Communities of practice are groups that bring together disciplines, practices, and knowledge systems to discuss a common theme and exchange knowledge, discuss best

practices, and co-produce new knowledge. The focus groups were in some ways a pilot for these types of groups:

> *"I think when we get together in these conferences and focus groups that we collaborate and that we continue to have these discussions, but also to do something about it."*

Shuswap Lake in Salmon Arm, traditional territory of the Secwépemc (Shuswap) people. *iStock photo*

Research and knowledge mobilization agenda part 2:

Implementing opportunities

Risk assessments are an important tool for evidence-based risk management and informing adaptation practices that reduce the increasing costs and impacts of climate change. However, there needs to be more efficient and effective integration of climate change research and risk assessment practices to support transformative risk management, adaptation, and emergency response.

> *"There needs to be more efficient and effective integration of climate change research and risk assessment practices to support transformative risk management, adaptation, and emergency response.*

PICS sets forth three resilience pathways to implement the opportunities described in part 1; specifically, to strengthen risk assessments, improve the integration of climate change research into risk assessments, and address research needs in more meaningful and effective ways.

In this second part of the report, PICS describes each resilience pathway, and outlines action indicators and information priorities:

1. **Action indicator:** actions that can be taken to better integrate climate change research into risk assessments.
2. **Information priorities:** further research, analysis, or collaboration to address current information needs and challenges.

Resilience pathway 1: Improving risk assessment frameworks and processes

To bring climate change research into risk assessments, practitioners need a strong framework and process. Resilience pathway 1 presents an opportunity for governments and public and private sectors to shift from what risk assessments currently do—produce a prioritized list of risks—and what risk assessments could do with more robust frameworks, processes, and adequate funding: build relationships, unpack the nuances of local vulnerability and resilience, action reconciliation, increase public awareness, adequately assess the full risk landscape, and produce a prioritized list of risks.

Action indicators

- Risk assessments use mixed methodologies to consider both qualitative and quantitative information.
- Risk assessments use collaborative and participatory processes to bring together and reflect diverse knowledge systems, lived experiences, and disciplines.
- Risk assessment frameworks make space for Indigenous Knowledges and knowledge is exchanged in culturally safe ways.
- Risk assessment frameworks are holistic and integrated to assess all-hazard risks and consider the interconnectedness between risks.
- Risk assessment frameworks identify opportunities for action (e.g., adaptation and emergency management).
- Risk assessments are publicly available (e.g. compiled on ClimateReadyBC so that research and future risk assessments can build on past work).

There are several information needs that could support continued improvements to collaborative risk assessment frameworks and process (Table 13). As risk assessments inevitably evolve, practitioners and researchers should continue to evaluate and integrate innovative and emerging concepts and frameworks (e.g., Indigenous-led assessments, values-based assessments, health-specific assessments, and frameworks that include risk drivers).

TABLE 13: INFORMATION PRIORITIES TO SUPPORT RESILIENCE PATHWAY 1

Information needs identified by participants	Connection to risk assessment frameworks and processes
Approaches to advance First Nations rights and title in risk assessments	Indigenous-led and/or co-developed guidance to recognize and advance First Nations' rights and title (in alignment with UNDRIP) and action reconciliation in risk assessments at local and regional levels in B.C.
Approaches to integrate equity and justice into risk assessment processes	Additional evidence-based methods for integrating equity and justice considerations into assessments. Note: the Government of B.C. is currently developing guidelines to consider equity in risk assessments and emergency management plans.
Guidance on risk assessment terminology	Improve consistency and communication across governments and organizations (e.g., terms and definitions align with Canada's National Emergency Response System standards and mutual aid agreements).
Synthesis of adaptive capacity and resilience characteristics across B.C.	Better integrate social and institutional capacity, strengths, and resilience into risk assessments.
Evaluate the optimal geographic scale for risk assessments based on jurisdictional responsibilities, hazard events, and implementing solutions	Improve regional coordination, partnerships, and avoid duplication of assessments.
Synthesis of common barriers to adaptation and emergency management in B.C.	Improve tools and guidance that support the transition from risk assessments to actionable adaptation and emergency management planning.

Resilience pathway 2: Improving methods for integrating climate change research

To better integrate climate change research into risk assessments, there are opportunities to improve methods for sharing and applying climate change research. Resilience pathway 2 focuses on increasing the use of existing research in risk assessments, enhancing the availability and useability of research, and supporting good practices for considering climate change research in risk assessments.

Knowledge mobilization—communicating and sharing research and evidence in a way that meets practitioner needs—has been a long-standing challenge facing the global research community. However, B.C. has the ingredients for strong knowledge mobilization pathways with extensive academic, practical, and Indigenous expertise. B.C. is also home to "boundary spanners," or "boundary organizations," (e.g., Simon Fraser University's Mitigating Wildfire Initiative and UBC's Agricultural Climate Action Research Network (ACARN)) which support long-term knowledge mobilization, increase research useability, and provide opportunities to bridge research and application.[61, 71, 90] The Government of B.C. is working to centralize climate change information on ClimateReadyBC, which could also serve as a platform to disseminate key climate change research and data relevant to risk assessments.

> *"B.C. has the ingredients for strong knowledge mobilization pathways with extensive academic, practical, and Indigenous expertise."*

Good practices for considering climate change research in a risk assessment include collating relevant region-and-hazard-specific research and considering it alongside climate projections and insights from participatory processes. Climate change research should be considered when assessing hazard, exposure, and vulnerability, and determining the likelihood and consequence in a risk assessment. Recognizing the need for additional capacity and expertise for practitioners to integrate climate change research, partnerships with professional associations (e.g., engineers, consultants, planners) and climate data experts may support the development of consistent risk scoring guidelines that can be leveraged by both consultants and practitioners conducting risk assessments.

Action indicators

- Practitioners have channels to actively communicate emerging information needs with academic organizations.
- Governments and organizations draw from shared climate projection datasets and climate change research for all climate risk work they conduct (e.g., asset management and emergency planning) to improve efficiency and consistency.
- Boundary organizations and researchers are funded and support frequent knowledge exchange for academics, decision makers, practitioners, and Indigenous knowledge holders.
- Practitioners, decision makers, and researchers have opportunities to share learnings about different risk and resilience activities, projects, and methodologies for challenging, complex, or poorly understood topics.
- Indigenous-led research on climate risks is uplifted and highlighted across the province to support shared learning.
- Partnerships and data agreements between data owners and researchers improve access to raw proprietary datasets (e.g., flood risk, housing, critical infrastructure) and develop decision-ready datasets or information packages.
- Government-funded research is open-access and publicly available. If research cannot be made public, funding supports translating the most relevant outcomes into lay language.
- Practitioners have access to a climate change research and risk assessment repository (e.g., on ClimateReadyBC) with concise summaries of key climate change research, links to literature, and additional resources. Relevant tagging mechanisms for easy filtering are used to increase accessibility.

There are several information needs related to improving the way climate change research is shared, mobilized, and considered in risk assessments (Table 14).

TABLE 14: INFORMATION PRIORITIES TO SUPPORT RESILIENCE PATHWAY 2

Information needs identified by participants	Connection to methods for integrating climate change research
Establish guidelines for translating climate change research and projections into likelihood trends or scores. It may be useful to centralize likelihood estimates for all climate hazards by region to support capacity and remove the layer of technical expertise required.	Consistent interpretation of likelihood (e.g., a 1:100 event is a "medium likelihood") and method for determining likelihood scores.
Guidance on improving decision-making under uncertainty	Enhance evidence-based practices for making decisions under different degrees of uncertainty.
Additional evidence on effective approaches for knowledge mobilization and communicating risk information	Enhance the effectiveness of mobilization and communication techniques.
Outline accessibility barriers for key datasets needed in risk assessments.	Improve understanding of data accessibility barriers and needs.
Evaluate and co-develop good practices for data sharing that uphold Indigenous data sovereignty.	Ensure that risk and resilience data sharing practices align with privacy acts and Indigenous data sovereignty principles (OCAP®[89] and OCAS). The First Nations Leadership Council (FNLC) is working to strengthen First Nations data governance to generate, manage, and access climate information to inform decision-making, and engaging in respectful and reciprocal generation of climate data with First Nations.[74]

Resilience pathway 3: Innovative research approaches to address climate change research needs

To address climate change information needs in more meaningful and effective ways, academic organizations should engage in innovative and interdisciplinary research approaches with all orders of government and public and private sectors. There is a growing consensus around co-designed and co-developed research, and longer-term knowledge exchange opportunities (e.g., communities of practice) between researchers, decision makers, and rightsholders. These approaches, built on reciprocity and relationships, increase the relevance and useability of research findings for practitioners in the long term.[68, 91]

> *"Academic organizations should engage in innovative and interdisciplinary research approaches with all orders of government and public and private sectors."*

Research models in B.C. will also need to become nimbler to meet the evolving challenge of climate change and to incentivize researchers to step into research questions that have less literature to build upon or poor datasets. This is a broad challenge that requires higher-level direction, accountability, and incentive from research funders. PICS is uniquely positioned to catalyze and mobilize climate change research in B.C., and PICS' three new program streams intend to support more transformative research models. For example, the Climate Foresight stream is supporting transdisciplinary research to address complex and poorly understand climate issues; the Community Co-Design stream is focused on co-designed research in partnership with communities; and the Decision Impact stream is developing and mobilizing decision-relevant research for key policy challenges.

Action indicators

- Key hazard information needs identified throughout the research agenda are prioritized through research funding calls and initiatives.
- Researchers have funding to address key research needs and/or significant unknowns or uncertainties of the risk and resilience landscape.
- Researchers have access to proprietary datasets (e.g., flood data, B.C. Assessment data, and critical infrastructure data) to develop decision-ready datasets or information packages, through partnerships and data sharing agreements.
- Rural, remote, and First Nations communities have adequate research and data to assess the climate hazards and impacts.
- Research needs are addressed by interdisciplinary teams and approaches (e.g., to consider cross-sector, multi-hazard, and interdisciplinary research questions).
- Indigenous-led research in B.C. has funding and Indigenous Knowledges are reflected in disaster and climate change scholarship.
- Academic organizations support co-designed and co-developed research with practitioners and decision makers to support highly relevant research outputs.
- Local and regional governments have opportunities to partner with researchers and academic institutions to engage in relevant research projects (e.g., through local government granting programs such as the UBCM Community Emergency Preparedness Fund).
- Communities of practice and regional knowledge hubs have funding to build long-term research partnerships and increase information sharing across hazards, disciplines, and practices. This project convened four hazard-specific groups with researchers, practitioners, and Indigenous knowledge holders that could be further engaged and leveraged in the future.

There are many information needs and priorities related to understanding the risk of each climate hazard in B.C., including data gaps, more information on risk factors that increase vulnerability, and improved understanding of immediate and cascading impacts (see Climate change research Tables 3, 6, 8 ,10). Further, there are also substantial information needs for evidence-based risk reduction, emergency response, and recovery for each climate hazard (see Climate change research Tables 4, 5, 7, 9, 11).

Burned trees in arid landscape near Kamloops, Tk'emlúps te Secwépemc territory. *iStock photo*

Next steps

The objectives of this report are to provide recommendations on how to integrate climate change research into risk assessments and to identify research needs that support on-the-ground risk and resilience in B.C. The research agenda was co-developed with a diverse constituency of practitioners, researchers, and Indigenous Knowledge Holders and brings forward a state of play around how risk assessments are being deployed and key opportunities to improve the integration of climate change research into this tool and process. The research agenda also articulates information that practitioners need in order to support more effective climate resilience.

There are clear pathways to build upon and implement the research agenda. First, this project brought together experts to identify challenges with current risk assessments and identify solutions to improve frameworks and processes. As B.C. public and private sector organizations continue to deploy risk assessments, there are opportunities for practitioners to integrate practices identified in Resilience pathway 1 and to identify additional risk assessment research needs as they arise.

Second, this project brought together experts to identify on-the-ground information needs for each climate hazard. While the literature review was not designed to validate each identified information need, the information needs do reflect real or perceived information gaps. There are opportunities to further analyze and cross-reference information needs with literature to support development of specific research questions (e.g. through additional research or through knowledge mobilization).

While the process for developing the research agenda intended to bridge Indigenous Knowledges with western science, this research agenda does not speak for Indigenous communities and their distinct priorities and research needs. Throughout the project, participants identified information needs specific to B.C. First Nations and opportunities for more respectful, relational, and rights-based collaborations and opportunities in risk assessments and research. The research agenda provides high-level insight and guidance on next steps related to these themes. To further uplift and support First Nations-specific climate research, PICS is working with the First

Nations Leadership Council through a Relationship Protocol to support First Nations' research needs and priorities outlined in the Climate Strategy and Action Plan.

> *"As disaster and climate risks increase across the province, more efficient and effective integration of climate change research and risk assessment practices can support transformative risk management in ways that safeguard B.C. communities, ecosystems, and economic well-being and prosperity."*

Third, the research agenda identified information needs that provide a foundation for future research directions for academic organizations, researchers, and research funders. However, the information needs were not prioritized. There are opportunities to compile and consider the research needs identified in other EMCR-funded projects (e.g. the UBC Disaster Resilience Research Network Research Agenda) and the provincial and regional disaster and climate risk and resilience assessments, alongside this research agenda to support robust prioritization of research needs.

Fourth, the research agenda identified information needs across the risk management cycle, from understanding risk to implementing risk reduction. The number of information needs specific to adaptation and emergency response are an important reminder that risk assessments are intimately linked to risk reduction. Prioritizing climate change risk research alongside adaptation and emergency response research is necessary to ensure risk assessments are useful and effective.

Finally, this report provides criteria for how to approach climate change research questions with practitioners and communities in more meaningful and effective ways. Opportunities for formal research partnerships and informal and long-term opportunities to bring researchers, practitioners, and Indigenous Knowledge Holders together will keep research highly relevant and unlock the value-add of research for B.C. decision makers.

Risk assessments are an important tool in evidence-based risk management and a key step to reducing the costs and impacts of climate change. As disaster and climate risks increase across the province, more efficient and effective integration of climate change research and risk assessment practices can support transformative risk management in ways that safeguard B.C. communities, ecosystems, and economic well-being and prosperity.

Glossary

Adaptation: The process of adjusting to expected or actual climate change impacts. For human systems this process may include plans and actions that moderate adverse consequences and/or take advantage of emerging opportunities.

Adaptive capacity: The ability to leverage knowledge, skills, and resources to respond, manage, or adjust to adverse conditions or consequences.

Cascading impact: When an initial hazard triggers a sequence of secondary events that result in larger effects than the initial event. Cascading impacts are complex, multi-dimensional, and associated more with vulnerability than the hazard itself.

Cascading hazard: An initial hazard triggers a secondary hazard(s) which results in effects that are worse than the initial event.

Climate change: A shift in the average meteorological and environmental conditions of a specific place and/or the entire planet over an extended period of time (several decades or more). Although a small amount of climate change is due to natural processes, the rapid increase in global temperature over the last 100 years is attributed to human activities that alter the global atmosphere.

Compounding impact: Two or more hazards coincide and/or interact and result in effects that are worse than the disruption of a given hazard on its own.

Consequence: An adverse effect on people, communities, infrastructure, services, ecosystems, and economic, social, or cultural assets that arises from the exposure of vulnerable systems to hazardous events.

Decision maker: An individual or group of individuals who have authority to make decisions, for example, councils and governing boards.

Disaster: Substantial disruptions to a community or society that occur when hazardous events interact with conditions of exposure, vulnerability, and adaptive capacity, and cause human, material, economic, and environmental impacts and losses.

Disaster risk reduction: The process of reducing the likelihood and or consequence of a negative event.

Emergency management: The process of preparing for, responding to, and recovering from disasters. In British Columbia, emergency management is guided by four pillars: mitigation, preparation, response, and recovery.

Equity: A principle and a process that promotes fair conditions for all people to participate in society. Equity recognizes that not all people or groups of people experience even access to power, resources, opportunities, and benefits due to historical, persistent, and/or systemic marginalization. As such, specific strategies or measures may be needed to ensure fair outcomes.

Equity-denied: People or groups of people who experience barriers to equal access, resources, and opportunities due to the intersection of social categories (e.g., race, gender, Indigeneity, sexuality, age, disability, housing status, and economic status) that are correlated with discrimination, disadvantage, and/or disproportionate effects. In the context of climate change, equity-denied groups are systemically vulnerable to climate change.

Exposure: The presence of something of value located when and where a hazard may occur.

Hazard: A natural or human-caused process or event that may result in adverse consequences. Climate hazards are hazards influenced by climate change (e.g., wildfire, drought, extreme heat, and floods) that may become more frequent and severe over time.

Impact: An effect arising from realized risks. Impacts can be adverse or beneficial.

Knowledge mobilization: Connecting research findings to real-world applications and decision making.

Likelihood: The probability or chance of a hazard or specific impact occurring.

Practitioner: An individual or group of individuals who implements decisions, for example, public service, consultants, or emergency managers.

Resilience: The ability for human and natural systems to cope with climate change in ways that maintain their historic cycles and patterns. Climate resilience is positive when it promotes adaptation, learning, and transformation.

Risk: The potential for adverse consequences for human and natural systems, recognizing the diversity of values and objectives associated with such systems. Climate risk refers specifically to climate hazards, whereas disaster risk includes hazards that are geophysical, biological, environmental, hydrometeorological, and technological. In the context of risk assessment, risk results from the interaction between hazards, exposure, and vulnerability, considering the likelihood and consequence of the risk.

Risk assessment: The practice of identifying and prioritizing risks to a system by considering how likely a risk event is (likelihood) and the consequences of the risk event.

Risk driver: Factors that influence the level of risk by increasing exposure and/or vulnerability.

Risk management: The process of identifying, assessing, and reducing risks to a human system.

Vulnerability: The degree to which people, ecosystems, infrastructure, or something of value, is susceptible to experiencing harm when exposed to a hazard. Physical, social, economic, and/or environmental factors create conditions that can increase susceptibility to experiencing harm.

All definitions are adapted from the IPCC AR6 glossary[8] and Sendai Framework glossary[92] with the exception of "Emergency management" which is adapted from the Government of B.C. website[93] and "Equity" and "Equity-denied" which are both adapted from the UBC equity and inclusion office glossary[94] and Canada Arts Council glossary.[95]

References

1 Hoogeveen, D., Klein, K., Brubacher, J., & Gislason, M. K. (2021). *Climate change, intersectionality, and GBA+ in British Columbia summary report.* https://www2.gov.bc.ca/assets/gov/environment/climate-change/adaptation/resources/climate_change__gba_in_bc_summary_report.pdf

2 Adger, W. N., Brown, I., & Surminski, S. (2018). Advances in risk assessment for climate change adaptation policy. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376*(2121). https://doi.org/10.1098/rsta.2018.0106

3 Canadian Council of Ministers of the Environment. (2021). *Guidance on good practices in climate change risk assessment.* https://ccme.ca/en/res/riskassessmentguidancesecured.pdf

4 Bednar, D., Raikes, J., & McBean, G. (2018). *The governance of climate change adaptation in Canada.* Institute for Catastrophic Loss Reduction. https://www.iclr.org/wp-content/uploads/2018/04/cca-climate-change-report-2018.pdf

5 United Nations Office for Disaster Risk Reduction. (2015). *Sendai framework for disaster risk reduction 2015-2030.* https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030

6 Ministry of Emergency Management and Climate Readiness. (2023). *Emergency management and climate readiness 2023/24-2025/26 service plan.* https://www.bcbudget.gov.bc.ca/2023/sp/pdf/ministry/emcr.pdf

7 Office of the Auditor General of British Columbia. (2018). *Managing climate risks: An independent audit.* https://www.oag.bc.ca/app/uploads/sites/963/2024/07/OAGBC-2018-02-01-Climate_Change_FINAL.pdf

8 Intergovernmental Panel on Climate Change. (2022). *Annex II: Glossary* (V. Möller, R. van Diemen, J. B. R. Matthews, C. Méndez, S. Semenov, J. S. Fuglestvedt, & A. Reisinger, Eds.). In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 2897–2930). Cambridge University Press. https://doi.org/10.1017/9781009325844.029

9 BC Assembly of First Nations. (2019). *Briefing note: Analysis of the BC government "Preliminary Strategic Climate Risk Assessment for BC."* https://www.bcafn.ca/sites/default/files/docs/reports-presentations/2019.12.10_BCAFN%20BN%20re%20BC%20Risk%20assessment.pdf

10 Emergency Management British Columbia. (2020). *Hazard, risk, and vulnerability analysis (HRVA) for local authorities and First Nations: Companion guide for the HRVA tool.* https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/emergency-preparedness-response-recovery/local-government/hrva/guides/companion_guide_to_the_hrva.pdf

11 Government of B.C. (2025, April 1). *Disaster and climate risk and resilience assessments.* https://www2.gov.bc.ca/gov/content/environment/climate-change/adaptation/disaster-and-climate-risk-and-resilience-assessment

12 McDermott, T. K. J., & Surminski, S. (2018). How normative interpretations of climate risk assessment affect local decision-making: An exploratory study at the city scale in Cork, Ireland. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376*(2121). https://doi.org/10.1098/rsta.2017.0300

13 Johnson, D. E., Parsons, M., & Fisher, K. (2022). Indigenous climate change adaptation: New directions for emerging scholarship. *Environment and Planning E: Nature and Space*, 5(3), 1541–1578. https://doi.org/10.1177/25148486211022450

14 First Nations Leadership Council, British Columbia Assembly of First Nations, First Nations Summit, Union of British Columbia Indian Chiefs, First Nations Emergency Services Society, Four Directions Management Services Ltd. (2023). *Action plan for disaster risk reduction.* https://www.bcafn.ca/sites/default/files/2023-11/Action%20Plan%20for%20Disaster%20Risk%20Reduction%20by%20First%20Nations%20in%20BC%202023%20-%202030%20-%20Online.pdf

15 Reed, G., Littlechild, D., McGregor, D., Lewis, D., Popp, J., Wray, K., Kassi, N., Ruben, R., Morales, S., & Lonsdale, S. (2024). *For our future: Indigenous resilience report.* https://changingclimate.ca/site/assets/uploads/sites/7/2024/03/Indigenous-Resilience-Report_Final_EN.pdf

16 Kythreotis, A. P., Hannaford, M., Howarth, C., & Bosworth, G. (2024). Translating climate risk assessments into more effective adaptation decision-making: The importance of social and political aspects of place-based climate risk. *Environmental Science and Policy, 154*. https://doi.org/10.1016/j.envsci.2024.103705

17 Safaie, S., Johnstone, S., & Hastings, N. L. (2022). *Resilient pathways report: co-creating new knowledge for understanding risk and resilience in British Columbia.* Geologic Survey of Canada, Open File 8910, p. 278. Natural Resources Canada. https://doi.org/10.4095/330521

18 Wale, J., & Huson, B. (2024). *From risk to resilience: Indigenous alternatives to climate risk assessment in Canada.* Yellowhead Institute. https://yellowheadinstitute.org/from-risk-to-resilience/

19 Simpson, N. P., Mach, K. J., Constable, A., Hess, J., Hogarth, R., Howden, M., Lawrence, J., Lempert, R. J., Muccione, V., Mackey,

B., New, M. G., O'Neill, B., Otto, F., Pörtner, H. O., Reisinger, A., Roberts, D., Schmidt, D. N., Seneviratne, S., Strongin, S., & Trisos, C. H. (2021). A framework for complex climate change risk assessment. One Earth, 4(4), 489–501. https://doi.org/10.1016/j.oneear.2021.03.005

20 Hedlund, J. (2023). The politics of climate risk assessment. *npj Climate Action, 2*(48). https://doi.org/10.1038/s44168-023-00078-x

21 Dawson, R. J. (2015). Handling interdependencies in climate change risk assessment. *Climate, 3*(4), 1079–1096. https://doi.org/10.3390/cli3041079

22 Wale, J. (2022). *Climate rez-ilience: Building transformative climate resilience in Indigenous communities.* [Master's thesis, University of British Columbia Okanagan]. UBC Open Collections. https://doi.org/10.14288/1.0416163

23 City of Surrey. (2019). *Coastal flood adaptation strategy.* https://www.surrey.ca/sites/default/files/media/documents/CFASFinalReportNov2019.pdf

24 Semá:th First Nation & University of the Fraser Valley's Community Health and Social Innovation Hub. (2024). *Sumas First Nation: Resilience in action – managing risk and recovery.* https://sumasfirstnation.com/wp-content/uploads/2024/12/UPDATED-VERSION-12.03.24-SemathDRR-Digital.pdf

25 Tsleil-Waututh Nation. (2019). *Understanding our community's climate change vulnerabilities.* https://changingclimate.ca/map/understanding-our-communitys-climate-change-vulnerabilities/

26 Fears, R., Abdullah, K. A. B., Canales-Holzeis, C., Caussy, D., Haines, A., Harper, S. L., McNeil, J. N., Mogwitz, J., & ter Meulen, V. (2021). Evidence-informed policy for tackling adverse climate change effects on health: Linking regional and global assessments of science to catalyse action. *PLoS Medicine, 18*(7). https://doi.org/10.1371/journal.pmed.1003719

27 Harmsworth, G., Awatere, S., & Procter, J. (2014, November). Meeting water quality and quantity standards to sustain cultural values. *21st Century Watershed Technology Conference and Workshop Improving Water Quality and the Environment Conference.* https://doi.org/10.13140/2.1.3507.8086

28 Ministry of Environment and Climate Change Strategy. (2019). *Preliminary strategic climate risk assessment for British Columbia.* https://www2.gov.bc.ca/assets/gov/environment/climate-change/adaptation/prelim-strat-climate-risk-assessment.pdf

29 SHIFT Collaborative. (2019). *Northeast climate risk project series.* https://retooling.ca/communities-adapt/northeast-climate-resilience-network/

30 Integral & Tamsin Mills Resilience Consulting. (2021). *Simon Fraser University climate change risk assessment final report.* Simon Fraser University. https://www.sfu.ca/content/dam/sfu/sustainability/Reports/2021_SFUClimateRiskAssessmentReport.pdf

31 Vancouver Coastal Health & Fraser Health. (2022). *Climate change and health vulnerability and capacity assessment.* https://www.vch.ca/sites/default/files/import/documents/HealthADAPT-Vulnerability-Capacity.pdfhttps://www.vch.ca/sites/default/files/import/documents/HealthADAPT-Vulnerability-Capacity.pdf

32 Kanaka Bar Indian Band. (2018). *Kanaka Bar Indian Band climate change vulnerability assessment.* https://www.kanakabarband.ca/downloads/climate-change-vulnerability-assessment-pdf-2.pdf

33 Ebbwater Consulting Inc. & SHIFT Collaborative. (2024). *Cowichan Region hazard, risk, and vulnerability analysis.* Emergency Management Cowichan. http://emcowichan.ca/wp-content/uploads/2024/11/2024-10-30-Cowichan-Regional-HRVA.pdf

34 MacCharles, L. (2019). *City of Nelson hazard, risk, and vulnerability analysis.* City of Nelson. https://www.nelson.ca/DocumentCenter/View/4278/City-of-Nelson-Hazard-Risk-and-Vulnerability-Analysis-2019

35 Kerr Wood Leidal Associates Ltd. (2019). *Xwu'nekw park sea dike climate lens resilience assessment.* District of Squamish. https://pievc.ca/wp-content/uploads/2019/12/20191211_climateresiliencereport_final_signed_pievc.pdf

36 The PCL Team. (2020). *St. Paul's Hospital climate hazards, vulnerability and risk assessment.* https://vancouver.ca/files/cov/1002-station-st-appendix-h.pdf

37 Asset Management BC. (2019). *Asset management for sustainable service delivery: A BC framework.* https://www.assetmanagementbc.ca/wp-content/uploads/Asset-Management-for-Sustainable-Service-Delivery-A-BC-Framework-.pdf

38 Kerr Wood Leidal Associates. (2021). *Asset management guide for BC First Nations.* https://www.nautsamawt.org/_files/ugd/392f8f_f786c68c653e441e9eb82f56aac95e33.pdf

39 Kerr Wood Leidal Associates Ltd. (2021). *North Shore sea level rise risk assessment and adaptive management strategy final report. District of North Vancouver.* https://docs.dnv.org/documents/sea-level-rise-strategy-2021.pdf

40 Cowichan Valley Regional District. (n.d.). *Cowichan Valley Regional District natural hazard risk assessments.* https://www.cvrd.ca/3199/Risk-Assessment-Reports

41 Engineers and Geoscientists BC. (2023). *Landslide assessments in British Columbia.* https://tools.egbc.ca/Registrants/Practice-Resources/Guidelines-Advisories/Document/01525AMW2FC5GZAROI4ZBZ7KMIRPIFG7JN/Landslide%20Assessments%20in%20British%20Columbia

42 Engineers and Geoscientists BC. (2018). *Legislated flood assessments in a changing climate in B.C.* https://www.egbc.ca/getmedia/f5c2d7e9-26ad-4cb3-b528-940b3aaa9069/Legislated-Flood-Assessments-in-BC.pdf

43 Parisien, M. -A., Barber, Q. E., Bourbonnais, M. L., Daniels, L. D., Flannigan, M. D., Gray, R. W., Hoffman, K. M., Jain, P., Stephens, S. L., Taylor, S. W., & Whitman, E. (2023). Abrupt, climate-induced increase in wildfires in British Columbia since the mid-2000s. *Communications Earth and Environment, 4*(1). https://doi.org/10.1038/s43247-023-00977-1

44 Donaldson, D., Barnett, A., Brandes, O. M., Kriese, K., & O'Riordan, J. (2024). *Learning to live with fire: State of wildfire in B.C., policy, programs, & priorities* – A primer. POLIS Project on Ecological Governance, Centre for Global Studies, University of Victoria. https://poliswaterproject.org/wp-content/blogs.dir/162/files/sites/162/2024/05/POLIS-Learning-to-Live-with-Fire-State-of-Play-Final-.pdf

45 Kirchmeier-Young, M. C., Gillett, N. P., Zwiers, F. W., Cannon, A. J., & Anslow, F. S. (2019). Attribution of the influence of human-induced climate change on an extreme fire season. *Earth's Future, 7*(1), 2–10. https://doi.org/10.1029/2018EF001050

46 Baron, J. N., Gergel, S. E., Hessburg, P. F., & Daniels, L. D. (2022). A century of transformation: fire regime transitions from 1919 to 2019 in southeastern British Columbia, Canada. *Landscape Ecology, 37*(10), 2707–2727. https://doi.org/10.1007/s10980-022-01506-9

47 Coogan, S. C. P., Daniels, L. D., Boychuk, D., Burton, P. J., Flannigan, M. D., Gauthier, S., Kafka, V., Park, J. S., & Mike Wotton, B. (2021). Fifty years of wildland fire science in Canada. *Canadian Journal of Forest Research, 51*(2), 283–302. https://doi.org/10.1139/cjfr-2020-0314

48 Wang, X., Parisien, M. -A., Taylor, S. W., Candau, J. -N., Stralberg, D., Marshall, G. A., Little, J. M., & Flannigan, M. D. (2017). Projected changes in daily fire spread across Canada over the next century. *Environmental Research Letters, 12*(2). https://doi.org/10.1088/1748-9326/aa5835

49 Jain, P., Sharma, A. R., Acuna, D. C., Abatzoglou, J. T., & Flannigan, M. (2024). Record-breaking fire weather in North America in 2021 was initiated by the Pacific northwest heat dome. *Communications Earth and Environment, 5*(1). https://doi.org/10.1038/s43247-024-01346-2

50 Philip, S. Y., Kew, S. F., Van Oldenborgh, G. J., Anslow, F. S., Seneviratne, S. I., Vautard, R., Coumou, D., Ebi, K. L., Arrighi, J., Singh, R., Van Aalst, M., Pereira Marghidan, C., Wehner, M., Yang, W., Li, S., Schumacher, D. L., Hauser, M., Bonnet, R., Luu, L. N., … Otto, F. E. L. (2022). Rapid attribution analysis of the extraordinary heat wave on the Pacific coast of the US and Canada in June 2021. *Earth System Dynamics, 13*(4), 1689–1713. https://doi.org/10.5194/esd-13-1689-2022

51 White, R. H., Anderson, S., Booth, J. F., Braich, G., Draeger, C., Fei, C., Harley, C. D. G., Henderson, S. B., Jakob, M., Lau, C. A., Mareshet Admasu, L., Narinesingh, V., Rodell, C., Roocroft, E., Weinberger, K. R., & West, G. (2023). The unprecedented Pacific Northwest heatwave of June 2021. *Nature Communications, 14*(1). https://doi.org/10.1038/s41467-023-36289-3

52 Prairie Climate Centre. (2019). *Heat waves and health: A special report on climate change in Canada.* University of Winnipeg. https://climateatlas.ca/sites/default/files/PCC%20-%20Heat%20Waves%20and%20Health%20-%20Nov%202019.pdf

53 Beugin, D., Clark, D., Miller, S., Ness, R., Pelai, R., & Wale, J. (2023). *The case for adapting to extreme heat: Costs of the 2021 B.C. heat wave. Canadian Climate Institute.* https://climateinstitute.ca/wp-content/uploads/2023/06/The-case-for-adapting-to-extreme-heat-costs-of-the-BC-heat-wave.pdf

54 Intergovernmental Panel on Climate Change. (2023). Technical summary. *In Climate change 2021: The physical science basis* (pp. 35–144). Cambridge University Press. https://doi.org/10.1017/9781009157896.002

55 Chiang, F., Mazdiyasni, O., & AghaKouchak, A. (2021). Evidence of anthropogenic impacts on global drought frequency, duration, and intensity. *Nature Communications, 12*, 2754. https://doi.org/10.1038/s41467-021-22314-w

56 Tam, B. Y., Szeto, K., Bonsal, B., Flato, G., Cannon, A. J., & Rong, R. (2018). CMIP5 drought projections in Canada based on the Standardized Precipitation Evapotranspiration Index. *Canadian Water Resources Journal, 44*(1), 90–107. https://doi.org/10.1080/07011784.2018.1537812

57 Zhang, X., Flato, G., Kirchmeier-Young, M., Vincent, L., Wan, H., Wang, X., Rong, R., Fyfe, J., Li, G., & Karin, V. V. (2019). Changes in temperature and precipitation across Canada. In E. Bush & D. S. Lemmen (Eds.), *Canada's changing climate report* (pp. 112–193). https://publications.gc.ca/collections/collection_2019/eccc/En4-368-2019-eng.pdf

58 Dierauer, J. R., Allen, D. M., & Whitfield, P. H. (2019). Snow drought risk and susceptibility in the Western United States and Southwestern Canada. *Water Resources Research, 55*(4), 3076–3091. https://doi.org/10.1029/2018WR023229

59 Dierauer, J. R., Allen, D. M., & Whitfield, P. H. (2021). Climate change impacts on snow and streamflow drought regimes in four ecoregions of British Columbia. *Canadian Water Resources Journal, 46*(4), 168–193. https://doi.org/10.1080/07011784.2021.1960894

60 Shrestha, R. R., Bonsal, B. R., Bonnyman, J. M., Cannon, A. J., & Najafi, M. R. (2021). Heterogeneous snowpack response and snow drought occurrence across river basins of northwestern North America under 1.0°C to 4.0°C global warming. *Climatic Change, 164*, 40. https://doi.org/10.1007/s10584-021-02968-7

61 Gifford, R., Brown, C., Baron, C., Clement, D., Melnychuk, N., Nelson, H., Sales, L., & Spittlehouse, D. (2022). British Columbia chapter. In F. J. Warren, N. Lulham, & D. S. Lemmen (Eds.), *Canada in a changing climate: Regional perspectives report.* Government of Canada. https://changingclimate.ca/site/assets/uploads/sites/4/2020/11/British-Columbia-Regional-Perspective-Report-.pdf

62 Ministry of Emergency Management and Climate Readiness. (n.d.). *ClimateReadyBC Floods*. Retrieved October 16, 2024, from https://climatereadybc.gov.bc.ca/pages/floods

63 Curry, C. L., Islam, S. U., Zwiers, F. W., & Déry, S. J. (2019). Atmospheric rivers increase future flood risk in Western Canada's largest pacific river. *Geophysical Research Letters, 46*(3), 1651–1661. https://doi.org/10.1029/2018GL080720

64 Cohen, S., Bush, E., Zhang, X., Gillett, N., Bonsal, B., Derksen, C., Flato, G., Greenan, B., & Watson, E. (2019). Changes in Canada's

regions in a national and global context. In E. Bush & D. S. Lemmen (Eds.), *Canada's changing climate report (pp. 424–443). Government of Canada.* https://changingclimate.ca/site/assets/uploads/sites/2/2019/01/CCCR-Chapter8-ChangesInCanadasRegionInANationalGlobalContext.pdf

65 Brown, C., Jackson, E., Harford, D., & Bristow, D. (2021). Cities and towns. In F. J. Warren & N. Fulham (Eds.), *Canada in a changing climate: National issues report.* Government of Canada. https://changingclimate.ca/site/assets/uploads/sites/3/2020/04/Chapter-2_Cities-and-Towns_Final_EN-1.pdf

66 Sandink, D. (2016). Urban flooding and ground-related homes in Canada: an overview. *Journal of Flood Risk Management, 9*(3), 208–223. https://doi.org/10.1111/jfr3.12168

67 Westra, S., Fowler, H. J., Evans, J. P., Alexander, L. V., Berg, P., Johnson, F., Kendon, E. J., Lenderink, G., & Roberts, N. M. (2014). Future changes to the intensity and frequency of short-duration extreme rainfall. *Reviews of Geophysics, 52*(3), 522–555. https://doi.org/10.1002/2014RG000464

68 Milne, C., Legere, T., Eaton, J., Shneiderman, S., & Molina Hutt, C. (2024). The state of disaster and resilience literature in British Columbia, Canada. A systematic scoping review. *International Journal of Disaster Risk Reduction, 113*. https://doi.org/10.1016/j.ijdrr.2024.104848

69 Gower, T., & Barroso, A. (2019). *Tapped out: A special report on water scarcity and water solutions in British Columbia*. Watershed Watch Salmon Society. https://watershedwatch.ca/wp-content/uploads/2019/09/2019-09-24-Tapped-Out-RGB.pdf

70 Public Safety Canada. (2023). *National Risk Profile: A national emergency preparedness and awareness tool.* https://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/2023-nrp-pnr/index-en.aspx

71 Council of Canadian Academies. (2022). *Building a resilient Canada.* The Expert Panel on Disaster Resilience in a Changing Climate, Council of Canadian Academies. https://cca-reports.ca/wp-content/uploads/2022/01/Building-a-Resilient-Canada-web-EN.pdf

72 Reidmiller, D. R., Avery, C. W., Easterling, D. R., Kunkel, K. E., Lewis, L. M., Maycock, T. K., & Stewart, B. C. (2017). *Impacts, risks, and adaptation in the United States: Fourth national climate assessment, volume II.* U.S. Global Change Research Program. https://doi.org/10.7930/NCA4.2018

73 Weaver, C. P., Moss, R. H., Ebi, K. L., Gleick, P. H., Stern, P. C., Tebaldi, C., Wilson, R. S., & Arvai, J. L. (2017). Reframing climate change assessments around risk: Recommendations for the US National Climate Assessment. *Environmental Research Letters, 12*(8). https://doi.org/10.1088/1748-9326/aa7494

74 First Nations Leadership Council. (2022). *Climate strategy and action plan.* https://www.bcafn.ca/sites/default/files/2022-04/BCFNCSAP%20Final%20Draft%20%2822April2022%29.pdf

75 Copes-Gerbitz, K., & Comeau, V. (2023). *Pathways to cooperative community wildfire response with First Nations phase 1 report for discussion.*

76 Dickson-Hoyle, S., & John, C. (2021). *Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery.* Secwepemcúl'ecw Restoration and Stewardship Society. https://www.srssociety.com/docs/elephant_hill_-_secwépemc_leadership_and_lessons_learned.pdf

77 Nikolakis, W., & Ross, R. M. (2022). Rebuilding Yunesit'in fire (Qwen) stewardship: Learnings from the land. *The Forestry Chronicle, 98*(1). https://doi.org/10.5558/tfc2022-001

78 Sharp, K., & Krebs, A. (2018). *Trial by Fire: Nadleh Whut'en and the Shovel Lake Fire.* Nadleh Whut'en First Nation. https://www.resonantstrategic.ca/wp-content/uploads/2018/12/Trial-By-Fire.pdf

79 Verhaeghe, C., Feltes, E., & Stacey, J. (2019). *Nagwedizk'an Gwanes Gangu Ch'inidzed Ganexwilagh: The fires awakened us.* Tsilhqot'in National Government. https://tsilhqotin.ca/wp-content/uploads/2025/01/Tsilhqot-in-Nation-Wildfire-Report-The-Fires-Awakened-Us-2019.pdf

80 Abbott, G., & Chapman, M. (2018). *Addressing the new normal: 21st century disaster management in British Columbia.* https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/emergency-preparedness-response-recovery/embc/bc-flood-and-wildfire-review-addressing-the-new-normal-21st-century-disaster-management-in-bc-web.pdf

81 Australian Institute for Disaster Resilience. (2020). *National emergency risk assessment guidelines.* https://www.aidr.org.au/media/7600/aidr_handbookcollection_nerag_2020-02-05_v10.pdf

82 Calgary Emergency Management Agency. (2022). *Disaster risk report.* https://www.calgary.ca/emergencies/preparedness/disaster-risks.html

83 Washington Emergency Management Division. (2023). *Washington State enhanced hazard mitigation plan.* https://mil.wa.gov/asset/651ec296d76a9/2023_WA_SEHMP_final_20231004.pdf

84 European Environmental Agency. (2024). *European climate risk assessment – Executive summary.* https://doi.org/10.2800/204249

85 Ministry for the Environment. (2019). *Arotakenga Huringa Āhuarangi: A framework for the national climate change risk assessment for Aotearoa New Zealand.* New Zealand Government. https://environment.govt.nz/assets/Publications/Files/arotakenga-huringa-ahuarangi-framework-for-national-climate-change-risk-assessment-for-aotearoa-FINAL.pdf

86 Climate Risk Institute, Dillon Consulting Limited, ESSA Technologies Limited, Kennedy Consulting, & VIRIDI Global. (2023). *Ontario provincial climate change impact report*. Ministry of the Environment, Conservation and Parks. https://www.ontario.ca/files/2023-11/mecp-ontario-provincial-climate-change-impact-assessment-en-2023-11-21.pdf

87 Climate Risk Institute. (2024). *Shared resilience to a changing climate in the NWT: NWT climate change risks and opportunities assessment.* https://www.gov.nt.ca/ecc/sites/ecc/files/resources/4414_-_gnwt_ecc_-_ccroa_plainlang_report_online_1.pdf

88 ICLEI Canada. (n.d.). *Changing climate, changing communities: Guide and workbook for municipal climate adaptation.* https://icleicanada.org/wp-content/uploads/2019/07/Guide.pdf

89 First Nations Information Governance Centre (FNIGC). (n.d.). *The First Nations Principles of OCAP®*. https://fnigc.ca/ocap-training/

90 Hoffman, K. M., Copes-Gerbitz, K., Dickson-Hoyle, S., Bourbonnais, M., Axelson, J., Cardinal Christianson, A., Daniels, L. D., Gray, R. W., Holub, P., Mauro, N., Minocher, D., & Pascal, D. (2024). Boundary spanners catalyze cultural and prescribed fire in western Canada. *FACETS, 9*, 1–11. https://doi.org/10.1139/facets-2023-0109

91 Wreford, A., Peace, S., Reed, M., Bandola-Gill, J., Low, R., & Cross, A. (2019). Evidence-informed climate policy: mobilising strategic research and pooling expertise for rapid evidence generation. *Climatic Change, 156*, 171–190. https://doi.org/10.1007/s10584-019-02483-w

92 United Nations Office for Disaster Risk Reduction. (2017). *The Sendai framework terminology on disaster risk reduction*. https://www.undrr.org/drr-glossary/terminology

93 Government of B.C. (2024, June 19). *What is emergency management.* https://www2.gov.bc.ca/gov/content/safety/emergency-management/emergency-management/emergency-activation

94 UBC Equity and Inclusion Office. (2023, May). *Equity and inclusion glossary of terms*. https://equity.ubc.ca/resources/equity-inclusion-glossary-of-terms/

95 Canada Council for the Arts. (n.d.). *Glossary*. https://canadacouncil.ca/glossary

Pacific Institute for Climate Solutions

PO Box 1700 STN CSC
Victoria, BC V8W 2Y2 Canada

T 250-853-3595
F 250-853-3597

pics@uvic.ca
pics.uvic.ca

We acknowledge and respect the lək̓ʷəŋən Peoples on whose traditional territory the University of Victoria stands and the Songhees, Esquimalt and WSÁNEĆ peoples whose historical relationships with the land continue to this day.