Indicators of Climate Adaptation in the Columbia Basin

How 'State of The Basin' Indicators can be used to Measure Climate Changes, Impacts and Progress Towards Adaptation

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Terms and Acronyms

CACCI	Communities Adapting to Climate Change Initiative
CRI	Community Resilience Index
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
RDI	Rural Development Institute
SoTB	State of the Basin
SoCARB	State of Climate Adaptation and Resilience in the Basin
The Trust	Columbia Basin Trust
The Basin	Columbia Basin Trust Region (see Map 1)

1. Introduction

Using Columbia Basin 'State of the Basin' Indicators to Measure Climate Adaptation was a project funded by Natural Resources Canada (NRCan) and Columbia Basin Trust (the Trust). This project was undertaken by the Trust's Communities Adapting to Climate Change Initiative (CACCI) in cooperation with the Columbia Basin Rural Development Institute (RDI) at Selkirk College. The RDI currently manages the State of the Basin (SoTB) indicator program. Additional project products include a summary report, detailed literature review and a short introductory video. These products are available at www.cbt.org/climatechange and www.cbrdi.ca/climatechangeadaptation.

Purpose of Project

Climate change is a serious issue facing communities around the world. Given the climate changes that have already occurred and are expected to occur on both a local and global scale, climate adaptation has become an important undertaking for individuals, communities and all levels of government. Local governments in particular are on the front lines of many climate impacts related to infrastructure and essential community services and, as a result, need to undertake adaptation actions. Measuring progress on climate adaptation and climate resilience using indicators is an important component of climate adaptation. Indicators are helpful for informing residents, organizations, and governments regarding key trends in climate adaptation and resilience, facilitating understanding of complex issues, evaluating the effectiveness of various adaptation measures, and motivating change.

The purpose of the project was to review SoTB indicators for the Columbia Basin Trust region (the Basin) and assess their ability to measure the effectiveness of climate adaptation. The goals of the project were to develop a suite of regional-level climate change indicators to measure community climate adaptation efforts, assist communities in understanding climate change and adaptation, help decision makers in the Basin make informed decisions and measure the success of adaptation efforts.

This project had five objectives:

Objective 1: Conduct a detailed assessment of SoTB indicators to evaluate how they can measure climate change, climate impacts, and progress on climate adaptation in communities in the Columbia Basin and beyond.

Objective 2: Identify and prioritize additional indicators to address gaps in existing indicators in terms of measuring climate adaptation.

Objective 3: Document the project's learning methodology for assessing and using existing indicators to measure climate adaptation.

Objective 4: Provide recommendations on: 1) how the existing indicators could be improved and new indicators developed to better document and measure the ability of communities to thrive in the face of climate change, and 2) how indicators can support decision-making at the community level within and beyond the Columbia Basin.

Objective 5: Draft a detailed and summary report to document the process, results, recommendations and learning that emerge from this effort.

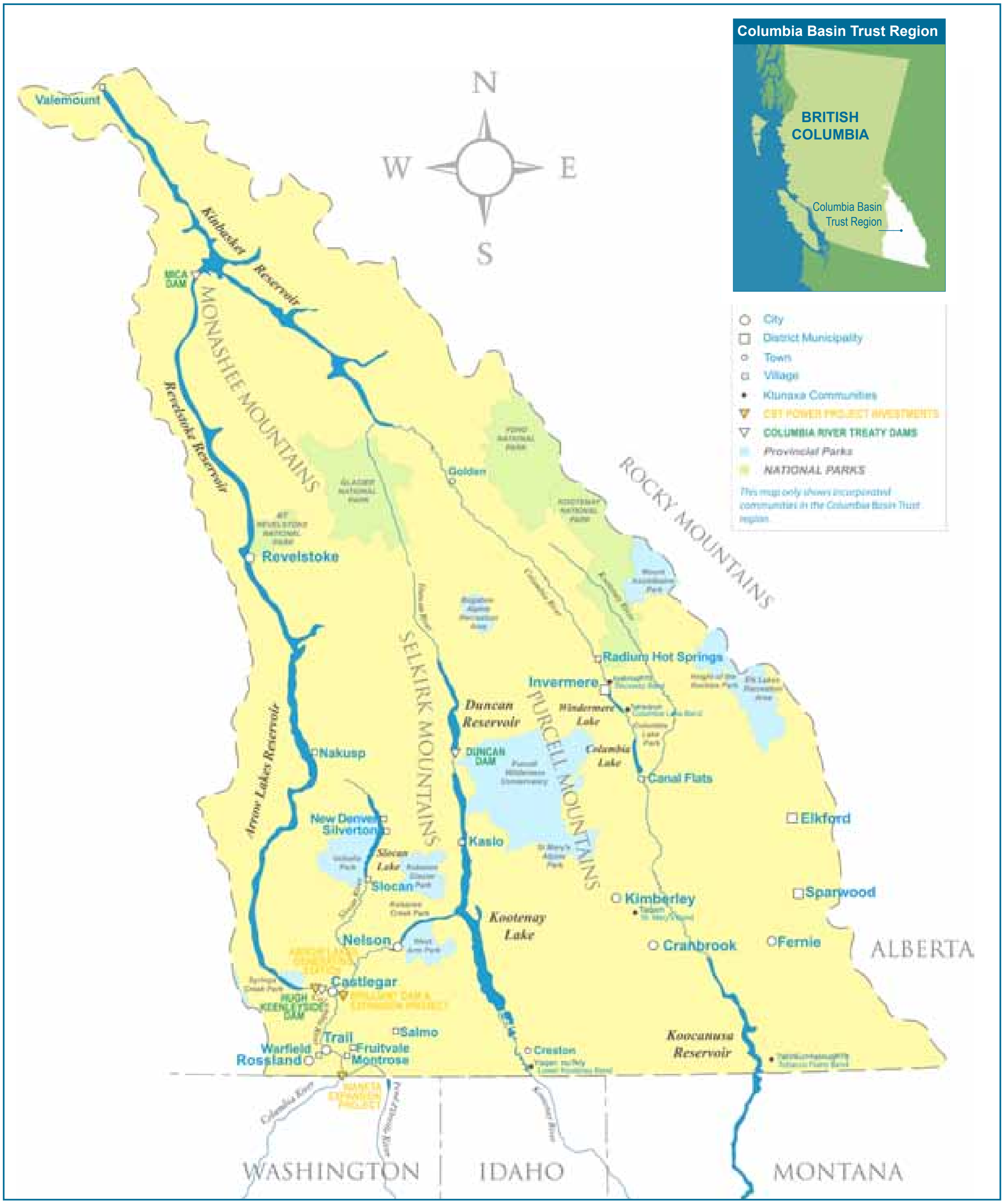
The primary audiences for this work are local governments and engaged community members in the Columbia Basin. As such, local government representatives—both staff and decision makers—were engaged early in the process to ensure that the products developed were useful for them. Secondary audiences include Basin residents, businesses, and community groups, as well as other organizations, governments and researchers in Canada interested in measuring climate adaptation using indicators.

While the local context—including local economies, vulnerabilities and climate changes—is critical to selecting an appropriate set of climate adaptation indicators, portions of the SoCARB indicator suite and the process used to develop it should be applicable to other jurisdictions with relatively minor adjustments. Many of the indicators selected rely on Statistics Canada or BC Stats data. Similar data should therefore be available in other Canadian jurisdictions.[1]

Moreover, even if the indicators are not all relevant, the conceptual models developed and process utilized to create the SoCARB should be very applicable to other communities or agencies in Canada interested in developing their own "State of Climate Adaptation" program.

1 The data sources for all indicators developed for the SoCARB suite are identified in Appendices B and C.

Map 1: Columbia Basin Trust Region



Organizations Involved in the Project

Communities Adapting to Climate Change Initiative

Since 2008, the Trust's Communities Adapting to Climate Change Initiative[2] worked directly with local governments in the Columbia Basin to plan and implement climate adaptation strategies and projects. Fourteen communities participated in the initiative and implemented a variety of climate adaptation actions, including:

- **Updates to Official Community Plans** with consideration of climate science and impacts;
- **Establishment of development permit areas** to address wildfire, flooding, landslides, and other risks related to climate change;
- **Climate risk and adaptation communications strategies**;
- **Flood hazard studies** that incorporate climate projections;
- **Infrastructure vulnerability assessments** based on climate projections;
- **Water source protection plans** that assess risks associated with climate change; and
- **Local water source monitoring frameworks** to track changes in stream flow that may be related to climate change.

CACCI has received provincial, national and international attention among adaptation practitioners for its innovative work on climate change adaptation for communities and was highlighted in a 2011 U.N. Framework Convention on Climate Change report.

Rural Development Institute

The Rural Development Institute (RDI) is a regional centre[3] of excellence in applied research and information provision focused on strengthening rural communities in the Columbia Basin Boundary region. The RDI's mission is to support informed decision-making by Columbia Basin-Boundary communities through the provision of information, applied research and related outreach and extension support.

The Institute was formed in 2011 as a result of a funding partnership between Selkirk College and Columbia Basin Trust. Based at the College, the RDI provides a unique link between the region's decision-makers and learning community. The RDI engages in research related to diverse subjects that are identified as regional priorities by its primary audiences (local governments, non-profit organizations and community-based initiatives).

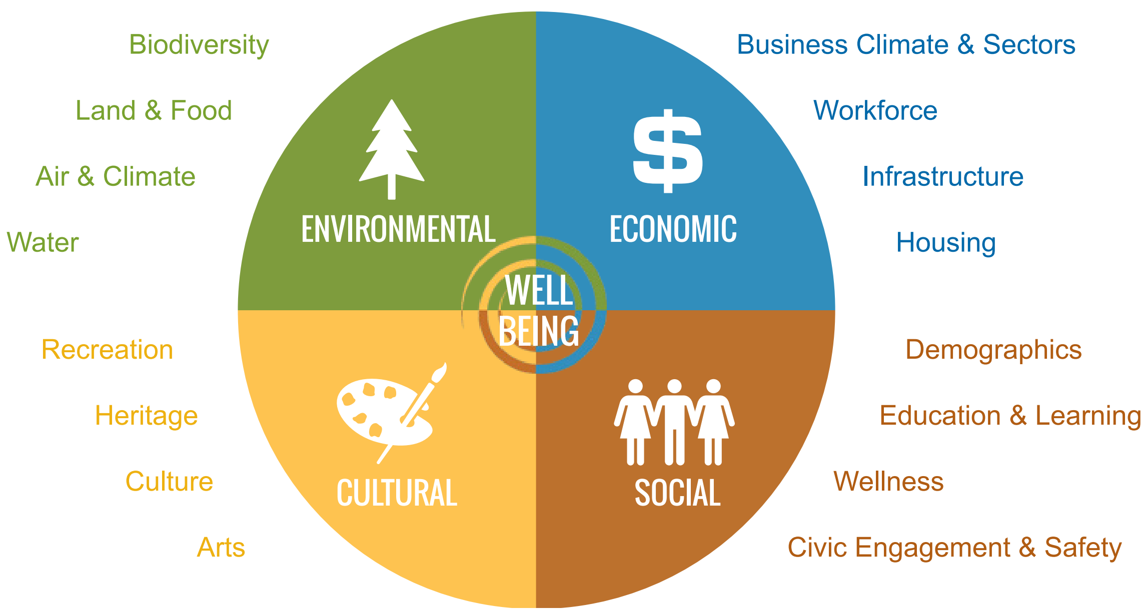
2 For more information, visit adaptationresourcekit.squarespace.com
3 For more information, visit www.cbrdi.ca

Background on the State of the Basin Indicators

The State of the Basin is an initiative — originally developed by the Trust — to monitor and report on information relating to well-being within the Columbia Basin Boundary region. The initiative involves collecting, analyzing and reporting on indicators relating to well-being in the Canadian portion of the Columbia River Basin as well as the Boundary region of British Columbia.

The SoTB framework organizes research and indicators into the RDI's four research pillars, each of which has several defined sub-themes as highlighted in Figure 1.

Figure 1: State of the Basin research framework



SoTB research is shared through a series of annual, graphic-style "Snapshot Reports", in-depth "Long Reports" released following each Census, a series of indicator-specific "Trends Analysis Briefs," and an online geospatial portal called the Digital Basin (www.cbrdi.ca).

SoTB research is undertaken by RDI researchers with support from the Selkirk Geospatial Research Centre and relies on a variety of data sources including government records, research completed by local organizations and surveys undertaken by the RDI and partner institutions.

As of 2014, the RDI provides analysis of over 40 indicators including job creation, major investment, income, total population, dependency, high school completion, stream flow timing and air quality. The suite of indicators has evolved over time and will continue to evolve as new data becomes available, new types of analysis are possible, and new priorities emerge in the region. The full suite of 39 2013 SoTB indicators can be viewed in Appendix A.

Process and Approach

This project was undertaken in three phases over a 15-month period by a six-person project team comprised of representatives from CACCI and RDI. A Project Advisory and Steering Committee (PASC) supported the project team with advice and feedback at several key junctures, and project results were field-tested with local government representatives. This section provides an overview of the project team's process and approach.

The project required the team to balance methodological rigour with practicality in order to navigate data constraints, address the complexity of the issues, and provide information relevant to local government. A detailed screening based on the best science available was undertaken to rank and evaluate every indicator considered. **The final suite of indicators represents the best indicators with available data to tell the 'story' of climate change and adaptation in the Columbia Basin to the target audience.**

Taking A Two-Pronged Approach

A two-pronged approach was used to separate SoTB indicators into:

Five thematic adaptation pathways measuring climate change, climate change impacts, and climate change adaptation; and

A community resilience index to measure socio-economic resilience and vulnerability.

The need for this approach became apparent after an initial gap analysis of the SoTB indicators confirmed that they would be insufficient to measure climate adaptation directly and that new indicators would have to be developed. At the same time the links between well-being and climate resilience were recognized, creating an avenue for some SoTB indicators to be considered as potential measures of community climate resilience.

The adaptation pathways are a "made-in-the-Basin" methodological approach developed by the project team to illustrate connections between climate change and adaptation in Basin communities, whereas the CRI was informed by a similar model developed to measure adaptive capacity in the Canadian prairies.

Project Phases

The project was undertaken in three phases. The following activities were undertaken in each phase:

Phase One

- A Process Advisory and Steering Committee was established;
- A kick-off meeting with the PASC was undertaken; and
- A literature review on climate change indicators was completed.

Phase Two

Indicator screening criteria and a screening process were developed, which set the path for development of the adaptation pathways and community resilience index.

- Initial screening of SoTB indicators with potential to measure climate changes, impacts and/or adaptation was undertaken;
- SoTB indicators that could be utilized to measure community resilience were flagged for further consideration as part of a resilience index.
- New potential indicators to measure climate changes, impacts and/or adaptation were identified and subjected to a preliminary screening;
- SoTB indicators that passed the screening process and new indicators were organized into five pathways reflecting critical community assets and risks (agriculture, extreme weather and emergency preparedness, flooding, water supply, and wildfire);
- The pathways and associated indicators were reviewed by the PASC and field-tested with local government representatives;
- The pathway indicators were screened and the screening results were reviewed to determine a final set of indicators for each pathway;
- SoTB indicators flagged as resilience indicators and new potential resilience indicators were organized into a resilience index; and
- Indicators in the resilience index were reviewed and ranked by each member of the project team to determine a final set of resilience index indicators.

Phase Three

The results of the assessment and analysis were developed into a detailed report outlining the process undertaken, the results, recommendations for indicators and future indicator development and next steps.

- The PASC and additional stakeholders were invited to review the project and their comments were incorporated into the final product;
- An illustrated summary report and short animation were developed to help share project learning with a wide range of audiences; and
- Lessons learned were shared through the Trust's CACCI Learning Network and a national webinar presentation.

Role of The Project Advisory and Steering Committee

The PASC was comprised of representatives of key organizations in the Basin, province and Canada with an interest and expertise in climate change, adaptation and resilience. The committee was invited to participate in interactive webinars and review of project materials at four key stages in the project. Feedback from the PASC was incorporated into project concepts, approaches and products.

Local government representatives formed part of the PASC and played a key role in supporting development and assessment of suitable climate adaptation indicators and the resilience index. Representatives included staff members from the City of Kimberley, City of Castlegar and Regional District of East Kootenay (see Acknowledgements). In addition to providing invaluable advice throughout the project, the local government representatives reviewed the draft indicators for applicability, appropriateness and practicality.

Organization of the Report

Sections Two and Three present the project literature review and project models. Section Four outlines the five adaptation pathways, while Section Five discusses the community resilience index. The report concludes with recommendations and lessons learned in Sections Six and Seven.

2. Adaptation Indicators Literature Review

In fall 2013, a comprehensive literature review was undertaken to understand the types of indicators currently in use or proposed for tracking climate change, impacts and adaptation in other jurisdictions. The literature review was intended to contribute to the development of a framework and criteria for selection of an appropriate suite of climate change, climate impact and climate adaptation indicators.

The literature review explored the following:

- The status of adaptation indicator development in other jurisdictions;
- Types and classification systems for indicators including:
  - Climate change indicators,
  - Climate impact indicators,
  - Climate vulnerability indices,
  - Climate adaptation indicators, and
  - Climate resilience indices;
- Suites of indicators in use in other jurisdictions;
- Challenges associated with measuring climate change, impacts, vulnerability, resilience and adaptation; and
- Criteria and processes for selecting indicators in other jurisdictions.

Despite the challenges associated with developing indicators related to climate change, many countries and regions—particularly Germany, the United Kingdom and the European Union—are moving forward with their development and implementation, offering many useful lessons.

The literature review was instrumental for understanding the various types of indicators along with the challenges and opportunities associated with each of them.

Climate change indicators measure changes in climate over time through the use of data on key trends relating to temperature and precipitation, and ***climate impact indicators*** measure the impacts of changes in climate on biophysical systems and on human systems and infrastructure. Both are frequently incorporated into a single indicator suite, and comprehensive climate change and impact indicator suites have been used in a wide variety of countries for almost a decade.

Vulnerability indicators are in an early stage of development and are the most challenging type of climate change-related indicator to develop. This is due to the composite nature of the vulnerability construct, which typically includes exposure, sensitivity and adaptive capacity. Measuring vulnerability to one potential climate impact often requires consideration of climate data, socio-economic data and biophysical data. As a result, many vulnerability indicators are composite indicators or indices with many sub-indicators or sub-indexes that must be aggregated to produce a final result. Developing appropriate methodologies for aggregation, identifying the appropriate data to include, and acquiring that data are all major challenges. Despite these difficulties, many potential vulnerability indices have been developed and, due to their complexity, can potentially serve as a more comprehensive measure of community, population, ecosystem or economic sector preparedness for climate change than single indicators. Operating on the notion that reduced vulnerability is a measure of successful adaptation, some organizations are focusing on vulnerability indicators instead of adaptation indicators to measure climate adaptation.

Climate adaptation indicators are also in an early stage of development and can be divided broadly into *process indicators,* which measure the development and implementation of climate adaptation actions and policies, and *outcome indicators***,** which measure the effects of and the effectiveness of those actions and policies. Climate impact indicators and climate adaptation outcome indicators are often the same. Critical challenges associated with measuring climate adaptation include the long time scales associated with adaptation, lack of data, the reverse logic of many adaptation actions (i.e. if there are no impacts, the measure was successful) and challenges in attributing outcomes to adaptation actions due to the presence of external factors that influence the original vulnerability either positively or negatively.

Resilience indicators can be defined more narrowly to reflect just one component of vulnerability (adaptive capacity), two components of vulnerability (sensitivity and adaptive capacity), or they are not defined in counterpoint to vulnerability at all. As a result, there are many different approaches to defining resilience and therefore many different approaches to developing resilience indicators. Resilience can also be considered the opposite of vulnerability. That is, the more resilient a community or region is, the lower its vulnerability. As with vulnerability indicators, resilience indicators are composite indicators, or indices, and therefore are more challenging to develop.

There is a wide range of potential criteria for selecting indicators that can fall into one of three categories:

- ***Data criteria:*** data availability, reliability, cost and spatial representation,
- ***Usefulness criteria:*** degree to which the indicator is relevant and sensitive to climate change and provides useful information, and
- ***Understandability and acceptance criteria:*** the transparency, understandability and public acceptance of an indicator.

Most organizations use some combination of relevance, data quality, sensitivity to climate and understandability in selecting indicators related to climate change. Once potential indicators have been selected, some organizations classify indicators based on whether appropriate data and modelling techniques are available immediately, expected in the medium-term or not available at all.

The literature review formed the basis for developing the project indicator model, which is outlined in more detail in the next section. The full literature review entitled *Climate Resilience Indicator Literature Review* is available as a separate document.

3. Project Models

Two indicator models informed the work undertaken in this project. The project indicator model conceptually defines and relates four key types of indicators and other elements of climate change. The pathways and resilience model highlights the two-pronged approach used to develop a suite of pathway indicators and a resilience index, and provides a snapshot of the organization and relationships among the final set of SoCARB indicators.

Project Indicator Model

To facilitate review of the SoTB indicators and the development of new indicators, a project indicator model was developed based on the findings in the literature review (see Figure 3). The project indicator model lays out the conceptual understanding of climate change and adaptation used to inform this project and shows the types of indicators that were identified and developed. The model provided a structure for both the development of indicators and for presenting and understanding indicators.

The project indicator model incorporates four types of indicators that were the focus of this project:

1. ***Climate change indicators*** measure changes in climate over time through the use of data on key trends relating to temperature and precipitation.
2. ***Environmental impact indicators*** measure the impacts of changes in climate on biophysical systems.
3. ***Community impact indicators*** measure the impact of changes in climate on human systems and infrastructure.
4. ***Climate adaptation indicators*** measure how communities respond to climate impacts by building capacity and implementing adaptation actions, and the outcomes of those efforts.

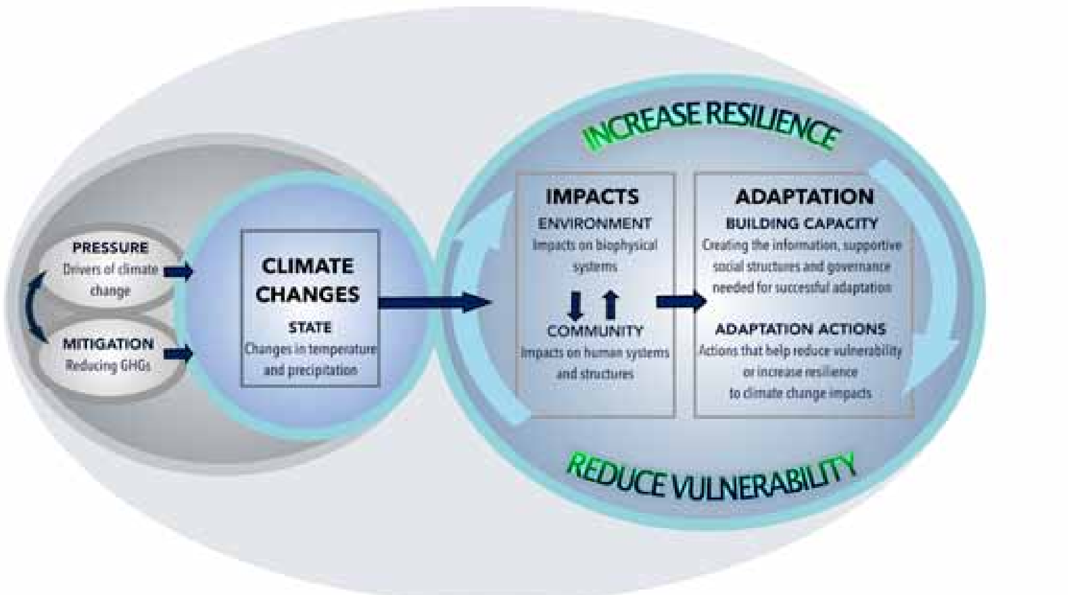
Vulnerability and resilience are important constructs relevant to the indicator development process. They are generally portrayed using composite indicators or indices, made up of a combination of the four types of indicators defined above. For the purposes of this project and to facilitate understanding of the concepts, the following definitions for vulnerability and were developed based on definitions in the literature.

- ***Vulnerability*** is the degree to which human or ecological systems are susceptible to and unable to cope with adverse climate impacts.
- ***Resilience*** is the ability of human and ecological systems to absorb disturbances while retaining the same basic structure and ways of functioning, as well as the capacity of those systems to cope with, adapt to and recover fully or partially from stress and change.

Drivers of climate change are also considered in the project model. These include greenhouse gas emissions and atmospheric gas concentrations. Since this project was focused on climate change adaptation indicators, new climate change driver indicators were not explicitly identified or developed. However, existing SoTB indicators that represent drivers of climate change were flagged for the purposes of developing a more complete climate change indicator suite and future potential indicator work.

These indicators, concepts and the relationships among them are depicted in Figure 3.

Figure 3: Project Indicator Model



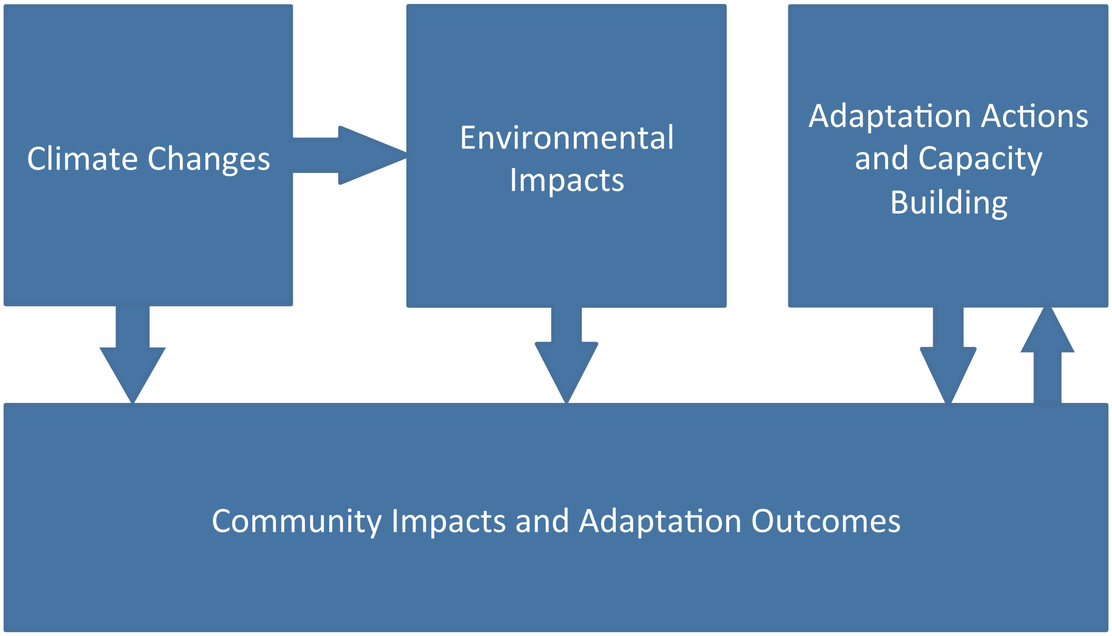
Pathways and Resilience Model

The need for a two-pronged approach using adaption pathways and a community resilience index became apparent after an initial review found that SoTB indicators alone would be insufficient to measure climate adaptation directly and new indicators would have to be developed. As well, many social and economic SoTB indicators were seen as relevant to measuring community resilience to climate change, which resulted in the idea of creating a resilience index. This section reviews the overall pathway and resilience index approaches and presents a model illustrating how the two approaches fit together to provide a more comprehensive picture of climate adaptation.

Explanation of Adaptation Pathways

To develop an indicator suite addressing the core dimensions of climate impacts and adaptation, the project team chose to think about climate change, impact and adaptation indicators in the form of *a*daptation pathways. An adaptation pathway shows the relationships among four types of indicators—climate change, environmental impact, community impact and adaptation—based on a particular theme of concern such as, for example, wildfire, water supply, or agriculture. Figure 4 shows a basic adaptation pathway.

Figure 4: Basic Adaptation Pathway



The adaptation pathways were used to select an indicator suite that:

- Demonstrates the connections between changes in climatic conditions, environmental and community impacts, and adaptation capacity building, action and outcomes;
- Organizes indicators conceptually to tell a story regarding climate change using the different types of indicators related to a particular thematic area; and
- Facilitates gap analysis.

The five adaptation pathways developed for this project are based on assessment of critical community assets and risks for Columbia Basin communities. They include:

- **Agriculture;**
- **Extreme weather and emergency preparedness;**
- **Flooding;**
- **Water supply; and**
- **Wildfire.**

For each thematic pathway the goal was to identify one to three indicators for of each of the four types of indicators. The indicators selected for these pathways can be found in Section Four.

Development of the Community Resilience Index

Resilience and vulnerability are important concepts that cast a broader lens on a community's ability to adapt to climate change. However, as both are relatively complex constructs due to the many factors that determine a community's level of resilience, they are almost are always measured as indices that use a suite of indicators to measure across broad dimensions of a community.

The initial review of SoTB indicators highlighted 14 indicators—such as workforce education, voter turnout, and median employment income—with general relevance to climate adaptation yet without specific relevance to a pathway. Many of these indicators were of a socio-economic nature. These indicators were flagged as ones that could become part of a more general CRI that could, in turn, provide supplemental insights regarding climate adaptation in the Basin and serve as a valuable context for the adaptation pathways.

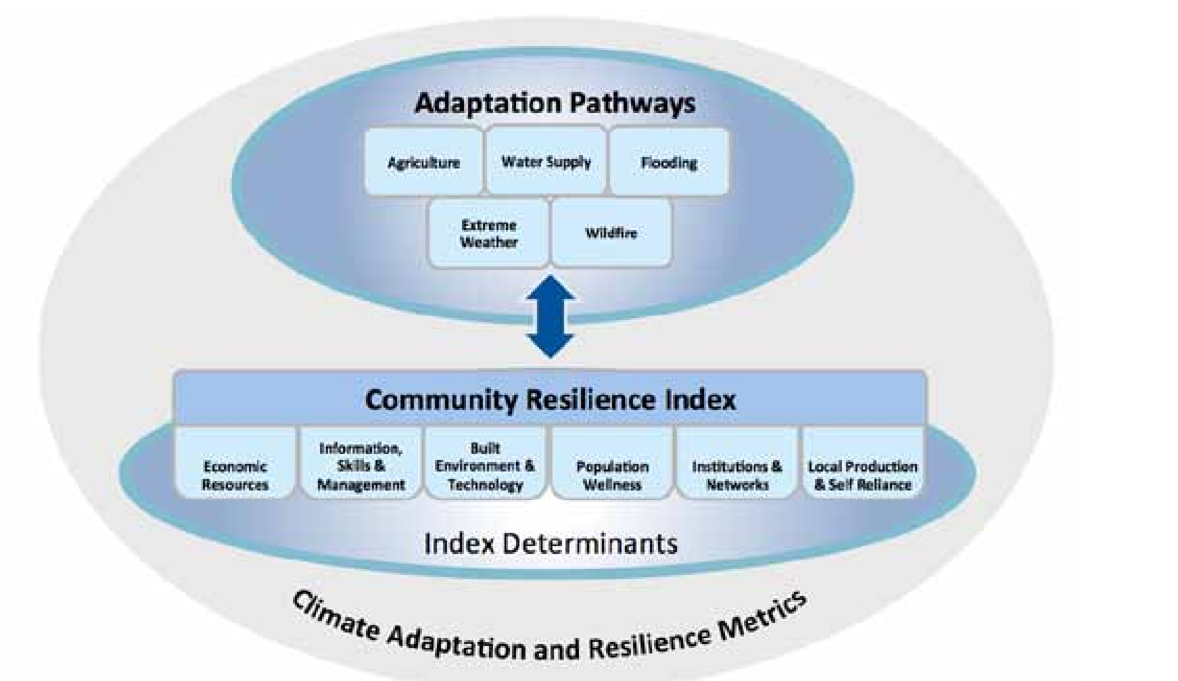
The six determinants selected to measure a community's socio-economic resilience to climate impacts include:

- **Economic resources;**
- **Information, skills and management;**
- **Institutions and networks;**
- **Population wellness;**
- **Built environment and technology; and**
- **Local production and self-reliance.**

The flagged SoTB indicators were re-screened to determine whether they could help measure a determinant. The goal was to identify three to four indicators per determinant. New indicators were developed whenever SoTB indicators could not satisfactorily address the six determinants. A more detailed description of the CRI can be found in Section Five.

Used together, the pathways and CRI are intended to provide a more complete picture of climate adaptation in Basin communities. Figure 5 further illustrates the relationship between the adaptation pathways and CRI.

Figure 5: Pathways and Resilience Model



4. Adaptation Pathway Indicators

This section describes the approach to developing and populating the five adaptation pathways. It also shares the results of a gap analysis of Basin adaptation risks and priorities that could not be addressed by the five pathways.

Pathway Indicator Screening and Selection

Informed by the literature review, **12 indicator screening criteria were identified by the project team to facilitate selection of indicators** to measure climate changes, climate impacts and climate adaptation. These criteria were incorporated into an indicator screening tool.

A process for applying the indicator screening tool and prioritizing climate change, impact and adaptation indicators was also developed. The indicator screening tool and the indicator selection process are outlined below.

Indicator Screening Tool and Criteria Descriptions

The indicator screening tool was designed to capture the performance of potential indicators against criteria important for indicator development. These criteria were extracted from the literature review and refined for this project. Below are detailed descriptions of each criterion used to screen and prioritize potential climate adaptation indicators.

Project applicability criteria:

Used to assess existing RDI SoTB Indicators to determine if a given indicator could be effective in measuring at least one of the identified project indicator types:

- Drivers of climate change
- Climate change
- Environmental impacts
- Community impacts
- Building adaptation capacity
- Adaptation actions
- Adaptation outcomes and/or
- Resilience factors

Data Criteria:

Historical data: is historical data available for the indicator, making it more feasible to analyze and track trends?

Availability: is data available in an appropriate and reliable format, and easily collected at regular intervals from appropriate locations?

Reliability: can the data be collected and analyzed using valid methods that can support sound conclusions?

Data condition: is the data available in a state that is readily interpretable? What level of additional analysis is required to generate meaningful findings from the data?

Usefulness criteria:

Representativeness: is the indicator relevant across the entire geographic area?

Comparability: does the data allow for community-level comparability? Is it available in a disaggregate form for all or most communities, and is it relevant to compare communities?

Relevance to decision-making: does the indicator measure progress for an important or determining factor in adaptation, rather than a less important one, and contribute to making important climate-resilient policy and planning decisions?

Attributable: can trends in the indicator be directly attributed to changes in the climate, climate impacts, or adaptation?

Acceptance criteria:

Public Interest: are communities interested in it?

Understandability: can communities, decision makers and other individuals using the indicators easily understand the significance of changes in the indicator?

Acceptability: is the indicator non-controversial and politically acceptable? Will it lead to negative press/communications/imagery for communities and/or other stakeholders?

The indicator screening tool was used to assess the performance of potential indicators against the criteria outlined above. Both existing SoTB and new and/or modified indicators were assessed using a 10- or 5-point Likert type scale (depending on the weighting of the criteria).

Recognizing that some indicators could fall into multiple categories (i.e. climate change indicators, environmental impact indicators, etc.), indicators were classified prior to screening. The performance of these indicators was assessed for each category to see if they scored better in one category than in another. In practice, scores were not significantly different.

Table 1: Indicator Screening Tool

		Worst ←									→ Best
Indicator and Category		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Project applicability (*applies to existing SoTB indicators only*)		Not applicable to project									
Data	Historical data (rate out of 5)	No historical data				Historical data available					
	Availability	Not readily available or easily collected									
	Reliability	Collection and analysis is or may be unreliable									
	Data condition (rate out of 5)	Collection or interpretation of data requires extensive effort				Data is in an accessible form and ready for analysis					
Usefulness	Representativeness	Indicator only applies to a small portion of the geographic area under consideration									
	Comparability	Comparable data is only available for certain communities, or for the Basin as a whole, or it does not make sense to compare it									
	Relevance to decision-making	Measures factors that are not important to adaptation									
	Attributable	Difficult to attribute to climate change									
Acceptance	Public interest (rate out of 5)	Is not interesting to or supported by communities				Is interesting to and supported by the public					
	Understandability (rate out of 5)	Significance of changes in indicator are poorly understood				Significance of changes in indicator are easily understood					
	Acceptability (rate out of 5)	Controversial and likely unacceptable to certain stakeholders				Non-controversial and acceptable to all stakeholders					

Six Step Process for Screening and Selecting Pathway Indicators

The indicator screening and selection process and the pathway selection process were undertaken in six steps.

Step One – SoTB Screening Mini-Groups

Three mini-groups, each comprised of two project team members, conducted initial screenings of the SoTB indicators, scoring them on their ability to measure some aspect of climate change and brainstorming new or modified indicators beyond the existing SoTB set.

Step Two – SoTB Indicator Assessment Workshop

Potential indicators identified by the mini-groups were brought forward to an indicator assessment workshop where team members reviewed and finalized the scores for each indicator. SoTB indicators that could help measure climate change, impacts, adaptation or community resilience were identified. SoTB indicators identified as having no potential to measure climate change, impacts, adaptation or resilience were discarded.

It became evident that the SoTB indicators with potential to measure climate change, impacts, and adaptation would be insufficient to provide a clear picture of climate adaptation in the Basin, and many were better suited as measures of community resilience. New indicators were needed to effectively measure climate adaptation, so the team adopted the two-pronged approach to measuring climate adaptation—using adaptation pathways and the CRI.

New and modified indicators were also reviewed at the workshop. A preliminary screening, based primarily on potential data availability and ability to measure some aspect of climate change adaptation, was used to identify indicators worthy of further consideration.

Step Three – Selection and Development of Pathways

Subsequent to the indicator assessment workshop, the focus shifted to selecting new indicators. The pathway concept was seen as the most effective way to organize indicators in an interrelated fashion and identify key gaps. Given the importance of creating a manageable suite of indicators, it was decided to focus on five pathways deemed critical for communities — extreme weather and emergency preparedness, water supply, agriculture, wildfire and flooding. Each team member was assigned one pathway for which to identify relevant indicators — both SoTB and new indicators. The goal was to identify more indicators than would be needed or desirable and provide a more complete picture of the pathway, thus allowing for the best indicators to be chosen. Tables identifying the indicators, rationale for the indicators, and potential data sources were created for each pathway. These were reviewed and revised by the project team several times until complete drafts existed for each pathway.

Step Four – Pathway Screening Mini-Groups

Working in mini-groups, the project team reviewed each of the indicators in the five pathways and scored them using the indicator screening tool. The scores were shared in preparation for the pathway indicator assessment workshop.

Step Five –Review with Local Governments and the PASC

Prior to the pathway indicator assessment workshop, the proposed pathways were presented to local government representatives and the PASC for review and comment.

Interviews were conducted with the three local government representatives, reviewing the initial set of indicators and answering three questions:

1. Are the adaptation pathways and indicators of value to your local government and community?
2. For indicators requiring data and information from local governments, is that data consistently available across all Basin communities?
3. If the data is available consistently, is the data obtainable with minimal effort?

Additional interviews were conducted to ensure the indicators were neither ambiguous nor controversial, and to discuss whether there were any additional indicators to be considered.

Step Six – Pathway Indicator Assessment Workshop

The project team met face-to-face to review PASC and local government feedback, and the mini-group scores of each indicator for each of the pathways. This data was used to select a final set of indicators for each pathway.

The results of the PASC and local government interviews helped eliminate indicators that had little value to Basin communities, questionable sustainability over the long term, or involved complicated and expensive data acquisition that lacked feasibility due to cost and effort.

Final Selection of Pathway Indicators

This section presents the indicators and storyline for each of the five adaptation pathways. Details regarding data sources for the indicators are provided in Appendix B, highlighting how many of the indicators rely on information from Statistics Canada and BC Stats. Provided that other provincial agencies are collecting similar information, most of the SoCARB indicator suite should be quite transferrable. However, some SoCARB indicators are based on local data that may or may not be readily available in other communities or regions.

Potential pathway indicators considered and subsequently rejected are listed in Appendix E along with the rationale for their exclusion. The local context definitely influenced the indicators considered, therefore some indicators relevant in other jurisdictions were not even reviewed because the project team recognized in advance that they were not suitable for the Basin context.

A key requirement of the project was to develop a suite of indicators to measure climate adaptation that would be practical for a research organization, such as RDI, or government agency, to implement over the long-term. Limiting the number of indicators is an important parameter requiring choices on which indicators to include and exclude. The rationale for these choices varied for each pathway. Often, the choice was data-related, and the indicators with the best available data were the ones selected. However, if two indicators on a pathway measured the same aspect of climate change, impacts or adaptation, one of them was often dropped to avoid being repetitive, even if one indicator measured a climate impact, while the other measured an adaptation to that impact. The goal was to select the indicators that could most effectively tell the story of the changes and progress occurring within each pathway.

In each pathway, the existing SoTB indicators are presented in light green font, while new indicators are presented in white font. Some indicators, especially the climate change indicators, appear in multiple pathways reducing the total number of new indicators recommended.

In some cases there are indicators used in one pathway that are relevant to other pathways, yet are not listed in those other pathways. These are called **crossover indicators**. For example, extremely strong wind events is an indicator for the extreme weather and emergency preparedness pathway, and also has relevance to the agriculture pathway since extreme wind events can damage crops. This has occurred because of deliberate efforts made to choose the best indicators for each pathway and avoid overpopulating pathways with related—yet lower scoring—indicators.

Agriculture

Agriculture, while not one of the most economically important sectors in the Basin, is a key economic driver for several communities. Moreover, the availability of agricultural areas and locally produced food is becoming increasingly important to Basin communities, a trend that could strengthen as climate change negatively affects agricultural production in other parts of the world. In addition, small-scale and backyard agriculture is on the rise as many Basin residents aim to become more self-sufficient with locally grown food.

The agriculture pathway tracks the climate-related viability of both large and small-scale agriculture in the Basin, the impact of climate change on agricultural activity and the degree to which farmers and backyard growers are prepared to deal with climate changes.

Climate has a significant, but complex, impact on agriculture, particularly on crops. Temperatures, carbon dioxide (CO_2) concentrations in the air, extreme weather events, and water supply all affect agriculture. The overall effect on agriculture is uncertain because some aspects, such as temperature increases, may benefit agriculture in some areas, while other aspects, such as more frequent extreme weather events, could have negative implications. The net overall implications of climate change for agriculture on a global scale are expected to be negative, yet this is not certain. Even if the effects are positive for agriculture in the Basin, growers and producers will have to adapt to changing growing conditions. For example:[4]

- Increases in average temperatures and CO_2 concentrations may increase photosynthesis and plant growth rates. However, faster growth reduces the amount of time seeds have to grow and mature and increases the rate of demand for nutrients from the soil, which can reduce yields (i.e. the amount of crop produced from a given amount of land);
- Warmer spring and fall temperatures could increase the length of the growing season, but negatively affect crops with required chilling hours. This would allow for the survival of more pests, and could also damage crops due to an increase in early budding, decreased protective snow cover and reduced cold hardening in the fall;
- Very high summer temperatures may reduce yields and increase water demand; and
- Reduced water availability, due to changes in precipitation or streamflow timing, particularly if temperatures are higher, could have significant negative effects on crops.

Figure 6 shows the agriculture indicators and pathway.

4 See Crawford, E. and R. Beveridge. (2013). Strengthening BC's Agriculture Sector in the Face of Climate Change. Pacific Institute for Climate Solutions. http://pics.uvic.ca/sites/default/files/uploads/publications/Strengthening%20BC%27s%20Agriculture%20Sector_0.pdf and Hatfield, J., G. Takle, R. Grotjahn, P. Holden, R. C. Izaurralde, T. Mader, E. Marshall, and D. Liverman, 2014: Ch. 6: Agriculture. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 150-174. doi:10.7930/J02Z13FR.

Figure 6: Agriculture Pathway*

*SoTB indicators are displayed in light green.

Three climate-related indicators are recommended for tracking long-term climate changes relevant to agriculture:

1. **Climate extremes:** frequency of days when maximum temperature exceeds 90th percentile for baseline period (temperature), amount of total precipitation (in millimetres) that occurs during days when precipitation exceeds the 95th percentile for the year in question (precipitation);
2. **Frequency of hailstorms:** annual frequency of occurrence of hailstorms; and
3. **Climate averages:** average monthly temperature and precipitation values.

Extreme heat, extreme precipitation, and hailstorms are all weather events that can damage crops and cropland. Monthly average temperature and precipitation, especially during the summer months, play a role in determining the heat and amount of water available to crops. Tracking and reporting these climate changes may help growers prepare for some events by planting more heat or hail-resistant crops, changing their irrigation practices or getting crop insurance.

These climate changes can, in turn, contribute to environmental impacts on growers and the overall agricultural industry. For example, extreme heat and reduced average monthly precipitation can contribute to drought. In addition increases in average annual temperature can result in environmental impacts with implications for agriculture, including changes in the length of the growing season and the number of invasive species in the Basin.

Four indicators are recommended to help track the environmental impact of climate change. These include:

1. **Drought index:** the B.C. drought index measures availability of water for human and ecosystem needs and recognizes drought may be caused by combinations of insufficient snow accumulation, hot and dry weather or a delay in rainfall. It is comprised of four core indicators:
   - Basin snow indices,
   - Seasonal volume runoff forecasts,
   - 30-day percent of average precipitation, and
   - 7-day average streamflow;
2. **Length of the growing season:** number of days between last and first frost;
3. **Growing degree days:** amount of heat energy available for plant growth, calculated by multiplying the number of days that the mean daily temperature exceeded 5 C (average base temperature at which plant growth starts) by the number of degrees above that threshold; and
4. **Invasive species:** list of invasive species present in the Basin and estimate of aggregate area covered by them.

These environmental impacts can affect growers and the agricultural industry directly by contributing to changes in agricultural productivity (both positive and negative), or by causing crop damage and, in the long-term, influencing the viability of farming and the amount of land being farmed.

Three indicators are recommended to track the impacts of climate change and its related environmental impacts on the agricultural industry:

1. **Amount of area being farmed:** annual number of hectares being farmed;
2. **Crop damage due to drought, high temperatures, frost, storms, pests, and disease:** annual insurance payouts for crop damage and loss as a result of drought, high temperatures, frost, storms, pests and disease; and
3. **Agricultural productivity:** measured as a ratio of agricultural outputs to agricultural inputs with output measured as market value.

These indicators also measure adaptation outcomes—that is, how well farmers are adapting to changes in climate and its related impacts. Over the long-term, if farmers are adapting, one would not expect to see declines in agricultural productivity and increases in crop damage. If climate change has negative impacts on agriculture in other parts of the world, an increase in the amount of land being farmed in the Basin over time could reflect an adaptation outcome. It should be noted that these community impact and adaptation outcome indicators focus on the agricultural industry, not backyard growers, as data is more readily available for larger-scale operations.

It is proposed that **specific adaptation actions and capacity building efforts be tracked to measure adaptation on a process (as opposed to outcome) level. These include:**

1. **Hectares irrigated:** number of hectares irrigated by electoral area;
2. **Farming practices to reduce soil erosion and increase fertility:** number of farms engaging in summer fallow land, no-till seeding, tillage incorporating most crop residue into soil, manure application, crop rotation, rotational grazing, ploughing down green crops, winter cover crops, and nutrient management planning; and

3. **Community food production:** number of people in the Basin, by community, who grow at least a small portion of their own food.

There is one potential crossover indicator for the agriculture pathway, which is frequency of strong wind events.

Extreme Weather and Emergency Preparedness

Extreme weather events can have significant impacts on communities in the Basin and include extreme rain and snowfall, windstorms and heat.

The extreme weather and emergency preparedness adaptation pathway tracks short duration and intense weather events, their impact on communities and how prepared communities are to deal with them.

Many Basin communities already experience these events and future projections suggest an increase in some extreme weather events, including:[5]

- The frequency of warm days in the summer is projected to increase, occurring 1.5 to 3.3 times as often;
- Extreme warm days (of the type that recur only once every 25 years) are projected to increase in frequency, occurring 1.4 to 12.5 times more often;
- The frequency of cool nights in the winter is projected to decrease, occurring 0.7 to 0.4 times less often;
- The total number of days when the average daily maximum temperature is lower than 0 C is projected to decrease, by between 10 per cent to 30 per cent; and
- Extreme wet days (of such magnitude that they only happen, on average, once every 25 years) are projected to occur between 0.3 to 4.1 times as often as in the past.

Figure 7 shows the indicators and pathway. **Since all of the impacts associated with the extreme weather pathway are community impacts, there is no environmental impact component in this pathway.**

Four climate change indicators are recommended for tracking long-term trends in the frequency of extreme weather events. These include:

1. **Maximum 1-day rainfall:** the heaviest precipitation day or monthly maximum 1-day precipitation (in millimetres) in a given year;

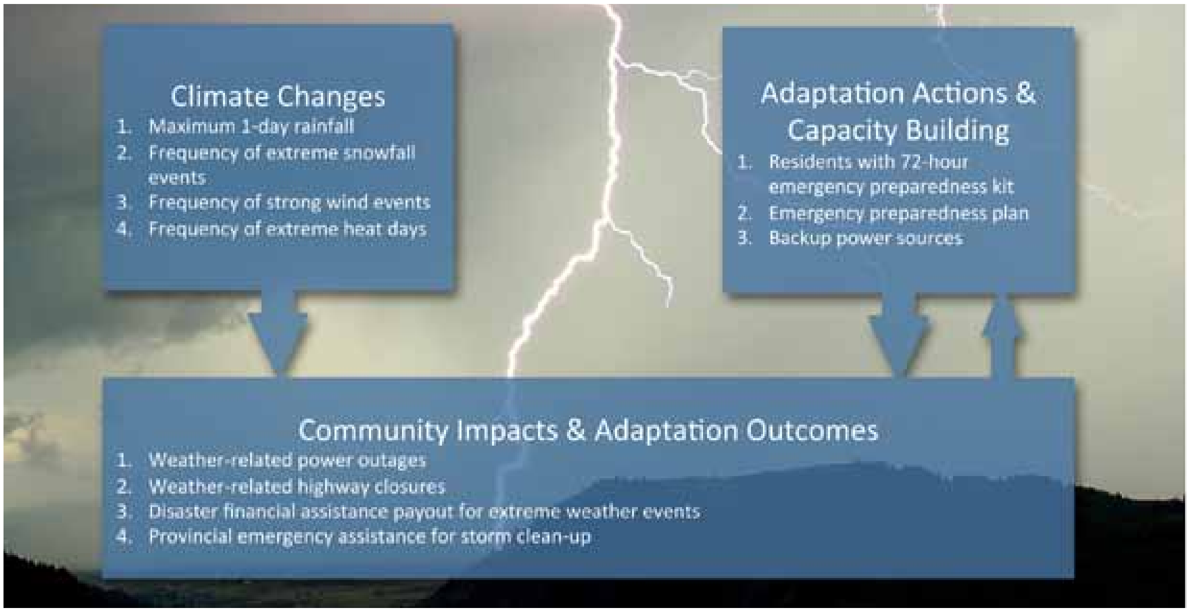
2. **Frequency of extreme snowfall events:** total number of days each year with snowfall amounts of 15 cm or more within 12 hours or less;

3. **Frequency of strong wind events:** total number of days each year with 70 km/h or more of sustained wind and/or gusts to 90 km/h or more; and

4. **Frequency of extreme heat days:** total number of days each year when maximum daily temperature exceeds 30 C.

5 Projections are from the Pacific Climate Impacts Consortium – Climate Extremes in the Columbia Basin (2013). All projections are for the 2050's (2041-2070), relative to a baseline period of 1971-2000. Based on 10th to 90th percentile of results for all grid boxes and all model runs.

Figure 7: Extreme Weather and Emergency Preparedness Pathway



Tracking and reporting of these indicators will provide communities with a measure of how extreme weather events may be changing, and the degree to which local planning and operational decisions need to be adapted.

The four climate extremes, as well as other extreme climate events, can impact communities directly. For example, this can occur through increased overland flooding and damage to infrastructure from extreme precipitation, road closures from winter storms and extreme snowfall events, power outages caused by wind, freezing rain, and other events, or through increased heat stress on vulnerable populations.

Four indicators are recommended to help track the impact of extreme weather events on Basin communities:

1. **Weather-related power outages:** the number (per year) and/or duration (hours) of power outages caused by landslides, avalanche, snow, wind, or freezing rain;
2. **Weather-related highway closures:** the number (per year) and/or duration (hours) of highway closures caused by landslides, avalanche, snow, wind, or freezing rain;
3. **Disaster financial assistance for extreme weather events:** total amount ($) of disaster financial assistance payouts to property owners in the Basin for extreme weather events caused by landslides, avalanche, snow, wind, or freezing rain; and
4. **Provincial emergency assistance for storm clean-up:** the total amount ($) of provincial emergency assistance paid to local governments in the Basin for extreme weather events caused by landslides, avalanche, snow, wind, or freezing rain.

These indicators also measure adaptation outcomes. That is—how well are Basin communities adapting to climate changes and reducing community vulnerability over the long-term? Trends in these indicators can provide evidence of the effectiveness of local climate adaptation and resilience planning. In the future, with proactive and effective planning, one would hope to see fewer weather-related power outages, highway closures, disaster financial assistance payouts, and provincial emergency assistance paid to local governments.

This pathway also tracks three specific actions by Basin residents and local governments that support capacity development and climate resilience:

1. **Residents with 72-hour emergency preparedness kits:** proportion of residents with 72-hour emergency preparedness kits including adequate food, water, cooking supplies, etc.;
2. **Emergency preparedness plan:** number of local governments with updated emergency preparedness and evacuation plans; and
3. **Backup power sources:** number of local governments with back up power sources for critical community services and infrastructure.

These three adaptation action indicators will be tracked through surveys with residents and local government representatives.

Potential crossover indicators for the extreme weather pathway include: frequency of hail storms, drought index and percentage of residents with a backup energy source.

Flooding

Flooding, including debris flows and debris floods, can have significant impacts on Basin communities. For example, flooding can affect drinking water quality, destroy homes and infrastructure and disrupt transportation networks, all with negative consequences for our economy, environment and quality of life.

The flooding pathway focuses on the main causes, environmental changes, potential impacts on communities, as well as community adaptation actions and their outcomes.

Future climate projections indicate more frequent intense rainstorms, increased glacier melt, rain-on-frozen ground, rain-on-snow and higher winter peak flows, all of which may increase the risk of flooding in the future.[6] In fact, the number of extreme wet days (precipitation events of such magnitude that they only happen, on average, once every 25 years) is projected to occur between 0.3 to 4.1 times as often as in the past.[7] These wet conditions are also likely to increase landslide risk since many landslides are triggered by soils saturated by prolonged and intense rainfall.[8]

6 Columbia Basin Trust (2012). Climate Change Impacts and Adaptation in the Canadian Columbia Basin: From Dialogue to Action

7 Projections are from the Pacific Climate Impacts Consortium – Climate Extremes in the Columbia Basin (2013). All projections are for the 2050's (2041-2070), relative to a baseline period of 1971-2000. Based on 10th to 90th percentile of results for all grid boxes and all model runs.

8 Columbia Basin Trust (2012). Climate Change Impacts and Adaptation in the Canadian Columbia Basin: From Dialogue to Action

Figure 8 shows the indicators and pathway.

Three climate change indicators are recommended for tracking long-term trends in the frequency of extreme weather events:

1. **Maximum 1-day rainfall:** the heaviest precipitation day or monthly maximum 1-day precipitation (in millimetres) in a given year;
2. **Climate extremes (precipitation):** amount of rain falling on days when 1-day rain values exceed 95th percentile for the year in question (precipitation); and
3. **Frequency of rain-on-frozen-ground events:** number of days each year with rain-on-frozen-ground; this is assumed to be days during winter (December to February) when precipitation is recorded as rain.

Figure 8: Flooding Pathway

Changes in climate will have direct and indirect impacts on Basin communities. Indirect impacts are experienced through changes in the environment. For example, long-term shifts in temperature and precipitation patterns are likely to affect stream flow timing and volume, as well as snowpack.

The following environmental impact indicators are recommended for tracking indirect effects related to flooding:

1. **Stream flow timing:** timing of annual peak yield on monitored, unregulated streams;
2. **Peak stream flow volume:** annual maximum daily discharge on monitored, unregulated streams; and
3. **April 1st snow pack:** depth of the snowpack on April 1st each year.

These environmental impacts can affect communities directly, for example through increased flooding and damage to roads, infrastructure, and property.

Four indicators are proposed to help track the long-term impact of flooding on Basin communities:

1. **Disaster financial assistance for flooding events:** total amount ($) of disaster financial assistance payouts to property owners in the Basin for flooding events;
2. **Flood-related highway closures:** the number (per year) and/or duration (hours) of highway closures caused by flooding;
3. **Provincial emergency assistance for flood response and clean-up:** total amount ($) of provincial emergency assistance paid to local governments in the Basin for flooding events; and
4. **Developed properties in the floodplain:** total number of developed properties that are located within known and active floodplains in the Basin.

These four indicators also measure adaptation outcomes. That is, how well Basin communities are adapting to climate changes and reducing community vulnerability over the long-term. Trends in these indicators reflect the effectiveness of local climate adaptation and resilience planning. In the future, with proactive and effective adaptation planning, the hope is for fewer flood-related disaster financial assistance payouts, highway closures, provincial emergency assistance to local governments and fewer developed properties in the floodplain.

The flooding pathway also tracks four specific actions by Basin communities supporting capacity development and climate resilience:

1. **Flood mapping extent and updates:** the proportion of Basin floodplains where flood maps are available, and the proportion that have updated their flood maps since 2003;
2. **Emergency preparedness plan:** the proportion of Basin communities with emergency preparedness and evacuation plans updated in the last five years;
3. **Local government expenditures on flood protection:** the amount ($) or budget proportion of local government expenditures allocated towards flood protection; and
4. **Percentage of impervious surface in municipality:** the proportion of land area within municipalities that is impervious (roads, sidewalks and buildings).

Water Supply

Many Basin communities have developed with historically reliable access to clean and plentiful water. Research indicates, however, that projected changes to the Basin climate may influence patterns of both the supply of and demand for fresh water for human use.[9]

9 See "Climate Change, Impacts and Adaptation in the Canadian Columbia Basin: From Dialogue to Action" (Columbia Basin Trust, 2012) for more information.

The water supply adaptation pathway focuses on changes in the climate, environment, adaptation actions and outcomes that relate to the quality and quantity of water available for consumptive use by Basin communities and residents. Water supply for agricultural irrigation is included in the agriculture pathway.

Figure 9 shows the indicators and the pathway.

Two climate change indicators are recommended for tracking temperatures and precipitation:

1. **Climate extremes:** frequency of days when maximum temperature exceeds 90th percentile for baseline period (temperature), amount of total precipitation (in millimetres) that occludes during days when precipitation exceeds the 95th percentile for the year in question (precipitation); and
2. **Climate averages:** average monthly temperature and precipitation values.

Figure 9: Water Supply Pathway

Climate changes have direct and indirect impacts on Basin water users. Indirect impacts are experienced through changes in the environment. For example, long-term shifts in temperature and precipitation patterns may affect water storage in the environment (in the form of glaciers) and influence the quality, quantity, and timing of flow for surface and ground water sources in other ways. Extreme temperature and precipitation events can raise water temperatures (thereby enabling growth of pathogens) or otherwise affect water quality by causing erosive runoff or the overflow of wastewater systems.

The following environmental impact indicators are recommended for tracking:

1. **Glacier extent:** area of glaciated terrain in the Basin;
2. **Stream flow timing:** timing of annual peak yield and late summer minimum yield on monitored, unregulated streams;

3. **Stream flow volume:** total annual maximum and minimum daily discharge on monitored unregulated streams;
4. **Ground water level:** average monthly ground water level for monitored aquifers;
5. **Source water temperature:** average monthly temperature for monitored surface water sources in summer months; and
6. **Source water turbidity:** Monthly average Nephelometric Turbidity Units (NTU) for monitored surface water sources.

Changes in the climate and environment will likely affect water supply and demand in Basin communities. It will be important for communities to adapt to these changes by ensuring their water systems are prepared to cope with potentially lower water quality, less available supply, and higher demand.

The following indicators measure both the impact of climate and environmental changes on Basin water users, and the extent to which Basin communities have been able to adapt:

1. **Per capita water consumption:** volume of total water supplied annually, reported by utility and expressed per capita (service population);
2. **Drinking water quality:** number of water systems on a drinking water advisory or boil water notice as of June 10 annually;
3. **Water loss:** percentage of total water supplied annually that is lost to leakage; and
4. **Implementation of water restrictions:** number of days annually when water restrictions are active, reported by utility.

Communities' efforts to adapt may include the implementation of plans, bylaws, infrastructure upgrades, or new operational policies. These actions can improve the security of water supplies in several ways, including protecting water quality and quantity at the source, ensuring adequate treatment, maximizing the efficiency of water use, or influencing the behaviour of water users in a way that reduces demand on a stressed system.

The following indicators could help the region understand the extent of actions taken by Basin communities to prepare for the projected impacts of climate change on the water supply:

1. **Policies to reduce water consumption:** number of water utilities that have incorporated water consumption considerations in policies and legislation (tools will vary by community);
2. **Water protection plans:** number of water utilities that have undertaken water planning measures that consider projected climate changes; and
3. **Water loss detection practices:** percentage of Basin population served by water systems that have implemented water loss detection practices, including connection or district meters, night flow analysis and leak detection.

Wildfire

While fire is a natural process in forested ecosystems in the Basin, wildfires can cause serious damage to infrastructure, community water supplies and human health. Climate projection models suggest that there will be a significantly larger area burned annually due to warmer, drier summers,[10] which could also increase and intensify impacts on communities.

The wildfire adaptation pathway tracks the danger of wildfire, the impact fires have on the environment and communities and how communities are preparing to deal with them. Wildfire can have serious impacts on communities and ecosystems in the Basin.

The wildfire pathway is illustrated in Figure 10.

Only one climate variable is recommended for tracking long-term trends in the danger of wildfires due to weather and climate change. It is a composite index and incorporates other potential indicators that were under consideration. The recommended indicator is:

1. **Number of days in extreme danger class:** total number of days when there is extreme danger of fires starting easily and spreading rapidly. This is a composite index based on temperature, relative humidity, precipitation and wind.

Tracking and reporting on this indicator will provide communities with an indication of how threats of wildfire may be changing, and the degree to which local planning and operational decisions need to be adapted.

Figure 10: Wildfire Pathway

10 Utzig, G., J. Boulanger and R.F Holt. 2011. Climate Change and Area Burned: Projections for the West Kootenays. Report #4 from the West Kootenay Climate Vulnerability and Resilience Project. Available at: www.kootenayresilience.org

Changes in climate will have direct impacts related to wildfire. For example, increased temperatures and decreased precipitation during the summer months will lead to larger and more frequent wildfires.

Three environmental variables are recommended for tracking long-term trends in wildfire impacts:

1. **Annual area burned:** number of hectares burned on an annual basis in the Columbia Basin;
2. **Air quality:** measures concentrations of fine particulate matter in the air - $PM_{2.5}$ (particulate matter with a diameter of less than 2.5 micrometres); and
3. **Wildfire starts:** total number of both human- and lightning- caused wildfire starts per year.

Tracking and reporting on these indicators will help communities understand and recognize the increasing threats and impacts of wildfire to infrastructure and human health.

Increases in the numbers and size of wildfire can impact communities directly through increased interface fires, direct cost of fighting fires, interruptions to services, damage to infrastructure and evacuations.

Five indicators are recommended to help track the impact of wildfires on Basin communities: Frequency of interface fires: annual number of wildfires within two kilometres of a Basin community;

1. **Cost of fire suppression**: amount of money spent on fire suppression in the Southeast Fire Region annually;
2. **Fire-related road closures:** number (per year) and/or duration (hours) of highway closures caused by wildfire;
3. **Fire-related power outages:** number (per year) and/or duration (hours) of power outages due to wildfire; and
4. **Wildfire evacuation orders:** number of evacuation orders due to the threat of wildfire issued by the B.C. Wildfire Management Branch.

The wildfire adaptation pathway tracks specific adaptation actions taken by residents, local governments and the B.C. Wildfire Management Branch to mitigate the threat of wildfires to residents and communities.

Three specific actions to reduce impact and threat will be tracked:

1. **Interface fire risk reduction:** the forests immediately surrounding communities have been mapped, and this indicator tracks the percentage of the high priority interface fire area that has been treated to reduce wildfire risk;
2. **FireSmart-recognized communities:** number of Basin communities recognized through FireSmart Canada's Community Recognition Program; and

3. **Campfire bans:** tracks the number of days each year that the B.C. Wildfire Management Branch issues bans on open fires, campfires and forest use in the Basin.

Crossover indicators for the wildfire pathway include drought index, climate averages and climate extremes.

Gaps in Pathway Coverage

Subsequent to the final selection of indicators for the adaptation pathways, a gap analysis was undertaken to determine if any broad aspects of climate change adaptation were left unaddressed by the pathways or any significant groups of indicators identified initially had been left out.

Gaps were anticipated especially since the project team narrowed its focus to five adaptation pathways to ensure robust indicator development and avoid recommending an unrealistic number of new indicators.

The gap analysis was undertaken primarily to identify and highlight potential gaps for future research rather than to ensure that every possible aspect of climate change had been covered. Options for addressing the identified gaps were considered and implemented in some cases, as discussed below.

Gaps not addressed by the five adaptation pathways:

- **Biodiversity and ecosystems;**
- **Forestry, mining and tourism;**
- **Energy; and**
- **Infrastructure.**

These are examined in detail below.

Gaps in Biodiversity and Ecosystems

A biodiversity and ecosystems pathway would include indicators that reflect the general health and changes in species and ecosystems in the Basin, including indicators relating to red-listed species, migratory bird return times, or lake thaw dates.

The exclusion of biodiversity and ecosystems was due largely to the fact that this report is aimed at local governments. While biodiversity and ecosystems are important to communities for a variety of reasons (e.g. flood control, existence value, quality of life, recreation, etc.), they are not central to local government mandates. Moreover, adapting to climate change from a biodiversity and ecosystem perspective is primarily the jurisdiction of provincial and federal governments.

The incorporation of some ecosystem-related indicators into the CRI was considered, but since the focus of the CRI is more on socio-economic factors and self-reliance, it was decided not to do so. This remains a gap for consideration in the future.

Gaps in Forestry, Mining and Tourism

Many communities in the Basin are dependent on forestry, mining, and tourism, and some are highly dependent on just one of these economic sectors. Forestry and tourism in particular could be influenced by climate change. A pathway relating to these sectors could include indicators relating to forest productivity, types and numbers of tree species, or measures of local or regional economic dependence on these industries. However, like biodiversity and ecosystems, many of the adaptation actions that could be undertaken in relation to these industries are not within the jurisdiction of local governments, but rather provincial government and the private sector. In addition, since forestry and mining are heavily influenced by global commodity prices, changes in these industries may not be influenced directly by climate change.

Because of the importance of these industries to the economy of some Basin communities, it was decided to address this gap through the inclusion of an indicator in the CRI focused on measuring employment in climate-sensitive sectors.

Gaps in Energy

Energy, like water and food, is a key constituent of well-being for Basin residents. An energy pathway could include indicators such as hydroelectricity production, stream flows, number of heating-degree days and number of power outages. Hydroelectric production could be affected by changes in stream flows and increased water demands by other users. In addition, heating-degree days (which influence energy demand for heating) are expected to decrease, while cooling-degree days (which will influence energy demand for cooling) are expected to increase.

Given that the vast majority of B.C.'s energy comes from large hydroelectric dams, which are beyond the legislative jurisdiction of municipalities, an energy adaptation pathway was not included. To address concerns relating to power outages from extreme weather events, an indicator relating to the number of residents with a backup energy source was considered for the CRI and is already included in the extreme weather and emergency preparedness pathway.

Gaps in Infrastructure

The final gap relates to a series of proposed indicators associated with increasing the resilience of Basin infrastructure, including roads, water supply, sewer, storm water management infrastructure and buildings. It was agreed that while these indicators are critical—because infrastructure affects everyone and is very relevant to local governments—increasing the resilience of Basin infrastructure is too difficult to define and data on Basin infrastructure is too difficult to acquire at this time. Alternatives such as investment in infrastructure, age of infrastructure or local government debt levels were considered. However, data for these indicators was also considered too difficult to acquire and interpret.

To gain some insight into Basin infrastructure, an indicator measuring local government adoption of asset management planning was included in the CRI, as were indicators on access to broadband, cell phone coverage and backup energy sources.

Many of the adaptation pathway indicators have implications for infrastructure, including those related to climate extremes and indicators that address impacts and actions for flooding, extreme weather and water supply. While the adaptation pathways address, to some degree, how flooding, fires and extreme weather might affect infrastructure, some important gaps remain.

In the future, risk assessments of infrastructure undertaken by local governments may serve as a useful infrastructure indicator (either in binary yes/no form, or as an index that assesses and itemizes infrastructure for which risk assessments have been undertaken), as might the choice to include a climate risk assessment component in an asset management plan. Since local governments are still in early stages of the asset management planning process it will be some time before more robust infrastructure indicators become meaningful.

5. Community Resilience Index (CRI)

Climate resilience is generally defined as being able to respond to, cope with and recover from climate variations and impacts. Resilience can be operationalized in a number of different ways. This section details the rationale for development of, and indicators selected for the CRI.

As outlined previously, one of the goals in developing the CRI was to capture SoTB indicators relevant to a community's capacity to adapt to climate change yet that did not specifically measure climate changes, climate impacts or climate adaptations. It was felt that there was value in measuring factors that can influence a community's capacity to adapt and respond to climate impacts. Decreases in vulnerability and increases in resilience can in some ways be considered outcome measures of successful adaptation and, as outlined in the literature review, some agencies are using vulnerability and resilience indices to measure adaptation rather than specific process or outcome adaptation indicators.

There is, inevitably, some overlap between measuring resilience to climate change and climate change adaptation. Climate change adaptations will, generally speaking, increase the climate resilience of a community or region. However, specific indicators can help capture and reflect a broader perspective in that some communities or regions have characteristics that are not specific climate change adaptations yet serve to increase a community's or region's resilience to climate change. These include factors such as mean incomes, high workforce education, a strong sense of community, and an abundant supply of fresh water. These types of indicators are captured in the CRI.

Approaches to developing resilience indices and the differences between resilience and vulnerability indices are outlined in detail in the literature review.

Overview of CRI Development

Step One – Flagging of SoTB Indicators

SoTB indicators that appeared as though they could influence a community's ability to adapt to climate change in some manner, yet were not specific climate change, climate impact, or climate adaptation indicators, were flagged as potential resilience indicators in the initial mini-group process and indicator assessment workshop.

Step Two – Selection of Resilience Index Model

Resilience index models identified in the literature review were examined to determine if there was one that aligned with the project team's concept of resilience and could appropriately house SoTB indicators flagged as resilience indicators. As a result of this assessment, Swanson et al.'s (2009)[11] climate change resilience index model that uses six determinants of adaptive capacity—economic resources; technology; information, skills and management; infrastructure; institutions and networks;

11 Swanson, D., J. Hilley, H.D. Venema and R. Grosshans (2009). Indicators of Adaptive Capacity to Climate Change for Agriculture in the Prairie Region of Canada: Comparison with Field Observations. The Prairie Climate Resilience Project. International Institute for Sustainable Development. http://www.iisd.org/pdf/2009/pcr_adaptive_cap_ag.pdf

and equity—was selected as the most appropriate for use with SoTB indicators. Deciding factors in its selection included its straightforward structure and relative comprehensiveness of factors relating to resilience. For a more detailed description of this model, including the resilience indicators identified for the Canadian prairies, see the literature review.

Step Three – Incorporation of SoTB Indicators into Model

SoTB indicators flagged as potential climate change resilience indicators were examined for applicability and sorted according to the determinant they reflected most closely. Applicable indicators were incorporated into the existing model under the appropriate determinant. See Table 2 for an outline of Swanson et al.'s original determinants of adaptive capacity and resilience.

Table 2: Swanson et al.'s Determinants of Resilience*

Determinant	Rationale
Economic resources	Greater economic resources increases adaptive capacity
	Lack of financial resources limits adaptation options
Technology	Lack of technology limits range of potential adaptation options
	Less technologically advanced regions are less likely to develop and/or implement technological adaptations
Information, skills and management	Lack of informed, skilled and trained personnel reduces adaptive capacity
	Greater access to information increases likelihood of timely and appropriate adaptation
Infrastructure	Greater variety of infrastructure can enhance adaptive capacity, since it provides more options
	Characteristics and location of infrastructure also affect adaptive capacity
Institutions and networks	Well-developed social institutions help to reduce impacts of climate-related risks and therefore increase adaptive capacity
	Policies and regulations may constrain or enhance adaptive capacity
Equity	Equitable distribution of resources increases adaptive capacity
	Both availability of and entitlement to resources are important

•Note that Swanson et al. largely used the terms resilience and adaptive capacity interchangeably.

Step Four – Review and Adjustment of the Index

An important element of Swanson's model is having a balanced number of indicators per determinant. Accordingly, four to six potential indicators were brainstormed by the project team for each determinant as a starting place for discussion. Since Swanson's model was developed specifically for agriculture in the Canadian prairies, it had to be adapted for the Basin. The model was reviewed for its robustness and comprehensiveness in reflecting what makes a community resilient, and the literature was consulted again for additional ideas. As a result of this review, a new determinant (local production and self-reliance) was added and a few of Swanson's determinants were revised. On the basis of this review, a draft CRI was developed.

Step Five – Presentation of the draft CRI to the PASC

A conceptual framework for the CRI was presented to the PASC and local government representatives for review and comment.

Step Six – Rating of CRI Indicators

Proposed CRI indicators were scored for suitability by each project team member on a scale of 1 to 5. This simplified process was used because most of the indicators under consideration had previously been screened using the indicator screening tool. The scores were averaged, and the deltas analyzed. Indicators scoring less than two were eliminated. A gap analysis was undertaken and it was agreed that additional indicators would be sought for the infrastructure determinant since none of the original set achieved the minimal score.

Step Seven – Finalization of the CRI

Based on analysis of the scores and deltas for each CRI indicator, a final suite of CRI indicators was selected and a final gap analysis was conducted.

Step Eight – Confirmation of CRI with Local Governments and the PASC

Once refined, the CRI indicators were verified with the PASC and the three local government representatives.

Establishing the Community Resilience Index

The CRI determinants are presented in Table 3, and the final CRI complete with indicators is presented in Table 4. Each determinant of adaptive capacity/resilience has three to four indicators. Table 4 shows the desired directionality of the indicator and whether it is an existing SoTB indicator. More detailed rationales and data sources for CRI indicators are provided in Appendix C.

As Appendix C highlights, many of the indicators were developed using information from Statistics Canada and BC Stats. Provided that other provincial agencies collect similar information, the indicator suite should be transferable to other jurisdictions. Indicators based on locally available data may or may not be available in other communities or regions.

As outlined in Table 3, the determinants of adaptive capacity/resilience used in the CRI remain largely the same as those used by Swanson et al. with a few minor adjustments. Infrastructure and Technology were combined and renamed Built Environment and Technology. Equity was broadened to Population Wellness to incorporate indicators of both population and healthcare. Local Production and Self-Reliance, which focuses on the ability of communities to provide their own food, water and energy in the event of climate-related failures that reduce access to food, water and energy from external sources, was added as a determinant.

A key assumption of this model is that the CRI will be utilized to measure the resilience of communities on a relative, not absolute scale, with the focus on tracking increases or decreases in a community's or region's resilience over time, rather than comparing communities. It is important to note that the indicators to be tracked using poll questions for residents can only be reported Basin-wide (rather than by community) due to the small sample size.

Table 3: CRI Determinants of Adaptive Capacity

Determinant	Rationale
Economic resources	Greater economic resources increase adaptive capacity
	Lack of financial resources limit adaptation options
Built environment and technology	Lack of infrastructure and technology limits range of potential adaptation options
	Less technologically advanced regions are less likely to develop and/or implement technological adaptations
	Greater variety of and investment in infrastructure can enhance adaptive capacity, since it provides more options
	Characteristics and location of infrastructure also affect adaptive capacity
Information, skills and management	Lack of informed, skilled and trained personnel reduces adaptive capacity
	Greater access to information increases likelihood of timely and appropriate adaptation
Institutions and networks	Well-developed social institutions help to reduce impacts of climate-related events and therefore increase adaptive capacity
	Policies and regulations may constrain or enhance adaptive capacity
Population wellness	Equitable distribution of resources increases adaptive capacity
	Both availability of and access to resources are important
	Human resources are a valuable asset
Local production and self-reliance	Some degree of local production and self-sufficiency increases adaptive capacity
	Access to and control of important resources such as water and energy increases adaptive capacity

The indicator results for the CRI are intended to be presented in a disaggregate form as this allows for tracking of trends in each indicator, rather than trends in an overall index score. In addition, the degree to which the indicator results are reported at different scales and in different units—i.e. dollar values, percentages, Likert scales—would make aggregation challenging and potentially skew the data. Some indicators in the CRI were flagged as potentially being more important and could therefore receive a higher weighting in an aggregated index. However, the project team felt that the CRI should be applied in a few communities or regions and the results analyzed to assess the relative importance of the indicators before any weighting or aggregation is applied. Presenting the results in disaggregate form allows the user to decide which indicators are most important for assessing the resilience of their community.

As noted above, there are three to four indicators per determinant to ensure the index is balanced. **Several indicators that cannot currently be tracked—but could be added to the CRI in the future should the data become available or the practices in question become more common—include:**

Population wellness determinant

Reliance on food banks:

- Amount of food received from food banks
- Number of people using food banks

Local production and self-reliance determinant

Local energy production (commercial and personal):

- Amount of energy produced via local alternative energy production such as solar, geothermal or wind power

Water storage capacity:

- Total water storage capacity in Basin municipalities and rural areas

Table 4: The Community Resilience Index

Determinant	Aspect	Indicator	Further Definition	Direction	Existing SoTB
Economic resources	Income generation	Income	Average and median income of Basin population.	Higher is better	Yes
	Business climate	Employment by sector	Total number of people employed by sector with a focus on climate sensitive sectors.	Higher is better	Yes
	Employment opportunities	EI and income assistance dependency	Employment Insurance (EI) and income assistance dependency ratios.	Lower is better	Yes
Information, skills and management	Education	Workforce education	Proportion of workforce with post-secondary education.	Higher is better	Yes
	Access to information	Access to broadband	Percentage of population with access to broadband internet services.	Higher is better	No
	Knowledge	Knowledge of important environmental issues, including climate change	Poll question for residents – percentage of residents who believe they have a good understanding of regional environmental issues including climate change.	Higher is better	Yes
	Practices	Completion of climate change adaptation actions	Poll question for municipalities – have they implemented any climate change adaptation measures – yes/no, number completed, or rating.	Higher is better	No
Institutions and networks	Civic engagement	Voter turnout	Percentage of eligible Basin voters who participate in local government elections.	Higher is better	Yes
		Volunteerism	Poll question for residents – percentage of residents who volunteer on a regular basis.	Higher is better	No
	Sense of community	Belonging and attachment to community	Poll question for residents – Likert scale question asking about belonging and attachment to community.	Higher is better	Yes (as of 2014)
Population wellness	Dependency	Age/gender	Total number of people in the region in five-year age groups or 'cohorts' reported by gender.	No direction	Yes
	Equity	Income disparity	Gini index score—a measure of the equity of a distribution of incomes.	Lower is better	Yes (as of 2014)
	Health care	Life expectancy	Number of years a person is expected to live from birth.	Higher is better	Yes
Built environment and technology	Municipal infrastructure	Asset management planning	Poll question for municipalities – where are they are along a defined spectrum of asset management planning.	Higher is better	No
	Communication infrastructure	Basin cell phone coverage	Percentage of region/major highways with cellphone coverage.	Higher is better	No
	Housing and neighbourhoods	Housing stock in need of repair	Percentage of private dwellings in need of major repair.	Lower is better	No
		Walkability	Percentage of developed properties within 500 metres of a food store.	Higher is better	No
Local production and self-reliance	Food production	Amount of area farmed	Area being farmed on a regional district basis.	Higher is better	Yes
	Energy	Residents with a backup energy source	Poll question for residents – types of backup energy sources.	Higher is better	No
	Water availability	Late summer streamflow volume	Change in late summer stream yield, reported by monitoring station.	Higher is better	Yes

6. Conclusions, Lessons Learned and Recommendations

This section addresses conclusions, lessons learned and recommendations developed. Much of the material in this section may also be relevant to the development of climate adaptation indicators in other jurisdictions.

The SoCARB indicator suite was developed for use at a regional level in a predominantly rural environment. Nevertheless, the indicators, processes and tools developed may be applicable to other levels and jurisdictions, including the provincial level and large metropolitan communities (with some minor adjustments to reflect more urban contexts). While the indicators can be applied to individual communities, the level of effort associated with data collection and analysis may not make them practical for use by smaller communities working on their own. The processes developed through this project may be of interest to any organization considering the development of climate adaptation indicators.

It is recognized that different communities and regions in Canada are at varying stages of readiness to develop climate adaptation indicators. The Trust has been supporting climate change adaptation for communities through CACCI, and indicators of well-being, since 2008. As a result, communities in the Basin may be better situated to utilize the SoCARB indicators. For communities, regions or agencies with less experience, it may be valuable to start with a single relevant adaptation pathway, the CRI or with a suite of indicators of well-being similar to SoTB.

Communities in B.C. may benefit from consulting the Plan2Adapt tool developed by the Pacific Climate Impacts Consortium that provides maps, plots, and data describing projected future climate conditions for regions throughout the province.[12] A champion, such as a provincial or regional government agency, could also play an important role in coordination and capacity building to measure progress on climate adaptation.

Conclusions

Measuring climate adaptation and resilience through indicators is an important and worthwhile undertaking

Climate change is a serious issue facing the world, and adapting to climate change is an important task for individuals, communities and all levels of government. It is particularly important for local governments, given their responsibility for local infrastructure and basic needs such as water supply, to be on the front line of climate adaptation.

Measuring progress on climate adaptation and resilience is an important component of adaptation efforts. Indicators are an essential element of an overall monitoring and evaluation framework for climate adaptation and resilience that can help determine whether communities are undertaking

12 See http://www.pacificclimate.org/analysis-tools/plan2adapt.

the best and most appropriate adaptation measures, the effectiveness of those measures, and subsequent increases or decreases in community resilience. If adaptation and resilience efforts are not monitored, it may be more difficult for communities to determine how they are vulnerable and whether adaptation actions are effective.

Indicators are measures, generally quantitative, that help in the analysis and communication of complex information in a simple format to enable tracking of trends and progress over time. Indicators have multiple purposes including:

- Tracking key trends in climate adaptation and resilience in a community or region,
- Facilitating understanding of complex issues,
- Evaluating the effectiveness of various adaptation measures,
- Informing residents, organizations, and governments regarding key trends and adaptation outcomes,
- Supporting decision-making by local, regional and higher levels of government, and
- Motivating change.

While indicators are an important element of an overall climate adaptation and resilience monitoring and evaluation system, indicators only provide an overview of change—they do not explain how or why that change came about, provide the total picture of all of the changes that could occur as a result of climate change or the effectiveness of all climate adaptation measures. Ideally they will comprise part of a larger monitoring and evaluation program for climate adaptation.

Well-being indicators alone are insufficient to measure climate adaptation

The review determined well-being indicators alone are insufficient to measure climate adaptation. This resulted in development of the SoCARB indicator suite that includes five adaptation pathways and the CRI, and is envisioned as a companion and complement to the SoTB.

While it was necessary to propose many new indicators to measure climate adaptation and resilience, the SoTB indicator suite was nonetheless a useful starting point. Of the 39 2013 SoTB indicators examined, 21 were incorporated into the recommended SoCARB indicator suite—12 were incorporated into the adaptation pathways and 11 were incorporated into the community resilience Index. Two of the new SoTB indicators added in 2014 are included in the SoCARB indicator suite. Moreover, 36 of the 39 2013 SoTB indicators were deemed to have some relevance to measuring climate adaptation, either directly through a pathway or indirectly as a measure of resilience, and some of those were excluded only because there was not a relevant pathway or because there were other more appropriate indicators in the SoTB suite. **As a result of the review process, 56 new indicators are recommended for SoCARB's adaptation pathways and CRI.**

Using adaptation pathways can facilitate understanding

Due to the complexities associated with how communities cope with the impacts of climate change, adaptation pathways were devised to show the connections between different indicators, tell a story about how communities can adapt to climate change, and make the indicators relevant to users. Likewise, the project team found that the pathways alone do not tell a complete story and that it is also important to think of the factors that combine to determine a community's resilience to climate impacts. Combining indicators in these ways helps reflect the dynamic interplay among the various actors, valued community assets, ecosystem components, and critical climate changes. The adaptation pathways and the CRI complement one another in measuring communities' climate resilience and adaptation efforts.

Local context and local knowledge are important in measuring climate adaptation and resilience

It should be noted that some sectors initially identified in the project proposal—energy, health, infrastructure, flood management, and transportation—were bypassed. **Priority was given to climate risks expressed by local governments over the last several years.** Input from those who will be primary users of the indicators (and who will be relied upon to provide data) has been important in determining which indicators to use and the final shape of the pathways.

The approach and tools developed in this project could be used in other jurisdictions with adjustments to reflect local context and knowledge

Adapting similar general indicator suites of well-being or sustainability to measure climate adaptation is a good starting point, and will likely pose similar challenges. The tools developed and the collaborative and iterative approaches used to develop the adaptation pathways and CRI were effective. The same approach could be utilized to develop a suite of SoCARB indicators in other jurisdictions, based on local priorities and using the same or similar pathways. However, as noted above, local context and priorities matter in measuring climate adaptation and resilience, and if the adaptation pathways and CRI in this project are used elsewhere, they should be modified for local conditions. In particular, adjustments may be necessary if the SoCARB suite is adopted at a provincial or individual community level, and/or in a more urban environment.

Lessons Learned

Assessing how 'State of The Basin' indicators can be used to measure climate changes and impacts and support progress on adaptation was a rich learning experience. The team started with a general framework and proposed approach and developed a significant number of tools and insights along the way, including the indicator screening tool, the project indicator model, the adaptation pathway approach, and the CRI.

Key lessons learned were:

Using existing well-being indicator suites can serve as a valuable starting point

- Indicator suites intended for the measurement of general well-being or sustainability provide an entry point for developing a climate adaptation indicator suite and may contribute an initial set of indicators (and associated reporting structure) to build from.
- The proposed SoCARB indicators are linked to the SoTB indicators but they are not integrated initiatives. However, the RDI Digital Basin would provide a useful platform for reporting on SoCARB indicators.

Local knowledge and expertise are invaluable in developing climate adaptation indicators

- In adapting a general indicator suite, it is important to use local knowledge and expertise; climate adaptation indicators should reflect local priorities, risk areas, and knowledge.
- The local or regional context is important to indicator development and will limit the applicability of certain indicators developed through this project to other regions or communities, in the same way it limited the applicability of certain indicators used in other communities to this project. The indicators developed through this project were developed for use on a regional level in a rural environment, thus some indicators may not be applicable at a community or provincial level, or in an urban environment.
- Engaging the target audience and data providers—in this case local government representatives— was a valuable step for ground-truthing proposed indicators and determining which ones could realistically be tracked in a consistent manner across the region.
- The dispersed nature and diversity of Basin communities (particularly with regard to terrain and population size) made the development of some indicators challenging as risks and vulnerabilities were not necessarily shared, and comparable data was not available across all communities and municipalities.

Selecting indicators to measure climate adaptation is an iterative process that requires balancing methodological rigour with practicality and a need for flexibility

- Indicators as initially conceived often evolve as the realities of data availability become evident. Many prospective indicators were originally more 'notional' and reflected the type of information the project team thought would be useful in understanding climate change, and had to be dropped or adjusted to reflect what could be measured, and available or collectable data.
- Adaptation pathways will only approximate the links between climate changes, impacts and adaptations, largely due to constraints on data availability and the need to limit the number of indicators. This is further complicated by the fact that the relationships between climate changes, impacts, and adaptations are complex with feedback loops and non-linear connections.
- Compartmentalizing indicators into adaptation pathways, while essential for facilitating understanding and telling a story, cannot provide the total picture of climate change for any given thematic area.

Developing a manageable suite of indicators requires clear priorities

- It was necessary to prioritize the thematic areas selected for pathway development and the indicators considered for the pathways and the CRI due to limitations on the scope and time frame of the project and the need to develop a manageable indicator suite that could be sustainable in the long-term.

- Lengthy polls for residents and local governments often result in lower response rates. Being able to collect the data in a consistent and ongoing manner is an important consideration in selecting the final suite of indicators. If too much data must be provided by external sources, this may not be achievable. It is important to be realistic about how much and what kind of data a suite of indicators will require from residents, local governments and other agencies.

There will always be gaps in data and measurability—some of which need to be acknowledged and accepted, while others highlight areas that need attention

- Tracking climate change-related impacts on infrastructure and local government expenditures to upgrade infrastructure to be more climate-resilient could be useful. However, there is currently no mechanism to compile this data across the Basin. Some key indicators related to climate change such as infrastructure and asset management, floodplain mapping, water supply and storage, and certain climate factors (i.e. wind speed, freezing rain) could not be incorporated into the pathways or CRI due to unresolvable data collection or measurement challenges. These gaps highlight areas where efforts should be made to improve data availability in the Basin.
- It is tempting to use polling-type indicators to fill in data gaps and construct more complete pathways and indices. However polling-type indicators do not generally provide as high a quality of data due to reliability issues. Asking too many poll questions can also result in reduced response rates.

Consider end users when choosing language and terminology

- Appropriate terminology can facilitate understanding and acceptability. The concept of vulnerability, in particular, is constrained by its IPCC definition and it is conceptually difficult for local governments to understand. Focusing on climate resilience is more accessible in terms of working with local governments and citizens.

Recommendations for implementation of SoCARB in the Basin

Implicit in these recommendations is the need for an agency or organization to take the lead on implementation.

The project team suggests that the RDI, as the organization responsible for the SoTB indicator suite and Digital Basin, may be the best-positioned to implement the SoCARB indicators process. Other organizations in the Basin, British Columbia, and Canada may be able to provide support.

The following recommendations outline key steps to implement the SoCARB indicator suite on a Basin-wide level. These recommendations will require adjustment if the SoCARB suite is implemented on a community level.

1. Complete one, full iteration of SoCARB for the Basin, including data collection and reporting on the full suite of indicators proposed in this project, to assess the SoCARB suite and establish baseline data for the indicators. Evaluate the outcomes and determine next steps, including potential changes to the SoCARB indicator suite and the value of repeating the process.
2. Assess the value of undertaking an iteration of the SoCARB indicator suite with two or three specific pilot communities to adjust and localize the suite and determine how well it performs on an individual community level.
3. Undertake subsequent complete iterations of data collection and reporting on the SoCARB every three to five years to measure progress on climate adaptation and resilience, provided the SoCARB indicators and the resulting indicator report are well received and, importantly, used to guide climate change adaptation measures.
4. Consider incorporating climate mitigation indicators into the SoCARB indicators suite to provide a more complete picture of climate resilience in the Basin.
5. Consider incorporating some of the climate adaptation indicators recommended in this project when assessing new indicators to add to the SoTB suite in the future, focusing on the climate adaptation indicators that are most strongly linked to regional well-being.
6. Identify funding options and secure sustainable funding for the initial and ongoing collection of the SoCARB indicator data, review and updating of the indicator suite, and communication of indicator information to Basin residents and local governments.
7. Secure sustainable funding for the ongoing collection of the SoCARB indicator data, review and updating of the indicator suite, and communication of indicator information to Basin residents and local governments.
8. Maintain the conceptual integrity of the adaptation pathways and CRI. If choices must be made regarding indicators to track, it is best to measure and report on fewer pathways or to postpone reporting on the CRI until the resources are available to measure all the associated indicators.
9. Help communities and local governments in the Basin understand the importance of the SoCARB indicators and how to utilize them in planning and undertaking adaptation efforts.
10. Provide technical assistance and support to local governments for SoCARB data collection and compilation.
11. Form a multi-stakeholder implementation advisory group to guide the SoCARB over the long-term.
12. Encourage data collection and compilation in the Basin for areas where there are significant data gaps, including infrastructure and asset management, floodplain mapping, water supply and

storage, and certain climate factors (i.e. wind speed, freezing rain).

Glossary

Adaptive capacity: The ability of a country, region, community, group or individual to monitor, assess and respond to change by moderating potential damages, taking advantage of opportunities, or coping with the consequences.

Biodiversity: The degree of variation of life forms within a given ecosystem, biome, region or other geographical location.

Climate*:* The prevailing weather factors, such as temperature, precipitation, atmospheric pressure, wind velocity and humidity, in a given region, measured over several decades.

Climate adaptation indicators: Climate adaptation indicators measure how communities respond to climate impacts by building capacity and implementing adaptation actions, and the outcomes of those efforts.

Climate change: A detectable shift in the average (mean) and/or the variability of a climate factor from one time period (typically decades or longer) to another.

Climate change adaptation: Climate change adaptation focuses on reducing the impacts of climate change. It is about being ready for a future that is different from what the community has experienced in the past due to changes in weather and climate.

Climate change impacts: The positive and negative effects of climate change on natural and human systems.

Climate change indicators: Climate change indicators measure changes in climate over time through the use of data on key trends relating to temperature and precipitation.

Community impact indicators: Community impact indicators measure the impact of changes in climate on human systems and infrastructure.

Climate change mitigation: Climate change mitigation is the act of reducing greenhouse gas emissions that contribute to climate change.

Drought: Drought exists when precipitation is significantly below average historic levels, causing serious hydrological imbalances that can negatively affect natural and human systems.

Ecosystem: The interactive system formed by all living organisms and their abiotic (non-living) environment in a given area.

Environmental impact indicators: Environmental impact indicators measure the impacts of changes in climate on biophysical systems.

Greenhouse gas: Gases in the atmosphere that absorb and emit radiation within the thermal infrared range causing the greenhouse effect. Key greenhouse gases include water vapour, carbon dioxide, nitrous oxide, methane and ozone. The burning of fossil fuels is a key anthropogenic source of carbon dioxide in the atmosphere.

Growing degree days: Growing degree days (GDD) are a measure of heat accumulation over a season and help determine when crops will reach maturity. GDD are calculated by subtracting a base temperature (below which plant growth is zero) from each day's average temperature, and cumulatively adding each day's growing degree contribution over the course of a season.

Indicator: A measure, often quantitative, that can be used to illustrate and communicate complex environmental, economic and social phenomena in a simple way and highlight trends and progress over time.

Index/indices: A composite indicator made up of several indicators developed to measure multi-dimensional concepts that cannot be captured by a single indicator, and are presented in aggregated or disaggregated form.

Mean: The average of a set of numbers. It is calculated by adding up the numbers and then dividing by how many numbers there are.

Rain-on-frozen ground events: A rain-on-frozen ground event occurs when rain falls onto frozen ground. The rain can cause the snow to melt, creating run-off and in some instances, leading to flooding.

Resilience: The ability of human and ecological systems to absorb disturbances while retaining the same basic structure and ways of functioning, as well as the capacity of those systems to cope with, adapt to and recover fully or partially from stress and change.

Stream flow: The flow of water in streams, rivers and other channels that is a major component of the runoff of water from land to water bodies and a key element of the water cycle. The water flowing in streams, rivers and other channels generally derives from runoff from higher elevations from rain, melting snow, or groundwater.

Temperature: The physical property of matter that expresses whether it is hot or cold. With respect to climate change, temperature generally refers to the air temperature near the surface of the earth.

Vulnerability: The degree to which human or ecological systems are susceptible to and unable to cope with adverse climate impacts.

Appendices

Appendix A: Utilization of SoTB Indicators

Appendix B: Rationale and Data Sources for Pathway Indicators

Appendix C: Rationale and Data Sources for CRI indicators

Appendix D: Recommended New Indicators

Appendix E: All Indicators Considered

Appendix A: Utilization of SoTB Indicators

This table outlines the full 2013 suite of State of the Basin (SoTB) indicators and highlights indicators incorporated into either the adaptation pathways or community resilience index (CRI). In total, 21 of the 39 2013 SoTB indicators examined through this project were incorporated into the recommended SoCARB indicator suite—12 were incorporated into one of the pathways to measure climate adaptation directly and 11 were incorporated into the CRI (two were utilized in both a pathway and the CRI).

It is important to note that some SoTB indicators not utilized in a pathway or in the CRI are still useful indicators for measuring climate adaptation and were not included either because there was not a relevant pathway (as only five pathways were developed) or because there were more appropriate SoTB indicators for a particular pathway. These indicators remain flagged as specific types of climate adaptation indicator for future consideration and the development of additional pathways.

Indicator	Type of indicator*	Status	Notes
Glacier extent	EI	Water Supply Pathway	
Climate extremes - annual number of warm days	CC	Agriculture, Water Supply and Wildfire Pathways	
Climate extremes - very wet days	CC	Agriculture, Flooding and Water Supply Pathways	
Gross annual community water consumption	CI, AO	Not utilized	Eliminated from water pathway in favour of per capita water consumption
Per capita water consumption	CI, AO	Water Supply Pathway	
Stream flow timing	EI	Water Supply Pathway, Community Resilience Index	
Air quality (fine airborne particulates)	EI	Wildfire Pathway	
Agriculture - amount of area farmed	CI, AO	Agriculture Pathway, Community Resilience Index	
Wildfire - annual area burned	EI, CI, AO	Wildfire Pathway	
Protected areas - percentage of public land	AA	Not utilized	Scored well but no relevant pathway – may be applicable to an Ecosystems Pathway
Species at risk - number of red list species	EI, AO	Not utilized	Scored well but no relevant pathway – may be applicable to an Ecosystems Pathway
Invasive species: number of noxious weeds, bio-controls used, and invasive fish	EI, CI, AO	Partially incorporated into Agriculture Pathway	Number of noxious weeds incorporated into Agriculture Pathway
Threatened ecosystems (red listed ecosystems by BEC subzone)	EI, AO	Not utilized	Scored well but no relevant pathway – may be applicable to an Ecosystems Pathway
Length of growing season	EI	Agriculture Pathway	
Private land conservation	AA	Not utilized	To be combined with public protected land area as one indicator
Community forests	AA	Not utilized	May be applicable to an Ecosystems Pathway
Stream health (formerly water quality)		Not utilized	Not suitable as measured
Job creation - total number of people employed in the Basin	CI, RF	Community Resilience Index	Focus on climate sensitive sectors
Income - median and average	CI, RF	Community Resilience Index	
Drinking water quality - number of drinking water advisories	CI, AO, RF	Water Supply Pathway	Need to focus on cause of advisory
Total population	CI, RF	Not utilized	
Interface fire (area mapped as high priority for treatment, area treated)	AA	Partially incorporated into Wildfire Pathway	Focus on area treated only

Indicator	Type of indicator*	Status	Notes
Business starts and bankruptcies in the Basin	RF	Not utilized	
Major investment - investment greater than $15 million	RF	Not utilized	Would need to be filtered to focus on investment in resilience promoting projects
EI dependency	RF	Community Resilience Index	
Traffic - daily traffic volume		Not utilized	
Age and gender	RF	Community Resilience Index	
Dependency - ratio of those in workforce to those outside	RF	Not utilized	
Life expectancy	RF	Community Resilience Index	
High school completion	RF	Community Resilience Index	
Government spending on parks, recreation and culture (proportion of municipal spending)	RF	Not utilized	
Voter turnout	RF	Community Resilience Index	
Greenhouse gas emissions	CCD	Not utilized	
Unemployment	RF	Not utilized	
Workforce education - proportion of workforce with post-secondary education	RF	Community Resilience Index	
Transit service - area within 1 & 5 km of BC Transit service		Not utilized	
Commuting time		Not utilized	
Proportion of residents who agree that extreme weather events are occurring more frequently	AC	Not utilized	RDI open to improving questions
Proportion of residents who believe they have a good of important regional environmental issues	AC, RF	Community Resilience Index	RDI open to improving questions

* Types of indicators: CC – climate change, EI – environmental impact, CI – community impact, AA – adaptation action, AO – adaptation outcome, AC – adaptation capacity, RF – resilience factor, CCD – climate change driver.

Appendix B: Rationale and Data Sources for Pathway Indicators

This appendix presents the rationale and data sources for the pathway indicators. It includes both the SoTB indicators proposed for each pathway and the new indicators developed as a result of this project. SoTB indicators are presented in plain font in the first column, while new indicators are in italics.

Agriculture Pathway

Indicator	Description	Rationale	Data
Climate extremes (temperature, precipitation)	Temperature: frequency of days when maximum temperature exceeds 90th percentile for baseline period. Precipitation: annual amount of total precipitation (in millimetres) that occurs during days when precipitation exceeds the 95th percentile for the year in question.	Flooding, drought and high temperatures are critical factors affecting agricultural and livestock productivity and failure.	Existing SoTB indicator. Available from the CLIMDEX website with frequent update cycles. Requires some additional analysis to assess trends.
Frequency of hail storms	Annual frequency of occurrence of hail storms.	Hail damage, after drought and excess heat, is the most common reasons for crop failure and insurance payout.	Hail data available at manned Environment Canada weather stations only. Not available from automated stations. Quality of data is observer dependent.
Climate averages (temperature, precipitation)	Average monthly temperature and precipitation values.	Provides overall picture of water potentially available for agriculture both falling in the summer and stored.	Available from Environment Canada weather stations.
Drought index	The BC drought index is comprised of four core indicators: • Basin snow indices; • Seasonal volume runoff forecasts; • 30 day percent of average precipitation; and • 7-day average streamflow.	Drought is the leading factor influencing agriculture and crop failure.	Data available from Ministry of Environment.
Length of the growing season	Number of days between last and first frost.	A longer growing season allows for greater diversity of crops (ones with longer days to maturity), and greater flexibility in early planting avoiding late summer drought and more plant growth time.	Existing SoTB indicator. Data readily available using daily temperature minimums.
Growing degree days	The amount of heat energy available for plant growth, calculated by multiplying the number of days that the mean daily temperature exceeded 5 C (average base temperature at which plant growth starts) by the number of degrees above that threshold.	Gives a sense better sense of how plants are affected by temperatures than straight up temperature data. But as calculated does not address high temperatures beyond which plants are negatively affected.	Temperature information available from Environment Canada weather stations.
Invasive species	List of invasive species present in the Basin (already collected) and estimate of aggregate area covered by invasive species.	Invasive species are considered to be a key emerging threat for agriculture associated with climate change.	Ministry of Forests, Lands and Natural Resource Operations Invasive Alien Plant Program might have number of hectares by regional district.
Amount of area being farmed	Annual number of hectares being farmed.	Gives some indication of the viability of farming and the amount of food being produced in the Basin.	Existing SoTB indicator.
Crop damage due to drought, high temperatures, frost, storms, pests and disease	Annual insurance payouts for crop damage and loss as a result of drought, high temperatures, frost, storms, pests and disease.	Annual insurance payouts for crop damage are key indicators both of ongoing climate impacts but also extreme events affecting agriculture.	Crop Insurance in B.C. is managed through the provincial government Production Insurance office. Data on losses is not provided, but it is presumed that they keep records.

Indicator	Description	Rationale	Data
Agricultural productivity	Measured as a ratio of agricultural outputs to agricultural inputs. Output often measured as market value or crop yield per hectare.	Important reflection of climate impact on plant growth – both positive and negative.	Census of Agriculture has gross farm receipts as well as farm operating expenses. Can combine with hectares farmed to give a ratio.
Hectares irrigated	Number of hectares irrigated by electoral area.	Drought is one of the biggest risks to agriculture associated with climate change. Irrigation is a good measure of adaptive capacity as farmers with irrigation are less vulnerable to drought.	Available through Census of Agriculture.
Farming practices to reduce soil erosion and increase fertility	Number of farms engaging in summer fallow land, no-till seeding, tillage incorporating most crop residue into soil, manure application, crop rotation, rotational grazing, ploughing down green crops, winter cover crops, and nutrient management planning.	Soil fertility and ability of the soil to hold moisture can be important factors that mitigate against drought. In addition, climate change is expected to have negative impacts on soil fertility.	Census of Agriculture reports the number of farms having summer fallow land, no-till seeding, tillage incorporating most crop residue into soil, manure application, crop rotation, rotational grazing, ploughing down green crops, winter cover crops, and nutrient management planning. May have to select one or two practices that are most important for indicator purposes.
Community food production	Number of people in the Basin, by community, who grow at least a small portion of their own food.	Backyard growing is an important aspect of self-sufficiency and Basin food security, particularly if agricultural production in other parts of the world declines.	Resident survey question.

Extreme Weather & Emergency Preparedness Pathway

Indicator	Description	Rationale	Data
Maximum 1-day rainfall	Measures the heaviest precipitation day or monthly maximum 1-day precipitation (in millimetres) in a given year.	Heavy rainfall can lead to stormwater management failure and flooding of creeks and rivers.	Available from select Environment Canada weather stations in the Basin.
Frequency of extreme snowfall events	Measures the total number of days each year with snowfall amounts of 15 cm or more within 12 hours or less.	Heavy snowfall can damage infrastructure, bring down power lines and cause power outages.	Available from Environment Canada weather stations in the Basin. Need to compile the number of events with snowfall exceeding the threshold.
Frequency of strong wind events	Measures the total number of days each year with winds of 70 km/h or more of sustained wind and/or gusts to 90 km/h or more.	Wind storms can damage infrastructure, bring down power lines and cause power outages.	Hourly wind speed data is available from 11 sites in the Basin. Most records are continuous over last few years, however longer records have gaps.
Frequency of extreme heat days	Measures the total number of days each year where maximum daily temperature exceeds 30 C.	Heat waves and heat extremes have significant negative impacts on vulnerable populations including – the elderly, socially isolated, chronically ill, and young infants.	Available from Environment Canada weather stations.
Weather-related power outages	Measures the number (per year) and/or duration (hours) of power outages caused by landslides, avalanche, snow, wind, or freezing rain.	Power outages caused by extreme weather events can have significant impacts on local economies and quality of life.	Available from BC Hydro power outage data and organized by 'cause code' and including: • adverse weather (lightning, wind, snow); • adverse environment (landslide, flood); and • trees (either wind or lightning caused).
Weather-related highway closures	Measures the number (per year) and/or duration (hours) of highway closures caused by landslides, avalanche, snow, wind, or freezing rain.	Highway closures caused by extreme weather events can have significant impacts on local economies and quality of life.	Limited data available from DriveBC historical event information.

Indicator	Description	Rationale	Data
Disaster financial assistance payout for storm events	Measures the total amount ($) of disaster financial assistance payouts to property owners in the Basin for extreme weather events - landslides, avalanche, snow, wind, or freezing rain.	Disaster financial assistance payouts provide an indication of the economic cost of extreme weather events in the Basin.	Data may be available through Emergency Management BC. Unsure about availability and history.
Provincial emergency assistance paid to local governments for storm clean-up	Measures the total amount ($) of provincial emergency assistance paid to local governments in the Basin for extreme weather events - landslides, avalanche, snow, wind, or freezing rain.	Provincial emergency assistance paid to Local governments provides an indication of the economic cost of extreme weather events in the Basin.	Data may be available through Emergency Management BC. Unsure about availability and history.
Residents with 72-hour emergency preparedness kits	Proportion of residents with 72-hour emergency preparedness kits - adequate food, water cooking supplies, etc.	Emergency kits are effective in mitigating negatives consequences of power outages and emergencies	Resident survey question.
Emergency preparedness plan	Total number of local governments with an emergency preparedness plan, including a community evacuation plan that has been updated within the last 5 years.	Communities who have developed solid plans will be better prepared to take action when/if required	Local government survey question.
Backup power sources	Total number of local governments with backup power source(s) for critical community services and infrastructure – water supply, emergency shelter, etc.	The availability of community services and infrastructure such as water supply and emergency shelters are essential in reducing negative impacts from extreme weather events and power outages.	Local government survey question.

Flooding Pathway

Indicator	Description	Rationale	Data
Maximum 1-day rainfall	Measures the heaviest precipitation day or monthly maximum 1-day precipitation (in millimetres) in a given year.	Heavy rainfall is a major cause of flooding of creeks and rivers.	Available from select Environment Canada weather stations in the Basin.
Climate extremes (precipitation)	Measures the annual amount of precipitation (in millimetres) that occurs during days when precipitation exceeds the 95th percentile for the year in question.	Indicator of how much of the total precipitation in a year falls during very wet events, which is a combination of both how often events occur that exceed 95th percentile threshold and the size of events.	Existing SoTB indicator. Available from select Environment Canada weather stations in the Basin.
Frequency of rain-on-frozen-ground events	Measures the total number of days each year with rain-on-frozen-ground; this is assumed to be days during winter (December to February) when precipitation is recorded as rain.	Frozen ground does not absorb water, and ice can also block storm drains leading to increased flooding.	Available from select Environment Canada weather stations in the Basin by compiling the number of days with rain during winter. Would not account for the impact of snowpack on ‘flashiness’ of flooding from rain on snow events.
Stream flow timing	Currently tracks half total flow date. RDI to update to track timing of annual peak yield (x-date).	The date of peak streamflow affects flood response planning and preparation. There is some indication that the date peak streamflow is changing.	Existing SoTB indicator. Available from Water Survey of Canada – active and non-regulated stations.

Indicator	Description	Rationale	Data
Peak stream flow volume	Total annual maximum daily discharge on monitored unregulated streams	Increases in streamflow volume are likely to increase flood risk over time.	Available from Water Survey of Canada – active and non-regulated stations.
April 1st snow pack	Depth of April 1st snow pack each year.	Snowpack depth is a determinant of flooding. Provides an indication of the amount of snow available to contribute to flooding.	April 1 snow-water equivalent available from 49 automated and manual snow pillow sites.
Disaster financial assistance for flooding events	Measures the total amount ($) of disaster financial assistance payouts to property owners in the Basin for flooding events.	Disaster financial assistance payouts provide an indication of the economic cost of flooding events in the Basin.	Data may be available through Emergency Management BC. Unsure about availability and history.
Flood-related highway closures	Measures the number (per year) and/or duration (hours) of highway closures caused by flooding.	Highway closures caused by flooding can have significant impacts on local economies and quality of life.	Limited data available from DriveBC historical event information.
Developed properties in the floodplain	Measures the total number of developed properties that are located within known and active floodplains in the Basin.	Additional properties in the floodplain increase the consequences of flood events.	GIS overlay of property and floodplain data.
Provincial emergency assistance for flood response and clean up	Measures the total amount ($) of provincial emergency assistance paid to local governments in the Basin for flooding events.	Provincial emergency assistance paid to local governments provides an indication of the economic cost of flooding events in the Basin.	Data may be available through Emergency Management BC. Unsure about availability and history.
Flood mapping extent and updates	Tracks the proportion of Basin floodplains where flood maps are available, and the proportion that have updated their flood maps since the 2003 *Flood Hazard Statutes Amendment Act* which shifted flood mapping responsibility to local governments.	Flood maps across the Basin are out-dated due to changes in climate, hydrology and land use. This indicator tracks community's that have proactively updated floodplain designations.	Extent information mapped using GIS. Update information obtained through research or survey with local government.
Emergency preparedness plan	Tracks the proportion of Basin communities with emergency preparedness and evacuation plans updated in the last 5 years.	Communities who have developed solid plans will be better prepared to take action when/if required.	Obtained through research or local government survey question.
Local government expenditures on flood protection	Measures the amount ($) or budget proportion of local government expenditures allocated towards flood protection.	Increased investment in flood protection measures would presumably reduce the damages caused by future floods.	Collected from local government budget Information. May not be available in a consistent format across the Basin.
Percentage of impervious surface in municipality	Assesses the proportion of land area within municipalities that is impervious (roads, sidewalks and buildings).	Determines the proportion of surfaces that are 'hard' and contribute to fast runoff and flooding.	Would require community-specific GIS analysis. May be difficult to obtain and present in a meaningful way.

Water Supply Pathway

Indicator	Description	Rationale	Data
Climate extremes (temperature, precipitation)	Temperature: frequency of days when maximum temperature exceeds 90th percentile for baseline period. Precipitation: annual amount of total precipitation (in millimetres) that occurs during days when precipitation exceeds the 95th percentile for the year in question.	Extreme temperatures contribute to drought, extreme precipitation can cause flooding which poses risks to water infrastructure and contributes to turbidity in surface sources.	Existing SoTB indicator. Available from the CLIMDEX website with frequent update cycles. Requires some additional analysis to assess trends.
Climate averages (temperature, precipitation)	Average monthly temperature and precipitation values.	Air temperature affects stream temperature, which affects conditions for growth of pathogens. High summer temperature also indicates high irrigation demand. Precipitation at different times of the year has different impacts. Rain/snow differentiation will also make this indicator more useful.	Available from Environment Canada weather stations. Five stations in the Basin have 100 years or more of data.
Glacier extent	Area of glaciated terrain in the Basin, and change in extent of glaciers over the 1985-2005 period.	A good indicator of water storage. Especially relevant to late-season availability.	Existing SoTB indicator. Update past 2005 is dependent on research by other parties, though an update for 2013 extent is expected in 2015.
Stream flow timing	Currently tracks half total flow date. RDI to update to track: • Timing of annual peak yield; and • Timing of late summer minimum yield.	Stream flow timing data helps decision makers understand how temporal trends in demand line up with the same in supply.	Existing SoTB indicator. Available from Water Survey of Canada – active and non-regulated stations.
Stream flow volume	Total annual maximum and minimum daily discharge each year.	Min volume is relevant to water availability. Max volume is relevant to flooding and risks to infrastructure.	Available from Water Survey of Canada – active and non-regulated stations.
Ground water level	Average monthly ground water level for monitored aquifers.	Relevant for communities that source their water from aquifers. Since many aquifers are closely hydraulically linked to surface sources, may be redundant.	Limited data is available from the Ministry of Environment Groundwater Observation Well Network. Availability of historic data varies, data for some sites is out of date, and some data is not validated.
Source water temperature	Monthly average temperature for monitored surface water sources in summer months.	An important water quality determinant (higher temps enable presence of certain pathogens).	Some data available from Streamkeepers and lake ambassadors. Pacific Yukon Freshwater Quality Monitoring database reports (mostly biweekly) on select sites in the Basin. The length of record varies by station and some sites are inactive.
Source water turbidity	Monthly average Nephelometric Turbidity Units (NTU) for monitored surface water sources.	An important water quality determinant (sediment carries contaminants).	Some data available from Streamkeepers and lake ambassadors. Pacific Yukon Freshwater Quality Monitoring database reports (mostly biweekly) on select sites in the Basin. The length of record varies by station and some sites are inactive.
Per capita water consumption	Volume of total water supplied annually, reported by utility and expressed per capita (service population).	Measures water use attributable to user demand and water loss.	Existing SoTB indicator. Available for some communities through the Trust's Water Smart program, or local government survey question.
Drinking water quality	Number of water systems on a drinking water advisory or boil water notice as of June 10 annually.	Some notices are implemented due to turbidity and/or presence of pathogens (frequency of both parameters could increase with climate change).	Available from Interior Health website.

Indicator	Description	Rationale	Data
Water loss	Percentage of water supplied annually that is lost to leakage.	A measure of infrastructure quality and preparedness to deal with potential future water shortages. A major contributor to water demand in our region. May be redundant, as this is included in the per capita demand indicator.	Available for some communities through the Trust's Water Smart program, or local government survey question.
Implementation of water restrictions	Number of days annually when water restrictions are active, reported by utility.	The need for implementation could increase with warming, population growth or increased irrigation demand, could decrease with infrastructure improvements and behaviour change.	Local government survey question.
Policies to reduce water consumption	Number of water utilities that have incorporated water consumption considerations in policies and legislation (tools will vary by community).	Though water scarcity is not a current concern for most utilities in our region, it may be in the future. Communities need to be prepared to take action.	Local government survey question. Inclusion of improvement districts and other water purveyors would be ideal but likely unfeasible.
Water protection plans	Number of water utilities that have undertaken water planning measures that consider projected climate changes.	Communities who have developed solid plans will be better prepared to take action when/if required.	Local government survey question.
Water loss detection practices	Percentage of Basin population served by water systems that have implemented water loss detection practices, including connection or district meters, night flow analysis and leak detection.	Water loss detection provides information on water use that contributes to better planning decisions.	Available for some communities through the Trust's Water Smart program, or Local Government survey question.

Wildfire Pathway

Indicator	Description	Rationale	Data
Number of days in extreme danger class	Measures the total number of days when there is extreme danger of fires starting easily and spreading rapidly. A composite index based on temperature, relative humidity, precipitation and wind using the 41 separate stations in the Basin.	Determined by weather and is sensitive to climate change.	Available from B.C. Forest Service Southeast Fire Centre (2004 – 2013). Historical data may be available. Current situation is always available online.
Annual area burned	Measures the number of hectares burned on an annual basis in the Columbia Basin.	A direct measure of how much fire is occurring on the landscape.	Existing SoTB indicator. Spatial data available through DataBC.
Air quality	Measures concentrations of fine particulate matter in the air - $PM_{2.5}$ (particle matter less than 2.5 micrometres in diameter).	Fine particulate matter is a major impact of forest fires and has a direct impact on human health. This indicator is heavily influenced by fires, although there are other sources.	Existing SoTB indicator. Data is available on a daily basis from multiple monitoring stations throughout the Basin. Historic data is limited however.
Wildfire starts	The total number of both human caused and lightning caused wildfire starts per year	Helps tell a more complete story – the area burned is impacted by the suppression efforts, and the ratio of number of starts caused by humans and lightning can change based on climate and public awareness.	Existing SoTB indicator. Available through DataBC.

Indicator	Description	Rationale	Data
Frequency of interface fires	Annual number of wildfires within 2 km of a Basin community.	Measures close calls.	Spatial data available through DataBC. Basic GIS analysis to overlay with municipal boundaries.
Cost of fire suppression	Total amount of money spent on fire suppression in the Southeast region annually.	Economic cost.	Available from Southeast Fire Centre (2004 – 2013) broken down into the six areas. Historical data may be available.
Fire-related highway closures	Measures the number (per year) and/or duration (hours) of highway closures caused by wildfire.	Highway closures have both economic and social cost.	Limited data available from DriveBC historical event information.
Fire-related power outages	Measures the number (per year) and/or duration (hours) of power outages due to wildfire.	Power outages have both economic and social cost.	Available from BC Hydro power outage data and organized by 'cause code' and including adverse environment (fire).
Wildfire evacuation orders	Number of evacuation orders due to the threat of wildfire issued by the wildfire protection branch.	A measure of direct threats to human life and infrastructure.	Available from Southeast Fire Centre. A very rare event – only happened in 2003 and 2009.
Interface fire risk reduction	The forests immediately surrounding communities have been mapped, and this indicator tracks the percentage of the high priority interface fire area that has been treated to reduce wildfire risk.	Measures mitigation actions directly.	Local government survey question
FireSmart-recognized communities	The number of Basin communities recognized through FireSmart Canada's Community Recognition Program.	A measure of citizen involvement in decreasing risk of wildfire to their homes.	Obtained from the B.C. FireSmart officer. There are currently no FireSmart recognized communities in the Basin
Campfire bans	Tracks the number of days each year that the B.C. Wildfire Management Branch issues a campfire ban.	A direct measure of social cost.	Available from Southeast Fire Centre (2004 – 2013) broken down into the six areas. Historical data may be available.

Appendix C: Rationale and Data Sources for CRI Indicators

This appendix presents the rationale and data sources for the community resilience index (CRI) indicators. It includes both SoTB indicators proposed for the index and new indicators developed as a result of this project. SoTB indicators are presented in plain font, while new indicators are presented in italics.

Indicator	Rationale	Data Sources
Income – median and average	Higher incomes may contribute to greater capacity to upgrade infrastructure, housing and undertake other adaptations.	National Household Survey and BC Stats income and taxation statistics.
Employment by sector	Declines in employment in climate-sensitive sectors may indicate that certain industries are failing to adapt or being significantly impacted by climate change.	Statistics Canada's Labour Force Survey, focusing on climate sensitive sectors.
Employment Insurance and income assistance dependency	High levels of dependence on employment and income assistance may signify a lower capacity to undertake climate change adaptations.	BC Stats and Institute of Chartered Accountants of BC.
Workforce education	A more educated workforce may contribute to a greater capacity to adapt to declines in certain industries and develop new businesses and industries in response to climate changes.	Statistics Canada's Labour Force Survey, National Household Survey.
Access to broadband	Broadband is key in determining a community's connectedness to information, outside support and services. Broadband also enables economic development opportunities.	Industry Canada and Network B.C. publish broadband coverage maps that report to the scale of a continuous series of hexagons, each representing an approximately 25km^2 area. Data displayed in these maps are currently undergoing verification.
Knowledge of important environmental issues, including climate change	Greater knowledge of environmental issues, including climate change, may contribute to greater motivation to prepare and adapt in advance, and greater ability to make appropriate adaptation decisions.	Resident survey question.
Completion of climate change adaptation actions	Municipalities that have completed climate change adaptation actions should be more resilient in a climate-changed future.	Local government survey question.
Voter turnout	Voting demonstrates level of engagement in civic politics and may signify more robust local institutions better prepared to address climate changes.	CivicInfo BC's compendium of local election results.
Volunteerism	Research is showing that levels of volunteerism are highly connected to community resilience. Even though it is part of the Institutions and Networks determinant levels of volunteerism could also be viewed as an indicator of population wellness.	Resident survey question.
Belonging and attachment to community	Belonging and attachment to community are overall reflections of resident's sense of community and ability to work together to adapt to climate change.	Poll question for residents. Consider expanding and using index used in Calgary and Canmore that measures belonging, pride, and commitment to remaining in community.
Age/gender	The age and gender makeup of a population are important reflections of level of dependency in a population including the number of children under 15 and the number of seniors over 65. A population with too high a level of dependency may be less resilient to climate change.	Census of Canada
Income disparity	Highlights the equity of the distribution of incomes in a community. Communities with significant income disparity may be less resilient to climate change.	Canada Revenue Agency's tax filer statistics.
Life expectancy	Life expectancy is widely used as an indicator of the health of a population. The general trend has been up in Canada. Changes in that trend could signify lower community resilience.	BC Stats' collection of vital statistics.

Indicator	Rationale	Data Sources
Asset management planning	Most communities will require significant infrastructure upgrades in the near future to address aging infrastructure and climate change. The degree to which communities are engaging in asset management planning is a reflection of their degree of preparation for climate change.	Local government survey question.
Cell phone coverage	Cell phones are a critical for emergency response. Communities and rural areas that do not have widespread cell phone coverage may be cut off in climate change-related emergencies.	Assessed using geospatial analysis. Development of this indicator is contingent on data sharing by telecommunications companies.
Housing stock in need of repair	Housing stock that is in poor repair is likely to be less able to withstand climate change-related extreme weather events, flooding and potentially wildfires.	National Household Survey
Walkability	Communities in which residents are able to access food stores and other critical community services on foot in a climate change-related emergency, or an on ongoing basis are likely to be more resilient.	Assessed using geospatial analysis. Development of this indicator is contingent on the outcome of an ongoing project that seeks to map food stores in the region.
Amount of area farmed	Communities that are able to produce their own food are likely to be more resilient in a climate-changed future.	Statistics Canada's Census of Agriculture.
Residents with a backup energy source	Residents who have a backup energy source are likely to be more resilient in the event of climate change related power failures.	Resident survey question.
Late summer stream flow volume	Communities with access to abundant fresh water at critical low flow times are likely to be more resilient to climate change.	Water Survey of Canada.

Appendix D: Recommended New Indicators

This appendix lists the 56 new pathway and community resilience index indicators developed through this project and are recommended for further development as part of a SoCARB indicator suite. It notes which pathway the indicator is recommended for, or if it is part of the community resilience index. It also notes whether the indicator has relevance to another pathway and was considered for one of those pathways but was cut in favour of more relevant indicators. The "also relevant to" recommendations mean that the information from that indicator could be considered for that pathway in the future. Note that two recommended CRI indicators added to the SoTB suite in 2014 (sense of community and income disparity) are not included in this list of new indicators.

Indicator	Recommended For
1. Frequency of hail storms	Agriculture Pathway, Also relevant to Extreme Weather Pathway
2. Climate averages (temperature and precipitation)	Agriculture Pathway, Water Supply Pathway
3. Drought index	Agriculture Pathway, Also relevant to Extreme Weather Pathway and Wildfire Pathway
4. Growing degree days	Agriculture Pathway
5. Number and area covered by invasive species	Agriculture Pathway
6. Crop damage due to drought, high temperatures, frost, storms, pests and disease	Agriculture Pathway
7. Agricultural productivity	Agriculture Pathway
8. Hectares irrigated (by electoral area)	Agriculture Pathway
9. Farming practices to reduce soil erosion and increase fertility	Agriculture Pathway
10. Number of people growing their own food	Agriculture Pathway
11. Maximum 1-day rainfall (RX1)	Extreme Weather Pathway, Flooding Pathway
12. Frequency of extreme snowfall events	Extreme Weather Pathway
13. Frequency of strong wind events	Extreme Weather Pathway; Also relevant to Agriculture Pathway
14. Frequency of extreme heat days	Extreme Weather Pathway
15. Percentage of residents with 72-hour emergency preparedness kit	Extreme Weather Pathway
16. Emergency preparedness plan	Extreme Weather Pathway, Flooding Pathway
17. Backup power sources for essential community services	Extreme Weather Pathway
18. Weather-related power outages	Extreme Weather Pathway
19. Weather-related highway closures	Extreme Weather Pathway
20. Disaster financial assistance payout for storm events	Extreme Weather Pathway
21. Provincial emergency assistance paid to local governments for storm clean-up	Extreme Weather Pathway
22. Frequency of rain-on-frozen-ground events	Flooding Pathway; Also relevant to Extreme Weather Pathway
23. Stream flow volume (peak and minimum)	Flooding Pathway, Water Supply Pathway
24. April 1st snow pack	Flooding Pathway, Water Supply Pathway
25. Flood mapping extent and updates	Flooding Pathway
26. Local government expenditures on flood protection measures	Flooding Pathway
27. Percentage of impervious surface in municipality	Flooding Pathway
28. Disaster financial assistance payout for flooding events	Flooding Pathway
29. Number of flood-related highway closures	Flooding Pathway
30. Provincial emergency assistance paid to local governments for flood response and clean-up	Flooding Pathway
31. Ground water level	Water Supply Pathway
32. Source water temperature	Water Supply Pathway

Indicator	Recommended For
33. Source water turbidity	Water Supply Pathway
34. Creation of policies to reduce water consumption (incl. water restrictions)	Water Supply Pathway
35. Creation/implementation of water protection plans	Water Supply Pathway
36. Water loss detection practices	Water Supply Pathway
37. Requirement for implementation of water restrictions	Water Supply Pathway
38. Number of days in extreme danger class	Wildfire Pathway
39. Interface fire – high priority area treated	Wildfire Pathway
40. Number of FireSmart-recognized communities	Wildfire Pathway
41. Campfire bans / campfire bans / forest use bans	Wildfire Pathway
42. Frequency of interface fires	Wildfire Pathway
43. Cost of fire suppression (annual)	Wildfire Pathway
44. Fire-related highway closures	Wildfire Pathway
45. Number of homes destroyed by wildfire	Wildfire Pathway
46. Number of evacuation orders due to fire	Wildfire Pathway
47. Income dependence on climate-vulnerable sectors	Community Resilience Index
48. Access to broadband	Community Resilience Index
49. Completion of climate change adaptation actions	Community Resilience Index
50. Volunteerism	Community Resilience Index
51. Reliance on food banks	Community Resilience Index
52. Asset management planning	Community Resilience Index
53. Basin cell phone coverage	Community Resilience Index
54. Percent of dwellings/ buildings that do not meet current building & safety codes	Community Resilience Index
55. Percent of residences within 500 metres of a food store	Community Resilience Index
56. Residents with a backup energy source	Community Resilience Index; also relevant to Extreme Weather Pathway

Appendix E: All Indicators Considered

This appendix includes all indicators considered in various rounds of the project, including those that did not make it into the SoCARB indicator suite. **Table One** presents the indicators developed in some detail for particular pathways or the community resilience Index and did not make the final cut. **Table Two** presents the initial list of indicators identified at the outset of the project and put through a preliminary screen for further development at the initial indicator development workshop.

Table One: Indicators Developed and Discarded

This table contains the indicators developed further for each pathway that did not make the final cut. The level of detail in the notes for these indicators varies as some indicators were developed further than others. The rationale for discarding the indicator is provided in the notes.

Agriculture	
Indicator	**Notes**
Frequency of storms (wind)	Increase in annual 95 percentile of daily maximum winds. Wind is an important factor that can damage crops, but not as important as drought and extreme heat. Data limited as daily and maximum hourly wind speed is only measured at some weather stations.
Types and numbers of insects and diseases	List of insects and diseases present in the Basin and estimates of populations and area of crops affected. Insects and diseases are a key emerging threat for agriculture associated with climate change. Data not available at this point in time. Pilot project (2014-2016) to collect this kind of data underway in the Peace Region.
Timing of flowering of indicator crops	First day in spring of budding or leaf emergence on indicator crops. Warmer winters and springs may result in earlier budding and leaf emergence of crops, which can allow for a longer growing season but also increase risk of crop loss as a result of frost kills. Would have to collect through a survey of farmers, which would be too challenging.
Implementation of water conservation and use optimization measures	Number and types of water conservation and use optimization measures implemented (such as new technologies, shifting timing of watering, increasing storage). Drought is considered to be one of the biggest risks to agriculture associated with climate change. Would have to collect through a survey of farmers, which would be too challenging.
Crop diversity	Diversity of crops planted by farm operation. A greater diversity of crops might mean that some are more resilient to certain climate events than others. Census of Agriculture has a count of number of farms reporting on various types of agriculture (e.g. Fruit and nut tree farming, hay farming, sheep farming etc.). But types reported on are likely too aggregate to be meaningful.
Planting of climate resilient crops	Number and/or hectares of designated climate resilient crops planted per year. Plants more resilient to drought or with shorter growing seasons, or resistant to pests, disease or invasive species may be an important climate change adaptation.Too hard to define what crops/varieties are climate resilient. Would have to collect through a survey of farmers, which would be too challenging.
Date of first plant	Date of planting certain indicator field and greenhouse crops. Earlier planting could help crops be more resilient to or harvested before late summer droughts. Would have to collect through a survey of farmers, which would be too challenging.
Average age of farmers	Increase in average age of farmers could suggest that young people are not interested in becoming or financially able to become farmers, or that farming is not an economically viable profession. Not sufficiently relevant to climate change.
Farm income	Net market income from farming, off-farm income and net program payments averages and totals by Basin reporting area.Trends in each of these will give insight into viability of farming as a profession and how climate change may be affecting farming. Available through Statistics Canada. Already captured in Agricultural Productivity indicator.
Agricultural input costs	Dollar values of capital, labour, land and buildings and materials (fertilizer, seeds, pesticides, feed, fuel, electricity and irrigation) utilized in farming. Hard to understand trends as increases in input costs could signify greater climate impacts on crops or greater farming activity. Available through Statistics Canada, but captured in Agricultural Productivity indicator
Soil moisture Index	No robust measures (most just use a combination of temperature and precipitation), actual soil data not currently collected, captured largely by drought index.
Consecutive dry days	Captured by drought index, but could replace drought index if drought index unavailable.

Agriculture	
Degradation of grazing land	Not as important as other indicators. Too hard to measure.
Range productivity	Not as important as other indicators. Too hard to measure.
Percent of income spent on food	Not as important as other indicators.

Extreme Weather and Emergency Preparedness Pathway	
Indicator	**Notes**
Frequency of freezing rain events	Measures the total number of days each year with freezing rain. Available at manned Environment Canada weather stations only. Not available from automated stations. Quality of data is observer dependent. Not as important as other indicators as an extreme weather event.
Local government expenditures on storm clean up	Measures the amount of local government expenditures allocated towards storm clean-up. Too difficult to acquire data.
Very dry days, drought index or soil moisture index	Not really an extreme weather event. Extreme heat days is better.
Severity of wildfire	Pathway is intended to focus on direct weather impacts, not environmental impacts, and fire is captured in wildfire pathway.
Number and severity of landslides/avalanches	Captured in weather related highway closures. Impossible to track.
Evacuation plan	Included in 'Emergency Preparedness Plan' indicator.
Bylaw to regulate weather-resistant building construction	Too difficult to define in a way that captures so many different weather variables.
Program in place to support weather-proofing of infrastructure	Too difficult to measure.
Emergency preparedness plan that addresses climate change	Emergency Preparedness Plans should not "address climate change". Climate change is a justification for having a robust and flexible plan.
Emergency communication capacity	Too hard to define. Too hard to track.
Number of properties impacted by storm events	Too difficult to define in a way that captures so many different weather variables.

Flooding Pathway	
Indicator	**Notes**
Floodplain development regulation	Tracks the proportion of developed or developable land within the floodplain where a bylaw is in place to regulate floodplain setbacks and Flood Construction Levels. Could be a Development Permit Area, Zoning Bylaw or Floodplain Management Bylaw. Use GIS overlay of all floodplains in the Basin with flood regulation extent.
Number of building permits issued in floodplain	Measures the total number of building permits issued in the floodplain each year and therefore new development / construction in the floodplain. Obtained through survey with local government staff. Not good indicator of adaptation since building permits could be issued for construction that increases or decreases flood risk.
Number of flood watch advisories per year	Measures the number and/or duration of flood watch advisories per year issued by Emergency Management BC. The advisories that the River Forecast Centre posts are publicly available.
Local government expenditures on flood clean up	Measures the amount of local government expenditures allocated towards flood clean up. Data obtained through research or survey with local governments. Would likely be too difficult to acquire.
Properties impacted by flooding	Measures the proportion of properties that experienced some water damage or other impact from flooding events. Obtained through resident survey. May not be accurate or useful.
Spring and winter precipitation	Maximum 1-day rainfall (RX1) and very wet day precipitation are better indicators.
Evacuation plan	Included in 'Emergency Preparedness Plan' indicator and survey question.
Program in place to support flood-proofing of infrastructure	Too difficult to define in a way that captures all the different activities that could be defined as 'flood-proofing'.
Emergency preparedness plan that addresses climate change	Emergency Preparedness Plans should not "address climate change". Climate change is a justification for having a robust and flexible plan.

Water Supply Pathway	
Indicator	**Notes**
Population served by water systems with treatment infrastructure	Percentage of population served by a water system with multi-barrier water filtration/treatment systems. Treatment can mitigate water quality risks posed by climate change. Data not available from one source that would be able to report on the hundreds of water systems in the region.
Water storage adequacy	Percentage of utilities with water storage concerns. Adequate storage can buffer supplies in times of scarcity. Would require survey of utilities – which might be too difficult to undertake.
Waterborne illness rates	Number of reported incidents (per 100,000 population) of cryptosporidiosis, giardiasis, etc. Waterborne illness incidents are correlated with heavy rainfall (esp. due to impacts on wastewater infrastructure). Illness rates can go up with decreased water quality and down with implementation of adaptation actions. The B.C. Centre for Disease Control reports on illness rates on an annual basis. Available to the scale of the development region. Not as important as other water supply indicators.
Supply/demand ratio	Ratio of total annual discharge and total licensed withdrawal in a few indicator streams. Water scarcity is a current concern for some utilities in the region, and may become a bigger concern as the climate changes. Licensed withdrawal can vary greatly from actual withdrawal, making results of this analysis limitedly reflective of actual conditions.
Average annual precipitation	Monthly values will be more useful to decision makers, as they give more detailed information on when the changes are happening.
Consecutive dry days	Does not distinguish between seasons. Dry spells in the winter are less important in terms of climate adaptation.
Total annual stream volume	More important questions center around the extremes of stream flow—peak and minimum.
Low elevation snow depth	To some extent, this would be covered by monthly precipitation. Low elevation snow is not important to the issue of storage, and other indicators would cover the issue of flooding.
Climate-proofing of water infrastructure	Difficult to define in a systematic way.
Irrigation for agriculture	Not important for this pathway to distinguish types of demand.

Wildfire Pathway	
Indicator	**Notes**
Number of lightning days	May be available from Environment Canada. However this aspect of wildfire is captured in the number of fire starts caused by lightning.
Percentage of residences that have taken action to fire proof homes	Resident survey "I have fire-proofed my home by doing this:" Offer list of actions i.e. removing vegetation or piling firewood away from my house. Measures mitigation actions directly, but likely variable quality of responses and understanding of question, and does not measure risk level. This information will be captured via the number of FireSmart communities. Would be a challenging question for homeowners who are not sure what 'fire-proofing' looks like.
Value of properties in fire risk areas	Use high-risk areas data and property value data to complete analysis. May be sensitive data and would require extensive analysis. Local governments may not have data required.
Communities engaging in climate change adaptation planning	Covered in number of FireSmart communities.
Number of homes destroyed by wildfire	A very rare event.
Number of evacuation orders due to fire	Orders are issued by the provincial Wildfire Protection Branch. But is a very rare event and only happens once every few years. Covered by frequency of interface fire indicator
Precipitation during fire season	Number of days in extreme fire danger (composite index) is a better measure.
Mean annual temperature/ precipitation	Not specific enough for fires. Replaced by number of days in extreme fire danger.
Soil moisture index (during fire season)	Part of the composite index that records the number of days in extreme fire danger.
Severity of wildfires	Would be a good indicator, but would have to go through all the individual fire records to get data, which would be too labour intensive. There would likely be a positive correlation with the annual area burned indicator (years with lots of area burned would also have higher severity of burns)
Indicator species	Difficult to link directly the reduction of fire dependent species on red list to increased fire when there would be so many other confounding factors.
Economic cost of wildfires	Replaced by cost of fire suppression.

Community Resilience Index	
Indicator	**Notes**
Business starts and bankruptcies in the Basin	Measure of business climate. Higher is better for starts, lower is better for bankruptcies. Would be useful if broken down by sector, but data not available by sector.
Diversity of small businesses	Measure of business climate. Too complicated to calculate.
Unemployment	Measure of employment opportunities. Based on Labour Force Survey Data, which is less robust than EI and income assistance dependency, which was included in the CRI.
Home affordability – ratio of average home sale to average household income	Economic resources determinant, but discarded in favour of other measures of economic resources.
High school completion	Discarded in favour of workforce education.
Availability of information on local climate risks and adaptation approaches	Covered to some extent by resident knowledge of important environmental issues and local government completion of climate change adaptation actions indicators, both of which were included in the CRI.
Non-profit density	Measure of sense of community. Too difficult to interpret results. Higher non-profit density could be an indication of government downloading, or lack of non-profit coordination, not resilience.
Implementation of sustainability and climate change actions	Already captured in local government completion of climate change adaptation actions indicator.
Total population by community	Higher is not necessarily better for resilience. Too difficult to interpret.
Water and storm water supply infrastructure	Spending on local government water and stormwater supply infrastructure. Too difficult to acquire data from local governments. Discarded in favour of asset management planning indicator.
Spending on municipal infrastructure renewal	Difficult to measure and interpret. Number may go up with climate related disasters, so higher is not necessarily better.
Municipal debt	High debt may reflect infrastructure investment, or inability to invest. May be challenging to interpret.
Major investment	Indicator as it exists in the SoTB includes a large number of tourism infrastructure projects. Would be difficult to filter for 'resilience-promoting' projects.
Housing stock diversity	Percentage of housing stock that is single family dwelling. Not totally relevant.
Percent of dwellings and buildings in municipal tax arrears	More an economic resources determinant than a built environment and technology determinant and there are already sufficient economic resource determinants.
Percent of land in communities or near highways at risk of sliding	Too labour intensive to analyze data. Only relevant in certain areas of certain communities.
Spending on research and development/innovation	Too hard to measure.

Table Two: Initial List of New Indicators

This table contains all of the indicators brainstormed and reviewed at the initial indicator assessment workshop. They are organized according to whether they made it through the first round of screening. It is important to note that some of these indicators made it through all of the rounds of screening and are included in the SoCARB indicator suite.

Data is available – put into pathway and screen	Investigate availability of data	Indicator needs more definition and thought
• Volume peak 24-hr stream flow • Timing of peak 24-hour stream flow • Value of buildings situated inside of floodplain • Average annual precipitation • Value of properties in fire-risk areas • Minimum x-day stream discharge • Length of wildfire season • Irrigation for agriculture • Climate-resilient OCPs • Communities engaging in climate change adaptation planning • April 1st snow pack • Frequency of interface fires • Snow depth at lower elevations • Water temperature in lakes, rivers and streams • Forest growth • Farming practices related to soil erosion & fertility • Fire bans • Food reserves • Tree cover in communities • Leaf and bloom dates • Date of first lake and river ice and date of first melt • Arrival and departure of migratory birds • Vector-borne diseases • Water supply demand ratio for specific communities • Trail accessibility dates • Weather-related deaths/hospitals admissions	• Disaster relief fund payout for extreme weather events in the Basin • Number of weather-related power outages • Number and duration of highway closures • Economic cost of wildfire damage • Frequency of different types of storms • Number of flood watch advisories • Number of 1/200 year floods • Planting climate-resilient crops • Insurance premiums for specific areas disaggregated • Agricultural productivity • Crop diversity • Backyard rink dates • Per cent of impervious surface in municipality • Percentage of homes in an interface area that are fire-proofed • Rates of alternative energy production/consumption • Fish-run dates for indicator species • Agricultural input costs • Number of households on water systems with no storage capacity • Uptake of climate-related insurance premiums • Frequency of wildfires • Climate-resilient source water protection plans • Mean river flows • Timing and flow of peak river flow • Training of health professionals on health-related illness • Insurance claims disaggregated • Mountain pine beetle range	• Number of natural wildfire starts • Heating degree days • Soil moisture index • Drought index • Distribution of indicator plant and animal species • Cooling degree days • Implementation of municipal water restrictions • Climate proofing of water infrastructure • Severity of wildfires • Storm water vulnerability assessments • Implementation of measures to reduce soil erosion • Incorporating climate considerations into bylaws or policy • Assessments or research that includes climate impacts and vulnerabilities • Incorporation of climate considerations into emergency preparedness plans • Engagement of community on climate change issues • Climate-proofing of storm water infrastructure • Undertaking flood protection measures • Training for local government and stakeholders • Implementation of emergency preparedness plans • Golf course opening dates • Ski hill and backcountry lodge opening/closing dates • Swim advisories • Respiratory disease rates • Range production • Actions by homeowners to fire-proof homes • Loss of arable land due to urbanization • Shut down dates for forestry • Number of people impacted by flooding • Number of people impacted by fire • Control of disease vector species • Percent of income spent on food • Distance food travels