CCME

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STATE OF CLIMATE ADAPTATION AND RESILIENCE MEASUREMENT IN CANADA

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NOTE TO READER

The Canadian Council of Ministers of the Environment (CCME) is the primary minister-led federal, provincial and territorial intergovernmental forum for action on environmental issues of national and international concern.

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EXECUTIVE SUMMARY

Canada is facing increasing climate change impacts, prompting governments to advance adaptation and resilience efforts. All federal, provincial and territorial (FPT) governments have progressed on adaptation and resilience in areas such as comprehensive climate risk assessments, specific strategies and plans, and the integration of resilience considerations into policies. In this context, understanding outcomes becomes valuable for many reasons, including transparency, accountability, value and return on adaptation investment, to name a few. These benefits can be derived when governments monitor and report on the performance of their adaptation and resilience initiatives. Measuring adaptation and resilience is not easy, but a phased approach that starts with a small number of indicators supported by a monitoring and evaluation program can grow over time.

The international scholarship on adaptation and resilience measurement (ARM) indicates that although the techniques associated with the measurement of climate change adaptation and resilience are understood, practice is generally in its infancy. This state of maturity and evolution is similar in Canada. Measurement of adaptation and resilience varies among orders of government across the country and is primarily focused on tracking and reporting policy implementation. An exploration of the state of ARM in Canada uncovered challenges initiating and maintaining the ARM process, particularly connecting appropriate adaptation and resilience measures to uncertain future climate change, the need for both short- and long-term monitoring, the potential need to start measuring something not already being measured, difficulty obtaining data fit for ARM purposes, the broad spatial scale of measurement and the overall costs associated with an adequate ARM monitoring and evaluation program. These challenges are consistent with those in the ARM literature, including the experiences from other countries.

This report summarizes a point-in-time evaluation of the state of ARM in Canada, as supported by a literature review and interviews with FPT governments (March to July 2024). The supporting analysis offers suggestions for establishing or improving ARM in Canada, along with a process for selecting adaptation and resilience indicators from an accompanying inventory. The indicator inventory is contained within a framework that fully characterizes 51 indicators and addresses important features and functions such as data requirements and the incorporation of equity, diversity and inclusion.

The indicator inventory and accompanying selection process are resources to help FPT governments mobilize ARM in their respective jurisdictions. Even in these early stages of ARM development in Canada, there are some connections and similarities between government adaptation actions and monitoring and evaluation initiatives across the country, and this can facilitate the reporting of Canada-wide climate change adaptation and resilience.

GLOSSARY

Adaptation: "In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects" (IPCC 2023).

Adaptive capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences (IPCC 2023).

Adaptation and Resilience Measurement (ARM) Program: Government- or institution-established methods for measuring climate and disaster resilience, considering various dimensions, conditions, capacities and functions essential for adaptation (Laurien, Martin and Mehryar 2022).

Attribution: Process of evaluating the relative contributions, if any, of multiple interventions, including adaptation, to address the impacts of climate change in human and natural systems.

Built infrastructure: Engineered assets and systems, such as roads, ice roads, bridges, buildings, telecommunications, and energy, water, wastewater and transportation systems, among others (EPCCARR 2018).

Climate: In a narrow sense, the average weather, or more rigorously, the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state of the climate system, including a statistical description (IPCC 2023).

Climate change: "Change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.' The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes" (IPCC 2023).

Community: "Social or theoretical group (professional communities, identity-based communities and similar) or geographically fixed population (municipalities, local governments, and so on)" (EPCCARR 2018).

Composite vulnerability: Indicator that provides a metric characterizing the vulnerability of a system by combining, with or without weighting, several indicators assumed to represent vulnerability. This includes indicators that combine two or more indicators of exposure, sensitivity or adaptive capacity. In some cases, in the literature, this has been described as a "vulnerability index indicator" (Mäkinen *et al*. 2018).

Critical infrastructure: "Processes, systems, facilities, technologies, networks, assets and services essential to the health, safety, security or economic well-being of Canadians and to the effective functioning of government" (Canada 2012). Closely associated with the definition of basic services (EPCCARR 2018).

Disaster: "Serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts" (United Nations General Assembly 2016).

Exposure: "Presence of people, livelihoods, species or ecosystems; environmental functions, services or resources; infrastructure; or economic, social or cultural assets in places and settings that could be adversely affected" (IPCC 2023).

Extreme weather event: "Event that is rare at a particular place and time of year. Definitions of 'rare' vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called 'extreme weather' may vary from place to place in an absolute sense" (IPCC 2023).

Hazard: "Potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources" (IPCC 2023). In this document, the term "hazard" usually refers to climate-related physical events or trends or their physical impacts.

Indicator: Quantitative or qualitative factor or variable that provides a simple and reliable measure to describe an issue that someone is concerned about, in a clear and understandable way, and track trends over time relative to a baseline (EPCCARR 2018).

Infrastructure: "Designed and built set of physical systems and corresponding institutional arrangements that mediate between people, their communities and the broader environment to provide services that support economic growth, health, quality of life and safety" (IPCC 2023).

Logic model: Structured approach to understanding a program or project, focusing on intermediate outcomes rather than specific processes (Frechtling 2015).

Natural infrastructure: Naturally occurring or enhanced natural resources that provide adaptation or mitigation services to the gradual or sudden impacts of climate change or natural hazards. This definition includes naturally occurring natural assets such as wetlands, forests, parks, lakes, rivers, creeks, fields and soil as well as low-impact development projects such as rain gardens, green roofs, permeable pavements, bioswales, absorbent landscapes and rainwater harvesting (EPCCARR 2018).

Resilience: "Capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding to or reorganizing them in ways that maintain their essential function, identity, and structure. Resilience is a positive attribute when it maintains the capacity for adaptation, learning or transformation" (IPCC 2023).

Risk: "Potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as from human responses to climate change. Relevant adverse consequences include those on people's lives, livelihoods, health and well-being; on economic, social and cultural assets and investments; on infrastructure and services (including ecosystem services); and on ecosystems and species. In the context of climate change impacts, risks result from dynamic interactions between climate-related hazards and the exposure and vulnerability of the affected human or ecological system to the hazards. Hazards, exposure and vulnerability may each be subject to uncertainty in terms of magnitude and likelihood of occurrence, and each may change over time and space due to socioeconomic changes and human decision-making" (IPCC 2023).

Vulnerability: Predisposition to be adversely affected by a change in climate, depending on sensitivity or susceptibility to harm and capacity to cope and adapt (IPCC 2023). Vulnerability results from diverse historical, social, economic, political, cultural, institutional, natural resource-related and environmental conditions and processes (IPCC 2023).

Weather: State of the atmosphere at a specific time. It is the short-term or instantaneous variations of the atmosphere, as opposed to the long-term, or climatic, changes (Canada 2025).

ACRONYMS

ADAPT	adaptive, dynamic, active, participatory, thorough
ARM	adaptation and resilience measurement
CREAM	clear, relevant, economic, adequate, monitorable
EEA	European Environmental Agency
EDI	equity, diversity and inclusion
FPT	federal, provincial and territorial
GHG	greenhouse gas
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
M&E	monitoring and evaluation
MEL	monitoring, evaluation and learning
SMART	specific, measurable, achievable, relevant, time-bound
UNFCCC	United Nations Framework Convention on Climate Change

1.0 INTRODUCTION

The implementation of measures to improve adaptation and resilience to climate change impacts continues to gain momentum in Canada and worldwide, driven largely by experiences with extreme weather events and the projections of continued climate change. In Canada, a significant amount of climate risk assessment has been done, both for the provinces and territories and at municipal, regional and watershed scales, yet evidence of large-scale adaptation implementation is not commensurate with the magnitude of risks. In circumstances where resilience measures have been adopted, there is a sound rationale for monitoring their effectiveness and outcomes. However, there are challenges in identifying and developing appropriate indicators to measure adaptation and resilience. Uncertainty concerning future greenhouse gas (GHG) emissions and the broad interaction of climate and non-climate drivers within human and natural systems are among the aspects that constrain direct and clear measurement and reporting on adaptation and resilience (United Kingdom 2023). Adaptation and resilience measurement (ARM), both in general and across orders of government, is still a relatively new field of practice. As a result, new lessons and knowledge continue to emerge as ARM programs are developed and implemented. There is a particular need to improve knowledge and gain experience in defining and using indicators and metrics for effective monitoring and evaluation (M&E) of adaptation actions in ARM programs.

Climate change adaptation M&E provides important insights into differences and dividends resulting from adaptation and resilience actions. M&E's purpose in adaptation is to provide important feedback through cycles or iterations which make it possible to recalibrate planning according to the changing climate, realign policies to the changing context, and refocus implementation if desired outcomes from climate action are not achieved. This feedback also provides a degree of accountability and can contribute to the evolution of best practices for adaptation. Considerations of equity, diversity and inclusion (EDI) in adaptation M&E help ensure that the fundamental and underlying factors that contribute to climate change vulnerability are effectively being addressed. Monitoring involves making observations of "progress made in implementing a specific adaptation action in relation to its objectives and inputs" (UNFCCC 2023). Evaluation aims to "systematically and objectively determine the effectiveness of an adaptation action" (UNFCCC 2023). It is possible that M&E programs in related areas (e.g., environmental M&E programs) can inspire those for climate adaptation and resilience. Furthermore, indicators used in these programs may also be transferable to the context of adaptation and resilience and may already measure facets underlying climate change vulnerability.

Another component of M&E—learning—is prominent in international adaptation M&E programs and has been applied in some national adaptation plans (e.g., France and the United Kingdom). The learning component informs subsequent iterations of climate change risk assessment and adaptation planning and implementation. Thus, monitoring, evaluation and learning (MEL) regarding the progress and effectiveness of adaptation and resilience efforts within the adaptation cycle (see Figure 1) build the foundations for a robust ARM program. ARM programs help

promote accountability, transparency and the ability to learn from experience, which is vital for refining adaptation and resilience policies, initiatives and practices.

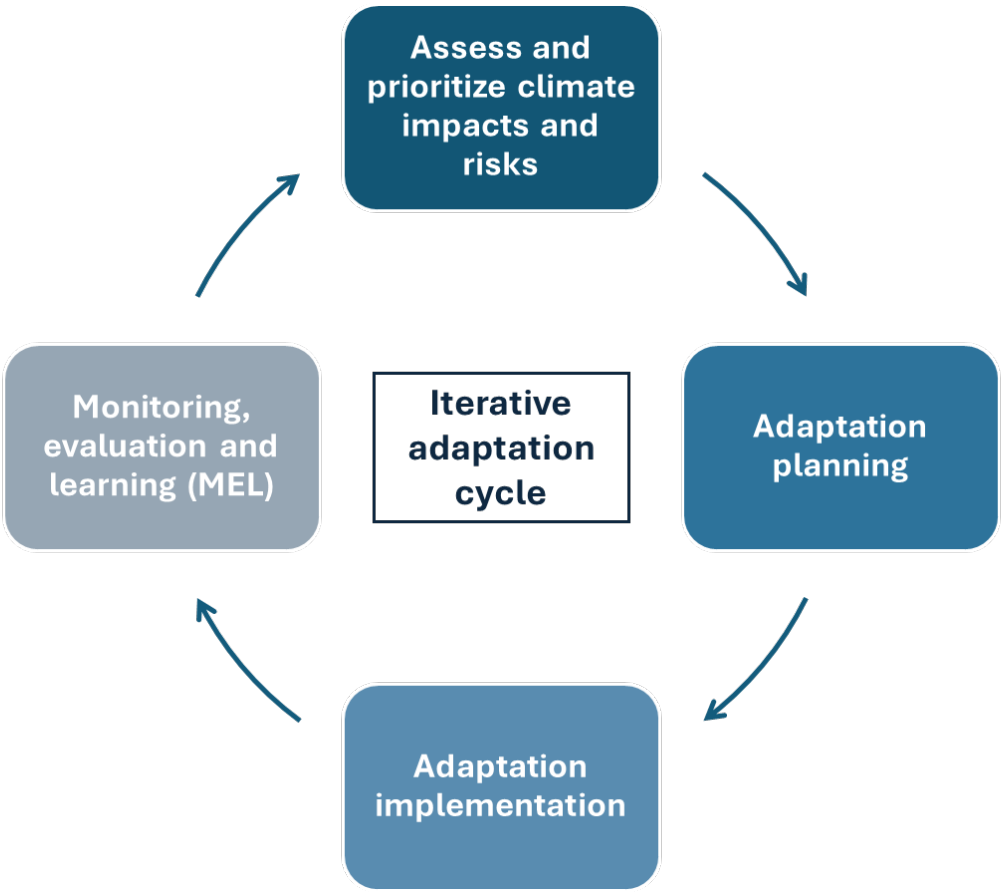


Figure 1: Monitoring, Evaluation, and Learning in the Iterative Adaptation Cycle

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1.1 Purpose of this Guidance Document

The increasing frequency and severity of climate change impacts in Canada have led federal, provincial and territorial (FPT) governments to adapt and build resilience. As they respond to climate risks, it has become imperative for them to monitor the performance of policies and actions and to evaluate the effectiveness of these initiatives. This document is intended to guide FPT governments in establishing or improving ARM while offering considerations for making measurements efficient and consistent across Canada. To this end, a domestic and international review of ARM literature, frameworks and indicators has been conducted to inform the development of an ARM framework and indicator inventory that may be suitable for Canadian jurisdictions.

1.2 How to Use this Guidance Document

This guidance document has been designed for FPT governments to inform the establishment or enhancement of their climate ARM, including the selection of indicators most appropriate for measurement in their jurisdiction. To support this goal, an inventory of indicators accompanies this guidance document (Appendix I).

The document begins with an introduction to the fundamentals of ARM within the climate adaptation cycle, followed by the methodology used for creating this guidance document. It then provides an overview of the current state of ARM practices in Canada, along with the design characteristics of the indicator inventory. Next, it offers a step-by-step guide for selecting indicators to align with the needs and context of each FPT jurisdiction. Finally, it discusses the key limitations of this work and offers considerations for users regarding this document and the indicator inventory.

2.0 METHODOLOGY

The details contained in this document, including the indicator inventory and user guidance, are informed by two main research elements: a review of available literature and engagement with FPT governments (March to July 2024).

2.1 Literature Review

The literature review sought relevant sources from Canada as well as other countries around the world. Domestic literature included seminal work conducted by the Expert Panel on Climate Change Adaptation and Resilience Results (EPCCARR 2018) and other scholarly work from leading researchers and practitioners such as the International Institute for Sustainable Development (IISD), the Canadian Climate Institute and Concordia University. Additional resources from Canadian FPT governments—such as government reports, adaptation plans, non-climate M&E programs (as analogues) and indicators for climate- and non-climate contexts—yielded specific contextual information. This research was supplemented with literature from recognized international organizations and national and local governments from Europe and North America.

The following criteria were part of the search process:

- national and international frameworks, research papers, reports and indicator repositories
- sources from development organizations, non-profit organizations, sectorial institutions, and national, subnational and local governments
- climate change ARM combined with aspects of EDI
- publicly available ARM indicator frameworks
- ARM in subnational jurisdictions and other geographical scales

- national and international indicator databases
- thorough review of citations within sources.

The literature review helped to identify state-of-the-art, transferrable lessons and best practices for developing and selecting adaptation and resilience indicators in Canada. It informed the indicator inventory by identifying indicator archetypes and characterizations, regionally specific elements, and frameworks for housing an inventory. Finally, the research also included a review of sources regarding the integration of EDI aspects related to climate adaptation and resilience and their measurement facets.

2.2 Engagement with Federal, Provincial and Territorial Jurisdictions

The literature review was supplemented by interviews with representatives from FPT governments who are responsible for, or connected to, ARM and was designed to gain insights into the context of adaptation and into important facets of ARM strategies. The interviews yielded suggestions about ways to advance ARM in Canada and provided information about how FPT governments are using indicators and M&E programs more broadly.

The process consisted of two rounds of semi-structured interviews, which took place between March and July of 2024 (see Appendix IV). The first round of the interviews sought to understand the degree of activity and maturity in implementing adaptation indicators and ARM in general. Given that FPT governments are at different levels of ARM maturity, two different questionnaires (tracks one and two) were developed for this round of interviews with all jurisdictions. The track one questionnaire was directed to jurisdictions that self-identified as active in ARM. It asked about the FPT jurisdiction adaptation and ARM strategies, ARM components (including EDI aspects), implementation and reporting experiences, and additional documentation available on their ARM programs. The track two interview was directed to FPT governments that considered themselves at earlier stages of ARM. Track two interview questions were more general in nature and asked about geographic needs, barriers of ARM, ideal characteristics for an ARM framework, and other indicator-based or M&E programs that might serve as ARM inspiration. This approach helped provide insights into the needs across jurisdictions and into the state of ARM in Canada. Given that jurisdictions were asked to self-identify, 10 out of 14 FPT governments opted for the track two questionnaire.

The second round of interviews was conducted with the four FPT governments that are the most active in the ARM field: Saskatchewan, the Yukon, British Columbia and Canada. This round of interviews sought more advanced information on indicators and ARM processes. At the time of the interviews, New Brunswick was undertaking a province-wide risk assessment and was included in the second round of interviews to gain insights on how this process was guiding the development of future ARM programs. All second-round interviews also sought a preliminary review of the proposed design for the indicator inventory, which included sample indicators to

demonstrate how fields in the inventory would be populated and to help inform the inventory design.

Throughout this process, FPT governments provided written feedback on the literature review and engagement findings. The input was addressed and integrated into the final documents.

3.0 STATE OF PRACTICE OF ADAPTATION AND RESILIENCE MEASUREMENT IN CANADA

The research revealed the current needs, challenges and opportunities for ARM practice and policies in Canada. ARM in Canada is ever-changing, and new initiatives continue to be launched. As such, the data collection for this report represents the state of practice at one point in time.

Not unlike other countries, climate change impacts and risks in Canada are increasing in frequency and severity, prompting governments to advance adaptation and resilience, and monitor the effectiveness of their adaptation actions and initiatives. While climate risks vary across different parts of Canada, there are common climate resilience milestones across FPT governments, such as reducing impacts and increasing knowledge and capacity for adaptation and resilience. The measurement of adaptation is in its infancy in Canada; however, all FPT governments have taken steps forward on adaptation and resilience in some form. Some have undertaken climate risk assessments (e.g., British Columbia, the Yukon, Prince Edward Island, Northwest Territories, Ontario, New Brunswick, Nova Scotia, Québec), some have developed specific adaptation strategies and plans, others have combined adaptation and mitigation strategies or plans, and others have embedded adaptation and resilience considerations into broader policies. Each jurisdiction also reports on adaptation implementation in different ways, including monitoring local adaptation plans and adaptation programs, implementing impact monitoring or surveillance programs, and collecting data. However, the literature review and interviews with FPT government representatives found that ARM programs in Canada are still in development and do not yet include an explicit evaluation of the effectiveness of their implementation. Nonetheless, governments are aware of this necessity. The interview process also revealed that there is a tendency for measuring adaptation and resilience actions tied to initiatives or plans of relatively short duration, with less emphasis on the longitudinal or long-term nature of ARM and the adaptation cycle that would allow the FPT government to evaluate and correct actions.

While they recognize the need for ARM, FPT governments face challenges in developing ARM programs. Firstly, the intrinsic contextual and scientific uncertainty under which climate change adaptation and resilience indicators are selected and developed is a critical challenge, along with the complexity and long timescales needed to evaluate the effectiveness of adaptation actions. Moreover, a lack of adequate human and financial resources constrains this process, primarily when it comes to time investment, active participation, staff expertise and the requisite staff availability.

Differing approaches could be taken in the governance of ARM, either centralizing or sharing capacity and expertise. In some cases, reporting adaptation and resilience action is required by legislation (e.g., British Columbia's *Climate Change Accountability Act*) or policy (e.g., Saskatchewan's Climate Resilience Measurement Framework). This centralizes ARM responsibility and capacity in FPT environment ministries and departments and requires a substantive engagement process with other departments. Some FPT governments reported that a decentralized ARM governance structure may be desirable, with a single governmental unit coordinating ARM mandates across the government's ministries, departments and agencies. Funding opportunities or programmatic requirements can also incentivize third parties outside the FPT government (e.g., Indigenous organizations, municipalities, civic organizations, universities and so on) so that the responsibility of monitoring, measuring and reporting on adaptation and resilience action is shared throughout each jurisdiction.

Although ARM programs and indicators are relatively novel in Canada and abroad, five FPT governments (Saskatchewan, the Yukon, British Columbia, Québec and Canada) had taken concrete steps toward an ARM program at the time of the interviews. These jurisdictions follow commonly used guidelines or principles for developing and implementing indicators, such as specific, measurable, achievable, relevant and time-bound (SMART); clear, relevant, economic, adequate and monitorable (CREAM); and other tools such as a logic model.

Data requirements—including availability, accessibility, format and periodicity—are early planning and scoping considerations and can play a significant role in the feasibility of ARM indicator selection and ARM reporting. Interviews with jurisdictions revealed that spatial scales of measurement are crucial to indicator data requirements. New indicators present an opportunity for new data collection and monitoring options, especially if the indicator is highly relevant to ARM in that jurisdiction. Given that data are critical for adaptation and resilience MEL, it is important to define, explore, solicit and formalize data for ARM, and scales of measurement should map to Canadian jurisdictions and respond to their unique ARM needs.

EDI aspects are also important considerations for adaptation and resilience, and they most often manifest within the element of vulnerability. For instance, the number of boil water advisories by community indicates a community's vulnerability to climate change impacts on safe drinking water systems. The inequitable access to adequate potable water systems in some communities can increase vulnerability to the impacts of climate change. As such, when a government integrates EDI aspects into ARM, it must identify elements of social systems that disproportionately impact certain groups or individuals. This can be accomplished using direct and deliberate indicators or indicators that have EDI as an inherent component, or by disaggregating other indicators according to vulnerable areas or people. Thus, the treatment of EDI considerations can be more prominent—for example, as noted in the guiding principles of the federal government's National Adaptation Strategy—or it can be included less explicitly but remain inherent within the chosen indicators.

4.0 THE ADAPTATION AND RESILIENCE MEASUREMENT INDICATOR INVENTORY

As FPT governments advance adaptation implementation in Canada, there is an opportunity to strive for synergies and alignment in ARM within and across jurisdictions. While different FPT government mandates, policies and ARM program maturities make it difficult to align measurements, identifying common measurement interests within indicator domains[1] could facilitate ARM alignment. Such collaboration could promote improved sharing of ARM lessons learned across FPT governments (UNFCCC 2023). In any case, the current state and understanding of ARM, as well as the challenges, needs and lessons learned among FPT governments, can help shape the design of an ARM framework to improve measurement across Canada.

The indicator inventory in Appendix I is intended to assist FPT governments in exploring and developing a suite of indicators for their unique adaptation and resilience circumstances. The inventory serves as a shared repository for indicators and may improve the consistency of their application across the country. A series of adaptation and resilience indicator characteristics are included in the inventory, which helps the user, during the selection process, to match indicators to their jurisdictional context and other considerations such as data availability, EDI or type of adaptation measurement.

4.1 The Indicator Inventory Design

In the indicator inventory, indicators are organized into the following four main sections, each with a detailed description or characterization:

- **description of use:** purpose and application context, relevance and domain of use
- **category of measurement:** adaptation and resilience policy processes and climate risk and vulnerability indicators
- **intrinsic characteristics:** EDI aspects, strengths and limitations, temporal and spatial scalability, and transferability
- **data requirements:** data needs, sources, availability, unit of measurement, metrics and proxies, baselines and indicator sources.

The literature review did not uncover many examples of how an ARM indicator database was designed or a detailed process for selecting indicator characterizing fields. In most cases, inventories of ARM indicators had some degree of characterization that provided insights into important elements and limitations. As mentioned in the methodology section, the second round of interviews gathered feedback on elements of the framework and how indicators are inventoried and characterized. To enhance the information accompanying each indicator, the research also

[1] Indicator domains are the six areas where indicators could be used that are relevant for jurisdictions; see Section 4.2.

drew on the past experience in ARM activity in Canada and the expertise of those executing the project work.

When users are aware of each indicator's characteristics and limitations, they can more easily select appropriate indicators, particularly in cases where ARM programs are in the early stages of development. In this process, the highly context-specific nature of adaptation and resilience means that ARM programs are location-specific, and as a result, ARM goals and objectives differ across and within FPT governments. Particular emphasis is given to spatial scalability characteristics to underline the geographical and regional differences within Northern Canada.

Data requirements for ARM are also critical factors in the development of ARM programs. Data availability, reliable access and adequate formats are some crucial characteristics to look for when choosing indicators for ARM programs. Even if the other aspects of an indicator could fulfill the needs of an aspect of ARM, if data requirements are not satisfied, the indicator will be impracticable.

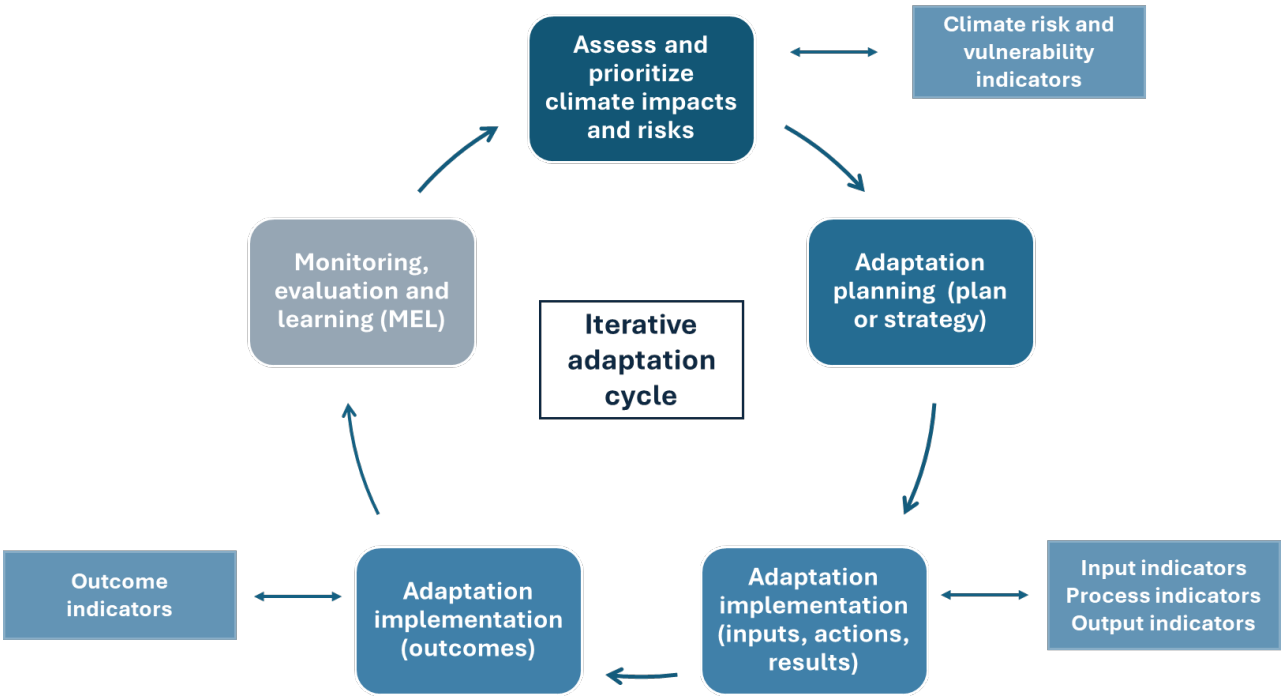


Figure 2: Indicators Commonly Used for Measuring Adaptation and Resilience Progress within the Adaptation Cycle

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To address the range of indicator types that match the goals and objectives for ARM (Figure 2), particular attention to the indicator category section of the inventory is warranted. The inventory uses two main indicator categories, as proposed by Mäkinen *et al*. (2018): adaptation policy

process and climate risk and vulnerability. The first category relates to policies and process indicators, which are further divided into four indicator types: input, output, process and outcome. Indicators in this category are intended to measure aspects of adaptation implementation progress (these concepts are presented in Table 1). Input, process, and output indicators require data through monitoring, while outcome indicators involve additional data collection, mostly qualitative, for evaluation purposes (Mäkinen *et al*. 2018). Climate risk and vulnerability category indicators (also presented in Table 1), which are linked back to risk and vulnerability assessment components, can establish a baseline and measure outcomes of adaptation and resilience action (Noltze *et al*. 2021). As such, discrete elements of risk and vulnerability, including adaptive capacity, exposure, sensitivity, climate impacts and climate hazards, have been incorporated as indicator types within the climate risk and vulnerability assessment category. Notably, jurisdictions in Canada with ARM frameworks developed or in development have considered or integrated both indicator categories, i.e., adaptation and resilience policy processes and climate risk and vulnerability indicators.

Table 1: Definition of the Indicator Category Used in the Inventory Framework

Indicator category	Indicator type	Definition	Examples
Climate risk and vulnerability indicator	Climate impact	An indicator about the observed impacts of climate change on human and natural systems.	Number of wildfire incidents and total area burnt (Indicator #42)
	Climate hazard	An indicator of the potential occurrence of a natural or human-induced physical event or trend or physical impact that may impact human and natural systems.	Changes in mean annual temperature (Indicator # 50)
	Exposure	An indicator of the exposure of people, livelihoods, species or ecosystems; environmental functions, services and resources; infrastructure; or economic, social or cultural assets in places and settings that could be adversely affected.	Number of emergency response facilities (hospitals, firefighter stations, shelters) located in areas at risk for flooding or coastal erosion (Indicator #25)
	Adaptive capacity	An indicator of the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences.	Percentage of communities that have issued heat warnings (Indicator #26)
	Sensitivity	An indication of the degree to which a system or species is affected, either adversely or beneficially, by climate change.	Status of key fish stocks (healthy, cautious or critical) (Indicator #30)
	Composite vulnerability	An indicator that provides a metric characterizing the vulnerability of a system by combining, with or without weighting, several indicators assumed to represent vulnerability. This includes indicators that combine two or more indicators of exposure, sensitivity or adaptive capacity. In some cases, in the literature, this has been described as a vulnerability index indicator.	Number of people displaced from homes as a result of flood, drought, wildfires or sea-level rise (Indicator #43)
Adaptation and resilience policy process indicator	Input	An indicator that provides a measure of resources, both human and financial, devoted to a particular adaptation activity, program or intervention.	Available funding for or amount of investment in schemes for residential and commercial building retrofits

Indicator category	Indicator type	Definition	Examples
			that consider adaptation (Indicator #35)
	Process	An indicator that tracks progress in adaptation policy processes and actions.	Percentage of management plans for terrestrial ecosystem conservation areas that include the impacts of climate change (Indicator #17)
	Output	An indicator that relates to the direct results of an adaptation policy or action without assessing whether these results lead to better adaptation outcomes.	Percentage of communities with culturally and locally relevant and ratified emergency preparedness and response plans (Indicator #39)
	Outcome	An indicator that assesses the level of success of a given governmental intervention in climate change adaptation and resilience (usually long-term changes).	Percentage of coastline under a coastal erosion management program (Indicator #16)

All of the fields in the indicator inventory are defined in the Definitions tab of the indicator inventory spreadsheet. Each field also corresponds to a step in the indicator selection process, which is described in Section 5.0 of this document.

4.2 Inventory of Potentially Suitable Indicators

Indicators from the domestic and international resources listed in Appendix I were identified and added to the inventory following a method developed specifically for this purpose (see Appendix III).

The domain is the primary field for selecting and classifying indicators within the inventory. Domains were derived from a review and comparison of the themes used (where applicable) in FPT government adaptation plans and strategies (Table 2). Some, but not all, of the identified indicators from the analyzed resources were directly transferable to the inventory design and, in some cases, required tailoring to suit the Canadian context. For example, as indicators were drawn from international resources, it was apparent that small adjustments to words or additions of new words changed the indicator significantly. This demonstrates the degree of sensitivity of the name of the indicator. This sensitivity makes it easy to modify and adjust indicators to suit local contexts or specific ministerial or departmental mandates. In other cases, accompanying details about each indicator were also adjusted but were aligned with the fields as defined. The process for identifying suitable indicators for the inventory also considered information compiled from the interviews with FPT representatives who reported on key domains, preference of indicator categories, key considerations and other factors.

Table 2: Indicator Domains Used in the Inventory Framework

Indicator domain	Definition
Infrastructure	Built physical structure and its components of interrelated facilities and systems—such as roads, bridges, airports, water supply systems, sewers and electrical grids—that are exposed to climate impacts.
Natural environment	All naturally occurring biotic and abiotic components that are exposed to climate change impacts.
Health and wellbeing	Climate-related physical impacts for public health and wellbeing, considering both physical and mental health outcomes.
Economy	Climate-sensitive economic components where climate change impacts are expected.
Disaster resilience and community preparedness	Efforts to prepare for climate hazards, adapt to changing conditions, and withstand and recover from climate-related impacts.
Cross-sectional	Climate-related aspects affecting multiple domains.

Regional geographies and landscapes across Canada were considered in the design and development of the indicator inventory. For example, indicators classified as "territorial" under the spatial scalability column in the inventory may be particularly relevant to the territorial jurisdictions and northern regions of Canadian provinces. Indicator selection would thus include reference to relevant landscapes such as coastal, mountain, prairie, urban and so on.

Outcome indicators and some indicators under the climate risk and vulnerability assessment category were more challenging to identify because of the need for specific contextual information from a climate risk assessment and because of the timeframe needed to ascertain measurements (e.g., extreme event frequency and accompanying effectiveness of resilience measures).

A set of 51 indicators was identified to comprise the inventory in Appendix I for measuring adaptation and resilience across the six domains, considering the needs of FPT governments in Canada. The indicators are, for the most part, simple and measurable. To a degree, the availability of data for each indicator in each individual jurisdiction is unknown, but where possible, sources have been identified in the inventory as examples.

5.0 INDICATOR SELECTION GUIDANCE

This section presents a set of considerations on ARM frameworks, indicators and EDI aspects for selecting ARM indicators and a detailed indicator selection guide for choosing indicators from the inventory listed in Appendix I.

5.1 Key Considerations for Adaptation and Resilience Measurement Indicator Selection

5.1.1 ARM Framework Considerations

An FPT government's adaptation and resilience plan or strategy is a cornerstone for the adaptation cycle process (see Figure 1). Its vision, its priorities and any accompanying action plan, often stemming from a climate risk assessment, are important primary sources of information that will guide the ARM indicator selection process.

The literature review and engagement with FPT governments revealed a number of considerations for the development of the ARM framework and of the indicators listed in Appendix I:

- The adaptation and resilience plan or strategy lends insight into the main themes (indicator domains), the nature of adaptation ownership (single or multiple ministries or departments), resilience priorities and priority government policies or programs that should be considered in the ARM framework.
- M&E frameworks provide an important structure to ARM, notably by lending their rigour to approaches to monitoring, reporting and growing or expanding ARM.
- Some ARM frameworks promote starting with fewer indicators to focus only on top priorities. In the early stages of ARM, selecting many indicators may tax program oversight and jeopardize reporting targets. Starting with fewer indicators also allows more thorough development, testing and piloting of ARM frameworks.
- Informing governments and other stakeholders and interested parties of meaningful results that emerge from adaptation and resilience is a primary consideration for ARM frameworks, which are primarily tied to the indicators. As such, the nature of the end users of ARM, including citizens, public officials, or decision-makers, should be considered when developing an ARM framework.
- While indicators are crucial in an ARM framework, they may not necessarily explain all of the changes associated with adaptation. Other elements fill out the story of successful adaptation implementation and stem from the process of implementing the measures or program. Linking to original goals and objectives for adaptation and resilience maintains calibration and direction for ARM. Organizational readiness, resources and skills help support the measurement process and provide critical elements of a robust ARM framework.

5.1.2 ARM Indicator Characteristics Considerations

The following are key qualities of indicators which serve as considerations for the Canadian context. They are divided into three main themes: characteristics and applications of indicators, types of indicators and metrics, and spatial scale requirements.

1. Characteristics and applications of indicators
    - Indicators serve as signposts to inform the degree of observable change and provide a reference point for monitoring, decision-making and evaluation. They also measure progress, ensure consistency between activities and goals, and assess the effectiveness of policies and actions.
    - Indicators may not provide scientific proof or detailed explanations about the changes intended to be measured, yet they can provide meaningful approximate information about critical aspects (e.g., direction) of change, which are important for decision-making.
    - Indicators that map to climate risk assessment priorities provide an opportunity for data alignment between adaptation and resilience actions and climate risks, and can complement vulnerability indicators.
    - Indicators with accompanying longitudinal data sets (historic) and certainty about continuance align well with the needs for ARM.
    - Indicators used in non-adaptation contexts may be suitable to facilitate the implementation of an adaptation M&E program.
    - Indicators should be considered through an integrated approach rather than in isolation. The classification of subcategories for indicators remains fluid, reflecting the complexity of climate risk. Ultimately, indicators should be interpreted within the broader context of a comprehensive risk assessment framework to ensure that they contribute meaningfully to understanding climate-related risks.

2. Types of indicators and metrics
    - Some indicators serve multiple purposes, such as capturing both climate hazard exposure and adaptation responses.
    - Outcome indicators are ideal for measuring changes in climate risk and resilience, but they are the most difficult to monitor. Output indicators such as counts (e.g., number of communities with an adaptation plan) are more often used for measuring results, but they are only partially suitable for evaluating outcomes. Output indicators are easier to measure but they are better suited for implementation and process monitoring rather than evaluating effectiveness and sustainability.
    - Proxy metrics (e.g., boil water advisories to assess water system vulnerability) are less directly connected to climate change impacts and adaptation and can be used in situations where there is a lack of suitable indicators and direct metrics. However, the use of these types of metrics and aggregated units of analysis may not properly or adequately account for the role of climatic interactions (i.e., attribution). For example, boil water advisories could be caused by numerous other non-climate factors.
    - Qualitative and quantitative measurement information is helpful for ARM, particularly for evaluating outcomes and learning from implementation experience. Quantitative indicators alone (e.g., the number of people trained in climate adaptation management) are insufficient to evaluate the effectiveness of adaptation and resilience actions in the

long term and identify the lessons learned through the implementation process. Qualitative information in the form of surveys or interviews can provide additional insight into how an outcome or impact was achieved and whether adaptation planning and implementation changes are needed.

3. Spatial scale requirements
    - There is no one-size-fits-all metric that can be applied to spatial scales. Some indicators are scale-specific, and some may be more suitable for measuring on a local scale. As such, it is possible, and sometimes ideal, to roll up local scale indicator outputs to subnational or national scales.
    - Identifying concrete data sources and availability at the spatial scale needed for ARM may be challenging. Although this may be seen as a setback, it could also be seen as an opportunity for new data collection tailored to the ARM program's spatial scale needs.

5.1.3 Equity, Diversity and Inclusion Considerations

EDI within climate change adaptation and resilience is growing in importance, yet adaptation planning and implementation processes to date have largely resulted in unjust and inequitable outcomes, indicating a need for improvements in this area (Coggins *et al*. 2021). Climate change highlights and exacerbates non-climate-related challenges, such as social injustices, and disproportionately affects vulnerable populations due to differences in their exposure to climate hazards, sensitivity to these hazards, and ability to cope and adapt (Gaskin *et al*. 2017). As climate change impacts become more common, effective actions are required to improve the adaptation and resilience of affected populations, particularly for the populations which are disproportionately more impacted by climate- and weather-related disasters. Actively removing barriers in order to support the meaningful participation and consideration of vulnerable and marginalized groups will lead to more inclusive adaptation initiatives and associated ARM (Tangirala 2022).

Adaptation and resilience indicators can include considerations for EDI in two ways. First, they can be specifically designed to measure equity, diversity or inclusion in the context of climate change. For example, "total population living below the monetary poverty line." Alternatively, specific indicators developed for climate adaptation and resilience action may integrate EDI principles (e.g., equity-deserving groups) within the indicator. For example, an exposure indicator such as "population living in flood plains" could integrate socioeconomic information such as income and be disaggregated to include the personal income of households living in flood plains to reference aspects of equity.

Diversity can be reflected in indicators by measuring the breakdown of different sub-populations within vulnerable areas. The exposure of different groups to various forms of climate impacts also reflects diversity in indicators. When EDI is integrated into ARM, metrics can point to responses that address the social or demographic context that underpins vulnerability among certain populations. Focusing only on one or two aspects of EDI may not deliver the intended results,

whereas striving to fully incorporate these considerations into adaptation and resilience policies and actions will drive actions toward a more just, equitable and resilient society. Furthermore, the development and application of adaptation and resilience indicators with EDI considerations can be strengthened by actively involving members of targeted populations in the co-development and data collection processes. This participatory approach ensures that indicators are more inclusive, representative and reflective of the diverse experiences and needs of affected communities.

Equity in the context of climate change is the concept of advancing climate resilience through degrees of fairness and justice, particularly for those who have been historically marginalized (Ghojeh *et al.* 2019). Achieving equity involves recognizing and addressing barriers to provide opportunities for all individuals and communities to thrive in resilience, regardless of their starting point. It focuses on power, access, opportunities, treatment, impacts and outcomes in three main areas: representational equity (the proportional participation at all levels of an institution), resource equity (the distribution of resources in order to close equity gaps) and equity-mindedness (the demonstration of an awareness of, and willingness to, address equity issues) (Tangirala 2022).

Diversity refers to the presence of differences, including race, age, ethnicity, religion, disability, gender identity, sexual orientation, mental and physical disabilities and socioeconomic status within the fulsome process of planning for climate change, which includes the monitoring and evaluation of adaptation results (Tangirala 2022).

Inclusion refers to creating an environment where everyone feels welcome, can fully participate without barriers to belonging, and has the opportunity to succeed. It is a deliberate and ongoing process to address inequities and build a diverse and respectful community that provides equal opportunities for all within the ARM process (Tangirala 2022).

Prioritizing adaptation actions to meet the needs of the most vulnerable in society is key. Measuring the effectiveness of these actions is achieved by developing indicators that specifically measure the EDI aspects that address the underlying and fundamental causes of vulnerability, or by measuring aspects of climate change adaptation that reference EDI, as mentioned earlier. The indicator inventory framework has a field explicitly tied to EDI which describes how aspects of EDI can be linked to the design and measurement of each indicator. Step 4 of the indicator selection process demonstrates how aspects of EDI are considered.

5.2 Indicator Selection Process

The literature review did not uncover many examples of an ARM indicator database that was designed for or accompanied by a detailed indicator selection process. This stands in contrast with to the relatively abundant literature that reports on indicators, either potential or in use. Still, a number of key resources informed the development of the selection process presented here (Bours *et al.* 2014, EPCCARR 2018, UNDP 2002, ICLEI 2022, Hammill *et al.* 2014, Solecki *et al.* 2015).

The following steps guide the user in identifying an indicator from the inventory that best fits the measurement requirements of each adaptation action within the FPT government strategy or plan. The sequential steps help select the indicator by narrowing the field through a selection process with the endpoint of an appropriate indicator. Figure 3 shows the step-by-step indicator selection process.

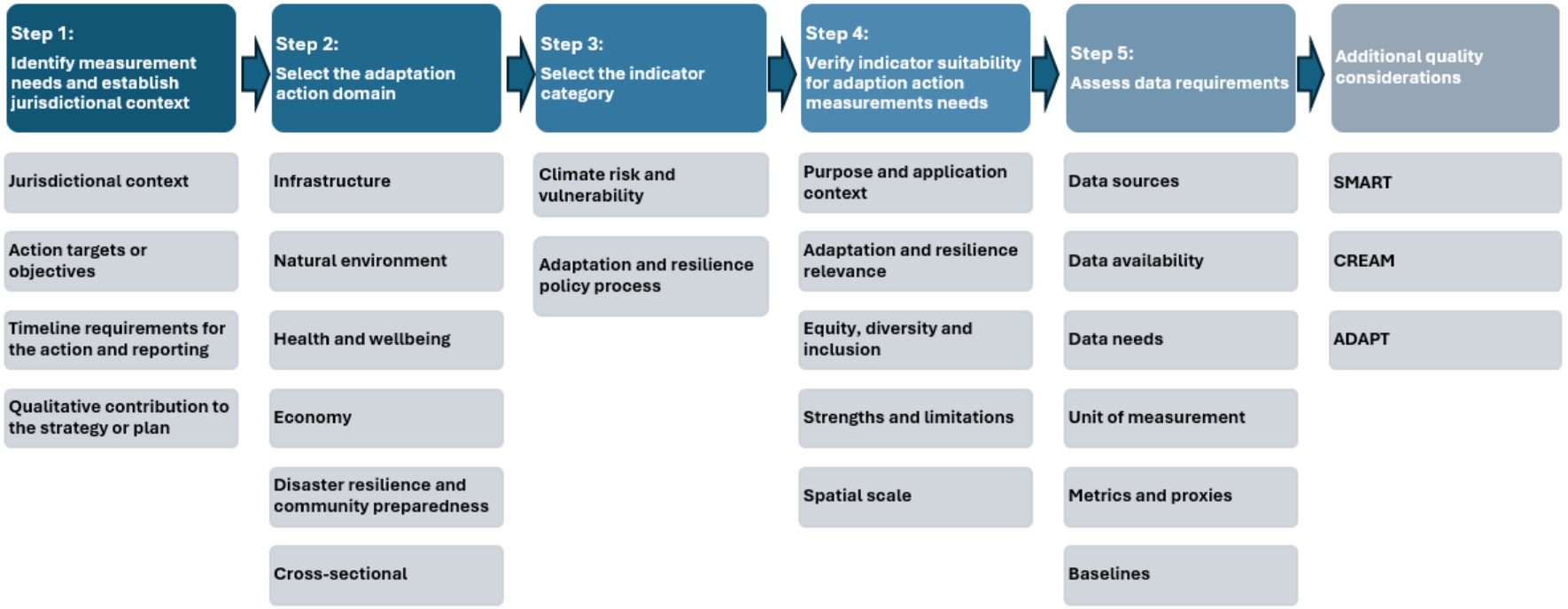


Figure 3: Steps in the ARM Indicator Selection Process

Step 1. Identify measurement needs and establish jurisdictional context

Adaptation and resilience implementation occurs primarily at the local scale; thus, local contextual factors will inform indicator decisions. Factors such as geographic and ecological features (e.g., permafrost, terrestrial or water ecosystems, topography), socioeconomic factors (e.g., vulnerable populations and regions) and predominant economic activities (e.g., agriculture, natural resources, services) must be considered in the indicator selection process.

The tangible measurements that are associated with each adaptation action are then identified and can often stem from priority risk scenarios developed during a climate change risk assessment. The overarching goals and objectives, as well as timelines for adaptation as found in the risk assessment, also help inform the selection of adaptation indicators.

The measurement for each adaptation action can include the following components, all of which are important for the selection and definition of indicators:

- action targets or results (e.g., increase of 10% on natural or shore protected area, establish a wetland monitoring system)
- timeline requirements for the action (e.g., by 2030, per year) and reporting (e.g., annual reporting)
- qualitative contribution to the strategy or plan (e.g., increased urban green areas will decrease climate risks on human health in urban centres).

This step also provides measurement details, such as units of measurement, data types and aggregation or disaggregation needs, which are important for subsequent steps in the process.

Step 2: Select the adaptation action domain

Step 2 involves narrowing the indicator inventory by mapping indicator themes in the adaptation strategy or plan to the domains contained in the inventory. The names of the domains in the inventory may not exactly align with each jurisdiction's adaptation strategy or plan, but the general theme should be apparent. In some cases, more than one domain may apply to a section of the adaptation strategy or plan, in which case more than one domain may be consulted. If a matching domain is not apparent or if there are adaptation actions that do not map well to the domains in the inventory, the cross-sectional domain may be appropriate. The domains in the inventory consist of the following (Table 2):

- infrastructure
- natural environment
- health and wellbeing
- economy
- disaster resilience and community preparedness
- cross-sectional.

Step 3: Select the indicator category

The indicator inventory hosts two categories of indicators, which were inspired by select current practices found in the literature review. The two categories are:

- adaptation and resilience policy processes indicators
- climate risk and vulnerability indicators.

Under each category, different indicator options measure different aspects of the adaptation actions. To select the appropriate category and indicator type, the user must determine the measurement need:

a. Will the measurement pertain to climate impacts relative to an adaptation baseline?

   If yes, then the indicator category is **climate risk and vulnerability indicators.** The user must then establish whether the adaptation action refers to one of the following characteristics: **climate impact, climate hazard, exposure, composite vulnerability, adaptive capacity** and **sensitivity**.

b. Will the measurement seek to identify aspects of resource allocation, progress or the short-term results of the adaptation action implementation, or a combination of these aspects?

   If yes, then the indicator category is **adaptation and resilience policy processes indicators**. There are three indicator types in this category:
   - **input,** which measures resource allocation
   - **process,** which measures progress on the implementation process
   - **output,** which measures the results of processes.

c. Will the measurement seek to identify the effectiveness of mid- and long-term adaptation actions?

   If yes, then the indicator category is **adaptation and resilience policy processes indicators.** In this case, the only option is outcome indicators**.** Outcome indicators assess the performance and effectiveness of actions that contribute to the adaptation strategy or plan's high-level goals and objectives and provide information over longer cycles. As such, additional contextual information from these strategies or plans is usually required to interpret the outcome effectiveness accurately.

Step 4: Verify indicator suitability for adaptation action measurement needs

At this stage, the level of refinement has significantly narrowed the indicator options. The user's role now is to review the simple characteristics of the remaining indicators to determine which suit the adaptation needs. This step contains two sub-stages.

a. The first part involves verifying the suitability of the indicator for the action to be measured by reviewing the following:
    - **Indicator name**: This information is specific regarding what precisely will be measured and should easily be linked to the adaptation action.
    - **Purpose and application context**: This information details the measurement characteristics and the context in which the measurement takes place.
    - **Adaptation and resilience relevance**: This provides additional context about the link to climate change impacts and adaptation and supplements the indicator description.

b. The second part of this analysis consists of verifying other important indicator characteristics relevant to the measurement needs. These characteristics and their priority will depend on the mission and vision of the adaptation strategy or plan.
    - Linkages to **EDI** help the user relate to aspects that underlie vulnerability and determine whether the indicator itself will help measure adaptation as it pertains to vulnerable populations.
    - The **strengths and limitations** of the indicators are very context-specific. These considerations help the user identify the pros and cons of an indicator.
    - Finally, considerations about **spatial scale**, including geographic and regional particularities, go hand-in-hand with data availability as well as how local or regional results may be rolled up or disaggregated to inform different scales of measurement.

Step 4 concludes with improved confidence that the indicators align with ARM needs for an adaptation action and leads to the final step in the selection process.

Step 5: Assess data requirements

The significance of data quality and availability for an indicator's inclusion cannot be understated. While these are critical elements in considering an indicator, the unavailability of data should not rule out advancing a process for selecting or identifying an indicator. The indicator inventory field dedicated to data gives some insights into what sources could be appropriate. Data sources were not readily available for all indicators in the inventory. Within the framework, there are six different considerations for data:

- data or indicator sources (if indicator already exists)
- data or indicator availability (if indicator already exists)
- data needs
- unit of measurement
- metrics and proxies
- baselines.

In Step 1, the user identified some of the necessary information regarding data requirements, such as units of measurement and metrics. Building on that information, sources (as listed in the

inventory) give ideas for who may be responsible for particular data, and availability indicates whether a source has been confirmed as part of this project.

Additional quality considerations

Outside of the indicator characteristics discussed so far, other considerations may also apply, either after an indicator is selected or during a process to more specifically define an indicator's readiness for implementation. For example, the SMART quality principles—standing for specific, measurable, achievable, relevant and time-bound—have been used generally to establish goal setting criteria. These and other indicator objective-setting principles such as CREAM (clear, relevant, economic, adequate, monitorable) and ADAPT (adaptive, dynamic, active, participatory, thorough) create a way to further test indicators that have surfaced through the stepwise process set out in this section. These quality considerations can help determine which indicators can be among the first to mobilize.

6.0 LIMITATIONS

It is important to reveal the constraints and limitations of this guidance and in the use of the indicator inventory and selection process. The most important limitation pertains to ARM generally. The diversity of climate risks and accompanying action on adaptation in Canada make consistency among measurement challenging. When combined with capacity constraints and differing administrative structures, it is easy to appreciate the challenge of developing clear, standard guidance and options for ARM. The guidance offered in this report in no way intends to downplay the effort required for ARM or to minimize the complexity associated with ARM at varied scales and across vast geographies.

The following limitations should be reviewed prior to changes to individual ARM programs, including indicator selection.

- Across Canada, the state of ARM practice continues to evolve. New governments, programs, priorities as well as the need to address new climate risks can all shift ARM activity and emphasis. The Canadian portion of the literature reviewed and interviews with FPT governments yielded information at a point in time. New information and ongoing changes to the state of ARM maturity should be considered.
- In an attempt to collate and describe indicators that could be suitable for as many FPT governments in Canada as possible, the granularity of the indicators contained within the inventory is limited. Certain jurisdictional specificities may not be captured by the coarser indicators, and as such, may require more tailoring to capture measurement in those specific contexts. A specific policy context or available data stand as examples where such context is important.
- The objectives of measuring and evaluating adaptation and resilience risks and capacities should be central to determining the number and type of indicators selected for each jurisdiction's ARM program. A clear understanding of the overall evaluation objectives is

essential, as it directly influences the combination of selected indicators. Ensuring that indicators accurately represent what is being measured and how they serve their purpose will enhance their effectiveness in supporting decision-making. A single indicator is unable to fully provide an accurate depiction of the broader adaptation and resilience context. It is beyond the scope of this guidance document to provide direction regarding the task of standardizing measurement and evaluating the efficacy of policy and programs. However, this document and its associated indicator inventory lay the groundwork for identifying points of commonality and informing further collaboration.

- Specific data sources from each jurisdiction are not included within the indicator inventory. While some jurisdictions referenced possible sources of data during interviews, identifying data sources from each government for each indicator would require a separate initiative or one undertaken by each jurisdiction following the selection of their preferred indicators. The inventory provides generic statements to guide the search for data sources, and includes examples in the Canadian context when available. The examples provided refer to the original indicator data sources from Canadian resources.
- Due to the highly context- and location-specific nature of climate risk and vulnerability indicators, this category presents a limited number of indicators in the inventory. Although they have been tailored for use in the Canadian context, they serve mostly as examples of how these types of indicators may be useful for ARM based on their international usage. Moreover, the inventory design provides the characteristics for these indicators, which can guide jurisdictions in identifying suitable indicators for their unique climate risk and vulnerability context.

7.0 CONCLUSIONS

Interest in ARM, and the practice of it, continues to grow internationally, providing more examples of how national and subnational governments are tackling the challenge of measuring adaptation and resilience. Consistent with international practice, Canadian FPT governments remain at an earlier stage of ARM maturity. The literature reveals the many challenges of ARM, balanced with clear indications of its importance to the adaptation process. Some of the hurdles relate to the contextual complexity of measurement and future state uncertainty, the difficulty of identifying universal metrics and measurement scales for ARM, data availability, and financial and capacity constraints for organizations in charge of ARM. Canada is among the nations striving to gain momentum in ARM in the context of both a federal climate adaptation strategy and provinces and territories advancing their own plans. FPT governments are at different stages of adaptation planning and implementation, and they may not be clearly inventorying their actions, which can challenge or even impede measurement.

The indicator inventory is expandable, and its indicator-defining fields can facilitate the uptake of ARM across Canada. While the state of ARM readiness appears to be high across the country,

governments' level of ARM-related maturity is relatively low. However, all jurisdictions show an eagerness to advance ARM, and in some it is already in place and functioning.

Indicator selection and usage is but one step in a broader adaptation monitoring and evaluation process which defines the ways in which ARM programs expand and evolve over time. The same desire to continue cross-jurisdictional collaboration in ARM is a catalyst for accelerating and improving ARM across the country and could eventually lead to the establishment of a fulsome picture of climate change adaptation progress in Canada.

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APPENDIX I: INDICATOR INVENTORY

The Excel file of indicators is available online at https://ccme.ca/en/resources/climate-change

APPENDIX II: FURTHER READING

Readers looking for resources on ARM indicators and other works that were consulted during the drafting of this report may find the following listing useful.

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APPENDIX III: METHOD FOR POPULATING THE INDICATOR INVENTORY

The indicators in this inventory comply with good practice as recommended in the literature, as well as insights from the engagement with FPT government representatives. The methodology used to identify, assess and select the indicators consists of five steps:

1. Identify indicators widely used to measure adaptation and resilience under the six proposed domains in the indicator inventory framework (infrastructure, natural environment, health and wellbeing, economy, disaster resilience and community preparedness, cross-sectional) using resources listed in Section 5.2 and Appendix II, and create a preliminary list of indicators that could satisfy the needs of each FPT region.
2. Under each domain, prioritize indicator options already in use or proposed by Canadian jurisdictions or organizations.
3. Also, under each domain, identify indicator options by international jurisdictions with similar socioeconomic and geographic contexts (North America and Europe) that have been in use by those jurisdictions.
4. Finally, assess indicators filtered through the previous steps against the indicator inventory framework characterization that stemmed from the literature review, interviews with FPT government representatives and common aspects from frequently used principles for indicator selection (SMART, CREAM and ADAPT).

The 51 indicators that remained after being filtered through these steps, in their original format or with modifications, were included in the inventory.

APPENDIX IV: FEDERAL, PROVINCIAL, AND TERRITORIAL INTERVIEW QUESTIONS

First Round Interview Questions

TRACK 1 QUESTIONNAIRE: Jurisdictions that have developed and implemented an adaptation and resilience measurement (ARM) framework.

1. The <jurisdiction adaptation plan/strategy> states that: <statement regarding ARM or Reporting aspects in the plan/strategy>. In this regard:
    a. To what extent have the actions in the adaptation strategy or plan been enacted to measure or report on adaptation and resilience?
    b. Have facets of the ARM program been developed or implemented? Which departments and branches are responsible for it or them?
    c. What are your jurisdiction strategy's current short- or mid-term plans regarding the ARM program?
2. Are the climate change adaptation and resilience measures developed or implemented in <jurisdiction> the result of a climate change impact and risk assessment (CCIRA)? If yes, is the ARM program also linked to the CCIRA?
3. Did your jurisdiction develop or implement adaptation and resilience indicators before considering a structured ARM program?
4. Does your ARM program have the following elements in place (or planned)? (Check yes or no)
    a. Presence and details, including frequency of monitoring and reporting, of a structured monitoring and evaluation (M&E) plan ☐Yes ☐ No
    b. Thematic areas to be measured ☐Yes ☐ No
    c. Indicators ☐Yes ☐ No
    d. Data, sources, metrics and aggregation (roll-up) ☐Yes ☐ No
    e. Governance and accountability: Levels of responsibility and authority for collecting data, evaluating and reporting, including Indigenous and community-based governance ☐Yes ☐ No. Comments or details:
    f. Purpose (e.g., legislative, policy or program requirement; public or third-party accountability; funding). ☐Yes ☐ No. If yes, please specify:
    g. Defined audience for reports: ☐Yes ☐ No. If yes, please specify:
    h. Development of sufficient resources and skills. ☐Yes ☐ No.
    i. Other. Please specify:
5. Has there been a full cycle of measurement and reporting?

    If yes:
    a. What are the ingredients that led to the successful development or implementation of the ARM program in your jurisdiction?

b. Has a report (or reports) been issued? Consider formal and informal formats and internal and external formats.
c. Are there any lessons learned from the implementation?
d. Has the implementation process resulted in changes to the M&E framework?
e. Has the process led to changes to indicators?
f. Has the process led to climate adaptation and resilience programs or policy changes?
g. Are there plans to revisit or expand the ARM program?
h. What are (or have been) the real or perceived barriers involved with implementing ARM, and how can you or have you overcome them?

If there is an ARM in development but no implementation yet:

i. When is the anticipated start of implementation?
j. What are the real or perceived barriers and enablers to developing or implementing ARM program?
k. How can those barriers be overcome?

6. Based on what has been discussed so far:
   a. What are the most important elements of an ARM in <jurisdiction>?
   b. Which of those aspects are unique to your jurisdictional context?
   c. Are there any plans to alter or improve the ARM process in your jurisdiction?
   d. How could this project benefit your ARM work (e.g., specific guidance or tools)?
7. Have the ARM in <jurisdiction> considered or integrated elements of equity, diversity and inclusion (EDI)?

If yes:

a. What are the EDI aspects being measured?
b. What socioeconomic groups are included?
c. How were indicators chosen, and what data are being used?
d. How are the results of those indicators being used, or will they be used?

If no:

e. Would <jurisdiction> be interested in including EDI aspects in the ARM?
f. Which EDI aspects would be relevant for <jurisdiction>?

8. Could you please share any written documents that would support your activity on ARM for <jurisdiction>?
9. Would you be open to a follow-up interview in the event that a second round happens?

TRACK 2 QUESTIONNAIRE: Jurisdictions that plan to develop an ARM or are reporting progress on the jurisdiction strategy or plan without a specific ARM framework.

1. The <jurisdiction adaptation plan/strategy> states that: <statement regarding ARM or Reporting aspects in the plan/strategy>. In this regard:
    a. To what extent have the actions in the adaptation strategy or plan been enacted to measure or report on adaptation and resilience?
    b. Have facets of the ARM program been developed or implemented? Which departments and branches are responsible for it or them?
    c. What are your jurisdiction strategy's current short- or mid-term plans regarding the ARM program?
2. Do the climate change adaptation and resilience measures developed or implemented in your jurisdiction stem from a climate change impact and risk assessment (CCIRA)?

    If yes, will an ARM program also link to the CCIRA results and adaptation measures?
3. Has your jurisdiction developed or implemented non-adaptation or non-resilience-related indicators (not within an ARM framework) to measure aspects of climate change adaptation and resilience?

    If yes:
    a. How are they categorized (e.g., theme-based, region-based, program-based, policy-based and so on)?
    b. Please describe how those categories were decided upon.
4. What would be an ideal approach to monitoring adaptation for your current resilience initiatives (e.g., green infrastructure, flood management, forest fire strategies)? What are the most important aspects to be monitored and why?
5. What are the most important initial steps for developing and implementing ARM?
6. What other ingredients are important for a successful ARM program in your jurisdiction?
7. What are the real or perceived barriers to developing an ARM program, and how can you or have you overcome them?
8. Monitoring and evaluation programs that operate in other areas or within other departments may yield lessons that are transferable to the context of adaptation and resilience measurement.
    a. Are you aware of any monitoring and evaluation (M&E) examples in different government contexts?
    b. If there are other M&E programs within your government, what aspects could be transferable to an ARM program in your jurisdiction? Please consider aspects such as M&E frameworks, indicators, data and data collection, purpose and objectives, authority and responsibility, reporting and audiences, and more, that could be used in an ARM program for your jurisdiction.
9. Would your jurisdiction consider integrating equity, diversity and inclusion (EDI) elements into a future ARM?
    a. If yes, which EDI aspects would be relevant for your jurisdiction, and what indicators would be useful for this purpose?

10. Could you please share any written documents supporting your ARM activity for your jurisdiction?
11. Would you be open to a follow-up interview in the event that a second round happens?

Second Round Interview Questions

1. General questions on the <jurisdiction> measurement system or plans

- Were indicator development principles such as SMART, CREAM or ADAPT used in developing your jurisdiction's ARM program to select the most appropriate indicators? If so, can you share your experience using them?
- Can you comment on the characteristics of successful indicators that would be useful for other jurisdictions?
- Can you comment on the lessons learned from indicators that didn't work as expected?

2. Questions on the indicator inventory sections and some of its components

Section: Indicator description

Component: Domains

The ARM program may be structured in one of the diverse domain types: sectoral, themes, values, focus areas, cross-cutting, systems, pathways, etc.[2] The literature review showed that the number of domains within a type varies across jurisdictions and ARM programs. The research has also revealed that one indicator could be effective in several domains. For example, the number of households affected by drought could indicate climate impacts on agriculture-related economic activity, the public health system and water resources management.

The <jurisdiction reference> is divided into <#> areas of focus, following the <jurisdiction> strategy. Based on the <jurisdiction> experience, can you think of the ideal domains for measuring adaption and resilience that could be transferable across jurisdictions in Canada?

Section: Indicator category

Component: Indicator category

The literature review indicates several approaches to classifying indicators for measuring adaptation and resilience. Based on this research, the most common categories among programs are:

1. Adaptation and resilience policy processes category: input indicator, process indicator, output indicator and outcome indicators.
2. Climate risk and vulnerability category, including indicators based on the climate risk and vulnerability assessment components: climate impact indicator, climate hazard indicator,

[2] Note that while these domain types were part of the interview questions, the responses received did not lead to them being part of the final methodology or report findings.

exposure indicator, adaptive capacity indicator, sensitivity indicator, and composite vulnerability indicator.

National and international ARM programs use indicators from both these categories, which are not mutually exclusive.

- To what point do you agree with this classification, and what categories would be most helpful to your ARM program?
- Could you also provide some insights regarding indicators for measuring the long-term outcomes from adaptation and resilience action?

Section: Indicator characteristics

Component: Equity, diversity and inclusion (EDI) aspects

EDI aspects and EDI stand-alone indicators are relatively new in ARM. Very limited experience in implementation has been retrieved, although research on this topic is emerging, and it shows that EDI aspects could be integrated into ARM programs in different ways.

- For your jurisdiction, would EDI aspects be more appropriate to implement as stand-alone indicators or as companions to other indicators (composite indicators or indices)? Please consider factors related to the feasibility of such indicators, such as data availability, measurability and reliability.

Component: Strengths and limitations

- Can you think of any crucial general strengths and limitations of the <jurisdiction> indicators when it comes to measuring adaptation and resilience in <jurisdiction>? Using the proposed sample indicators (other than the <jurisdiction> indicators), would those indicators have any strengths and limitations in your jurisdiction?

Section: Data requirements

Component: Data sources

Could you provide a list of the main data source organizations from which your ARM program compiles data? Are they municipal, provincial, federal, private or a mix? What is the main approach used to get access to the needed data?