Climate Science 2050: National Priorities for Climate Change Science and Knowledge Report

Executive Summary

Environment and Climate Change Canada
Environnement et Changement climatique Canada
Canada

Cat. No.: En4-541/2-2023E-PDF
ISBN: 978-0-660-48854-7
EC24145

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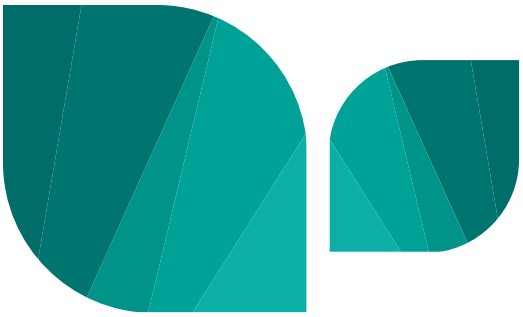

Introduction

The evidence is clear: Canada's climate is warming and will continue to warm in the future, primarily due to human activities. Ambitious and urgent action is needed to reduce greenhouse gas (GHG) emissions, undertake adaptation to adjust to actual or expected future climate change, and increase resilience to the current and likely impacts of global warming. Science and knowledge will continue to be crucial to guiding and informing climate change mitigation and adaptation policy and program decision-making. As we increase the speed and ambition of our climate change action, building science and knowledge capacity while aligning science activities with climate objectives will be critical to building a resilient, net-zero Canada.

This document provides a short summary of the *Climate Science 2050: National Priorities for Climate Change Science and Knowledge* (CS2050 Priorities Report) report and highlights key activities that are needed to continue making advancements in climate science in the coming years. This summary organizes the science priorities that were identified in the CS2050 Priorities Report under six themes, reflecting the societal outcomes that they can inform. These themes provide a clear picture of how science can be used to inform the societal changes that are necessary in a changing climate.

The CS2050 Priorities Report is based on two years of extensive engagement with climate program leaders across governments and sectors, as well as academics and experts from the Canadian climate change science community. It brings together multiple expert views on key scientific research activities in different domains. The Report is intended to serve as a "north star" for all of those working in climate change policy and programs—a directional document that aims to guide research needed now for delivery of science results leading into 2030, and to guide ongoing science coordination.

Both Western and Indigenous science input contributed to the content of the CS2050 Priorities Report through science expert roundtables, stakeholder surveys, webinars and numerous discussions with partners, experts, and stakeholders. The audience for this report is all those who have an opportunity to shape the strategic planning, funding, coordination, and implementation of climate change science activities across Canada. This report can help guide the full range of science actors across government, academia, non-governmental organizations (NGOs), national Indigenous organizations, foundations, and the private sector – anyone who is active in the delivery of science to better inform climate change mitigation and adaptation policies, programs, and services.

Context

Canada's strengthened climate plan, *A Healthy Environment and a Healthy Economy*, the 2030 Emissions Reduction Plan (ERP) under the *Canadian Net-Zero Emissions Accountability Act* and the *National Adaptation Strategy* are the key policy drivers that influenced the identification and prioritization of the science activities presented in this report. This prioritization effort also recognized the potential contributions and benefits of science to the numerous climate-related challenges facing society, including in the areas of biodiversity, freshwater, and sustainable development.

Any advances in climate change science and knowledge and collaboration must reflect the diversity of Canadians, including where and how they live. Climate change affects everyone, but not all the impacts and risks of climate change are experienced equally by all people across Canada. As part of the guiding principles, this report considered Canadians' regional and equity-based experiences of climate change. This framing also reflects understanding climate change as a risk multiplier, meaning it could contribute to or exacerbate other problems for communities and regions (e.g., risks to health, culture, economy, or security).

Developing the Report

The CS2050 Priorities Report was developed as part of an ongoing science policy dialogue that started in 2019 with the first *Climate Science 2050* report. In 2021–22, Environment and Climate Change Canada engaged with more than 500 climate program leaders across governments and sectors, as well as academics and experts from the Canadian climate change science community to support the development of this report. This included seven expert roundtables organized by different themes. Indigenous perspectives were sought through conversations and direct contributions to the report, including perspectives gathered through an Indigenous Scholars' workshop. Further, insights from the engagement undertaken for the ERP and the National Adaptation Strategy also shaped the identification of the priority science activities. Working with the Office of the Chief Science Advisor's network of departmental science advisors, a Science Advisory Group was established to guide engagement and development of the CS2050 Priorities Report and was later used to peer review.

Climate Change Science Priorities

Based on the engagement with Canada's climate change community, the report has identified key science activities that will inform our net-zero and adaptation goals. These activities have been organized under the six themes below to reflect the societal outcomes they can inform and to highlight the overarching value of climate science for Canadians. These activities are underlined by the overarching needs to bridge, braid, and weave Western and Indigenous science and knowledge into science activities, to actively engage Inuit and First Nations organizations when setting research priorities in the Arctic, to strengthen climate change data platforms and analytics for more accurate predictions and estimates, and to motivate behavioural change and action.

The key science activities identified in the CS2050 Priorities Report (see Annex) are important factors in informing the following societal outcomes:

Theme 1. Supporting a Strong Canadian Economy

Virtually every sector of the Canadian economy is affected, directly and/or indirectly, by the impacts of climate change. Research has shown that by 2025, climate impacts will slow Canada's economic growth by $25 billion annually, which is equal to 50 per cent of projected GDP growth. Most households will lose income, and low-income households will suffer the most. To minimize these impacts, research is needed to assess the risks and opportunities of climate change within and between natural resource sectors, including fisheries, aquaculture, forestry, agriculture, and mining. Climate change research to support accelerated and equitable climate action is essential to sustainable development and moderating vulnerability and the associated risk. For example, research is required to understand how climate change affects poverty, livelihoods, health, food security, and community resilience. All orders of government, economic sectors and Canadians need this science-based information to integrate adaptation and net-zero-GHG-emission considerations into decision making to maintain public safety, critical services, infrastructure, livelihoods, and the livability of our communities.

Theme 2. Resilient Communities and Built Environments

Canadians are experiencing first-hand the impacts of climate change through devastating wildfires, heatwaves, floods, hurricanes, and droughts. In 2023, Canada faced its worst wildfire season on record, producing unhealthy air quality and impacting communities and infrastructure, costing billions of dollars to governments, businesses, and individuals, as well as costing the lives of both humans and wildlife. The frequency and magnitude of these extreme events are expected to increase significantly under a changing climate. Science is needed to understand how frequent and severe extreme weather events will become and how they may unfold simultaneously or sequentially. Most of Canada's buildings and infrastructure were not designed or built with a changing climate in mind. This is especially true in the Arctic where permafrost has been thawing rapidly over the last three decades, impacting northern infrastructure, communities, and lifestyles. Buildings and infrastructure are also affected by extreme weather events, such that Canadians may lose transportation links, water supply, and other vital services during and after these events. Climate change data and predictions need to better align with the regional to local decision-making scales to reduce risks related to future extreme events. For example, climate knowledge and tools can be used to predict water supply changes and improve or maintain water quality for communities and natural resource sectors, including hydroelectric facilities, to inform planning to reduce risks.

Theme 3. Getting to Net-Zero Greenhouse Gas Emissions

Reducing future climate risk requires limiting future warming by achieving net-zero GHG emissions globally. Accurate and timely monitoring of emission reductions and removals through changes to things like energy systems, transportation, urban infrastructure, management of ecosystems, and manufacturing is essential to evaluate the effectiveness of policies and to inform decision makers and the public on the progress toward net-zero. Net-zero pathway science can help us understand the interconnected biophysical, technological, and socio-economic processes that influence planning and efforts to achieve decarbonization. This research informs planning for a net-zero future by understanding the drivers and needed shifts in a wide range of natural and socio-economic factors, including building a deeper understanding of Canadian audience's attitudes and beliefs to establish relevance of climate risk and action to individuals and to motivate social change.

Theme 4. Protecting Nature and Ecosystems

Natural ecosystems are facing multiple stresses—including climate change—that combine to influence their resilience and integrity as the climate continues to change over time. Understanding climate change impacts on ecosystem resilience will help to inform the management and conservation practices that sustain and restore ecosystem services and protect biodiversity and wildlife habitat. Nature-based solutions are an important aspect of mitigation action, protecting, sustainably managing, and restoring natural ecosystems to address climate change, reduce human health impacts and protect food and water security, and effectively and adaptively reduce disaster risk. Ecosystems naturally act as both carbon sinks and sources of GHG emissions. For example, large amounts of carbon are stored in the soil and plant life of forests, wetlands, grasslands, and in the oceans, but changing climate and disturbances, such as wildfires, can cause this carbon to be released. The effectiveness and carbon sequestration potential of nature-based solutions is determined, in large part, by how the carbon cycle will respond to further climate change. Carbon cycle research is therefore needed to understand the potential of nature-based solutions and carbon dioxide removal methods and inform their inclusion in net-zero pathway analyses and emissions reporting.

Theme 5. Health and Security of Canadians

Climate change poses a risk to the physical and mental health of Canadians, to Canada's health systems, and to those disproportionately affected and vulnerable. This can also include risks to people's well-being, safety, and security, including geopolitical risks, risks to financial systems and energy supply, humanitarian responses, and foreign policy. Human health cannot be protected from climate change impacts without robust knowledge of current and projected risks to Canadians and their health and security systems, economic costs of impacts, and effective adaptation measures. Climate change risks are complex and interconnected, and impacts can spread through natural and human systems in ways that are difficult to anticipate. The One Health approach recognizes that the health of humans, animals, plants, and the wider environment (including ecosystems) are interdependent and should be investigated in a collaborative, multi-sectoral, and transdisciplinary way that recognizes and upholds Indigenous science and supports science-based adaptation.

Theme 6. Indigenous Science and Knowledge

The First Nations, Inuit, and Métis Peoples, their knowledge, and their relationship with the land, water, and ice make a critical contribution to developing solutions and responding to environmental challenges, including climate change. Indigenous science is about the long-term understanding of ecological cycles and environmental processes that are embedded in the intimate knowledge of environment and traditional and cultural activities. Bridging Indigenous science priorities and Indigenous leadership to the entire spectrum of science practice, from hypothesis generation to policy development and implementation, is essential to support Canada's commitments toward renewed nation-to-nation relationships and reconciliation with Indigenous Peoples. The respectful bridging of Indigenous and Western science enables this to proceed, sensitive to the capacity of Indigenous communities to engage equitably.

Building on Actions Taken to Date

The science activities identified in the CS2050 Priorities Report complement and rely on existing Canadian climate change science capacity, which acts as the foundation for future advancements. Canada is already conducting a variety of critical climate change science activities, ranging from foundational research to identify changes occurring across Canada, to improving understanding of associated impacts and risks, to better quantifying GHG emissions. These critical science activities help to inform effective climate change adaptation and mitigation actions. The CS2050 Priorities Report identified the most pressing climate change science activities needed to inform and refine Canada's climate change adaptation and mitigation actions. A tiered approached was used to identify the most urgent and/or transformative science actions.

While progress is being made to reach net-zero GHG emissions by 2050 and implement strong adaptation measures, both within Canada and internationally, our climate continues to warm and change. Mitigation and adaptation planning are informed by the best evidence available; however, existing national science capacity does not reflect increasing information demands, nor fully address emerging issues, such as geoengineering, and the transdisciplinary science challenges associated with net-zero pathway development, motivating behavioural change, implementing effective nature-based solutions, or measuring progress. Climate science efforts to bridge these gaps will need to continue and likely increase to face upcoming challenges.

Coordinating Climate Change Science Efforts

The science activities outlined in the CS2050 Priorities Report are intended to address information needs that respond to the diversity of climate impacts across all regions of Canada and inform all sectors in their response to climate change. A key priority across all areas of research is to enhance the coordination of existing scientific activities, including both research and knowledge mobilization (promoting and facilitating the use of research among users), to engage more effectively within and across disciplines and enable transformative climate action. Improving science coordination and strengthening relationships between the domestic and international science community and those developing climate change policy and programs will enable greater scientific progress and facilitate the uptake of knowledge.

Need for Strengthened National Coordination

The engagement and analysis undertaken for the CS2050 Priorities Report demonstrated that climate change science coordination in Canada remains largely disconnected. Although Canada has expertise and talent in climate change science, our current system is fragmented and difficult to navigate for individuals or organizations looking to collaborate within or across disciplines or sectors. This fragmentation points to the need for better national coordination across the climate science ecosystem, including government, non-government organizations, universities, Indigenous organizations, communities, and the private sector. The science priorities identified in the CS2050 Priorities Report will be more successful if accompanied by strong national science coordination and close relationships between the science community and those developing climate change policy and programs. The report aims to encourage actors to use collaborative approaches when advancing climate change science.

In parallel, First Nations, Inuit, and Métis knowledge systems must be strengthened as integral components of Canada's climate change science capacity. Enhancing Indigenous science capacity and leadership in the funding, coordination, and implementation of climate change science is of utmost importance, as well as continuing relationship-building between Indigenous science and knowledge systems and Western science across all elements in this report.

There is a role for the federal government, particularly Environment and Climate Change Canada, to create opportunities for science policy dialogue that would inform prioritization of the science, facilitate collaborative research partnerships, and serve as a conduit for science outcomes to inform national climate action. This may include hosting targeted workshops on key areas of interest for the climate science community to facilitate communication, collaboration, and leveraging of ongoing science activities and resources. Extensive expert engagement confirmed the importance of an ongoing national science policy dialogue to help the science community understand the information needs of those designing and implementing climate action.

International Engagement

Canadian climate change science cannot occur in isolation. Just as climate change is a global issue that requires global solutions, Canadian climate change science must be part of the contributions and activities of the larger international science efforts to understand climate change. Equally, areas where Canada has distinct climate change science competency or expertise (e.g., Arctic science, methane emissions science) should be brought to the international stage.

The CS2050 Priorities Report notes the importance of participating in and leveraging international science efforts to ensure that Canada continues to build its science capacity while taking advantage of the international science base, and that state-of-science evidence and knowledge informs Canadian climate action. Continuing to participate and lead in international science programs is, therefore, key in allowing Canadian data and knowledge to meet the most rigorous scientific standards for quality, accuracy, and credibility, while leveraging international efforts and partnerships. For example, Canadian scientists are active participants and leaders in global and regional science assessments through influential organizations, such as the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Accessible and Complementary Data

To aid in coordination efforts, another important cross-cutting priority identified in the CS2050 Priorities Report is the importance of climate change data platforms and analytics, which underpin progress in all science activities. For example, creating and strengthening accessible and interoperable platforms for data on climate (i.e., terrestrial, hydrological, ocean, atmospheric), GHGs, ecosystems, and biodiversity with related socio-economic, finance, and health indicators will support understanding changes and impacts of climate change on environmental, socioeconomic, and health systems. Overall, it is critical to address the lack of interoperable and accessible data platforms, which enable transdisciplinary science to leverage socio-economic and health data, in order to make the most of the investments made in collecting such data and to avoid further hampering of climate change science progress.

Looking Ahead

This CS2050 Priorities Report represents a moment in time. As knowledge evolves, the strategic planning and implementation of science must also evolve. Climate action must continue in parallel with advancing science, drawing on existing knowledge and incorporating new insights as they become available. Canada's climate change science capacity is distributed across academia, governments, the private sector, non-government organizations, as well as Indigenous governments, organizations, and communities. Ongoing engagement with these partners will continue to shape national science planning, bringing an ever-broader relevance to Canada's science research. There is a role for governments to create opportunities for science policy dialogue, informing prioritization of the science, facilitating collaborative research partnerships and coordination of investments, and serving as a conduit for science outcomes to inform national climate action.

The priorities identified in this report indicate *what* science activities need to advance, not *how* these should unfold. To make progress on the science priorities, we must address systemic barriers to multidisciplinary science, different knowledge systems, and barriers based on race, gender, and youth. Targeted efforts and investments are required to expand relationship-building between First Nations, Inuit, and Métis science and knowledge and Western science. This would aim to braid and weave these knowledge systems within the national climate change science community.

Conclusion

Climate change science has a critical role to play in Canada to help achieve the goals and objectives of national policy commitments and strategies. The CS2050 Priorities Report provides a Canada-wide perspective across many disciplines, requiring further detailed discussions and development of detailed research plans and programs.

One of the highlights of the CS2050 Priorities Report is the need for better national coordination between the work being done and those developing climate change policy and programs (e.g., governments, municipalities, private sector). Environment and Climate Change Canada sees itself as a crucial partner in climate science and aims to continue to work towards opportunities for national coordination mechanisms to bring together science practitioners, users, and policy makers to ensure knowledge is shared across disciplines and is used for continued policy development.

The urgency of climate mitigation and adaptation action requires effective deployment of national science resources. This report aims to guide climate change science and enable greater coordination of the science for delivery of results over the next five to 10 years. The next step is for those across the Canadian climate change science community to use this report to guide science investments, coordinate and plan research activities, and mobilize the necessary knowledge to support and inform a more resilient, net-zero future for Canada.

Annex

Climate Change Science Priorities – Key Science Activities

1. Supporting a Strong Canadian Economy Includes priorities spanning: Sustainable natural resources; and Climate change research and sustainable development.	
1.1	Understand how natural resource sectors in Canada are affected by climate change.
1.2	Develop and track indicators of social-ecological resilience in natural resource sectors and communities and understand how these sectors contribute to climate action.
1.3	Develop relevant tools to enable evidence-based climate actions for all levels of policy and decision making.
1.4	Incorporate behavioural and social science in decision making and communication strategies specific to each sector.
1.5	Use collaborative research and transdisciplinary approaches to explore mitigation and adaptation actions, trade-offs, and benefits across natural resource sectors.
1.6	Examine the relationships between climate change and sustainable development.
2. Resilient Net-Zero Communities and Built Environments Includes priorities spanning: Resilient, net-zero communities and built environments; Predicting and projecting climate extremes and extreme events; and Water-climate nexus science.	
2.1	Generate climate data, predictions, and projections to inform risk assessment, adaptation, and actions to reduce GHG emissions from the built environment.
2.2	Create maps of multiple hazards to identify and prioritize high-risk areas, manage interdependencies, and address potential cascading risks to infrastructure systems.
2.3	Expand the use of performance-based design to find innovative construction and operating solutions.
2.4	Develop and apply an equity-based lens to better inform climate change adaptation and GHG emission mitigation actions.
2.5	Inform the transition to low-carbon, resilient buildings, transport, and infrastructure.
2.6	Improve understanding of nature-based solutions for use in the built environment.
2.7	Improve predictions and projections of extremes, on time scales of seasons to decades, and on kilometric spatial scales.
2.8	Improve monitoring, data collection, and accessibility.
2.9	Co-develop approaches to monitoring, conducting research, and predicting climate change with affected communities, including municipalities and First Nations, Inuit, and Métis communities.
2.10	Understand future water sustainability, including supply, demand, quality, and effects on human and ecosystem health.

2.11	Model water-related risks to the health of humans and ecosystems as well as the burden of disease from further warming.
2.12	Conduct effective water-climate knowledge mobilization, as part of climate literacy and outreach to Canadians.
2.13	Develop guidance for effective governance, coordination, and implementation of various adaptation and mitigation measures at various levels of government and at various phases of infrastructure life cycles.
2.14	Translate research results into guidance, protocols, and tools for practitioners to help them develop low-carbon, resilient built environments.
2.15	Incorporate behavioural science and understanding of the socio-economic context to foster climate action in the buildings, transport, and infrastructure sectors.
2.16	Understand climate change influences on traditional and cultural activities.
2.17	Conduct research to support secure and sustainable food systems, along with surveillance of the exposure of northerners to emerging food- and water-borne infectious diseases, contaminants, and parasites.
2.18	Conduct hazard mapping, vulnerability assessments, and adaptation planning for built infrastructure in northern communities.
2.19	Co-develop a distributed approach to delivering climate services for northern communities to inform evidence-based decision making.
3. Getting to Net-Zero Greenhouse Gas Emissions Includes priorities spanning: Informing progress towards net-zero greenhouse gas emissions; Net-zero pathway science; and Social science and climate change.	
3.1	Enhance GHG reporting by making advances in measuring and modelling GHG emissions and reconciling complementary techniques for estimating emissions.
3.2	Monitor, analyze, and assess changes in ecosystem carbon stocks.
3.3	Better understand the contribution of land use and land-use change to achieving net-zero by developing land-use monitoring systems with high spatial resolution.
3.4	Examine trade-offs involving GHG emissions and removals in economic, policy, health, and social spheres of Canadian society.
3.5	Build foundational knowledge, including societal and economic considerations, to inform net-zero scenarios for transformational change in Canada.
3.6	Understand socio-political, attitudinal, and behavioural processes in net-zero pathways and improve how these are integrated in modelling and analysis.
3.7	Develop a national strategy for modelling net-zero pathways to inform transformational change in Canada.
3.8	Understand Canadian audience segments and develop communication products that target these audiences.

3.9	Develop narratives about climate change impacts and action to empower Canadians, inspire hope, and accelerate societal transformation.
3.10	Understand public trust and information flow to support the flow of credible information, while limiting the spread of incorrect or misleading climate information.
3.11	Reconcile publicly available data, information, and knowledge needed to inform calculation of emissions.
3.12	Conduct intercomparisons and make improvements to ecosystem models to understand anthropogenic drivers of carbon change in the land sector.
3.13	Conduct regular, substantive science and knowledge assessments (on a five- to 10-year cycle), complemented by shorter, more frequent updates and targeted products.
4. Protecting Nature and Ecosystems Includes priorities spanning: Resilient aquatic and terrestrial ecosystems; and Carbon cycle science.	
4.1	Better understand climate change impacts on ecosystems and biodiversity resilience and change.
4.2	Advance multidisciplinary science and knowledge to inform climate mitigation and adaptation solutions that promote resilient ecosystems in a changing climate.
4.3	Conduct collaborative research in Earth system modelling and in understanding the carbon cycle.
4.4	Monitor carbon stocks to understand their responses to changing climate conditions and disturbances.
4.5	Improve, compare, and apply ecosystem models to estimate carbon fluxes on a national scale.
4.6	Synthesize and mobilize knowledge of ecosystem resilience to support and improve adaptive management and evidence-based decision making in a changing climate.
4.7	Undertake regular science assessments of the carbon cycle and the potential for increased carbon uptake in Canada.
4.8	Design monitoring programs that integrate surface observations and satellite data (existing and planned missions), to track key climate indicators and determine risks from changes in disturbances (such as wildfires and melting sea ice).
4.9	Advance and evaluate Earth system modelling to better represent the atmospheric, cryosphere, hydrological, oceanographic, ecological, and carbon cycle processes in northern regions.
5. Health and Security of Canadians Includes priorities spanning: Healthy and resilient Canadians; and Climate change and security.	
5.1	Understand the impacts of climate change on health and health systems, to advance effective, equitable, and feasible measures for health adaptation.
5.2	Conduct research to support the transition to a sustainable, low-carbon health system.
5.3	Improve understanding of policies, programs, measures, and new technologies available to health authorities and their partners to develop low-carbon and sustainable health systems.
5.4	Strengthen understanding of risks and drivers of change across the human, animal, plant, and environment interfaces.

5.5	Advance transdisciplinary approaches and First Nations, Inuit, and Métis ways of knowing in knowledge-sharing, data braiding, and analytics.
5.6	Evaluate climate change pathways and their security implications.
5.7	Study the risks and threat-multipliers of climate change for the operations of security institutions and for emergency preparedness.
5.8	Develop a suite of climate change responses, in all contexts, at the local, regional, national, and international levels.
5.9	Develop a "system of systems" response to climate change, reflecting interconnections and cascading responses across social and economic sectors and communities.
5.10	Conduct regular national, regional, and local-scale assessments of climate change and health.
5.11	Develop innovative strategies and approaches for knowledge exchange among health professionals, practitioners, and administrators.
5.12	Effect behavioural change among decision makers, stakeholders, and the public by improving strategies for effective communication of the health risks of climate change, adaptation options, and the health benefits of proactive action.
6. Indigenous Climate Change Science and Knowledge	
6.1	Develop Indigenous leadership in climate change science and Indigenous science networks; support science and knowledge clusters and networks that actively build relationships with Indigenous Peoples in creating pathways that respect local grassroots climate science concerns and priorities.
6.2	Braid and weave Indigenous and Western science planning and implementation with Indigenous governments, organizations, and citizens to craft approaches to climate change science and knowledge that are relevant to regions, based on distinctions, and uphold Indigenous rights and self-determination.
6.3	Create materials for Indigenous climate change science and knowledge that are responsive to Indigenous Peoples' goals of cultural revitalization, and develop policies, programs, and initiatives respecting Indigenous languages.
6.4	Strengthen scoping and funding mechanisms to establish Indigenous science research capacity.
6.5	Train and build capacity in Indigenous local and regional place-based science and knowledge practice.

There is an overarching need to create, maintain, and strengthen accessible and interoperable platforms for data on climate, greenhouse gases, ecosystems and biodiversity, and related socio-economic, finance, and health indicators.