

Tracking global climate change adaptation among governments

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The Paris Agreement and Katowice Climate Package articulate a clear mandate for all parties to undertake and document adaptation progress. Yet persistent challenges have prevented substantive developments in tracking adaptation and the assessment of adaptation actions and their outcomes. Here, we provide an overview of the challenges of adaptation tracking and propose a comprehensive conceptual framework for assessing adaptation progress by governments that is scalable over time and across contexts. The framework addresses the core components of adaptation assessment (vulnerability, goals and targets, adaptation efforts, and adaptation results) and characterizes subcomponents focused on adaptation effort (leadership, organizations and policy). In particular, we highlight how critical insights can be uncovered by systematically tracking policy efforts over time, and discusses novel approaches to data collection.

Adaptation to climate change is increasingly urgent¹. The Paris Agreement made historic strides in recognizing adaptation as a critical component of the global response to climate change, explicitly articulating in the Katowice Climate package rule-book for the Agreement a clear mandate for nations to undertake and document adaptation progress^{2,3}. Consistent with the global goal, >150 countries have included adaptation provisions in their pledges or nationally-determined contributions (NDCs). Assessing the progress governments are making in meeting their adaptation commitments is a critical step to achieving adaptation and reducing vulnerability to climate change. Despite this challenge, clear mechanisms and frameworks for governmental accountability and adaptation assessment remain methodologically elusive.

Adaptation tracking refers to the development and application of systematic approaches to assess progress on adaptation efforts over time and space, and between and across populations and sectors^{3–6}. Adaptation tracking approaches are a subcomponent of monitoring, reporting and evaluation (MRE) of climate adaptation^{7,8}. While MRE is typically designed to be tailored to individual projects or governments, adaptation tracking is applied systematically and consistently across governments or organizations, and over time. In doing so, adaptation tracking is particularly relevant to activities such as the Paris Agreement's five-year review cycles, which necessitates systematic methods for synthesis and appraisal of adaptation progress across diverse countries' contexts.

Beyond the United Nations process, tracking how businesses, cities, regions or governments are progressing on adaptation facilitates a soft policy approach to stimulate diffusion of adaptation, and encourages creative competition^{9,10}. Some nations, such as the

United Kingdom, have already formalized adaptation tracking into policy. A consistent framework is particularly useful to supranational states, such as the European Union, which has limited formal jurisdiction over adaptation¹¹. Tracking how adaptation is taking place allows us to document best practices, facilitate early adoption and collective experimentation¹², and enable sharing of lessons about what works, where and why.

There have been consistent and increasingly urgent calls for improved approaches to systematically assess adaptation in ways that are recognized as rigorous, consistent and transparent^{13,14}. To this end, we propose a conceptual framework for systematic and consistent tracking of adaptation by governments that is flexible and contextually sensitive, but also applicable across diverse contexts. While the framework was designed to assess adaptation-progress made by governments — which is the focus of this Perspective — it is largely translatable to non-governmental adaptation assessment.

Approaches and challenges in tracking adaptation

Despite the need to track adaptation, significant challenges have hampered progress on how to track adaptation. First, there remains no agreed definition for 'adaptation' (either theoretically or operationally)¹¹. Compounding this problem, no single unit of analysis is available to measure or compare adaptation^{5,6}. Moreover, there is also a trade-off between the need for detailed, meaningful and longitudinal data sources, and limiting the reporting burden on governments. Similarly, it is difficult to reconcile the need to have a consistent and systematic framework that applies a compatible assessment across nations yet respects the diversity of vulnerability contexts (for example, low- versus high-income; tropical versus temperate).

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There have been efforts to develop frameworks for climate change impacts and adaptation assessment (see refs. ^{6,12,14–19}). Some approaches to adaptation assessment have focused on vulnerability/risk assessment (for example, measuring the degree of vulnerability or risk of a population, system and/or asset to climate change impacts). Other approaches have focused on adaptation efforts, including adaptation processes (for example, agenda setting or governance) and outputs (such as policy, provision of information or economic incentives)^{20–28}. Ultimately, a core aspirational goal of adaptation assessment is the ability to attribute measurable reductions in vulnerability (results) to tangible adaptation efforts, and in doing so evaluate the relative success of specific adaptations^{10,29}. Existing adaptation assessment frameworks in most cases are, however, not designed to be applied consistently across governments, and are instead designed to be highly contextually-sensitive and applied on a case-by-case basis. Where frameworks are designed with consistency in mind, many include indicators that are only applicable to the project or programme level^{16,18,23,30–34}. The 2017 Adaptation Gap Report¹³ found, for example, no existing frameworks designed for systematic assessment of global adaptation progress using national-level data.

The gap between the need for systematic adaptation tracking frameworks and the methodological tools currently available is vast, reflecting a ‘grand challenge’ for adaptation research^{2,5}. It is also noteworthy that there is some reticence to engage in systematic adaptation studies⁷. Many argue that we cannot or should not impose assessment of adaptation progress homogeneously across government^{15,35}. Conversely, this Perspective is grounded in the argument that consistent, and meaningful, tracking of adaptation by governments is not only necessary, but also conceptually and methodologically feasible. Our framework aligns with the Katowice Climate Package by allowing consistent but contextually sensitive assessment and stocktaking of adaptation progress.

A framework for tracking adaptation

The aims of systematic adaptation tracking are ultimately to determine whether vulnerability is changing, and what works, where, in what context and why. This requires tracking of changing vulnerability (resulting from adaptations or otherwise), as well as the adaptation efforts that to varying degrees are influencing those changes. The framework presented in this Perspective aims to integrate both the contexts within which adaptation is generated by governments and the tangible actions that reflect what governments are doing (referred to here as adaptation efforts), together with changes in climate vulnerability (adaptation results) (Fig. 1). Adaptation efforts and results are placed alongside the vulnerability profile, jurisdiction and contexts that represent a government’s climate change adaptation mandate, as well as the adaptation goals and targets articulated by a government. Alignment across these four components — vulnerability profile and context, adaptation goals and targets, adaptation efforts, and adaptation results — underpins the framework’s approach to adaptation assessment (Fig. 1).

We do not propose new tools for assessing vulnerability or adaptation results, but rather situate these components within a single framework. We also do not focus a priori on identifying a suite of adaptation tracking indicators or metrics. Instead, we outline key concepts, elements and questions that can be used to systematically assess adaptation over time and across governments.

We distinguish descriptive from evaluative assessment. Descriptive assessment considers a government’s climate vulnerability and context, adaptation goals and targets, adaptation efforts, and adaptation results. The vulnerability profile of a government reflects the mandate that a government is tasked with responding to, and provides the motivation for adaptation efforts as well as the baseline from which adaptation goals and targets should be developed. While vulnerability is difficult to objectively assess, there is

a growing and well-established literature on vulnerability assessment³⁶. We also include a government’s jurisdiction and national contexts (for example, capacity and resources) as critical contexts underpinning its adaptation mandate. Importantly, longitudinal assessment of changing vulnerability is critical not only as an indicator of adaptation results, but also in monitoring changing climatic risks over time. Adaptation goals and targets are included as distinct from adaptation efforts and vulnerability profiles. This inclusion recognizes that a government’s adaptation efforts do not autonomously arise from vulnerability assessment, but are filtered through the articulation and prioritization of goals and targets. Assessing progress in goals and targets points to the reflexive nature of government MRE and collective learning. Adaptation goals and targets can be expected to evolve with changing vulnerabilities, expectations and ambitions. Adaptation efforts reflect what a government is actually doing in response to the vulnerabilities it faces and its adaptation goals, and also the ways in which governments discuss, mobilize and organize for adaptation. In this way, adaptation efforts include both process-based and output-based concepts. Progress (or change) in adaptation efforts may arise from changing vulnerability profiles and changing government goals, but also from increased implementation or governance effort and learning from adaptation results. Adaptation results consider the changes in vulnerability that arise in response to a government’s adaptation efforts, and are typically assessed through measures of changing vulnerability — using similar indicators as for vulnerability assessment — complemented by quantitative or qualitative evidence attempting to link these changes in some way to adaptation efforts (see ref. ¹⁰). The descriptive components draw on, and are compatible with, MRE literature but place different emphasis on the phases of adaptation assessment. Additional emphasis is placed on baseline vulnerability and impacts on vulnerability reduction (adaptation results) as core accountability components.

The framework also allows us to evaluate progress on adaptation by assessing alignment across the four components. Evaluation of adaptation goals and targets, for example, is based on the extent to which they are aligned with key population vulnerabilities and contexts. This might include consideration of a variety of measures: for example, are the right vulnerabilities being prioritized and addressed within goals and targets, and are goal and targets sufficiently ambitious given vulnerabilities? The adaptation actions in a coastal nation with high flood risk will necessarily be different from a land-locked nation with substantial drought risk. Similarly, low-income nations face different vulnerability profiles and obstacles compared to middle- and high-income nations. Evaluation of adaptation efforts is based on alignment of governmental efforts with their own vulnerabilities, goals and targets. Instead of asking ‘is a government doing enough of the right things?’, we ask ‘is a government articulating goals that are aligned with their vulnerability profile?’ (sufficiency of goals and targets), and ‘is a government undertaking adaptation efforts that are aligned with their own adaptation goals?’ (sufficiency of adaptation efforts). In both cases, a government’s specific contexts (that is, distinct vulnerabilities and jurisdictional responsibilities), recognizing diverse administrative structures and traditions (such as federalist versus unitary governance), are considered³⁷.

Linking adaptation results with adaptation efforts remains a methodological challenge. Rigorous quantitative studies providing causal evidence that adaptation efforts led to documented changes in vulnerability indicators—referred to as attribution research—are negligible and limited to natural experiments, quasi-experiments and case-studies³². Where systematic adaptation assessment is needed, contribution approaches have emerged as a feasible and appropriate approach for linking adaptation efforts to results. Contribution assessments are typically based on theories-of-change and mixed methods, combining qualitative narratives and

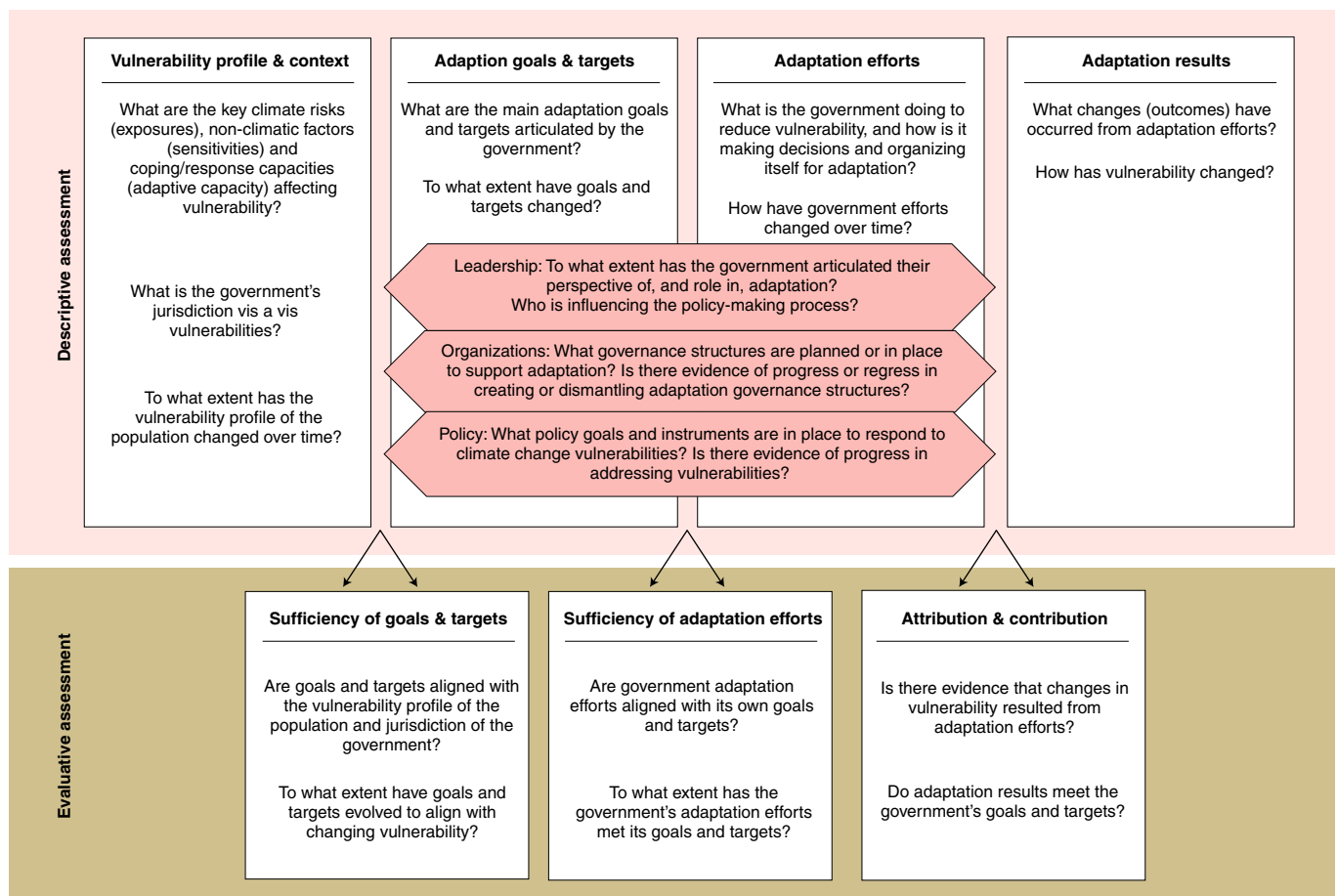


Fig. 1 | Key components and questions for adaptation assessment within the framework.

quantitative data to form an evidence base assessing the extent to which government actions contributed to changing vulnerability.

A systematic tracking framework should also characterize the range of barriers constraining adaptation across governments. A government might have ambitious goals and targets that are closely aligned with the population's vulnerability profile, yet fail to select appropriate governance or policy tools to meet those goals. In contrast, a government may employ appropriate governance or policy mechanisms for their goals and targets, but have articulated goals that neglect key vulnerabilities. Moreover, a government may articulate ambitious and appropriate goals, and identify and implement sensible mechanisms to achieve these goals, yet fail to see the desired adaptation results and reductions in vulnerability. These distinctions are important for identifying the key leverage points for evaluation and learning.

The framework facilitates scalability across all possible levels of government (vertically) or sectors (horizontally), though detailed indicators, data sources, and precision or resolution of data, will invariably differ across scales. National and global assessment of collective progress towards the global stocktake can use this framework, but it could also be used within nations to assess urban adaptation progress, progress within particular sectors or sub-national adaptation (for example, in states, provinces or districts).

Conceptualizing adaptation effort

Adaptation efforts are a key under-theorized area within adaptation literature. There are three interlinked sub-components within which adaptation efforts by governments can be understood and assessed vis a vis their goals and targets: leadership, organization

and policy (Fig. 1)^{33,34,38}. The leadership dimension aims to identify sources of leadership and influence on adaptation by examining who participates in adaptation decision-making; the organizations dimension captures how adaptation is institutionalized in governments; the policy dimension systematically catalogues the mix of tools that governments are adopting to respond to climate-change-related risk^{34,39–42}. These should be tracked together as each of these sub-components influences and shapes the others.

Leadership of adaptation. The concept of 'leadership' in this approach is principally concerned with understanding who is responsible for, and driving, policy change in response to perceived climate change risk. The approach seeks to identify and map state and non-state actors who participate in adaptation policy processes, and their relationship to one another. These relationships reflect complex processes that give shape to how organizations responsible are evolving, and how this affects design and implementation^{43–46}. This dimension of the framework poses two questions: who shapes adaptation decisions, what do patterns in actor participation indicate about the interests shaping how adaptation is defined and acted on?

The importance of non-state actors in shaping policy goals and commitments is commonly framed as a key defining characteristic of the international climate change regime^{47,48}. A variety of state and non-state actors contribute to goal setting and the design and implementation of climate policy, including national policy-makers, city and regional governments, non-government organizations, voluntary associations, and private companies⁴⁷. This role is articulated under the Paris Agreement's recognition of 'the importance of the engagements of all levels of government, and various stakeholders',

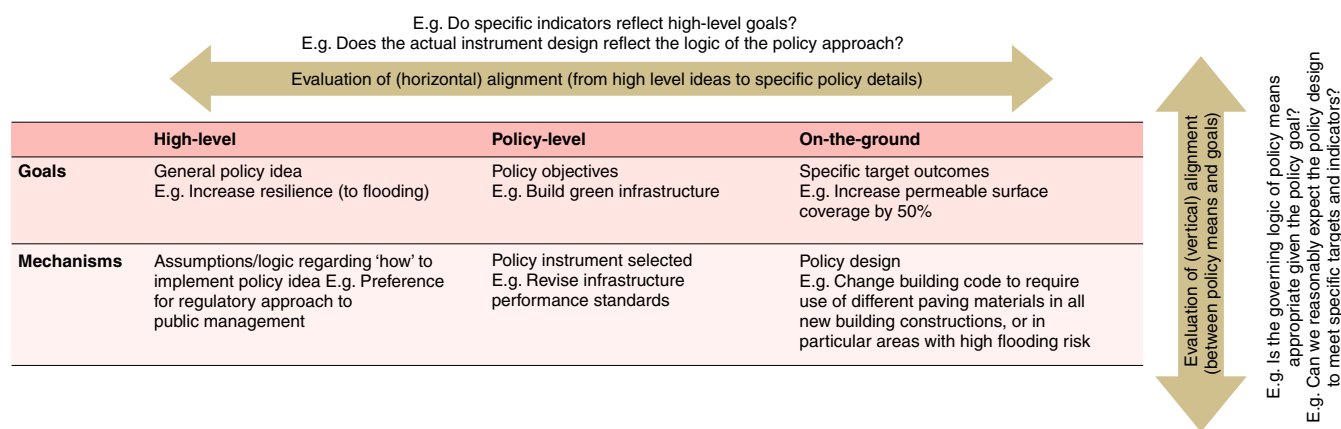


Fig. 2 | Measuring policy instruments.

and is institutionalized in the country-driven nature of the global agreement, where pledges emerge from domestic political decision-making rather than global negotiations^{49,50}. Leadership does not happen in a vacuum, but rather is influenced by institutional structures that both reflect and constrain actor preferences and their ability to formulate and implement policy⁵¹. Capturing the role of organizations and leaders is critical for recognizing processes of high-level formal legitimization, championing and agenda-setting for establishing the importance of adaptation^{40,52}. Variables within governments or non-governmental organizations could include the presence of high-profile and organizational adaptation champions; the participation of critical infrastructure providers and other private sector companies in adaptation-related institutions and/or processes; interest group pressures either for or against adaptation policy (for example, business lobbies, environmental organizations or the international aid community); and engagement of civil society in priority-setting (particularly organizations representing vulnerable populations or communities)^{27,53–55}.

Key methodological tools that could be used to elucidate these variables include: discourse analysis of goal setting and policy making, and topic modelling through computational text analysis,^{56,57} which provide promising avenues to comparatively assess the extent to which adaptation is pushed and how it is framed by governments and leaders. Variables capturing locations of decision-making power could include engagement with transnational or domestic climate networks; private sector investments in adaptation-related projects; and partnership-building with non-state actors.

Organizations making policy. Organizations making policy influence what (policy) actions are considered appropriate and legitimate to respond to climate change impacts, and how (scarce) governmental resources are generally allocated, as well as instigate certain procedures and practices in government response⁵⁸. For example the various ways in which different governments and private organizations have organized their knowledge generation on adaptation (for example, through in-house expertise, private sector consultants, think-tanks, or funding research institutes and universities), the allocation of tasks and responsibilities for adaptation (for example, highly centralized in some unitary states versus decentralized in federal systems⁵⁹), and how adaptation is organized ('mainstreaming' in existing systems or establishing a new policy field⁶⁰) are important factors to consider. Organizational structure is seen as both enabling and constraining climate change adaptation governance⁶¹. In well-designed organizational structures, institutions might enable adaptation to take place, whereas certain rules and procedures (or lack thereof) may act as constraints⁶². What is considered 'well designed' differs across contexts and might change over time.

Capturing organizational structure is therefore of critical importance to better understand how governments are creating an enabling (or constraining) environment for adaptation^{63,64}. Variables reflecting governance mechanisms are well-established and have been widely used in adaptation MRE frameworks. They include indicators of vertical or horizontal coordinative mechanisms (for example, interministerial working groups, committees and task-forces), mainstreaming, distribution of responsibilities on climate change, and how adaptation knowledge and expertise are organized and maintained (for example, through boundary organizations and partnerships). Various studies have identified the importance of inter-departmental coordinating bodies responsible for overseeing adaptation efforts, including the ability to mobilize leadership and resources, develop legal and regulatory frameworks for adaptation, and plan for the short- and long-term^{65,66}. Key methodological tools include structured surveys and self-assessments, or content analysis of policy documents that allows for a transparent way of collecting data.

Deconstructing adaptation policies. The concept of policy is defined here as the adaptation goals that governments adopt and the means by which they seek to fulfil those goals⁶⁷. Policy instruments are the mechanisms that governments use to translate policy goals into implementable actions, and might include, for example, legislation, taxation or knowledge-building activities such as research or training⁵⁴. Focus on policy instruments has been used in other comparative climate change policy studies^{68–72}, and we propose to build on these early efforts here to systematically identify and characterize adaptation policies across contexts.

The longitudinal aspects of our policy assessment arise from the regular or periodic collection of policy data in an iterative process designed to reveal both the appearance and disappearance of adaptation policies over time. Policy change can be observed when different elements of a policy shift, providing a complex and dynamic picture of policy progress over time. Figure 2 summarizes the key components of policies as understood by this approach⁶⁷. It identifies six components of policies that capture both the goals of policies and the means by which they are implemented. These components are organized across three levels of abstraction, in increasing level of detail. The broadest level of policy identification consists of the framing underpinning the policy, and the general preferences that governments have for how to achieve their goals^{73–77}. The greatest level of detail captures the scope of specific policy targets, and the nuances of how the policy is designed. This approach to measuring policy change accommodates the diversity of approaches that governments take to achieve their goals, but maintains a consistent definition for what constitutes 'policy' and thus can be systematically applied to diverse types of adaptation interventions.

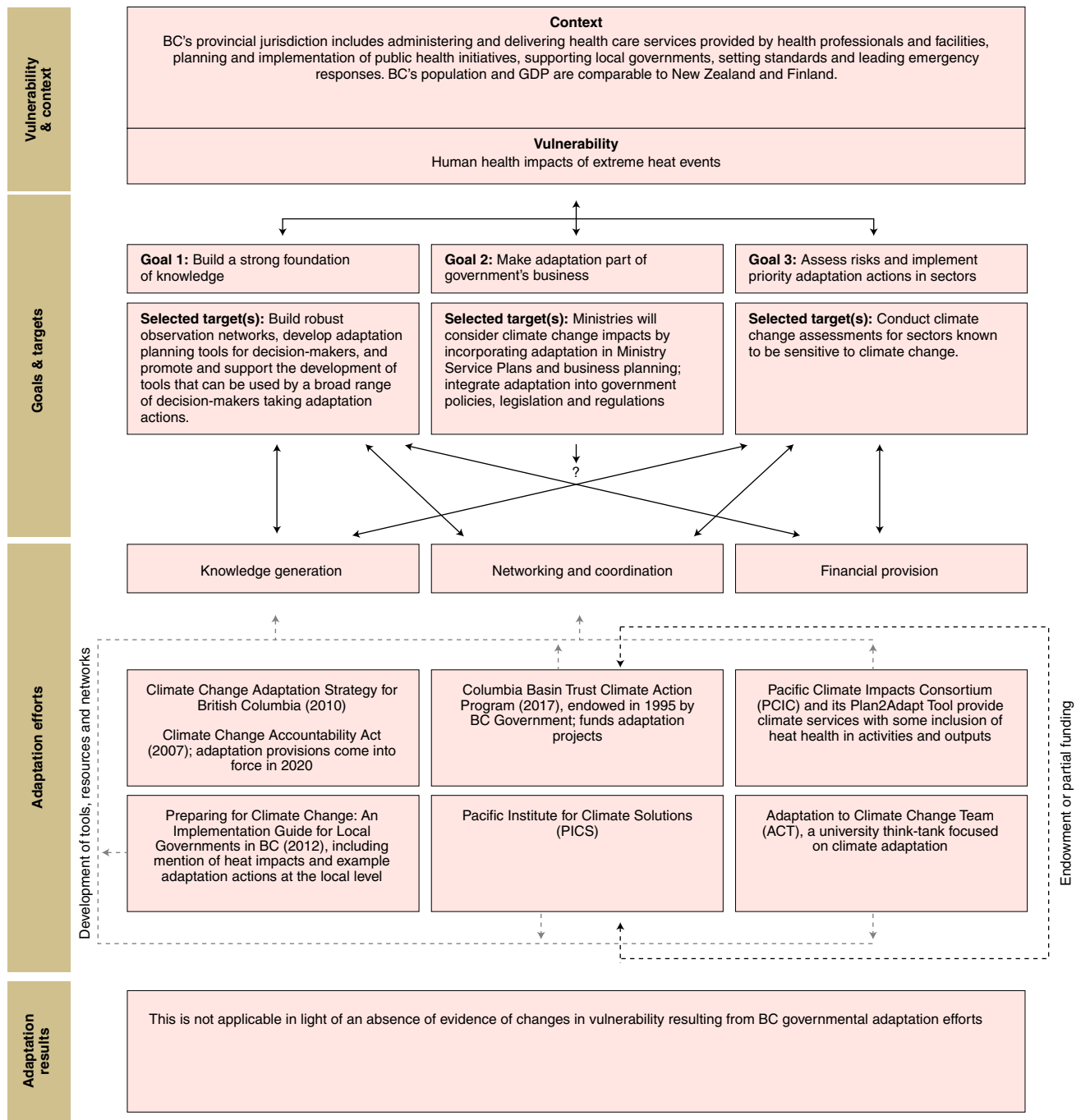


Fig. 3 | Adaptation to the impacts on public health via extreme heat in the Canadian province of British Columbia. Grey dashed arrows indicate adaptation efforts that act through development of tools, resources and networks to support knowledge generation along with networking and coordination. Black dashed arrows indicate programs or projects that are supported by financial provision by the BC government. There are thus a number of efforts that involve governmental provision of finances to support activities that contribute to knowledge generation, networking and coordination.

The policy component focuses on discrete adaptation policies, including for example: activities that generate knowledge or networks (for example, climate projections, vulnerability assessment, knowledge sharing, creation of boundary organizations, education or training, and collaborative networks); authority mechanisms (for example, legislation, intergovernmental mandates and regulation), treasury mechanisms (such as direct program spending, financial incentives such as grants or subsidies, and taxation), and organization mechanisms (such as procurement and demonstration of adaptive practices). For each policy mechanism, its goals, logic, mechanisms and implementation

should be documented. In the same way that alignment can be used to contrast vulnerabilities, goals and targets, efforts, and results, the extent to which policy goals and means are aligned across the components in Fig. 2 (either vertically or horizontally) should also be evaluated. For example, a vertical comparison of policy might ask: are regulatory approaches (policy means) a rational choice to generate increased resilience to flooding (policy goal), and is this choice logical or justified? A horizontal evaluation of alignment might ask whether the detailed indicators (policy specifications) are reasonably aligned with, and are appropriate measures of, the high-level policy goals.

Table 1 | Assessment of adaptation progress in BC in response to climate impacts on public health via extreme heat

Vulnerability & context	More frequent, severe, and prolonged heat waves and urban heat island effects are identified as climate impacts likely to increase heat-related illnesses. This is supported by literature identifying heat-related mortality and morbidity as key impacts of climate change in the province ⁸³ . In Canada, provinces have jurisdiction over health care, services and planning ⁸⁴ .
Goals & targets	BC has an Adaptation Strategy from 2010 that provides generalized objectives for adaptation activities in the province. The strategy does not include vulnerability or sector-specific targets, instead outlining broad aims. Targets focus on mainstreaming adaptation in government business, vulnerability assessment, prioritization and identification of adaptation options, provision of decision-making tools, and building collaborative networks. Goal 3 references implementation, but there are no implementation-related targets. More explicit provincial climate efforts are primarily focused on mitigation. Sufficiency of goals & targets. The literature supports heat as a key climate-health risk in the province. No targets explicitly emphasize public health or heat, limiting alignment with specific vulnerabilities. Focus on knowledge generation, networking and mainstreaming is consistent with the provincial mandate on adaptation, though there is lack of emphasis on direct planning and implementation of adaptation efforts. Goals and targets do not clearly reflect prioritization of key vulnerabilities, including heat.
Adaptation efforts	Adaptation efforts by the province are largely out-sourced via financial policy instruments (for example, grants and endowments) to research institutions to engage in knowledge generation and networking activities. There are no BC-specific guidelines for climate and heat. A provincial audit of climate change adaptation in the province in 2018 noted a lack of any province-wide vulnerability assessment, no clear prioritization of risks, no implementation plan, no clear plan to move forward, no updates to the adaptation strategy since 2010 and negligible monitoring of progress ⁸⁸ . Leadership efforts on climate change in BC are primarily outside or independent of government. Within the Ministry of Health, there is no reporting of climate change consideration in planning or services. Currently functioning adaptation governance and policy mechanisms remain minimal. Despite this, there is evidence of organizational governance that has not yet translated into tangible policy, through the BC Climate Change Accountability Act (2007) ⁸⁹ , that includes provision for regulatory powers and mandated reporting beginning in 2020. This assessment should be updated following the first report in 2020, when adaptation provisions come into effect. Sufficiency of adaptation efforts. Knowledge provision and networking efforts align closely with goals and targets. Out-sourcing via financial instruments limits coordination. There are numerous tools and guidelines that have emerged, though these are negligible for heat. Networking and coordination have been ad hoc and largely not heat-specific. There is an absence of clear evidence that government mainstreaming has occurred, or that ministries have undertaken adaptation planning or integrated adaptation considerations into policy as per Goal 2. While the Accountability Act provides provision for regulation and adaptation reporting, there is currently no evidence of governmental leadership, organizational mainstreaming or coordination across ministries, or direct policy mechanisms. It is unclear whether the act has facilitated (unreported) preparations for the 2020 reporting period, or deferred adaptation efforts until 2020.
Adaptation results	There are no data on the extent to which heat vulnerabilities have changed in BC. There are no published reports or programs to establish indicators or measures of changing heat vulnerability, and no information on the effectiveness of adaptation efforts on heat. Attribution and/or contribution of adaptation results. There is no clear theory of change for how targets or efforts might reduce heat impacts. An absence of sector- or vulnerability-specific adaptation activities constrains tracking of adaptation results and progress. Given limited provincial governmental focus on adaptation implementation, adaptation results are likely minimal at this time.

Methods and data to assess leadership, organizations and policy may be applied differently in different contexts depending on a government's goals, targets and vulnerabilities. A government with no targets related to organizational governance on adaptation, for example, may therefore be considered to have sufficient adaptation organization vis a vis its goals—that is, organizational efforts that are closely aligned with its goals—but insufficient organizational goals and targets vis a vis its vulnerability needs. Similarly, these sub-components of adaptation effort can be tracked over time to assess change.

Case-study

We present the results of a pilot case-study, applying the framework to the Canadian province of British Columbia (BC). We complement this with a more focused case-study at the local level, assessing adaptation policy in the city of Vancouver, BC. These two case-studies are used to illustrate the scalability of our framework across levels (regional to local) and depth of focus (generalized to detailed assessment).

Assessing adaptation progress in British Columbia. We draw on a case-study applying our framework to provincial adaptation in BC to highlight the added value of our framework compared to existing approaches. We selected BC given its recent participation in an audit of the government's response to climate change, providing an opportunistic source of information with which to pilot our framework⁷⁸. We drew on key provincial adaptation documents^{79–82}. We

illustrate this case-study using the example of heat-related public health impacts due to climate change in BC, which is among the province's top priority vulnerabilities⁸³. In Canada, provinces have jurisdiction over health care, services and planning⁸⁴. The provincial government is thus an appropriate jurisdictional level for assessment of its response to the public health impacts of heat-related extremes. A summary of key findings is provided in Fig. 3 and Table 1.

Existing goals and targets are primarily focused on mitigation, with more limited consideration of adaptation. There are no targets specific to heat risk, and no targets focused on implementation of adaptation efforts. Adaptation efforts are largely out-sourced via financial policy instruments to research institutions. Goals and targets align well with the province's responsibilities for networking, knowledge generation and mainstreaming, and adaptation efforts (though poorly coordinated and ad hoc) also align with these. Despite provincial jurisdiction over health service provision and planning, and the Climate Change Accountability Act's upcoming 2020 reporting period, there was limited evidence of tangible implementation or governmental mainstreaming. There are no clearly documented, provincial-level mechanisms for evaluating adaptation results in the context of public health impacts via heat.

The results of our case-study contrast with vulnerability-based indicators in highlighting what BC is doing on adaptation, in terms of its aims, objectives and efforts. Our vulnerability assessment is complemented by consideration of the jurisdictional context of provincial responsibilities for adaptation. We integrate components of vulnerability, context, goals and targets, efforts, and results within

Table 2 | Example of adaptation goals and instruments/means for flood and heat risk from the City of Vancouver’s Climate Change Adaptation Strategy (2012)

High level	Policy level	On-the-ground
General policy idea	Policy objectives	Specific target outcomes
Goals		
Strategic vision: to ensure that Vancouver remains a liveable and resilient city, maintaining its values, character and charm in the face of climate change.	Objective 1.1: Minimize rainfall-related flooding and associated consequences	Objective 1.1: Increase the capacity of the storm sewer
	Objective 2.1: Increase the resilience of Vancouver’s infrastructure and assets to coastal flooding and erosion	Objective 2.1: A city-wide sea level adaptation response will provide high-level direction to navigate through the complex issues and make civic investments without creating undue hardships in the short term.
	Objective 4.2: Minimize morbidity and mortality during heat waves	Objective 4.2: Minimize health impacts on vulnerable populations
Means		
Assumptions about how to implement goals	Policy instruments selected	Calibration of the selected instrument
Actions: focus on no-regrets actions that can be achieved through independent action within the City’s jurisdiction and responsibilities.	Treasure: financial resources	Action 1.1.2: Separate the sanitary and stormwater sewers.
	Nodality: information-gathering abilities	Action 2.1.1: Complete a Coastal Flood Risk Assessment and develop a sea level rise adaptation response
	Authority: regulatory power	Action 2.1.2: Update city flood-proofing policies including flood construction levels
	Organisation: staff resources	Action 4.1.2: Support Extreme Hot Weather Committee in expanding the Hot Weather Preparedness Work Program
	Nodality: information-gathering abilities	Action 4.1.2: Complete vulnerable population mapping for heat extremes

Adapted from ref. ⁸⁵, City of Vancouver.

a single framework, thus allowing for evaluative assessment through alignment across these components. In the case of BC, there are key constraints due to misalignment throughout these components, highlighting gaps in how adaptation is being prioritized, planned, implemented and monitored in the province.

Deconstructing adaptation policy in Vancouver. BC’s approach to adaptation implementation has largely focused on encouraging local governments to integrate consideration of climate change risks into strategic planning tools, land-use regulations and building decisions. We therefore present an additional example for the city of Vancouver, BC to demonstrate how our framework might be applied to the city level, in this case focusing in more detail on assessment of adaptation policy efforts vis a vis goals and targets, and using our policy instruments approach. Vancouver is among the most vulnerable Canadian cities and has developed a comprehensive strategy to deal with four main climate impacts: sea level rise, flooding, increased wind and rain storms, and health impacts⁸⁵. We systematically assessed these four climate risks using our policy instruments framework (from the section ‘Deconstructing adaptation policies’). We identified 108 proposed procedural and substantive policy actions. Table 2 provides an example excerpt of the goals and instruments proposed in the 2010 Vancouver adaptation strategy, which allows us to assess progress in achieving those goals and targets. For example, the 2010 strategy refers to the goal of organizing a design challenge for adaptation options that will engage builders and residents to come up with ideas for each section of Vancouver’s coastline. In July 2018,

slightly later than proposed, the Vancouver City Council approved the allocation of up to CAD\$500,000 toward organizing the challenge. This allows us to ask evaluative questions about the timing (is eight years after setting the goal acceptable?) and calibration (is investing CAD\$500,000 in a design challenge sufficient to achieve the goal?) of the goals and instruments.

Whether a particular instrument ‘works’ is difficult to evaluate as there are links to other instruments, problems of policy attribution, and the need for time to observe the impact of instrument effects. The example in Table 2 illustrates how our tracking framework addresses these challenges by unpacking the notion of adaptation policy, and allows for systematic evaluation of whether or not the goals that have been set are implemented. We can assess in detail whether government(s) are actually doing what they promised (goals → instruments) and whether they are doing the right things (vulnerability → goals). Evaluation of these efforts allows for recalibration of goal/instrument configurations (that is, adding new instruments and changing goals). Looking at the whole portfolio of 108 policy instruments for Vancouver, for example, allows for evaluation of whether the mix of instruments has resulted in the desired changes or whether further adjustments are needed. In Vancouver, this process is currently underway.

Similar to our broader framework, this approach to policy assessment contributes to an important gap in our ability to systematically track adaptation progress. There are currently no frameworks that allow systematic and scalable assessment of how adaptation policy evolves over time. This approach provides additional value in allowing for evaluation of policy progress through assessment of

the extent to which instruments/means align with goals (vertical comparison in Table 2), as well as how high-level goals and means are operationalized (or not) on the ground (horizontal assessment in Table 2).

Moving forward

There is already a wealth of literature presenting theory-driven adaptation assessment frameworks³⁰. Our approach focuses on concepts that are translatable and scalable across levels of government, and that can be systematically compared between governments. The use of a policy instrument as a consistent unit of assessment within the policy sub-component of adaptation efforts (Fig. 2) is an important contribution to adaptation tracking approaches. Similarly, benchmarking adaptation efforts to governmental goals and targets, and goals to population vulnerability and contexts, allows the framework (Fig. 1) to be consistently applied across governments while still respecting the diverse contexts and vulnerabilities governments face. This is consistent with the spirit of the Paris Agreement, and supports the development of accountability mechanisms and evaluation of adaptation efforts.

A central challenge of adaptation-tracking is availability and access to data that are comprehensive, comparable and measure meaningful proxies of adaptation^{7,19}. Much of the literature on documented adaptation responses is at the local level, and reporting is typically patchy and ad hoc across different levels of government. Even if we aspire to identify theoretically ideal indicators of adaptation, there are rarely sufficient data available for tracking. The few adaptation datasets that exist may contain meaningful information for some governments, but rarely comprehensive global coverage at a deep level, and the sample of governments with data available is typically subject to sampling bias¹⁰. It is difficult to gauge, for example, whether many middle- and low-income nations are not engaging in governmental adaptation, or whether they are under-reporting meaningful adaptation (reporting bias). Even more troubling, few indicators of adaptation are designed to reflect the need for longitudinal tracking of adaptation progress over time. The quality, quantity and accessibility of legislative and regulatory data also vary greatly between countries, creating barriers to producing rigorous analysis.

The paucity of adaptation-specific data underpins the importance of developing adaptation tracking systems through the Paris Agreement or other non-governmental partnerships. Yet it is not only a lack of data but also the absence of clear conceptual frameworks to first articulate what we want to track, thus informing a more focused identification or collection of relevant indicators and data. To date, efforts to track adaptation have been to a large extent indicator- or data-driven. This Perspective seeks to reverse this pattern by starting with the key questions that adaptation tracking seeks to answer, and using these to then interrogate existing or novel opportunities for data collection and indicator development.

New data sources and data-seeking approaches are required to achieve an acceptable trade-off between the goal of systematic tracking and the desire for more meaningful indicators of adaptation. Primary data is often in the form of document analysis of official government documents, primarily laws and ministry or executive actions at the national level, and comparable documentation at other levels of government. Meaningful tracking requires drawing on a broader diversity of knowledge sources, from existing indicators to publicly available reports and discourse, legislation and regulations, expert knowledge, crowd sourcing and digitally sourced big data⁸⁶. New methods for systematically synthesizing knowledge on adaptation⁸⁷ will be crucial to advance adaptation tracking, which employs systematic study design techniques while drawing on a diversity of knowledge sources.

Our framework is designed to assess government progress on adaptation. It is not solely meant to compare governments against

each other, though this should be feasible with this framework. It is intended to assess progress within a government and over time in a way that is systematic and consistent across governments. We offer a way of capturing the essence of what governments do in terms of planning, decision-making and implementation to deal with the climate vulnerabilities and risks they face, and how this changes over time. It is timely given the challenge governments face in tracking their progress under the Paris Agreement.

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Author contributions

The work presented in this paper was guided by a series of collaborative discussions and workshops within the Adaptation Tracking Collaborative (ATC). Launched as a collaboration of the Tracking Adaptation to Climate Change Consortium (TRAC3, McGill University, University of Leeds and Wageningen University), the Global Adaptation Initiative at the University of Notre-Dame (ND-GAIN), the University of California Los Angeles (UCLA) WORLD Policy Analysis Center, the Institute of Environment at the University of Minnesota and in collaboration with Yale-NUS College (Singapore). The ATC hosted three workshops with the goal of: assessing adaptation tracking needs, identifying a common goal, articulating key theoretical and methodological challenges, and collectively outlining a preliminary conceptual framework for global and systematic adaptation tracking. This paper is the result of those discussions. L.B.F., R.B., J.D.F. and A.L. conceived of the study. Conceptual development of the study goals, objectives and an outline of the framework were contributed

collectively by all authors over a series of three workshop meetings. These meetings provided the important intellectual content and interpretation of existing literature to develop a first draft. L.B.F. led manuscript writing, with substantial portions of text written by R.B., A.L. and J.D.F.; A.L., R.B., L.B.F., A.T. and F.M.W. contributed to case-study data collection and/or analysis. All authors critically revised the manuscript for important intellectual content over numerous drafts and teleconferences.

Competing interests

The authors declare no competing interests

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