Climate Policy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tcpo20

Sub- and non-state climate action: a framework to assess progress, implementation and impact

Thomas N. Hale, Sander Chan, Angel Hsu, Andrew Clapper, Cynthia Elliott, Pedro Faria, Takeshi Kuramochi, Shannon McDaniel, Milimer Morgado, Mark Roelfsema, Mayra Santaella, Neelam Singh, Ian Tout, Chris Weber, Amy Weinfurter & Oscar Widerberg

To cite this article: Thomas N. Hale, Sander Chan, Angel Hsu, Andrew Clapper, Cynthia Elliott, Pedro Faria, Takeshi Kuramochi, Shannon McDaniel, Milimer Morgado, Mark Roelfsema, Mayra Santaella, Neelam Singh, Ian Tout, Chris Weber, Amy Weinfurter & Oscar Widerberg (2021) Sub- and non-state climate action: a framework to assess progress, implementation and impact, Climate Policy, 21:3, 406-420, DOI: 10.1080/14693062.2020.1828796

To link to this article: https://doi.org/10.1080/14693062.2020.1828796

Published online: 09 Oct 2020.

CLIMATE POLICY
2021, VOL. 21, NO. 3, 406–420
https://doi.org/10.1080/14693062.2020.1828796

Taylor & Francis
Taylor & Francis Group

SYNTHESIS ARTICLE

Sub- and non-state climate action: a framework to assess progress, implementation and impact

Thomas N. Hale [a], Sander Chan [b,c], Angel Hsu [d], Andrew Clapper [e], Cynthia Elliott[f], Pedro Faria[e], Takeshi Kuramochi [g,h], Shannon McDaniel[i], Milimer Morgado[j], Mark Roelfsema [h], Mayra Santaella[k], Neelam Singh [f], Ian Tout[k], Chris Weber[l], Amy Weinfurter[d] and Oscar Widerberg [m]

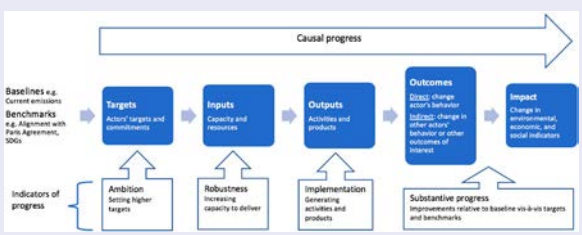
[a]Blavatnik School of Government, University of Oxford, Oxford, England; [b]German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE), Bonn, Germany; [c]Global Center on Adaptation (GCA), Groningen, Netherlands; [d]Yale-NUS College, Singapore, Singapore; [e]CDP, New York, NY, USA; [f]World Resources Institute, Washington, DC, USA; [g]NewClimate Institute and Copernicus Institute of Sustainable Development, Cologne, Germany; [h]Utrecht University, Utrecht, Netherlands; [i]Global Covenant of Mayors for Climate and Energy, Brussels, Belgium; [j]The Climate Group, London, England; [k]United Nations Framework Convention on Climate Change Secretariat, Bonn, Germany; [l]World Wildlife Fund, Washington, DC, USA; [m]Vrije Universiteit Amsterdam, Amsterdam, Netherlands

ABSTRACT

The rising importance of cities, states and regions, firms, investors, and other subnational and non-state actors in global and national responses to climate change raises a critical question: to what extent does this climate action deliver results? This article introduces a conceptual framework that researchers and practitioners can use as a template to assess the progress, implementation, and impact of climate action by sub- and non-state actors. This framework is used to review existing studies that track progress, implementation, and achievement of such climate action between 2014 and mid-2019. While researchers have made important advances in assessing the scope and future potential of sub- and non-state climate action, we find knowledge gaps around ex-post achievement of results, indirect impacts, and climate action beyond the realm of greenhouse gas reductions.

Key policy insights:

- While we increasingly understand the scale, scope, and potential of climate action by sub- and non-state actors, we lack rigorous evidence regarding the results achieved and their broader impacts.
- More information on progress and impact is essential for the credibility of sub- and non-state climate action. Policymakers need to understand which approaches are working and which are not, promoting the diffusion of best practice and creating conditions for stronger action in the future.
- The proposed conceptual framework can be tailored and applied to a wide range of initiatives that target mitigation, adaptation, and other spheres of climate action. By providing a template to identify key elements of progress tracking and evaluation, the framework can help align both research and practitioner communities around the data and metrics required to understand the overall impact of climate action.



ARTICLE HISTORY
Received 5 March 2020
Accepted 17 September 2020

KEYWORDS
Climate action; transnational governance; cities; business; effectiveness; progress; benchmarking

CONTACT Thomas N. Hale Thomas.hale@bsg.ox.ac.uk

1. Introduction

Climate action by cities, states and regions, firms, investors, and other subnational and non-state actors now comprises a central element of global and national responses to climate change. While advances in data collection and methodologies for calculating mitigation impact have given researchers and policymakers a more accurate sense of the potential of sub- and non-state climate action (Hsu et al., 2019), recent articles have noted that we still know too little about its actual results to assess the effectiveness and legitimacy of such action (Chan et al., 2019; Gilligan & Vandenbergh, 2020; Kuyper et al., 2018). This article reviews the state of knowledge on the progress, implementation, and impact of sub- and non-state climate action, and proposes a common conceptual framework for advancing this critical area of policy and research.

At the time of writing, the UN has identified commitments to act on climate change from over 10,000 cities and other sub-national jurisdictions, home to about 20% of the world population, and by over 6,000 businesses whose combined annual revenue exceeds 40% of global GDP (UNFCCC, 2019). This heterogenous landscape of climate action covers mitigation, adaptation, and other aspects of climate policy, and ranges in scale from local actions at the community level to globally significant actors and large cross-border initiatives. Reflecting its substantive importance, this 'groundswell' of climate action is now institutionalized in the international policy regime, for example in the Marrakech Partnership for Global Climate Action, and features prominently in policy debates in many countries (Hale, 2016). Estimates of the aggregate mitigation impact of these commitments suggests that they have enormous potential to help close the emissions gap alongside the efforts of national governments, perhaps avoiding several gigatons of CO_2e annually by 2030, although commitments that have been translated to concrete targets are significantly smaller (Kuramochi et al., 2020; Lui et al., 2020). In addition, the potential of sub- and non-state action to leverage resources, stimulate innovation, and contribute to adaptation and resilient development has been widely recognized (Bulkeley et al., 2014; Chan et al., 2019; Kuyper et al., 2018; UNFCCC, 2018).

The significant potential and rising salience of sub- and non-state climate action raises the question of what results have been delivered. Have actors taken steps to implement their commitments, what has been achieved so far, and what are the broader impacts of these efforts? Rising support for immediate responses to the climate crisis, as seen, for example, in the Fridays for Future movement, highlights the need for climate policies to demonstrate results. The global community requires answers to these questions to understand overall progress towards the Paris Agreement and the Sustainable Development Goals (SDGs), as well as to inform current and future strategies to advance climate action through sub- and non-state actors.

This review article seeks to make four contributions to this research agenda. First, it examines why tracking results matters for different stakeholders and objectives, highlighting the difference between estimating potential versus examining results. We focus on the role of sub- and non-state actors as 'implementors' of climate action, not as advocates or watchdogs, though that role is also important. Second, the article proposes a conceptual framework to clarify core concept terms like 'progress' and 'impact' in the context of sub- and non-state climate action (see definitions in Table 1 below), explain their relation to each other, and outline how they can be analyzed. The conceptual framework provides a template that researchers and practitioners can apply to a wide range of climate action areas.

Third, we use the conceptual framework proposed in this article to review existing assessments of climate action, showing what types and measures of progress and achievement have been reported by actors or third-party evaluators, and which have not. Using keyword internet searches and interviews with leading climate action organizations, we identified a sample of 42 published assessments of sub- and non-state climate action, including both individual actions and those that occur through networks or initiatives, between 2014 and mid-2019. While such analyses provide important information, they are skewed to the evaluation of future potential over results actually achieved, and focus almost entirely on greenhouse gas (GHG) reductions instead of adaptation, finance, or other areas of climate action. We highlight where current data sources and approaches to measuring progress, implementation, and impact are insufficient to gauge sub- and non-state contributions. Finally, the article outlines how the conceptual framework could be operationalized in two key areas of climate action: quantified emissions reductions and adaptation actions.

Table 1. Summary of definitions

Term	Definitions	
Performance indicator	Measure of performance toward a goal, e.g. increase of a positively valued measure like renewable energy or decrease of a negatively valued measure like GHGs	
Baseline	Current or historical value of performance indicator, or future trajectory likely without intervention (e.g. GHG inventory, current financial flows, Business-as-Usual scenario, etc.)	**Ambition**: Setting a higher target vis-a-vis the baseline or benchmark
Benchmark	Relates actors' target to appropriate standard (e.g. alignment with global goals, peer targets, etc.)	
Target	A future value of the performance indicator (in a future target year), measured from a baseline value	
Inputs	Level and/or types of input going into climate action, such as human (staff), financial (money), technical or other organizational resources, regulatory authority, etc.	**Robustness**: Increasing capacity and resources to take climate action
Outputs	Volume of output or work, often in terms of an amount such as number of investments, projects, standards/rules, workshops, publications, members, etc.	**Implementation**: Taking activities to deliver climate action
Outcome	Behavioural change by actor (direct) or other actors (indirect)	**Substantive progress**: Proportion of target currently achieved.
Impacts	Changes in environmental, economic, or social indicators of interest (e.g. actors reduce emissions by XX tonnes of carbon dioxide equivalent)	

2. Why tracking progress, implementation and impact matters

Researchers and policymakers have long recognized the importance of tracking national governments' progress toward climate targets. At the country level, a number of annual publications like the UNEP Emissions Gap Report, IEA World Energy Outlook, and Climate Action Tracker model national climate policies' potential impacts on future emissions, and countries report their current and past emissions levels through domestic processes and under the United Nations Framework Convention on Climate Change (UNFCCC). Efforts to track countries' adaptation efforts and climate finance have proven more difficult given the lack of widely agreed definitions and comparable data sources (Berrang-Ford et al., 2019). After 2020, under the Paris Agreement's 'enhanced transparency' framework, countries are required to report on progress toward their individual NDCs, with a 'Global Stocktake' assessing collective progress toward the Paris goals every five years. Significant capacity building measures have been taken to assist countries in developing GHG inventories (Bodansky, 2016).

In theory, an analogous system could be replicated for sub- and non-state actors. However, various challenges to its implementation arise. Because national governments have been the traditional focus of climate policy, data sources and models tend to be aggregated at the global, continental, and national levels. Moreover, the capacity limitations for monitoring and reporting that many national governments face are even greater for many sub- and non-state actors; while some sub- and non-state actors possess significant resources, many do not (Hsu et al., 2019). Finally, many sub- or non-state actors do not have de jure or de facto control over significant portions of their emissions or other climate-relevant outcomes (C40 & ARUP, 2015). For example, there are many non-state and subnational actors that have set GHG targets that cover not only direct emissions but also indirect emissions from electricity-use or value-chains, which are outside the actors' jurisdiction or control (CDP, 2019).

Despite these challenges, tracking the progress and impact of climate action provides a range of critical functions for multiple audiences. Climate action reporting platforms, such as CDP (formerly Carbon Disclosure Project), the Global Covenant of Mayors, or ICLEI's carbon*n* Center, or the UNFCCC's Global Climate Action Portal,[1] show 'enormous diversity in type, membership constellations, geographical scope, mode of governance, and thematic areas,' though efforts are underway to promote harmonization and standardization (Widerberg & Stripple, 2016). Where data that track results are incomplete, they stymie the potential for governments or other actors to acquire and utilize knowledge in policy processes (Bennett & Howlett, 1992; Howlett, 2009; Sabatier & Jenkins-Smith, 1993). These knowledge gaps hamper the learning and knowledge integration across scales that help 'polycentric' regimes to operate effectively (Andersson & Ostrom, 2008; Chan et al., 2019; Imperial, 1999).

Specifically, measuring progress, implementation and impact can provide concrete benefits for many actors across the climate action landscape. First, for the cities, businesses and other sub- and non-state actors themselves, measuring progress toward their own targets allows them to understand what practices and approaches work and which do not. This information helps these actors understand whether their efforts are in line with their selected benchmarks, such as modelling scenarios that describe what is needed to achieve global temperature goals. Given the uncertainty around how to achieve many aspects of deep decarbonization and adaptation, and the context-specific character these challenges exhibit in individual locations and areas of the economy, self-reflection and course-corrections are important (Gottschick, 2018; Hendriks & Grin, 2007; Meadowcroft & Steurer, 2018).

Moreover, information about individual actors' targets, activities, and achievements can have 'learning effects' and 'demonstration effects' on peers. Understanding what works and what does not for a certain city or business creates valuable knowledge that other actors can use to refine their approaches. It can also help sub- and non-state actors receive credit for their efforts, possibly creating the possibility of attracting greater funding or other support. Tracking and evaluation efforts that include exchange of best practices through online platforms or conferences, or via qualitative case studies, can particularly enable peer-to-peer learning. Seeing peers credibly deliver on ambitious targets can help other actors gain the confidence, as well as a potential roadmap, to follow suit. Moreover, if an actor believes others will not follow through on their commitments, they may be less likely to enact changes themselves (Imperial, 1999; Ostrom, 1990).

Second, for citizens, customers, shareholders, civil society groups, or other stakeholders of sub- and non-state actors, tracking progress and impact is essential for establishing the credibility of climate action and providing accountability. Pressure from these stakeholders is typically an important motivation for sub- and non-state actors to take climate action (Bulkeley et al., 2014). Tracking progress and impacts is therefore needed to show them results.

Third, national and international policymakers need to understand the progress sub- and non-state actors are making in order to accurately assess national and global progress on climate change. As policymakers design new national policies, they can also benefit from learning effects—understanding what measures are most effective and might be replicated and scaled up —and demonstration effects—understanding that ambitious climate action is possible and desirable—from sub- and non-state climate action (Chan et al., 2019). For mitigation, understanding sub- and non-state achievements is also needed to avoid 'double counting,' which is particularly important in the context of emissions trading. At the global level, the Paris Agreement's Global Stocktake institutionalizes aggregate tracking of 'where we are,' and explicitly solicits inputs from sub- and non-state actors on this question. Similarly, the rotating review process for the SDGs seeks to assess the contributions of sub- and non-state actors as well as national governments (Persson et al., 2016).

Finally, tracking sub- and non-state climate action gives researchers a more granular understanding of progress toward the goals of the Paris Agreement than is available from national inventories. If we can identify how different actors are delivering and understand their interactions, we can model overall progress much more accurately. At the same time, assessing progress made on past pledges can help us estimate the likelihood that pledges to reduce in the future will be realized by identifying general conditions of successful implementation.

Ultimately, we are interested in the systemic transformation of entire societies and economies. We aim to identify if the shift to a decarbonized, climate-resilient society is happening quickly enough to avert unacceptable outcomes. Given the scale and scope of sub- and non-state action, looking only at national policies' progress and impact is unlikely to provide sufficient information. This point is particularly important in the evaluation of interactions between sub- and non-state actors themselves and their interactions with national governments (Roger et al., 2017). We must better understand potential second-order effects such as learning, innovation and behaviour and societal change, and the potential for non-linear trajectories, tipping points, and other common features of complex systems (Chan et al., 2019; Farmer et al., 2019).

3. Methods: a logical framework for assessing climate action

We propose a conceptual framework to help systematize how we think about ideas like 'progress' and 'impact' in sub- and non-state climate action. Drawing on existing methods for monitoring and evaluating progress and

impact assessment common in policy analysis studies, this study adapts these methods to the climate action context (Coleman, 1987; Gasper, 2000; Sartorius, 1991). As scholars and practitioners have found in other policy areas characterized by complex, multi-actor processes, a simple conceptual framework to measuring progress can provide a helpful starting point. Such an approach cannot claim to capture all dynamics around climate action, such as second-order effects or unintended consequences (Uwizeyimana, 2020). However, we seek to draw approaches from other fields to create a simple and general template that researchers and practitioners can build on when evaluating climate action.

Figure 1 portrays a familiar logical framework or 'log frame' model that can apply to mitigation, adaptation, or other spheres of climate action (Sartorius, 1991). The log frame models the impact of climate action as a causal chain from the **targets** actors set (which may be quantitative or qualitative, and apply to mitigation, adaption, or other spheres) against relevant **baselines** and **benchmarks**), to the **inputs** they bring to bear, to the **outputs** they create, to the direct and indirect **outcomes** and **impacts** to which these outputs contribute. While in practice these processes are non-linear, and the outcomes and impacts exhibit multicausality, the log frame provides a parsimonious summary of the key processes to consider (Gasper, 2000). In this sense, it serves as a practical model that can help simplify complex processes in order to facilitate analysis of implementation and impact.

This framework allows us to define key terms and their relation to each other (Table 1 below). We start by noting that any measure of progress or impact is only meaningful in relation to a **baseline**, such as the current level of emissions, resilience or financing, and a **benchmark,** which typically relates an actor's target to some overarching objective. In climate mitigation action, the most salient benchmarks are alignment with the goals of the Paris Agreement, the SDGs, or 'net zero' emissions. The performance of peer actors or equity considerations related to an actor's 'fair share' may also provide relevant benchmarks (Höhne et al., 2014; Robiou du Pont et al., 2016).

The model allows us to think about progress in different ways. **Causal progress** refers to progression along the log frame. Evaluating causal progress allows us to answer questions like: Are actors setting targets and acquiring resources and capacities (inputs) to generate relevant activities and products (outputs)? Do these outputs contribute to meaningful outcomes and ultimately impacts? While it is conceptually clearest to model causal progress as progressing from left to right, in practice we know that each element of the chain can affect other elements in a non-linear fashion. For example, target setting may depend on what resources are available for implementation or on what outcomes have been achieved previously.

As the lower line of boxes in Figure 1 show, progress can also be observed at each stage along the causal chain. Setting or increasing targets and intermediate milestones represents progress on **ambition**. For example, a city might set a goal of achieving a certain percentage reduction in emissions by a certain date, with full

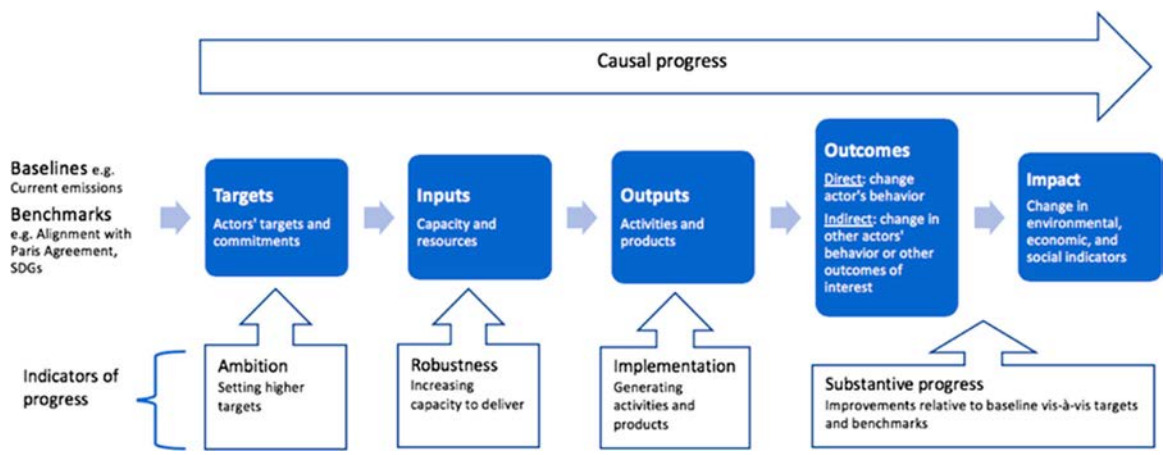


Figure 1. Log frame model for measuring progress, implementation, and impact of climate action

decarbonization by a later date. Acquiring new resources and capacities (e.g. securing financing for new infrastructure investments) represents forward movement, indicating increasing **robustness**. This is necessary for the next step of successful **implementation** via various outputs (e.g. a programme to retrofit city buildings to increase energy efficiency). Measuring progress at each of these stages provides useful information on whether a given climate action is moving along the chain of causal progress and is therefore likely to achieve its targets.

Ambition, robustness, and implementation are important precursors to **substantive progress**. Substantive progress refers to the final parts of the causal chain - outcomes and impacts – measuring how targeted behaviours, or social, economic and environmental indicators, have changed relative to targets and benchmarks. Importantly, outcomes may be direct (Do the city's emissions decline over time? Was there a reduction in vulnerability?) or indirect (Did other companies in the sector embrace similar targets? Did the national government adopt the policy innovation tested by the city?).

Defining these concepts allows us to think more clearly about how to assess climate action. For example, we can define **effectiveness** as the magnitude of the outcomes and impacts the climate action generates in comparison to the benchmark, and how quickly it leads to scale, i.e. more and/or bigger outcomes and impacts. **Efficiency**, in turn, can be understood as the effectiveness relative to the inputs invested (e.g. funds invested) in a given climate action.

The conceptual framework outlined above seeks to provide a general template for measuring the progress and results of sub- and non-state climate action across the very heterogeneous landscape of climate actions—including mitigation, adaptation, and related activities. Because the exact circumstances around climate action vary from country to country, or across different thematic areas or types of actors, different elements of the conceptual framework will be more or less salient in any application.

It is also important to note the limits of this approach. Log frames provide a practical way to summarize complex causal relationships, but, as with any model, researchers using them should remain aware of their assumptions and limitations. The way the log frame conceptual model is illustrated is linear, but each link in the chain is influenced by more than just the previous link. For example, inputs may not only follow from climate targets, but from unrelated policy processes or exogenous economic, biological or geophysical (Schneider, 2004), or technological changes. This 'multicausality' particularly affects impacts, which typically have many drivers, some of which are not necessarily connected to the behaviour of the actor in question. Such chains may be particularly difficult to trace in the realm of adaptation, where impacts may not be measurable until significantly into the future, and counterfactuals may be difficult to identify. Comprehensive evaluations of climate action will need to account not just for direct effects, but second-order effects and interactions as well. For example, actors may hope that their targets may influence national governments or peers, but not set this as an explicit aim. Moreover, some of these effects may not be intended.

Additionally, for sub- and non-state climate action, interactions may be particularly salient (Puig & Bakhtiari, 2020). For example, subnational government targets may be subsumed by, or dependent on, national frameworks. Business initiatives, on the other hand, may depend on shifts in technology or in consumer behaviour. Given these complexities, the log frame provides a useful 'umbrella' framework and common language for research on the impact and progress of sub- and non-state climate action against their intended goals. It can serve not as a 'one size fits all' model, but as a common starting point. Answering more specific questions about exact outcomes in a specific context will of course require richer models, but the log frame creates a template for how to answer many different questions across various categories of actors (e.g. cities and companies), of both mitigation and adaptation action, of different thematic areas and sectors (e.g. energy, land-use, transport), and of different types of targets. For example, emissions reduction targets may emphasize quantitative shifts in outcomes as the key measure of progress, while an initiative aiming at capacity building may instead emphasize outputs (e.g. number of people trained) as a better gauge of implementation.

This actor- and initiative-level tracking provides a useful complement to macro-scale tracking that seeks to measure progress on global emissions' reductions or overall progress toward renewable energy deployment, land-use changes, or other sectoral targets. The macro perspective tells us about the overall state of the transition, while the micro scale helps us understand the roles of key actors within it, as well as the impact of the micro scale on overall progress at the national and, ultimately, global level.

4: Results: current knowledge about progress, implementation, and impact

Using this framework, we investigate how the research and policy community has assessed sub- and non-state climate action to date. This section presents the results from a review of 42 major studies published between 2014 and mid-2019 by scholars, non-governmental organizations, and cooperative initiatives that in various ways map and measure progress and impacts of sub- and non-state climate action (see Appendix 1). Because we are interested in identifying the most salient studies of climate action, we focus on the subset of research outputs most likely to be seen by policymakers or actors engaged in sub- and non-state climate action, not a comprehensive literature review. We therefore analyzed studies that met at least one of the following criteria: reports that featured at major international climate summits,[2] those produced by the largest transnational networks of sub- and non-state actors,[3] and those featured in the top-ranking climate journals.[4] The list of reports and studies to review also received input from the UNFCCC-convened Climate Action Methods, Data, and Analysis (CAMDA) group.[5] While we do not claim to capture the full universe of non-state and sub-national climate action studies, we are confident the 42 major studies analyzed provide a meaningful perspective on trends in the literature.

Several key points emerge from the analysis. First, cities, regions, and companies are the most frequently analyzed actors, featuring in 48%, 31%, and 36% of the reports, respectively (see Figure 2). Other types of actors, such as investors and universities, are rarely mentioned. Twenty-seven percent of studies look at climate actions at the level of collaborative initiatives. For instance, while two publications by America's Pledge focus on the aggregated effects of climate actions by cities, US states, and companies, they focus on those sub/non-state actors who participate in collaborative initiatives (America's Pledge, 2018).

Second, nearly all studies, 95%, assess the potential or past impact of non-state and subnational climate action on GHG reductions, showing an overwhelming focus on mitigation. This focus misses large parts of the climate action universe. At the time of writing, approximately one third of the actions registered on the UNFCCC's Global Climate Action Portal have elements that address adaptation, and many mitigation-oriented actions target antecedents of emissions reduction like renewable energy deployment, financing, or developing standards (ClimateSouth, 2018).

Third, 61% of studies focus on potential (ex-ante) impacts in the future (i.e. ambition) while only 9% of studies focus on progress achieved in the past (ex-post), though 31% consider some aspect of both (see Figure 3). In other words, most impact evaluations answer the question: If all emission reduction targets are achieved, what would the aggregate impact on GHG emissions be in the future? Several studies also consider the broader impact of potential emissions. For instance, CDP and We Mean Business find that, 'By 2030, business could cut its GHG emissions by 3.2–4.2 $GtCO_2e$/year below current trends, by joining climate change initiatives.

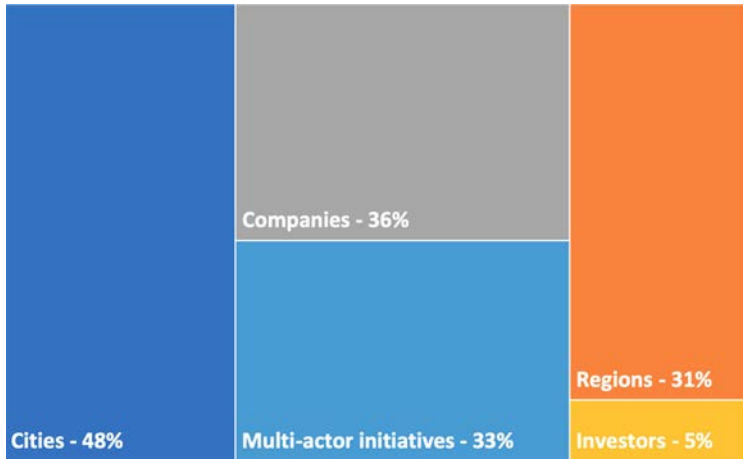


Figure 2. What actors do reports include? Percentage of reports that include analysis of different actors ($n = 42$). Percentages do not sum to 100% because some reports cover multiple categories of actors.

That's equivalent to up to 7–9% of the world's 2010 emissions' (Höhne et al., 2016). Another case in point is Data Driven Yale, NewClimate Institute and PBL's report that estimates to what extent cities, regions and businesses could bridge the ambition gap left by governments due to insufficient domestic policies, concluding that 'Accounting for overlaps between actors' commitments, global emissions in 2030 would be around 1.5 to 2.2 $GtCO_2e$/year lower than they would be with current national government policies' (Hsu et al., 2018).

Fourth, the bulk of studies focus on ambition and implementation, in particular on actors' targets and outputs, as opposed to substantive progress (see Figure 3). In 66% of the studies, the number of actors making a certain type of commitment is used as an indicator of progress. For instance, studies focusing on companies frequently mention the companies committing to use Science Based Targets to track progress. Others assess whether initiatives have certain design features they see as prerequisites for impact, such as quantified mitigation targets, defined baselines, and reporting procedures (Michaelowa & Michaelowa, 2017).

Similarly, 50% of the studies quote numbers of measures taken by sub- and non-state actors as signs of progress. For instance, when a company adopts an internal price on carbon, that is considered a sign of progress or success.

Fifth, while potential emission reductions, targets, and outputs are frequently used as indicators to measure progress, there is much less data and fewer studies monitoring input and outcome-level indicators. Only 14% of the studies mention some type of input indicator, such as financial or human resources going into climate measures. Even fewer studies, 11%, assess actual behavioural change at the outcome-level due to climate measures taken.

Finally, and strikingly, none of the studies have rigorously estimated the indirect and interactive impacts of sub- and non-state climate action. For example, we are not aware of any studies that show that adoption of climate targets by one actor have led other actors to adopt similar targets, or of studies that demonstrate a causal effect of sub- and non-state climate action on national policies.[6]

In summary, the literature review suggests that progress, achievement and impact are operationalized in quite different ways across studies that assess non-state and sub-national climate action. The vast majority of studies look at potential impact with the assumption that actors will fully achieve their commitments; in other words, that targets will drive implementation through inputs, outputs and outcomes. While some

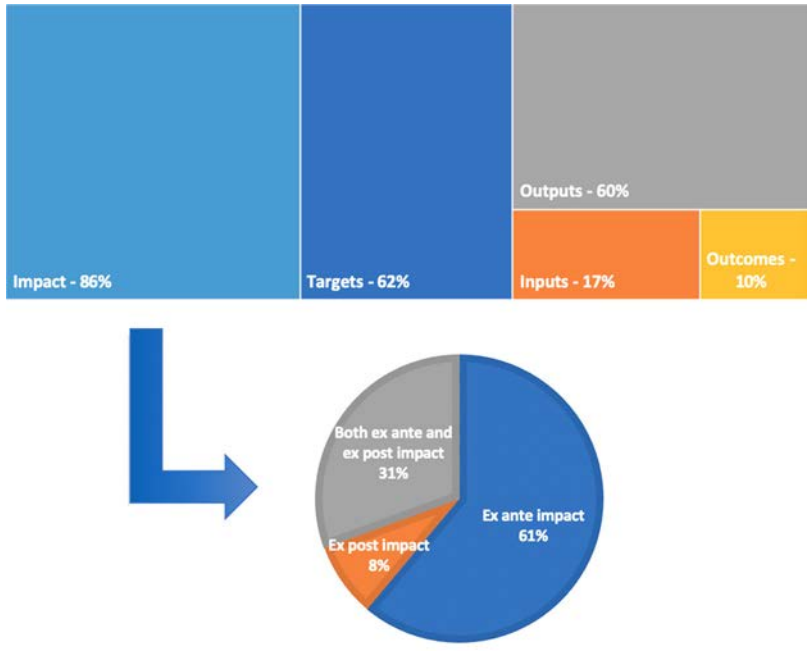


Figure 3. What indicators do reports measure ($n = 42$)? Of those that measure impact ($n = 36$), do they measure ex post or ex-ante impact?

individual case studies link target-setting to inputs, outputs, outcomes and impacts using observed data, such comprehensive analysis of climate action at the aggregate level is lacking (Lamb et al., 2019). Moreover, rigorous estimates of indirect or interaction effects are lacking. Consequently, while there is a substantial amount of data and approaches available to estimate the progress of non-state and sub-national climate action, we lack understanding of the causal chain, linking voluntary commitments, cooperative initiatives and actual results.

5. Discussion: applying the framework to ghg reductions and adaptation and resilience

The above framework provides a general template for assessing progress in sub- and non-state climate action. To demonstrate a practical way to advance this research agenda, we apply that framework to specific subsets of climate action to demonstrate how it can work in practice. As examples, we highlight climate action that seeks quantitative GHG reductions (Table 2) and climate action aimed at adaptation (Table 3), as these are large areas of practice and a major focus for many actors.

For mitigation, progress on ambition can be measured by looking at actors' GHG reduction targets. The preferred ambition benchmark is ultimately alignment with the Paris Agreement's goal of limiting warming to well below 2°C, or even 1.5°C. More specifically, many actors have adopted 'net zero' emissions before 2050 as a goal following the IPCC's, 2018 Special Report on Global Warming of 1.5°C (IPCC, 2018). The speed with which the actor aims to achieve this result is also a critical benchmark for ambition; some actors likely must reach net zero faster than mid-century, given that others will require greater time and resources. Other relevant benchmarks

Table 2. Tracking progress and impact for GHG reductions.

Type of progress	Benchmarks and baselines	Key indicators	Periodicity of monitoring
Ambition	• 'Business as usual' projected emissions • Alignment with Paris Agreement goals • Previous GHG targets • Peers' GHG targets • Additionality over previous targets and national government targets	• Level and type of target • Intermediate milestones	• Annual
Robustness	• Functional requirements of planned actions • Peer best practices	• Existence of GHG inventory • Technically credible plan for achieving targets • Dedicated budget • Adequate human resources • Robust and credible data • Adequate regulatory authority • Support from key stakeholders and decision-makers	• Annual
Implementation	• Realized outputs versus planned outputs • Fit between outputs and targets	• Adoption of key policies • Implementation of projects	• Annual
Substantive	***Direct*** • GHG baseline • GHG target ***Indirect*** • Demonstration and learning effects on other actors • Setting higher targets in the future	***Direct*** • Change in GHGs ***Indirect*** • Adoption of targets or policies by other actors for which process tracing reveals some degree of attribution	***Direct*** • Annual ***Indirect*** • Ad hoc
Causal	• Effectiveness and efficiency	• All of the above	• Ex post evaluation

Table 3. Tracking progress and impact for adaptation.

Type of progress indicators	Benchmarks and baselines	Key data points	Periodicity of reporting
Ambition	• Share of the projected harm (to lives, GDP, agriculture yields, health, biodiversity, or other dimensions) from climate impacts the actor plans to adapt to, or plans to help others adapt to (quantitative or qualitative)	• Type and specificity of adaptation target	• Annual
Robustness	• Functional requirements of planned actions • Peer best practices	• Detailed estimates of projected climate impacts • Technically credible plan for achieving targets • Dedicated budget • Adequate human resources	• Annual
Implementation	• Fit between outputs and targets	• Adoption of key policies • Implementation of projects • Other outputs	• Annual
Substantive	***Direct***	***Direct***	***Direct***
	• Current or projected values of climate-affected indicators (e.g. mortality or disease rates, crop yields, biodiversity loss)	• Difference between projected impacts on dimensions of interest (e.g. lives lost, health, GDP, etc.) versus actual outcomes	• Annual
	Indirect	***Indirect***	***Indirect***
	• Demonstration and learning effects on other actors • Second-order effects of negative climate impacts on socio-economic outcomes	• Adoption of targets or policies by other actors for which process tracing reveals some degree of attribution • Second-order benefits of positive socio-economic outcomes	• Ad hoc
Causal	• Effectiveness and efficiency	• All of the above	• Post hoc evaluation

may be the actors' previous targets, or those of peers. The adoption of targets, either individually or jointly, is a valid indicator of this form of progress, and can be reported annually.

Robustness, instead, measures actors' ability to achieve these targets, giving an indication of how likely is an actor is to achieve its commitments. The most relevant benchmarks are the functional needs required to achieve the targets that have been adopted (e.g. if a jurisdiction plans to adopt a carbon pricing system, does it have regulators with sufficient expertise to implement this policy?). As noted above, in some cases sub- and non-state actors lack the jurisdictional authority to address a certain sector, so regulatory authority is also a requirement for robustness in many cases. These functional needs can be ascertained from the actors' stated plans, but may also be estimated by those of peers (that is, what similar actors in similar situations declared to be their functional needs). Indicators of progress in this domain are then the presence or absence of those functional attributes (e.g. plans, resources, staffing, etc.) required to implement the project.

Similarly, progress on implementation can be measured by considering what outputs have been successfully delivered as compared to what outputs were planned, or what outputs would be needed to achieve the stated targets (Chan et al., 2018). Assessing implementation can help answer key questions around accountability and further indicate if actors are taking adequate steps to achieve their commitments. Given the wide range of actions and measures that can be used to achieve GHG reductions, these will be unique to the particular plan the actor has adopted.

Finally, substantive progress can be measured most directly against the GHG reduction targets and the actual changes in GHG emissions since the baseline year. This can answer the crucial question of whether the actor has achieved its commitments, or is on track to do so. We must also consider the impact relative

to appropriate benchmarks. If the target was ambitious, the impact may be large even if the targeted outcome was not achieved. Alternatively, even perfect outcomes may have little impact if targets were weak. Overlap and additionality of non-state actors to the national level is also relevant for direct impact (Hsu et al., 2019). Estimating indirect outcomes and impacts, such as demonstration and learning effects on other actors, may be much more complex. Careful research design, likely involving some degree of qualitative process tracing, will be needed to robustly identify these indirect effects.

Table 3 demonstrates how the framework might be applied to adaptation or resilience actions. Such actions are often difficult to measure and quantify because they can involve many different dimensions (e.g. lives lost to extreme weather, agricultural yields, health outcomes, etc.) and actors may not have sufficient data and analysis to understand precisely the impacts they face in the future, particularly in the most vulnerable contexts. Despite these difficulties, measurement is possible and can help actors better address adaptation challenges (Berrang-Ford et al., 2019). In this context, qualitative case studies may be the most useful way to evaluate progress in sub- and non-state adaptation actions. The conceptual framework articulated here can provide a structured way to guide such studies by creating a framework for process-tracing achievement, progress and impact in this critical realm of climate action.

Conclusion

As more and more cities, businesses, investors, and other sub- and non-state actors commit to help achieve global goals alongside national governments, assessing their progress, implementation and impact is critical. The existing literature focuses much more heavily on potential direct impacts on GHGs, and much less on achieved reductions, indirect impacts, and areas of climate action beyond emissions reductions.

The conceptual framework presented above aims to help the research and policy community build a more holistic approach to measuring progress, achievement and impact of climate action, helping to answer a more diverse array of questions. The policy and research community has already begun to focus on this issue. For example, the ACT initiative (formerly ACT project) aims to prospectively assess how companies' commitments match well-below 2°C scenarios requirements, as well as the means of implementation that will be required to achieve them (Faria et al., 2017), and recent studies are also providing post hoc evaluations of climate target achievement (Hsu et al., 2020). More work along these lines will be required going forward. We believe a simple framework like the template presented here can give policymakers a practical way to further realize the benefits of tracking progress specified in section two.

These findings highlight several important areas for further research. First, the need for more complex models to fully capture the interaction dynamics of climate action amongst sub- and non-state actors, and between such actors and national governments, is apparent. For example, while previous studies have tended to identify positive reinforcement, many dynamics are possible (e.g. substitution, reinforcement, trade-offs, synergies, catalysis) (Andonova et al., 2017; Puig & Bakhtiari, 2020). This issue highlights the inherent complexity of assessing any policy area, but particularly one with as many different actors, spheres and sites of activity as climate action.

Second, despite this challenge, there is still a need for more research to assess what makes climate action more or less successful, effective, and efficient. Gaining a better understanding of how to improve different forms of climate action across these dimensions will allow policymakers to better design and implement cooperative initiatives.

If practitioners and researchers of sub- and non-state climate action can rise to these challenges, the manifold benefits outlined in section two will not only improve efforts by individual cities, businesses, or cooperative initiatives, but can also catalyze climate efforts more broadly, by inspiring peers to follow and helping national governments to increase their own action. With sub- and non-state climate action now a key part of our global response, stronger tracking of progress, implementation, and impact is needed to realize its full potential.

Notes

1. Formerly the 'Non-state Actor Zone for Climate Action' (NAZCA).

2. UNFCCC Conferences of the Parties 20-24, the UN Climate Summit in 2014, the Global Climate Action Summit in 2018, the UN Climate Action Summit in 2019. To obtain a list of associated reports, we reviewed all conference websites and press releases, including, for the COPs all official side-events. This approach may have missed reports launched at events 'alongside' COPs but not officially connected to the UNFCCC meetings. We should therefore interpret the results as emphasizing those studies and reports more closely linked to the UNFCCC process.
3. C40, ICLEI, the Under 2 Coalition, We Mean Business, World Business Council on Sustainable Development
4. Climate Policy, Nature Climate Change, WIRES Climate Change. While relevant studies may also have been published in other journals, these three journals provide a useful window into the broader literature.
5. Information about CAMDA can be found on the UNFCCC website: https://unfccc.int/sites/default/files/resource/Recording-ProgressStatement.pdf (Accessed July 5, 2020).
6. However, a number of academic studies have assessed the opposite causal direction, evaluating how joining transnational networks affects actors' climate policies and actions (Lee, 2018; Leal & Azevedo, 2016; Croci et al., 2017).

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Thomas N. Hale http://orcid.org/0000-0002-8871-3376
Sander Chan http://orcid.org/0000-0001-7852-3838
Angel Hsu http://orcid.org/0000-0003-4913-9479
Andrew Clapper http://orcid.org/0000-0002-4158-4116
Takeshi Kuramochi http://orcid.org/0000-0002-3976-0133
Mark Roelfsema http://orcid.org/0000-0003-2316-2101
Neelam Singh http://orcid.org/0000-0002-9377-4915
Oscar Widerberg http://orcid.org/0000-0002-8088-3709

References

America's Pledge Initiative on Climate. (2018). Fulfilling America's Pledge: How states, cities, and business are leading the United States to a low-carbon future.

Andersson, K. P., & Ostrom, E. (2008). Analyzing decentralized resource regimes from a polycentric perspective. *Policy Sciences*, *41*(1), 71–93. https://doi.org/10.1007/s11077-007-9055-6

Andonova, L. B., Hale, T. N., & Roger, C. B. (2017). National policy and transnational governance of climate change: Substitutes or complements? *International Studies Quarterly*, *61*(2), 253–268. https://doi.org/10.1093/isq/sqx014

Bennett, C. J., & Howlett, M. (1992). The lessons of learning: Reconciling theories of policy learning and policy change. *Policy Sciences*, *25*(3), 275–294. https://doi.org/10.1007/BF00138786

Berrang-Ford, L., Biesbroek, R., Ford, J. D., Lesnikowski, A., Tanabe, A., Wang, F. M., Chen, C., Hsu, A., Hellmann, J. J., Pringle, P., Grecequet, M., Amado, J.-C., Huq, S., Lwasa, S., & Heymann, S. J. (2019). Tracking global climate change adaptation among governments. *Nature Climate Change*, *9*(6), 440–449. https://doi.org/10.1038/s41558-019-0490-0

Bodansky, D. (2016). The Paris climate change Agreement: A new hope? *American Journal of International Law*, *110*(2), 288–319. https://doi.org/10.5305/amerjintelaw.110.2.0288

Bulkeley, H., Andonova, L. B., Betsill, M. M., Compagnon, D., Hale, T., Hoffmann, M. J., Newell, P., Paterson, M., VanDeveer, S. D., & Roger, C. (2014). *Transnational climate change governance*. Cambridge University Press.

C40 & ARUP. (2015). *Powering climate action: Cities as global changemakers*. C40 & ARUP. London.

CDP. (2019). *Cascading commitments: Driving ambitious action through supply chain engagement*. CDP. London.

Chan, S., Boran, I., van Asselt, H., Iacobuta, G., Niles, N., Rietig, K., Scobie, M., Bansard, J. S., Delgado Pugley, D., Delina, L. L., Eichhorn, F., Ellinger, P., Enechi, O., Hale, T., Hermwille, L., Hickmann, T., Honegger, M., Hurtado Epstein, A., La Hoz Theuer, S., … Wambugu, G. (2019). Promises and risks of nonstate action in climate and sustainability governance. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(3), e572. https://doi.org/10.1002/wcc.572

Chan, S., Falkner, R., Goldberg, M., & van Asselt, H. (2018). Effective and geographically balanced? An output-based assessment of non-state climate actions. *Climate Policy*, *18*(1), 24–35. https://doi.org/10.1080/14693062.2016.1248343

ClimateSouth. (2018). Cooperative climate action 2013–2018: Global performance and geographic scope.

Coleman, G. (1987). Logical framework approach to the monitoring and evaluation of agricultural and rural development projects. *Project Appraisal*, *2*(4), 251–259. https://doi.org/10.1080/02688867.1987.9726638

Croci, E., Lucchitta, B., Janssens-Maenhout, G., Martelli, S., & Molteni, T. (2017). Urban CO2 mitigation strategies under the Covenant of Mayors: An assessment of 124 European cities. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2017.05.165

Faria, P., Hekman, J., Poivet, R., Stoakes, E., & Willoughby, C. (2017). *ACT: Assessing Low Carbon transition*. CDP. London.

Farmer, J. D., Hepburn, C., Ives, M. C., Hale, T., Wetzer, T., Mealy, P., Rafaty, R., Srivastav, S., & Way, R. (2019). Sensitive intervention points in the post-carbon transition. *Science*, *364*(6436), 132–134. https://doi.org/10.1126/science.aaw7287

Gasper, D. (2000). Evaluating the 'logical framework approach' towards learning-oriented development evaluation. *Public Administration and Development*, *20*(1), 17–28. https://doi.org/10.1002/1099-162X(200002)20:1<17::AID-PAD89>3.0.CO;2-5

Gilligan, J. M., & Vandenbergh, M. P. (2020). A framework for assessing the impact of private climate governance. *Energy Research & Social Science*, *60*, 101400. https://doi.org/10.1016/j.erss.2019.101400

Gottschick, M. (2018). Reflexive capacity in local networks for sustainable development: Integrating conflict and understanding into a multi-level perspective transition framework. *Journal of Environmental Policy & Planning*, *20*(6), 704–719. https://doi.org/10.1080/1523908X.2013.842890

Hale, T. (2016). "All hands on deck": The Paris agreement and nonstate climate action. *Global Environmental Politics*, *16*(3), 12–22. https://doi.org/10.1162/GLEP_a_00362

Hendriks, C. M., & Grin, J. (2007). Contextualizing reflexive governance: The politics of Dutch transitions to sustainability. *Journal of Environmental Policy & Planning*, *9*(3-4), 333–350. https://doi.org/10.1080/15239080701622790

Höhne, N., den Elzen, M., & Escalante, D. (2014). Regional GHG reduction targets based on effort sharing: A comparison of studies. *Climate Policy*, *14*(1), 122–147. https://doi.org/10.1080/14693062.2014.849452

Höhne, N., Kuramochi, T., Sterl, S., & Gonzales-Zuñiga, S. (2016). *The business end of climate change: How bold corporate action supported by smart policy can keep temperature rise below 2C*.

Howlett, M. (2009). Policy analytical capacity and evidence-based policy-making: Lessons from Canada. *Canadian Public Administration*, *52*(2), 153–175. https://doi.org/10.1111/j.1754-7121.2009.00070_1.x

Hsu, A., Höhne, N., Kuramochi, T., Roelfsema, M., Weinfurter, A., Xie, Y., Lütkehermöller, K., Chan, S., Corfee-Morlot, J., Drost, P., Faria, P., Gardiner, A., Gordon, D. J., Hale, T., Hultman, N. E., Moorhead, J., Reuvers, S., Setzer, J., Singh, N., … Widerberg, O. (2019). A research roadmap for quantifying non-state and subnational climate mitigation action. *Nature Climate Change*, *9*(1), 11–17. https://doi.org/10.1038/s41558-018-0338-z

Hsu, A., Tan, J., Ng, Y. M., Toh, W., Vanda, R., & Goyal, N. (2020). Performance determinants show European cities are delivering on climate mitigation. *Nature Climate Change*. https://doi.org/.org/10.1038/s41558-020-0879-9

Hsu, A., Weinfurter, A., Feierman, A., Xie, Y., Yeo, Z. Y., Lütkehermöller, K., & Roelfsema, M. (2018). *Global climate action of regions, states and businesses*. Retrieved from http://bit.ly/yale-nci-pbl-global-climate-action

Imperial, M. T. (1999). Institutional analysis and ecosystem-based management: The institutional analysis and development framework. *Environmental Management*, *24*(4), 449–465. https://doi.org/10.1007/s002679900246

IPCC. (2018). *Intergovernmental panel on climate change special report on global warming of 1.5C*.

Kuramochi, T., Roelfsema, M., Hsu, A., Lui, S., Weinfurter, A., Chan, S., Hale, T., Clapper, A., Chang, A., & Höhne, N. (2020). Beyond national climate action: The impact of region, city, and business commitments on global greenhouse gas emissions. *Climate Policy*, *20*(3), 275–291. https://doi.org/10.1080/14693062.2020.1740150

Kuyper, J. W., Linnér, B. O., & Schroeder, H. (2018). Non-state actors in hybrid global climate governance: Justice, legitimacy, and effectiveness in a post-Paris era. *Wiley Interdisciplinary Reviews: Climate Change*, *9*(1), e497. https://doi.org/10.1002/wcc.497

Lamb, W. F., Creutzig, F., Callaghan, M. W., & Minx, J. C. (2019). Learning about urban climate solutions from case studies. *Nature Climate Change*, *9*(4), 279–287. https://doi.org/10.1038/s41558-019-0440-x

Leal, V. M. S., & Azevedo, I. (2016). Setting targets for local energy planning: Critical assessment and a new approach. *Sustainable Cities and Society*. https://doi.org/10.1016/j.scs.2016.04.010

Lee, T. (2018). Local energy agencies and cities' participation in translocal climate governance. *Environmental Policy and Governance*. https://doi.org/10.1002/eet.1798

Lui, S., Kuramochi, T., Smit, S., Roelfsema, M., Hsu, A., Weinfurter, A., Chan, S., Hale, T., Fekete, H., Lütkehermöller, K., de Villafranca Casas, M. J., Nascimento, L., Sterl, S., & Höhne, N. (2020). Correcting course: The emission reduction potential of international cooperative initiatives. *Climate Policy*. https://doi.org/10.1080/14693062.2020.1806021

Meadowcroft, J., & Steurer, R. (2018). Assessment practices in the policy and politics cycles: A contribution to reflexive governance for sustainable development? *Journal of Environmental Policy & Planning*, *20*(6), 734–751. https://doi.org/10.1080/1523908X.2013.829750

Michaelowa, K., & Michaelowa, A. (2017). Transnational climate governance initiatives: Designed for effective climate change mitigation? *International Interactions*, *43*(1), 129–155. https://doi.org/10.1080/03050629.2017.1256110

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for collective action*. Cambridge University Press.

Persson, Å, Weitz, N., & Nilsson, M. (2016). Follow-up and review of the sustainable development goals: Alignment vs. internalization. *Review of European, Comparative & International Environmental Law*, *25*(1), 59–68. https://doi.org/10.1111/reel.12150

Puig, D., & Bakhtiari, F. (2020). Determinants of successful delivery by non-state actors: An exploratory study. *Int Environ Agreements*. https://doi.org/.org/10.1007/s10784-020-09482-8

Robiou du Pont, Y., Jeffery, M. L., Gütschow, J., Rogelj, J., Christoff, P., & Meinshausen, M. (2016). Equitable mitigation to achieve the Paris Agreement goals. *Nature Climate Change*, *7*(1), 38–43. https://doi.org/10.1038/nclimate3186

Roger, C., Hale, T., & Andonova, L. B. (2017). The comparative politics of transnational climate governance. *International Interactions*, *43*(1), 1–25. https://doi.org/10.1080/03050629.2017.1252248

Sabatier, P. A., & Jenkins-Smith, H. (1993). *Policy change and learning: An advocacy coalition framework*. Westview Press.

Sartorius, R. H. (1991). The logical framework approach to project design and Management. *Evaluation Practice*, *12*(2), 139–147. https://doi.org/10.1016/0886-1633(91)90005-I

Schneider, S. H. (2004). Abrupt non-linear climate change, irreversibility and surprise. *Global Environmental Change*, *14*(3), 245–258. https://doi.org/10.1016/j.gloenvcha.2004.04.008
UNFCCC. (2018). *Yearbook of Global climate action 2018*. United Nations Framework Convention on Climate Change. Bonn.
UNFCCC. (2019). *Yearbook of climate action 2019*. United Nations Framework Convention on Climate Change. Bonn.
Uwizeyimana, D. E. (2020). The logframe as a monitoring and evaluation tool for government interventions in a chaotic and complex environment. *Africa's Public Service Delivery and Performance Review*, *8*(1), 1–12. https://doi.org/10.4102/apsdpr.v8i1.328
Widerberg, O., & Stripple, J. (2016). The expanding field of cooperative initiatives for decarbonization: A review of five databases. *Wiley Interdisciplinary Reviews: Climate Change*, *7*(4), 486–500. https://doi.org/10.1002/wcc.396

Appendix 1: studies analyzed

Compact of Mayors. (2015). Climate Leadership at the Local Level: Global Impact of the Compact of Mayors.
Arup & C40 Cities. (2014). Global Aggregation of City Climate Commitments.
The Climate Group. (2015). Compact of States and Regions Disclosure Report 2015.
The Climate Group. (2016). Compact of States and Regions Disclosure Report 2016.
The Climate Group. (2017). Compact of States and Regions Disclosure Report 2017.
The Climate Group. (2018). Compact of States and Regions Disclosure Report 2018.
CDP (2016). Out of the starting blocks: Tracking progress on corporate climate action.
The business end of climate change
CDP & Carbon Trust. (2019). Cascading Commitments: Driving ambitious action through supply chain engagement. CDP Supply Chain Report 2018/19.
CDP. (2018). CDP Supply Chain Report 2017 / 2018.
Hsu, A., Moffat, A.S., Weinfurter, A.J., and Schwartz, J.D. (2015). Towards a New Climate Diplomacy. Nature Climate Change 5, 501–503.
Roelfsema, M., Harmsen, M., Olivier, J. and Hof, A. (2015). Climate action outside the UNFCCC; Assessment of the impact of international cooperative initiatives on greenhouse gas emissions. The Hague; PBL Netherlands Environmental Assessment Agency.
Roelfsema, M. (2017). Assessment of US City Reduction Commitments, from a Country Perspective.
United Nations Environment Programme (UNEP). (2015). Climate commitments of subnational actors and business: A quantitative assessment of their emission reduction impact.
Graichen, J., et al. (2017). International Climate Initiatives – A way forward to close the emissions gap? Öko-Institut e.V., NewClimate Institute, & Fraunhofer-Institut für System- und Innovationsforschung ISI.
Kuramochi, T., Höhne, N., Sterl, S., Lütkehermöller, K., and Seghers, J.C. (2017). States, cities and businesses leading the way: a first look at decentralized climate commitments in the US. NewClimate Institute and The Climate Group.
New Climate Economy. (2015). Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate. Urban section draws from and summarizes: Gouldson, A., Colenbrander, S., Godfrey, N., Sudmant, A., Millward-Hopkins, J., Fang, W. and Zhao, X., 2015. Accelerating Low-Carbon Development in the World's Cities. A New Climate Economy contributing paper for Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate. Available at: http://newclimateeconomy. report/misc/working-papers.
U.S. Climate Alliance Annual Report: Alliance States Take the Lead. (2017).
U.S. Climate Alliance Annual Report: Fighting for our Future. (2018).
ICELI. (2015). Measuring Up 2015: How US Cities Are Accelerating Progress Toward National Climate Goals
Carbon Climate Registry (2015) – 5 year overview report (2010–2015)
ICLEI, C40. SDI. UN-Habitat, & 100RC. Data speak louder than words: Findings from an initial stocktake of climate change adaptation and urban resilience efforts.
Albana Kona, Giulia Melica, Brigitte Koffi, Andreea Iancu, Paolo Zancanella, Silvia Rivas Calvete, Paolo Bertoldi, Greet Janssens-Maenhout, Fabio Monforti-Ferrario. (2016). Covenant of Mayors: Greenhouse Gas Emissions Achievements and Projections.
RE100 Annual Report 2016: Growing Market Demand for Renewable Power.
RE100 Annual Report 2017: Accelerating Change: how corporate users are transforming the renewable energy market.
RE100 Progress and Insights Annual Report, November 2018
C40 Cities & Arup. (2016). Deadline 2020: How U.S. cities will get the job done
C40 Cities & Arup. (2016). Deadline 2020: How cities will get the job done
Broekhoff, D., Erickson, P., & Lee, C. M. (2015). What cities do best: Piecing together an efficient global climate governance. Stockholm Environment Institute Working Paper 2015–15.
America's Pledge. (2017). America's Pledge Phase 1 Report: States, Cities, and Businesses in the United States Are Stepping Up on Climate Action
America's Pledge. (2018). Fulfilling America's Pledge: How States, Cities, and Businesses Are Leading the United States to a Low-Carbon Future
United Nations Climate Change Secretariat. (2017). Yearbook of Global Climate Action 2017: Marrakech Partnership.
United Nations Climate Change Secretariat. (2018). Yearbook of Global Climate Action 2018: Marrakech Partnership.

Global Covenant of Mayors for Climate and Energy. (2017). Raising Global Climate Ambition: Aggregate Impact of the Global Covenant of Mayors for Climate and Energy.
Global Covenant of Mayors 2018 Global Aggregation Report.
Erickson, P., Tempest, K. (2014). Advancing climate ambition: How city-scale actions can contribute to global climate goals
JOHN MOORHEAD (BSD CONSULTING) AND TIM NIXON (THOMSON REUTERS). (2016). GLOBAL 3500 GREENHOUSE GAS PERFORMANCE 2010–2015 KEY TRENDS & OPPORTUNITIES FOR LEADERSHIP
Data Driven Yale, NewClimate Institute, PBL 2018: Global climate action of regions, states and businesses. Research report published by Data Driven Yale, NewClimate Institute, PBL Netherlands Environmental Assessment Agency, prepared by project team of Angel Hsu, Amy Weinfurter, Andrew Feierman, Yihao Xie, Zhi Yi Yeo, Katharina Lütkehermöller, Takeshi Kuramochi, Swithin Lui, Niklas Höhne, Mark Roelfsema. Available at http://bit.ly/yale-nci-pbl-global-climate-action.
NYDF Assessment Partners. 2018 Progress Assessment on the New York Declaration on Forests. Available: http://www.forestdeclaration.org/wp-content/uploads/2018/12/nydf_report_2018-121818.pdf
International Cooperative Initiatives in Global Climate Governance: Raising the Ambition Level or Delegitimizing the UNFCCC?
Chan, S., Falkner, R., Goldberg, M. and van Asselt, H. (2016) Effective and geographically balanced? An output-based assessment of non-state climate actions. Climate Policy. ISSN 1469–3062
Hsu, A., Widerberg, O., Weinfurter, A., Chan, S., Roelfsema, M., Lütkehermöller, K., Bakhtiari, F. (2018). Chapter 5. Bridging the gap: The role of non-state and subnational actors. In Emissions Gap Report 2018. UN Environment: Nairobi.
Universal Metrics to Compare the Effectiveness of Climate Change Adaptation Projects?
JD Ford, L Berrang-Ford, R Biesbroek, M Araos, SE Austin, A Lesnikowski. (2015). Adaptation tracking for a post-2015 climate agreement. Nature Climate Change 5 (11), 967
M Araos, L Berrang-Ford, JD Ford, SE Austin, R Biesbroek, A Lesnikowski. (2016). Climate change adaptation planning in large cities: A systematic global assessment. Environmental Science & Policy 66, 375–382
Dupuis, J. & Biesbroek, R. (2013). Comparing apples and oranges: the dependent variable problem in comparing and evaluating climate change adaptation policies. Global Environmental Change (IN PRESS).
E Massey, R Biesbroek, D Huitema, A Jordan. (2014). Climate policy innovation: the adoption and diffusion of adaptation policies across Europe. Global environmental change 29, 434–443.
CONNELL, J. P. & KUBISCH, A. C. 1998. Applying a theory of change approach to the evaluation of comprehensive community initiatives: progress, prospects, and problems. In: Karen Fulbright-Anderson, Anne C. Kubisch and James P. Connell, eds. New approaches to evaluating community initiatives: Volume 2 Theory, Measurement and Analysis. Washington, DC: Aspen Institute. 15–44.
Averchenkova, A., & Bassi, S. (2016). Beyond the targets: assessing the political credibility of pledges for the Paris Agreement.
GHG Protocol Mitigation Goal Standard. 2014. Washington, DC: World Resources Institute. Accessible at http:// www.ghgprotocol.org/mitigation-goal-standard
GHG Protocol Policy and Action Standard. 2014. Washington, DC: World Resources Institute. Accessible at http://www.ghgprotocol.org/policy-and-action-standard.
Ge, M., K. Lebling, K. Levin, and J.
Friedrich. 2019. 'Tracking Progress of the 2020 Climate Turning
Point.' Working Paper. Washington, DC: World Resources
Institute. Available online at https://wri.org/2020-turning-pointprogress.
Hovi, Sprinz, and Underdal: 'The Oslo-Potsdam Solution to Measuring Regime Effectiveness:
Critique, Response, and the Road Ahead.'
Kutting, Gabriela, Environment, Society and International Relations: Toward More Effective International Environmental Agreements, Routledge. 2000, chapter 3 (Available as e-book via Yale Library at http://site.ebrary.com/lib/yale/docDetail.action?docID=10070514
O'Neill, Chapter 5; Introduction: The Environment and International Relations; 2 Global Environmental Problems 28; 4 State-Led Global Environmental Governance 79
Pam Chasek, David Downie, and Janet Welsh Brown, Global Environmental Politics: Dilemmas in World Politics: Sixth Edition, Chapter 5
Urban Climate Action Impacts Framework: A Framework Describing and Measuring the Wider Impacts of Urban Climate Action
CDP. (2019). The Sustainable Development Goals and the future of corporate reporting
Jaquot, P. (2013). Contribution of four initiatives from the 'Wedging the Gap' approach to achieve Copenhagen climate-change mitigation target. Wageningen University MsC Thesis.
de Boer, T. (2014). Wedging the Gap: Possible Impact of a 'Top 1000 Companies' Emission Reduction Initiative for Greenhouse Gas Mitigation in 2020. Wageningen University MsC Thesis.
Kovac, A. and W. K. Fong. 2015. 'Compact of Mayors Emissions Scenario Model.' Technical Note. Washington, D.C.: World Resources Institute. Available online at: www.wri.org/publication/compactdata2015