Chapter 14: International cooperation

Coordinating Lead Authors: Anthony Patt (Switzerland), Lavanya Rajamani (India)

Lead Authors: Antonina Ivanova Boncheva (Mexico), Alejandro Caparrós (Spain), Kamal Djemouai (Algeria), Izumi Kubota (Japan), Jacqueline Peel (Australia), Detlef F. Sprinz (Germany), Jørgen Wettestad (Norway)

Contributing Authors: Rachael Garett (Switzerland/USA), Oliver Geden (Germany), Kilian Raiser (Germany)

Review Editors: Esther Badiola (Spain); Pasha Carruthers (Cook Islands)

Chapter Scientist: Zyaad Boodoo (Mauritius)

Date of Draft: 08/01/2020

Table of Contents

Executive summary

International cooperation is vital for achieving climate mitigation goals in the context of sustainable development, but new considerations that have emerged since AR5 are relevant for assessing the effectiveness of particular forms of cooperation (*robust evidence, high agreement*) {14.3}. First, there are important synergies between undertaking climate mitigation and achieving other sustainable development objectives (*robust evidence, high agreement*). Second, there is an increasing recognition that sub-global and regional agreements, often described as "climate clubs," can play an important role in accelerating mitigation (*medium evidence, high agreement*). Third, the emerging study of socio-technological transitions suggests that international cooperation can be effective when it directly supports countries' development and diffusion of low-carbon technologies, often at the level of individual sectors (*medium evidence, medium agreement*).

The Paris Agreement represents an important new direction in international cooperation for climate policy, and its architecture is fundamentally different from that of the Kyoto Protocol (*robust evidence, high agreement*) {14.4}. The core national commitments under the Kyoto Protocol were oriented towards emissions outcomes, and tied to regimes for monitoring and enforcement, whereas those under the Paris Agreement are process-related (*robust evidence, high agreement*). The processes that parties commit to participate in are designed to build capacity and stimulate climate investments, particularly in developing countries, and to lead to rising levels of ambition across all countries (*robust evidence, high agreement*).

The effectiveness of the Paris Agreement is contested, and reveals conflicting views held by different scholars {14.4.2}. The strongest critique of the Paris Agreement is that current Nationally Determined Contributions (NDCs) are inconsistent in their level of ambition with achieving global climate mitigation goals identified in the Paris Agreement (*robust evidence, high agreement*). Arguments in support of the Paris Agreement are that the processes it initiates and supports will lead to rising levels of ambition over time, drawing from empirically grounded theories of technological transitions (*medium evidence, medium agreement*). These are met with counter arguments, either suggesting that the necessary change cannot happen within the narrow window of opportunity to avoid dangerous climate change, or that the incentives created under the Paris Agreement are insufficient to lead to necessary changes (*medium evidence, medium agreement*). The extent to which countries increase the ambition of their NDCs in the near future will determine the effectiveness of the Paris Agreement.

International cooperation outside of the UNFCCC is playing an increasingly important role in climate mitigation (*medium evidence, high agreement*) {14.4.3, 14.5}. Conventions addressing ozone depletion, transboundary air pollution, and mercury deposition all are leading to reductions in the emissions of greenhouse gases (*robust evidence, high agreement*). Climate change concerns are being reflected in a growing number of international agreements operating at the sub-global or sectoral levels, as well as within the practices of a number of multilateral institutions (*robust evidence, high agreement*). Trans-national partnerships and alliances involving non-state and sub-state actors are playing a growing role in stimulating low-carbon technology diffusion and emissions reductions (*medium evidence, medium agreement*).

International cooperation will have to be strengthened in several key respects in order to have a strong effect, consistent with achieving the mitigation goals in the Paris Agreement (*limited evidence, high agreement*) {14.6}. There are some areas where international cooperation has already had a strong effect, such as reducing many countries' CO_2 emissions from the AFOLU sector, as well as emissions of some non-CO_2 greenhouse gases (*medium evidence, medium agreement*). In most

areas, considering not only environmental effectiveness but also transformative potential, distributive outcomes, economic performance, and institutional strength, international cooperation is having a positive effect, but one that is as yet too weak to achieve the objectives of the Paris Agreement (*medium evidence, medium agreement*). In some areas, such as reducing non-CO_2 emissions from the AFOLU sector or promoting and managing technologies for negative emissions and solar radiation modification, international cooperation is currently having little to no effect (*robust evidence, high agreement*).

14.1 Introduction

This chapter assesses the role of international cooperation in mitigating the effects of climate change. Such cooperation includes multilateral global cooperative agreements between nation states such as within the context of the United Nations Framework Convention on Climate Change (UNFCCC) regime, but also plurilateral agreements involving fewer states, as well as those focused on particular economic and policy sectors, such as components of the energy system. Moreover, we assess the role of transnational agreements and cooperative arrangements between non-state and sub-state actors, including municipal governments, private-sector firms and industry consortia, and civil society organizations.

Past IPCC assessment reports have devoted considerable space to the theoretical literature, providing insights into the rationale for international cooperation, as well as guidance as to its structure and implementation. This chapter limits such theoretical discussion primarily to the new developments since AR5. Important developments in this respect are the Paris Agreement, and rules thereunder, attention to climate clubs – groups of countries that can work together to achieve particular objectives – and the effects of framing climate change mitigation as a problem of accelerating a socio-technical transition or transformation, in addition to (or rather than) solving a global commons problem.

The bulk of this chapter is then devoted to describing the existing cooperative international agreements, institutions, and initiatives with a view to clarifying how they operate, what effects they are meant to have, and ultimately, whether they are working. At the heart of this lies the Paris Agreement, which has taken over from the Kyoto Protocol as setting the overall framework for international cooperation at the global scale. In many ways, the Paris Agreement fundamentally reshapes the intention and structure of such cooperation, from one oriented around target setting, monitoring, and enforcement, to one that is oriented around supporting and enabling nationally determined actions, as well as catalysing non-state and sub-state actions. In addition to the Paris Agreement, there are many other forms of cooperation that have taken shape in parallel: those designed to address other environmental problems that have a significant impact on climate mitigation; those operating at the sub-global or sectoral level; and, those where the main participants are not nation states, but rather other organizations, including sub-national governments, private industry, and civil society. Early on, this chapter identifies and describes a set of criteria and indicators for assessing the effectiveness of each of these agreements, institutions, and initiatives. We use these criteria and indicators to assess the ongoing effectiveness of each of the forms of cooperation that we describe. Near the end of the chapter we synthesize these results to make an overall assessment of the effectiveness of international cooperation as it exists today, and to identify areas where the need for improved cooperation is acute.

14.2 Key findings from AR5 and recent developments

14.2.1 Key findings from AR5

AR5 found that two characteristics of climate change make international cooperation essential. First, it is a global commons problem; and second, the opportunities for mitigation, the origins of GHG emissions, the climate impacts, and the capacity for mitigation and adaptation are highly diverse (Chapter 13, 13.2.1.1). Consequently, evidence suggests that climate policies that are implemented across geographical regions are more effective (Chapter 13, 13.13, 13.6, 14.4). In the past, international cooperation has focused mainly on the coordination of national policies to address mitigation. More recently, there is recognition that regional cooperation offers opportunities beyond what countries are able to achieve through implementation in isolation. These opportunities are due to

geographic proximity, shared infrastructure and policy frameworks, trade, and cross-border investments. Examples include renewable energy pools across border, networks of energy infrastructure and coordinated forestry policies (Chapter 1, 1.2; Chapter 6, 6.6; Chapter 15, 15.2; 14.2). Policy linkages among regional, national, and sub-national climate policies also offer climate change and adaptation benefits (Chapter 13, 13.3.1, 13.5.1.3). Although UNFCCC remains the primary international forum for climate negotiations, many other institutions have become actively engaged at the global, regional, and local level, making international cooperation on climate change more institutionally diverse (Chapter 1, 1.3.3.1; Chapter 13, 13.4.1.4, 13.5). The inclusion of climate change issues across many other sectors and policy arenas have contributed to this diversity and has facilitated linkages between mitigation and adaptation (Chapter 13, 13.3, 13.4.13.5). Whereas international cooperation has traditionally been ruled by centralized authority, there is now the emergence of new transnational climate-related institutions of decentralized authority such as public-private sector partnerships, private sector governance initiatives, transnational NGO programs and city-let initiatives (Chapter 13, 13.2, 13.3.1, 13.12). These have resulted in a multiplicity of cooperation in the form of multilateral agreements, harmonized national policies and decentralized but coordinated national and regional policies (TS 38, Chapter 13, 13.4.1, 13.3.2, 14.4). International cooperation may also have a role in promoting a more active engagement of the private sector in technological innovation and cooperative efforts leading to technology transfer and development of new technologies (Chapter 13, 13.3, 13.9, 13.12).

14.2.2 Developments since AR5

14.2.2.1 Negotiation of the Paris Agreement

There architecture of global climate governance shifted fundamentally from Kyoto to Paris. This shift was driven by the need to engage developing countries in emissions reductions, to extend mitigation commitments to those developed countries that had rejected or withdrawn from the Kyoto Protocol, and to respond to the rapidly changing geopolitical context. The 2015 Paris Agreement is the culmination of a quarter-century of international climate diplomacy, launched with the UNFCCC at the Earth Summit in Rio de Janeiro. We provide an overview of the negotiations that led to the Paris Agreement in section 14.4.

14.2.2.2 2030 Agenda for Sustainable Development and the Sustainable Development Goals

On 25 September 2015, all the member states of the United Nations endorsed the 2030 Agenda for Sustainable Development, which contains 17 Sustainable Development Goals (SDGs). Through an aspirational narrative for future development and an actionable agenda, the SDGs offer a coherent framework for addressing diverse issues of development through goals that balance the economic, social and environmental dimensions of sustainable development as well as issues of governance and institutions (ICSU ISSC 2015). Scholars have noted that their implicit logic makes them dependent on each other (Nilsson, Mans, Griggs, Dave, Visbek 2016), and this inter-dependency reflects a belief that it is difficult if not impossible to achieve economic and social gains while neglecting environmental concerns, including climate change. The SDGs are therefore a framework to help countries address the challenges of development while addressing climate change (Le Blanc 2015), and are inextricably linked to the Paris Agreement, adopted a few weeks later. A large body of literature has focused on this linkage and on the socio-economic benefits of addressing climate change. AR5 provides an overview of the impacts of climate change on several sectors of the economy, finding that climate change exacerbates existing poverty, accentuates vulnerability and worsens inequality (IPCC 2014). But there is also a growing body of literature that examines the interlinkages between SDGs, including SDG 13 and others, concluding that without a proper response to climate change, success in many of the other SDGs would be difficult if not impossible (ICSU ISSC 2015; Le Blanc 2015; Nilsson, Mans, Griggs, Dave, Visbek 2016). Initiatives such as The

World in 2050 (TWI2050 2018), a large research initiative by a consortium of research and policy institutions from around the world, are based on the premise that pursuing climate action and sustainable development in an integrated and coherent way offers the strongest approach to enable countries to achieve their objectives in both agreements. But, TWI2050 suggests, this can only happen through truly integrated, comprehensive understanding of sustainable development pathways, accounting for the interlinkages (TWI2050 2018). In sum, the growing literature is evidence of the increasing awareness of the development co-benefits of climate mitigation, and linkages between these two issue areas.

14.2.2.3 IPCC 1.5 Special Report

In 2018 the IPCC released a special report on global warming of 1.5°C (IPCC 2018a). The report assessed on the one hand the differential impacts of limiting climate change to 1.5°C global average warming compared to 2°C warming, and on the other hand the emissions reductions necessary to stay within this limit. While the events that have unfolded since the report are recent, and not yet well documented in the literature, there are arguments that the report has led to a new perception of the urgency of climate mitigation (Wolf et al. 2019). In particular, the report appears to have crystalized media coverage around a need to reduce CO_2 emissions to net zero by 2050, rather than delaying such reductions until the latter half of the century, as had been previously understood. Its release is hence one factor explaining the rise in a trans-national climate mobilization efforts (Boykoff and Pearman 2019). There is reason to believe that the adoption of net zero targets for 2050 by a number of governments – at time of writing most recently by the European Union – follows as a result, although there is no literature as of yet testing this proposition.

14.3 Key concepts and frames for assessing international cooperation

14.3.1 Framing concepts for international climate policy

One of the developments in AR6 is the framing of climate mitigation not only as one of managing global commons or a public good, but also as one triggering a transformation to a low carbon society. As described briefly in this section, there are clear points of overlap between these two framings in the application to challenges of international cooperation, but there are also important differences. A brief understanding of these issues is important for assessing the value of existing international cooperation and understanding whether new forms of cooperation are valuable.

As pointed out in previous IPCC reports, climate change mitigation can be framed as a public good because benefits are non-excludable (everybody can enjoy the benefits of a more stable climate) and non-rival (the enjoyment of a stable climate by one party does not interfere with the enjoyment by another party) (Stavins et al. 2014). This is consistent with framing climate change as a tragedy of the commons problem (Gordon 1954; Hardin 1968). This framing implies that, although countries may abate emissions based on their own interest, they would abate more if they take into account that reducing their emissions benefits not only themselves but also other countries as well. It also implies that, although an international agreement could potentially bring the world closer to fully cooperative abatement levels, such an agreement is difficult to reach and enforce due to the incentives to free-ride (Gollier and Tirole 2015). The theory does not preclude that one particular country may be interested in reducing its emissions based only on its own interest, potentially even bringing its greenhouse gas (GHG) emissions to zero. However, in this case too, the country would be interested in making such a transition to a zero-carbon economy even faster if it were to take into account the benefits to other countries. In general, the literature considers that without international cooperation, mitigation efforts at a global level would be at best modest, mainly due to the free-rider problem (Stavins et al. 2014), although recent theoretical developments point to factors that can mitigate this (Battaglini and Harstad 2016). The public goods framing suggests that only a fully multilateral binding agreement, covering

all the countries of the world, could ensure that countries would take into account all the benefits that they are inducing to others by reducing their abatement (Stavins et al. 2014). However, given the difficulties encountered in reaching such an agreement (Asheim et al. 2006; Froyn and Hovi 2008), recent developments emphasize the importance of regional or sectoral agreements, or agreements focused on a particular subset of GHGs, which can be seen as building blocks towards a global approach (Sabel and Victor 2017; Stewart et al. 2017; Caparrós and Péreau 2017). The fact that global emissions have continued to grow (IPCC 2018b) can be taken as support for the proposition that the free-rider problem is important.

In addition to mitigation, technology innovation (knowledge) also has public good features: it is generally non-rival and partially non-excludable, resulting in less innovation than ideal in the absence of public-sector intervention (Jaffe et al. 2005). The combination of infrastructure lock-in, network effects with high switching cost, and dynamic market failures suggests that deployment and adoption of clean technologies is path dependent (Aghion et al. 2014; Acemoglu et al. 2012), with a multiplicity of possible equilibria. This implies that no outcome is guaranteed, although the most likely pathway will depend on economic expectations and initial conditions of the innovation process (Krugman 2011). Therefore, the government has a role to play, either by shifting expectations (e.g. credibly committing to climate policy), or by changing initial conditions (e.g. investing in green infrastructure or subsidizing clean energy research) (Aghion et al. 2014; Acemoglu et al. 2012). The general conclusion of this literature is that government intervention is needed, in the form of carbon taxes and/or subsidies for clean activities (Acemoglu et al. 2014). Introducing the irreversibility of energy investments, or the extremely long periods of operation of the typical energy investment, reinforces these results (Baldwin et al. 2019). In fact, not only subsidies but also flexible standards can be relevant in a dynamic context with irreversible investments, especially due to political economy considerations (Caparrós et al. 2015).

Since AR5 an alternative framing for climate policy has emerged in the scholarly literature. This framing views the issue as a case of accelerating a set of technological transitions: the wholesale transformation across different sectors from using one set of technologies (i.e., involving the combustion of fossil fuels) to produce a set of goods or services to using a different set of technologies (e.g., those relying on renewable energy sources). The roots of this transitions framing can be found in evolutionary economics. Here the guiding questions are not concerned with market failures – and indeed evolutionary economics does not start from a general hypothesis of efficient markets – but rather the processes that accelerate or postpone changes in economic production and consumption systems. A core finding is that established technologies enjoy lower production costs – as a result of past innovation and learning by doing – as well as higher value to consumers, when such value correlates positively with the number of other people using the same technology. These factors make it initially costly and unattractive to switch from an established technology to a newer one, even if the new one is objectively superior (Arthur 1989). This theory has been further developed with a set of empirical case studies, diving more deeply into social and political processes (Geels 2002).

As described in Chapter 1 of this report, theories of transitions suggest that overcoming lock-in, and enabling new technologies to flourish, often requires government action. This may be for the purpose of stimulating technological research and development, but also for adapting the 'regime' within which technologies operate – including physical infrastructure networks, firm production capacities, and institutional frameworks – in order to fit the new technologies' particular performance profiles (Mazzucato 2016; Geels 2002; Grubb 2014). In the case of climate change, the transitions framing suggests other possible causes for continued emissions of GHGs, compared to a market-failure framing and the emphasis on free-riding, and a somewhat different policy architecture in order to end them (Geels et al. 2017). Most importantly, neither the presence of a negative environmental externality nor the possibility for free-riding plays a major role in the transitions framing, and the

correction of such an externality may do little to induce change (Patt and Lilliestam 2018). Once the 'lock-in' factors have been addressed in this manner, the clean technology may require no continued policy support in order to maintain market dominance vis-à-vis the polluting one (Lilliestam et al. 2012).

With respect to considerations of international cooperation, the two framings call attention to different indicators of progress, and potentially different types of cooperative action. Within the public goods or global commons framing, the primary indicator of progress is the actual level of GHG emissions, and the effectiveness of policies can be measured in terms of whether such emissions rise or fall (Patt and Lilliestam 2018). In the transitions framing, by contrast, emissions levels are the end (and often greatly delayed) result of a large number of transformative processes. A given policy may be effective at stimulating such processes, even if a change in emissions is not yet evident (Patt 2017). In the public goods or global commons framing, there is traditionally an emphasis on treaties containing binding commitments (Olmstead and Stavins 2012), which are self-enforcing, as a way of dealing with the overarching problem of free-ridership (Barrett 1994; Finus and Caparrós 2015). In the transitions framing, by contrast, the emphasis is on treaties providing mechanisms to support parties' voluntary actions, such as with financial and capacity-building support for new technologies and technology regimes within specific economic sectors (Geels et al. 2019).

14.3.2 Mitigation links to adaptation, loss and damage, human rights and sustainable development

As discussed in chapter 1, the emerging framing for the issue of climate mitigation is that it is no longer to be considered in isolation but rather in the context of its linkages with other areas. Adaptation, loss and damage, human rights and sustainable development are all areas where there are clear or potential overlaps, synergies, and conflicts with the cooperation underway in relation to mitigation.

Adaptation involves actions to lessen the harm associated with climate change, or take advantage of potential gains (Smit and Wandel 2006). It can seek to reduce exposure to specific climate risks (Adger et al. 2003), mainstream climate information into existing planning efforts (Gupta et al. 2010), and reduce vulnerability (or increase resilience) of people or communities to the effects of climate change (Kasperson and Kasperson 2001). There is a body of literature highlighting potential synergies and conflicts between adaptation actions – in any of the three areas above – and mitigation actions (Watkiss et al. 2015; Casado-Asensio and Steurer 2014; Suckall et al. 2015; Locatelli et al. 2011; Duguma et al. 2014). Distinct from project or programmatic level activities, however, international cooperation for adaptation operates to provide finance and technical assistance (Bouwer and Aerts 2006). In some cases it involves transboundary actions, such as in the case of transboundary watershed management (Milman et al. 2013; Wilder et al. 2010). In others it involves the mainstreaming of climate change projections into existing treaties, such as for the protection of migratory species (Trouwborst et al. 2012).

International cooperation in adaptation and in mitigation share many of the same challenges, including the need for effective institutions. The UNFCCC, for example, addresses international financial support for adaptation and for mitigation in the same general category, and subjects them to the same sets of institutional constraints (Peterson and Skovgaard 2019). At a more general level, Sovacool and Linnér (2016) argue that the history of the UNFCCC and its sub-agreements has been shaped by an implicit bargain that developing countries participate in global mitigation policy in return for receiving financial and technical assistance for adaptation and development from industrialized countries. Khan and Roberts (2013) contend that this played out poorly under the Kyoto framework: the Protocol's basic architecture, oriented around legally binding commitments, was not

amenable to merging the issues of adaptation and mitigation. Kuyper et al. (2018a) argue that the movement from Kyoto to Paris represents a shift in this regard; Paris was designed not primarily as a mitigation policy instrument, but rather one encompassing mitigation, adaptation, and development concerns. While this argument suggests that the Paris architecture, involving voluntary mitigation actions and a greater attention to issues of financial support and transparency, functions better to leverage adaptation support into meaningful mitigation actions, this issue is not directly examined in the literature.

There are recognized limits to adaptation (Dow et al. 2013), and exceeding these limits results in loss and damage, a topic that is gathering salience in the policy discourse. The term 'loss and damage' refers to an evolving legal framework that covers issues of liability for the losses that states incur due to climate change, and the technical assistance to reduce those losses. The climate change regime has attempted to address the less controversial aspects of this. UNFCCC parties established the Warsaw international mechanism (WIM) to address loss and damage associated with climate change in particularly vulnerable developing countries (UNFCCC 2014), and the Paris Agreement contains a stand-alone article on loss and damage (see section 14.4.2.12). There are direct links between climate mitigation efforts, adaptation and loss and damage - the higher the collective mitigation ambition, and the likelihood of achieving it, the lower the need for adaptation and likelihood of loss and damage. The liability of states, either individually or collectively, for loss and damage is contested, and no litigation has yet been successfully launched to pursue such claims. The science of attribution, however, is developing (Marjanac and Patton 2018), and while it has the potential to address the thorny issue of causation, and thus compensation, it could also be used to develop strategies for climate resilience (James et al. 2014). There are additional links between climate mitigation efforts and liability for loss and damage that have not been explored in the literature, for instance the question of whether a state engaged in aggressive mitigation policies, and with an ambitious NDC, should be wholly or partly absolved of legal liability for loss and damage, should such liability ever come to pass.

Sustainable development refers to meeting the needs of the present generation – especially in countries where many needs are currently unmet – in a manner that will allow future generations to meet their needs as well (WCED 1987). The international agendas for mitigation and for sustainable development have shaped each other, around concepts such as common but differentiated responsibilities and respective capabilities, as well as the distinction – in the UNFCCC and later the Kyoto Protocol – between Annex I and non-Annex I countries (Patt 2015; Victor 2011). The same implicit bargain that developing countries would support mitigation efforts in return for assistance with respect to adaptation also applies to support for development (Sovacool and Linnér 2016). That linkage between mitigation and sustainable development has become even more specific with the Paris Agreement and the 2030 Agenda for Sustainable Development, each of which explicitly pursues a set of goals that encompass both mitigation and development (Schmieg et al. 2017), reflecting the recognition that achieving sustainable development and climate mitigation goals are mutually dependent (Gomez-Echeverri 2018). It is well-accepted that the long-term effects of climate mitigation will benefit sustainable development. A more contested finding is whether the mitigation actions themselves promote or hinder short-term poverty alleviation. One study, analysing the economic effects of developing countries' Nationally Determined Contributions, finds that mitigation actions slow down poverty reduction efforts (Campagnolo and Davide 2019). Other studies suggest possible synergies between low-carbon development and economic development (Hanger et al. 2016; Labordena et al. 2017a). Where these studies typically converge is that financial assistance flowing from developed to developing countries enhances any possible synergies or lessens the conflicts.

The literature also identifies institutional synergies at the international level, related to the importance of addressing climate change and development in an integrated, coordinated and comprehensive

manner across constituencies, sectors and administrative and geographical boundaries (Le Blanc 2015). Also stressed is the important role that robust institutions have in making this happen, including in international cooperation in key sectors for climate action as well for development (Waage et al. 2015). Since the publication of AR5, which emphasized the need for a type of development that combines both mitigation and adaptation as a way to strengthen resilience, much of the literature has focused on ways to address these linkages and the role institutions play in key sectors that are often the subject of international cooperation – for example, environmental and soil degradation, climate, energy, water resources, forestry (Hogl et al. 2016).

14.3.3 Lessons from the implementation of other environmental agreements

In assessing international cooperation on climate mitigation, lessons from the implementation of other multilateral environmental agreements (MEAs) provide guidance, particularly 'successful' agreements, such as the Montreal Protocol (Green 2009). There is a great deal of literature on this topic, most of which predates AR5, and which we will therefore not cover in detail here. Issues include ways to enhance compliance, and the fact that a low level of compliance with an MEA does not necessarily mean that the MEA has no effect (Weiss and Jacobson 1998; Victor et al. 1998; Downs et al. 1996). Recent research examines effectiveness from the viewpoint of the extent to which an MEA influences domestic action, including the adoption of implementing legislation and policies (Brandi et al. 2019). Evaluations of effectiveness typically require comparing observed results under an agreement with a theoretically driven counterfactual scenario, and the literature suggests challenges associated with this (Helm and Sprinz 2000; Hovi et al. 2003a; Young 2001, 2003; Hovi et al. 2003b). Furthermore, it is crucial to take into account the fundamental problem structure (such as the centrality of the behaviour causing the problem to the global economy), as well as the existing institutional capacities (Mitchell 2006; Miles et al. 2002; Young 2013, 2011). The Montreal Protocol, for example, may not be instructive in solving climate change, because the former was facilitated by factors such as the technically discoverable and calculable stock of ozone depleting chemicals, and the availability of commercially viable substitutes (Falkner 1998; DeSombre 2000; Parson 2003). On the other hand some features of the regime may be transferable, such as the provision of financial assistance to developing countries through the Multilateral Ozone Fund, which maximized participation by providing incentives for states to become party to the Protocol and its amendments (Benedick 1998; Barrett 2011), as well as the 'ratcheting up' of its commitments through an adjustment mechanism that does not require formal treaty amendments (Young 2016).

The Paris Agreement heralds a new era of 'hybrid multilateralism' (Bäckstrand et al. 2017) with greater flexibility for recognizing the benefits of working in diverse forms and groups and allowing for more decentralized 'polycentric' forms of governance that engage diverse actors at the regional, national and sub-national levels (Victor 2016; Jordan et al. 2015; Falkner 2016; Ostrom 2010). In this context, lessons drawn from studies of MEA regimes need to be supplemented with assessments of the effectiveness of cooperative efforts at other governance levels and in other forums. Emerging research in this area proposes methodologies for this task (Hsu et al. 2019a). Findings highlight the persistence of similar imbalances between developed and developing countries as at the global level, as well as the need for more effective ways to incentivize private sector engagement in transnational climate governance (Bansard et al. 2017; Chan et al. 2018b).

14.3.4 Criteria and indicators for assessing effectiveness

Building on these insights, we identify the following assessment criteria and indicators for different forms of international cooperation. These criteria and indicators strike a balance between applying the same standards developed and applied to international cooperation in AR5, maintaining consistency with other chapters of this report (primarily Chapters 1, 4, 13, and 15), and reflecting new

developments in social science theory. Table 14.1 provides an overview of the criteria and indicators, and the remainder of this section describes them in greater detail.

Table 14.1 Criteria and indicators for assessing effectiveness of international cooperation

Criterion	Indicators
Environmental effectiveness	AFOLU: limits CO_2 emissions
	AFOLU: limits other emissions of other Kyoto Annex A gases
	Non-AFOLU: limits CO_2 emissions
	Non-AFOLU: limits emissions of other Kyoto Annex A gases
	Non-AFOLU: limits emissions of non-Annex A gases
Transformative potential	Improves the cost/performance frontier of low-carbon technologies
	Promotes increased investment flows into low-carbon pathways
	Promotes low-carbon infrastructure planning and construction
	Improves low-carbon engineering and institutional capacity
	Promotes technologies or regimes for non-AFOLU negative emissions
	Advances technologies or institutions to manage solar radiation modification
Distributive outcomes	Industrialized country leadership in mitigation actions
	Differentiation in favour of developing countries
	Promotion of co-benefits
Economic performance	Cost effectiveness: reaches targets in a least-cost manner
	Efficiency: maximises the net benefits to society
Institutional strength	Regulative quality
	Mechanisms to enhance transparency and accountability
	Administrative capacity

A critical aspect of any environmental policy evaluation, including policies in the domain of international cooperation, is whether they do in fact lead to a change in the physical environment. It is clear that separate actions are required in different economic sectors (Chapters 1 and 13), and that achieving temperature targets such as 1.5°C – 2°C requires progress in all areas (Chapter 17). For that reason, it is essential not to group all actions together, but rather to ensure that progress with respect to environmental effectiveness is being made in each of many separate areas. Following this, and consistent with Chapter 4, we distinguish between progress made in the AFOLU sector, and that made in all other sectors. Furthermore, we distinguish between different types of gases, as these reflect different types of activities. Within the AFOLU sector, for example, CO_2 emissions which mainly result from land management practices such as deforestation, while other greenhouse gases such as methane result from agricultural practices, as well as societal dietary choices such as meat consumption. Outside the AFOLU sector, CO_2 primarily comes from the use of fossil energy, while other gases listed in Annex A of the Kyoto Protocol are covered by agreements with respect to

chemicals used in industry, such as the Montreal Protocol. A third group of gases, not included in Kyoto Annex A, have been recognized to have a substantial greenhouse forcing potential, including water vapour and particulates from the aviation sector (Chen and Gettelman 2013), and black carbon from biomass burning (Peng et al. 2016).

As is recognized throughout this report, the achievement of climate objectives such as limiting global average warming to 1.5°C – 2°C will require the transition from high- to low-carbon technologies, and the transformation of the sectors within which those technologies operate. It is clear that such transformations are not linear processes, and hence many of the early steps taken – such as supporting early diffusion of new renewable energy technologies – will have little immediate effect on GHG emissions (Patt 2015; Geels et al. 2017). Hence the effect of policies and cooperative frameworks that are potentially important for such transformation to take place may not appear in terms of their current environmental effectiveness, but rather in their laying the groundwork for future policies that will be environmentally effective. Consistent with Chapter 1 of this report, we frame the causal pathways by which transformation occurs according to the "multi-level perspective", or MLP, which in turn suggests three main areas where changes lead to transformation: at the level of individual new technologies, often operating in distinct niches; at the level of sector-specific regimes, which encompass infrastructure networks, supply chains, and governance institutions; and at the level of the societal landscape within which those regimes operate (Geels 2002). Shifts in niche technologies and regimes are influenced heavily by policy (Mazzucato 2016). Four indicators to cover these two levels can be identified: improvements in specific low-carbon technologies; levels of investment in the sectoral regime that are favourable to the low-carbon technologies; planning and development of infrastructure networks consistent with the envisioned transformation; and, capacity raising efforts in ways that will provide the institutional and human capital requirements for the new regime. Finally, there is a need to pay particular attention to two sets of technologies and associated regimes that cannot necessarily be considered low carbon, and yet which fall within this report: negative emission technologies lying outside of the AFOLU sector, such as ocean fertilization or direct air capture of CO_2 coupled to carbon storage (DACCS); and, solar radiation modification.

Equity is of central importance to the climate change debate, and hence for evaluating the effects of policies. This is reflected in the climate regime's principle of "common but differentiated responsibilities and respective capabilities" (Art 3, UNFCCC 1992), with the added dimension of "in light of different national circumstances" in the Paris Agreement (Art 2), and repeated references to "equity" in the UNFCCC, the Paris Agreement, and the Paris Rulebook (Rajamani and Guérin 2017; Winkler 2019). Equity encompasses the notion of distributive justice which refers to the distribution of goods, burdens, costs and benefits among agents (Kverndokk 2018). Drawing on cues from the international climate change regime, the following indicators can be identified to assess the effectiveness of intra-generational distribution of burdens and benefits: industrialized country leadership in mitigation actions; differentiation in favour of developing countries, both in terms of a recognition of their diminished capacity to respond, as well as in the availability of support for mitigation; and, the extent to which climate mitigation promotes co-benefits, and is embedded in larger sustainable development actions. There are inextricable links between inter-and intra-generational equity, in that in so far as inequities remain or are accentuated in current generations through current climate policies, future generations will be left with a greater burden of climate impacts, and of addressing such inequities.

As described in AR5, measuring the aggregate economic performance of a climate policy requires a consideration both of its economic efficiency and its cost-effectiveness. Economic efficiency refers to the maximization of net benefits, the difference between total social benefits and total social costs. Cost-effectiveness refers to the ability of a policy to attain a prescribed level of environmental performance at least cost, taking into account impacts on dynamic efficiency, notably technological

innovation. Unlike net benefit assessment, cost-effectiveness analysis takes the environmental performance of a policy as given and seeks the least-cost strategy to attain it.

The literature on the performance of other MEAs highlights the importance of institutional factors. Here, we identify three indicators: regulative quality; mechanisms to enhance transparency and accountability; and administrative capacity. Regulative quality has two dimensions: first, institutions and agreements have a fundamental guidance and signalling function (Oberthür et al. 2017). This derives from the principles and objectives on which they are commonly based (and hence from the normative dimension of international institutions). The second dimension relates to clear rules and standards to facilitate collective action. These rules and standards can be procedural or substantive, and entail obligations of conduct or of result (Oberthür and Bodle 2016). There is an important distinction to be made between legally binding obligations (which require the formal expression of state consent) and non-binding recommendations. Although binding rules are formally stronger than non-binding ones and could be expected to lead to greater behavioural change, research on international environmental cooperation indicates that non-binding international declarations can be just as effective, under certain conditions (Skjærseth et al. 2006). There is also an important distinction to be made between the form of an agreement (could be binding, such as a treaty) and the character of obligations within it (could be on a spectrum of bindingness) (Rajamani 2016a). Mechanisms to enhance transparency and accountability are essential to collect and analyse relevant data about parties' implementation of their obligations, and to identify and address challenges in implementation. Institutions/secretariats may collect and aggregate data themselves or – more commonly – rely on self-reporting by parties, and this may dovetail with compliance procedures and mechanisms. Administrative capacity refers to the strength of the formal bodies established to serve the parties to the regime and help ensure compliance and goal attainment (Biermann and Siebenhüner 2009; Bauer et al. 2017). An important dimension of this is the capacity of the secretariat, in particular whether its size and expertise is adequate in light of the breadth of participation in the regime, and the complexity of the regulatory architecture.

14.4 International cooperation through global agreements

14.4.1 The international climate change regime

The international climate change regime, in evolution for three decades, comprises the 1992 UNFCCC, the 1997 Kyoto Protocol, and the 2015 Paris Agreement. The UNFCCC is a 'framework' convention, capturing broad convergence among states on an objective, a set of principles, and general obligations relating to mitigation, adaptation, reporting and support. It also establishes the institutional building blocks for global climate governance.

The Kyoto Protocol concretizes the general obligations in the UNFCCC for developed countries, specifying GHG emissions reduction targets for the 2008-2012 commitment period for countries listed in Annex I to the UNFCCC (UNFCCC 1997, Art. 3 and Annex B). The Kyoto Protocol entered into force in 2005. Shortly thereafter, states began negotiating a second commitment period under the Protocol, as well as to expand the coverage of parties with GHG mitigation commitments.

At COP 13 in Bali in 2007 parties adopted the *Bali Action Plan* that launched negotiations aimed at a new agreement providing for the UNFCCC's 'full, effective and sustained implementation.' The agreement was to be adopted at COP 15 in Copenhagen in 2009, but negotiations failed to deliver a consensus document. The result instead was the *Copenhagen Accord,* which was taken note of by the COP; while it was a political agreement operating outside of the UNFCCC, it reflected significant progress on several fronts: setting a goal of limiting global temperature increase to 2°C; calling on all countries to put forward mitigation pledges; establishing broad terms for the reporting and verification

of countries' actions; setting a goal of mobilizing $100 billion a year by 2020 in public and private finance for developing countries; and, calling for the establishment of a new Green Climate Fund (Rogelj et al. 2010; Rajamani 2010). Following the Copenhagen Accord, the European Union (EU) approached developing countries that shared its desire for a legally binding regime covering all major emitters, and explored compromises with veto players, such as China and the United States (US). This bridge-building strategy was combined with a conditional pledge to agree to an extension of the Kyoto Protocol (Bäckstrand and Elgström 2013).

At COP 16 in Cancun in 2010, parties adopted a set of decisions termed the *Cancun Agreements* that effectively formalized the core elements of the Copenhagen Accord under the UNFCCC. The Cancun Agreements were regarded as an interim arrangement through to 2020, and parties left the door open to further negotiations toward a legally binding successor to the Kyoto Protocol (Freestone 2010; Liu 2011).

At the 2011 Durban climate conference, parties launched negotiations for 'a Protocol, another legal instrument or agreed outcome with legal force' with a scheduled end to the negotiations in 2015 (UNFCCC 2012b, Dec. 1, para. 2). At the 2012 Doha climate conference, parties adopted a second commitment period for the Kyoto Protocol, running from 2013-2020. This has yet to enter into force as only 134 of the required 144 countries (3/4 of Kyoto Parties) have thus far ratified the Doha amendment. In any case, the Kyoto Protocol is unlikely to continue beyond 2020 (Bodansky, Brunnée, & Rajamani, 2017). At the end of the compliance assessment period under the Kyoto Protocol, Annex B parties were in full compliance with their targets, in some cases, through the use of the Protocol's flexibility mechanisms (Shishlov et al. 2016).

The Kyoto Protocol and Paris Agreement represent fundamentally different approaches to international cooperation on climate change (Falkner 2016; Held and Roger 2018); the latter is characterized as a 'decisive break' from the former (Keohane and Oppenheimer 2016). The mitigation efforts under the Kyoto Protocol take the form of multilaterally negotiated targets, whereas under the Paris Agreement parties have 'nationally determined' contributions. Some have characterized this as a distinction between a 'top down' and 'bottom up' approach (Doelle 2016; Chan 2016). The Kyoto Protocol's core obligations are legally binding, substantive obligations of result. By contrast, the Paris Agreement's core obligations are legally binding procedural obligations, complemented by obligations of conduct (Rajamani 2016b).

The broad differences between the two treaties are summarized in Table 14.2 below. The Kyoto targets apply only to developed country/Annex B parties, but the procedural obligations relating to NDCs in the Paris Agreement apply to all parties, with some flexibilities for Least Developed Countries (LDCs), Small Island Developing States (SIDs), and developing countries that need it in light of their capacities. The Kyoto targets are housed in its Annex B, therefore requiring a formal process of amendment for revision, whereas the Paris NDCs are located in an online registry that parties can operate themselves. The Kyoto Protocol allows Annex B parties to use three market-based mechanisms – the Clean Development Mechanism (CDM), Joint Implementation and Emissions Trading – to fulfil their GHG targets. The Paris Agreement permits parties to cooperate voluntarily on markets, subject to rules relating to integrity and accounting. The Kyoto Protocol contains an extensive reporting and review process, backed by a compliance mechanism. This mechanism includes an enforcement branch, to ensure compliance, and sanction non-compliance, with its GHG targets. By contrast, the Paris Agreement relies on informational requirements and flows to enhance the clarity of NDCs, and to track progress in the implementation and achievement of NDCs.

Table 14.2 Key differences between the Paris Agreement and the Kyoto Protocol

Feature	Kyoto Protocol	Paris Agreement
Objective	Primarily mitigation-focused (although in continuation of UNFCCC objective, which refers to food security and sustainable development)	Mitigation in line with a long-term temperature goal, adaptation and finance goals, as well as sustainable development and equity
Architecture	Multilaterally negotiated ('top-down') with differentiated targets based on national offers	Nationally determined ('bottom-up' or 'hybrid') with contributions subject to transparency and multilateral consideration of progress
Coverage of mitigation-related obligations	Developed country parties (Annex I/Annex B)	All parties
Targets	Legally-binding, differentiated targets inscribed in treaty	Non-binding pledges incorporated in parties' NDCs but subject to several normative expectations relating inter alia to progression and common but differentiated responsibilities and respective capabilities, in light of different national circumstances, in their formulation
Timetable	Two commitment periods (2008-2012; 2013-2020 – latter not yet in force)	Initial NDCs for timeframes 2025 or 2030 with new NDCs every five years
Implementation	Flexibility mechanisms (emissions trading, joint implementation, CDM)	Voluntary cooperation on mitigation; encouragement of REDD+
Transparency	Reporting and review – developed country parties only	Enhanced transparency framework and five-yearly global stocktake for a collective assessment of progress towards goals – all parties
Compliance	Compliance committee with facilitative and enforcement branches; sanctions for non-compliance	Facilitative compliance committee; no sanctions

14.4.2 Paris Agreement

The 2015 Paris Agreement to the UNFCCC is at the centre of international cooperative efforts for climate change mitigation and adaptation in the post-2020 period. Although its legal form was heavily disputed in its four-year negotiating process (Maljean-Dubois and Wemaëre 2016; Rajamani 2015; Bodansky et al. 2017), the Paris Agreement is a treaty containing provisions of differing levels of "bindingness" (Bodansky 2016; Oberthür and Bodle 2016; Rajamani 2015). The legal character of provisions within a treaty, and the extent to which particular provisions lend themselves to

assessments of compliance or non-compliance, depends, *inter alia*, on the normative content of the provision, the precision of its terms, the language used, and the oversight mechanisms in place (Bodansky 2015; Oberthür and Bodle 2016; Rajamani 2016a; Werksman 2010). Assessed on these criteria, the Paris Agreement contains the full spectrum of provisions, from hard to soft law (Pickering et al. 2019; Rajamani 2016a) and even non-law, which plays a narrative-building and context-setting role (Rajamani 2016a). The key features of the Paris Agreement are set out in Box 14.1.

The centrepiece of the Paris Agreement is a set of binding procedural obligations requiring parties to 'prepare, communicate, and maintain' 'nationally determined contributions' (NDCs) (UNFCCC 2015, Art. 4.2) every five years (UNFCCC 2015, Art. 4.9). These obligations are complemented by: (1) an 'ambition cycle' that expects parties' successive NDCs, informed by five-yearly global stocktakes (Art 14), to represent a progression on their previous NDCs (Bodansky, Brunnée, & Rajamani, 2017; UNFCCC, 2015, Art. 4.3), and (2) an 'enhanced transparency framework' that places extensive informational demands on parties, and establishes review processes to enable tracking of progress towards achievement of NDCs (Oberthür and Bodle 2016). In contrast to the 'top-down' Kyoto Protocol with its internationally inscribed targets and timetable for emissions reduction, the Paris Agreement is a hybrid of 'bottom-up' national pledges embedded in an international system of transparency and accountability (Doelle 2016; Maljean-Dubois and Wemaëre 2016), which promises more durable international cooperation (Falkner 2016).

14.4.2.1 Context, objective and purpose

The preamble of the Paris Agreement lists several factors that provide the interpretative context for the Agreement (Carazo 2017; Bodansky et al. 2017), including a reference to human rights. The human rights implications of climate impacts garnered particular attention in the lead up to Paris (Duyck 2015; Mayer 2016). In particular, the Human Rights Council, its special procedures mechanisms, and the Office of the High Commissioner for Human Rights, through a series of resolutions, reports, and activities, advocated a rights-based approach to climate impacts, and sought to integrate this approach in the climate change regime. The Paris Agreement's preambular recital on human rights recommends that parties take into account 'their respective obligations on human rights' (UNFCCC 2015, preambular recital 14), a first for an environmental treaty (Knox 2016). The 'respective obligations' referred to in the Paris Agreement include those relating to the right to life (UNGA 1948, Art. 3, 1966, Art. 6), right to health (UNGA 1966b, Art. 12), right to an adequate standard of living, including the right to food (UNGA 1966b, Art. 11), which has been read to include the right to water and sanitation (CESCR 2002, 2010), the right to housing (CESCR 1991), and the right to self-determination (UNGA 1966a,b, Art. 1). In addition, climate impacts contribute to displacement and migration (Mcadam 2016; Mayer and Crépeau 2016), and have disproportionate effects on women (Pearse 2017). There are differing views on the value and operational impact of the human rights recital in the Paris Agreement (Adelman 2018; Boyle 2018; Savaresi 2018; Duyck et al. 2018; Knox 2019; Rajamani 2018), and notwithstanding opportunities to mainstream and operationalize human rights in the climate regime post-Paris (Duyck et al. 2018), the 2018 Paris Rulebook contains limited and guarded references to human rights (Duyck 2019; Rajamani 2019).

The overall purpose of international cooperation through the Paris Agreement is to enhance the implementation of the UNFCCC, including its objective of stabilizing atmospheric GHG concentrations 'at a level that would prevent dangerous anthropogenic interference with the climate system' (UNFCCC 1992, Art. 2). The Paris Agreement's aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, by '[h]olding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels' (UNFCCC 2015, Art. 2(1)(a)). This is a single temperature goal with two inseparable elements, the well below 2°C goal pressing towards 1.5°C (Rajamani and Werksman 2018). Although having a long

term goal has clear advantages, the literature has stressed that the long periods of time involved imply that the challenge of credible commitment over time looms (Urpelainen 2011). As noted by (Gerlagh and Michielsen 2015), even if available information does not change, future regulators may have incentives to relax current climate plans. Their numerical illustration shows that this may have a significant effect on the GHG stabilization level finally achieved.

As the risks of adverse climate impacts, even 2°C, are profound, the objective extends to increasing adaptive capacity and fostering climate resilience (UNFCCC 2015, Art. 2(1)(b)), as well as redirecting investment and finance flows (Thorgeirsson, 2017; UNFCCC, 2015, Art. 2(1)(c)). The finance and adaptation goals are not quantified in the Paris Agreement, but the temperature goal and the pathways they generate will enable a quantitative assessment of the resources necessary to reach these goals, and the nature of the impacts requiring adaptation (Rajamani and Werksman 2018). The decision accompanying the Paris Agreement records an agreement to set a new collective quantified goal prior to 2025 (not explicitly limited to developed countries), with $100 per year as a floor (Bodansky et al. 2017b; UNFCCC 2016a, para. 53) . The objective also references sustainable development and poverty eradication, and underscores the need to integrate the SDGs in the implementation of the Paris Agreement (Sindico 2016).

The Paris Agreement's objective is accompanied by an expectation that the Agreement 'will be' implemented to 'reflect equity and the principle of common but differentiated responsibilities and respective capabilities (CBDRRC), in the light of different national circumstances' (UNFCCC 2015, Art. 2.2). This carefully drafted provision generates an expectation that parties will implement the agreement to reflect CBDRRC, and is not an obligation to do so (Rajamani 2016b). Further, the inclusion of the term 'in light of different national circumstances' introduces a dynamic element into the interpretation of the CBDRRC principle. As national circumstances evolve, the application of the principle will also evolve (Rajamani 2016b). This change in the articulation of the CBDRRC principle is reflected in the shifts in the nature and extent of differentiation in the climate change regime (Maljean-Dubois 2016; Rajamani 2016b; Voigt and Ferreira 2016a), including through a shift towards 'procedurally-oriented differentiation' for developing countries (Huggins and Karim 2016).

Although NDCs are developed by individual state parties, the Paris Agreement requires that these are undertaken by parties 'with a view' to achieving the Agreement's purpose and collectively 'represent a progression over time' (UNFCCC 2015, Art. 3). The Paris Agreement also encourages parties to align the ambition of their NDCs with the temperature goal through the Agreement's 'ambition cycle', thus imparting operational relevance to the temperature goal (Rajamani and Werksman 2018). Article 4(1) contains a further non-binding requirement that parties 'aim' to reach global peaking of GHG 'as soon as possible' and to undertake rapid reductions thereafter to achieve net zero emissions 'in the second half of the century'. Coupling this requirement with the long-term temperature goal in Article 2.1(a) implies a need to reach net zero emissions considerably in advance of 2100; for example, by between 2045-2060 in energy systems (Rogelj et al. 2015). This, in turn, may imply resorting to carbon dioxide removal technologies (IPCC 2018c) on which there are divergent views. The Paris Rulebook, agreed at the Agreement's first meeting of the parties in 2018, further strengthens the operational relevance of the temperature goal by requiring parties to provide information when submitting their NDCs on how these contribute towards achieving the objective identified in UNFCCC Article 2, and Paris Agreement Articles 2.1 (a) and 4.1 (UNFCCC 2019a, Annex I, para. 7).

14.4.2.2 NDCs, progression and ambition

Each party to the Paris Agreement has a binding procedural obligation to 'prepare, communicate and maintain' successive NDCs 'that it intends to achieve.' Parties have a further binding procedural obligation to 'pursue domestic mitigation measures' (UNFCCC 2015, Art. 4.2). These procedural obligations are coupled with an obligation of conduct to make best efforts to achieve the objectives of NDCs (Mayer 2018; Rajamani 2016b).

The framing and content of NDCs is thus largely left up to parties, although certain normative expectations apply. These include developed country leadership through these parties undertaking economy-wide absolute emissions reduction targets (UNFCCC 2015, Art. 4.4), as well as 'progression and highest possible ambition' (Art 4.3). There is 'a firm expectation' that for every five year cycle a party puts forward a new NDC that is 'more ambitious than their last' (Rajamani 2016b). While what represents a party's highest possible ambition and progression is not prescribed by the Agreement or elaborated in the Paris Rulebook (Rajamani and Bodansky 2019), these obligations could be read to imply a due diligence standard (Voigt and Ferreira 2016b).

In communicating their NDCs, every five years (UNFCCC 2015, Art. 4.9), all parties have a binding obligation to 'provide the information necessary for clarity, transparency and understanding' (UNFCCC 2015, Art. 4.8). These requirements are further elaborated in the Paris Rulebook (UNFCCC 2019b; Doelle 2019) . This includes binding requirements—for Parties' second and subsequent NDCs—to provide quantifiable information on the reference point e.g. base year, reference indicators and target relative to the reference indicator (UNFCCC 2019a, Annex I). It also requires parties to provide information on how they consider their contribution 'fair and ambitious in light of different national circumstances', and how they address the normative expectations of developed country leadership, progression and highest possible ambition (UNFCCC 2019a, Annex I, para. 6). However, parties are required to provide the enumerated information only 'as applicable' to their NDC (UNFCCC 2019a, Annex I, para. 7). This allows parties to determine the informational requirements placed on them through their choice of NDC. In respect of parties' first NDCs or NDCs updated before 2020, such quantifiable information 'may' be included, 'as appropriate', signalling a softer requirement (UNFCCC 2019a, Annex I, para. 9).

Parties' first NDCs submitted to the registry maintained by the UNFCCC vary in terms of type of NDC, reference points, time frames, and scope and coverage of GHGs. A significant number of NDCs include an adaptation component, and several NDCs are conditional, for instance, on the use of market mechanisms or on the availability of support (UNFCCC 2016b). There are variations across NDCs with many omitting important mitigation sectors, providing little detail on financing implementation, and poorly designed to meet assessment and review needs (Pauw et al. 2018). These variations make it challenging to aggregate the efforts of countries and compare them to each other (Carraro 2016). For countries with NDCs conditional on the provision of support, international cooperation on finance, technology and capacity-building is essential for fulfilment of their NDCs (Kissinger et al. 2019). For others with NDCs conditional on the use of market mechanisms, international cooperation on markets is essential. Although parties attempted to discipline the variation in NDCs, including whether they could be conditional, through elaborating the 'features' of NDCs in the Rulebook, no agreement was possible on this. Thus, parties continue to enjoy considerable national discretion in the formulation of NDCs (Rajamani and Bodansky 2019; Weikmans et al. 2019).

There are several approaches to evaluating NDCs incorporating indicators such as CO_2 emissions, GDP, energy intensity of GDP, CO_2 per energy unit, CO_2 intensity of fossil fuels, and share of fossil fuels in total energy use (Peters et al. 2017). However, some favour approaches that use metrics beyond emissions such as infrastructure investment, energy demand, or installed power capacity (Jeffery et al. 2018; Iyer et al. 2017). One approach is to combine the comparison of aggregate NDC emissions using Integrated Assessment Model scenarios with modelling of NDC scenarios directly, and carbon budget analyses (Jeffery et al. 2018). Another approach is to engage in a comprehensive assessment of several approaches that reflect the different viewpoints of the Parties under the UNFCCC (Höhne et al. 2018; Aldy et al. 2017).

It is clear, however, that the NDCs communicated by parties for the 2020-2030 period are insufficient to achieve the temperature goal (Alcaraz et al. 2019; Schleussner et al. 2016; UN Environment

Programme 2018), and the emissions gap is larger than ever (Christensen and Olhoff 2019). Some even note that leadership by conditional commitments, and the system of pledge-and-review, does not motivate countries to make deeper contributions over time, rather contributions decrease (Helland et al. 2017). On a less sombre note, others note that many of the NDCs are conservative and may be overachieved, NDCs may be strengthened over time as expected under the Paris Agreement, and there are significant non-state actions that have not been adequately captured in the NDCs (Höhne et al. 2017). Further, if all conditional and unconditional NDCs are implemented, net land use, land use change and forestry emissions decrease in 2030 compared to 2010 levels, but large uncertainties still surround how Parties estimate, project and account for emissions and removals from this sector (Forsell et al. 2016). According to the estimates in Table 4.3 (chapter 4), communicated unconditional commitments imply about a 7% reduction of world emissions by 2030, in terms of Kyoto GHG, compared to a scenario where only current policies are in place. If conditional commitments are also included, the reduction in world emissions by 2030 would be about 12%.

14.4.2.3 NDCs, fairness and equity

The Paris Agreement encourages Parties, while submitting their NDCs, to explain how these are 'fair and ambitious' (UNFCCC 2015, Art. 4.8 read with UNFCCC 2016a, para. 27). The Rulebook obliges Parties to provide information on 'fairness considerations, including reflecting on equity' as applicable to their NDC (UNFCCC 2019a, paras 7 and 9, Annex, paras. 6(a) and (b); Rajamani and Bodansky 2019).

In the first round of NDCs, most Parties declared their NDCs as 'fair' (Robiou du Pont et al. 2017). Their claims, however, were largely unsubstantiated or drawn from analysis by in-country experts (Winkler et al. 2018). Although NDCs are bottom-up, a comprehensive content analysis of NDCs revealed pre-existing top-down institutional divisions and divergent climate priorities between Annex I and non-Annex I Parties, suggesting that long-standing equity and fairness concerns will likely remain salient and need to be addressed (Stephenson et al. 2019). It is challenging, however, to address fairness and equity in a world of voluntary climate contributions (Chan 2016), in particular since these contributions are insufficient (Robiou du Pont et al. 2017). One option is for Parties to provide more rigorous information to assess fair shares (Winkler et al. 2018), and another is for Parties to articulate what equity principles they have adopted in determining their NDCs, how they have operationalized these principles, and explain their mitigation target in terms of the portion of the appropriated global budget (Hales and Mackey 2017).

More generally, self-differentiation has led to fairness and equity being discussed in terms of individual national contributions rather than between categories of countries (Chan 2016). Given the limited avenues for multilateral determination of fairness, the onus is on the scientific community to generate methods to assess fairness (Herrala and Goel 2016), and on peer-to-peer comparisons to create pressure for ambitious NDCs (Aldy et al. 2017). There are a range of options to assess or introduce fairness. These include: adopting differentiation in financing rather than in mitigation (Gajevic Sayegh 2017); adopting a carbon budget approach (Alcaraz et al. 2019; Hales and Mackey 2017), which may occur through the transparency processes (Hales and Mackey 2017); quantifying national emissions allocations using different equity approaches (Robiou du Pont et al. 2017); using data on adopted emissions targets to find an ethical framework consistent with the observed distribution (Sheriff 2019); adopting common metrics for policy assessment (Bretschger 2017); and developing a template for organizing metrics on mitigation effort - emission reductions, implicit prices, and costs - for both ex ante and ex post review (Aldy et al. 2017). The burden of agricultural mitigation can also be distributed using different approaches to effort sharing (responsibility, capability, need, equal cumulative per-capita emissions) (Richards et al. 2018). Further, there are temporal (inter-generational) and spatial (inter-regional) dimensions to the distribution of the

mitigation burden, with additional emissions reductions in 2030 improving both inter-generational and inter-regional equity (Liu et al. 2017).

14.4.2.4 Transparency and accountability

Although NDCs reflect a bottom-up, self-differentiated approach to climate mitigation actions, the Paris Agreement couples this to an international transparency framework designed to track progress in implementing and achieving mitigation contributions (UNFCCC 2015, Art. 13). This transparency framework is applicable to all parties, although with flexibilities for developing country parties that need it in light of their capacities (Mayer 2019). Each Party is required to submit a national inventory report as well as 'the information necessary to track progress in implementing and achieving' its NDC (UNFCCC 2015, Art. 13.7) biennially (UNFCCC 2016a, para. 90). The Paris Rulebook requires all Parties to submit their national inventory reports using 2006 IPCC Guidance (UNFCCC 2019c, Annex, para. 20).

In relation to the provision of information necessary to track progress towards implementation and achievement of NDCs, the Paris Rulebook allows each party to choose its own qualitative or quantitative indicators (UNFCCC 2019c, Annex, para. 65), a significant concession to national sovereignty (Rajamani and Bodansky 2019). The Rulebook phases in uniform reporting requirements for developed and developing countries (except LDCs and SIDs) in 2024 (UNFCCC 2019c, para. 3), but offers flexibilities in 'scope, frequency, and level of detail of reporting, and in the scope of the review' for developing countries that need it in light of their capacities (UNFCCC 2019c, para. 5). Some differentiation also remains for information on support provided to developing countries (Winkler et al. 2017), with developed country parties required to report such information biennially, while others are only 'encouraged' to do so (UNFCCC 2015, Art. 9.7).

The information provided by parties in biennial reports and GHG inventories will undergo technical expert review, which must include assistance in identifying capacity-building needs for developing country parties that need it in light of their capacities. Each party is also required to participate in a 'facilitative, multilateral consideration of progress' of implementation and achievement of its NDC. Although the aim of these processes is to expose each party's actions on mitigation to international review, thus establishing a weak form of accountability for NDCs at the international level, the Rulebook circumscribes the reach of these processes (Rajamani and Bodansky 2019) . The technical expert review teams are prohibited in mandatory terms ('shall not') from making 'political judgments' or reviewing the 'adequacy or appropriateness' of a party's NDC, domestic actions, or support provided (UNFCCC 2019c, Annex, para. 149). This, among other such provisions has led some to argue that the scope and practice of existing transparency arrangements reflects rather than mediates ongoing disputes around responsibility, differentiation and burden sharing, and thus there is limited answerability through transparency (Gupta and van Asselt 2019). More generally, there has been weak translation of transparency norms into accountability (Ciplet et al. 2018). Hence, the Paris Agreement's effectiveness in ensuring NDCs are met will depend on additional accountability pathways at the domestic level involving political processes and civil society engagement (Karlsson-Vinkhuyzen et al. 2018; Jacquet and Jamieson 2016; Van Asselt 2016).

14.4.2.5 Global stocktake

The Paris Agreement's transparency framework is complemented by the global stocktake which will take place every five years (starting in 2023) and assess the collective progress towards achieving the Agreement's purpose and long-term goals (UNFCCC 2015, Art. 14). The scope of the global stocktake is comprehensive – covering mitigation, adaptation and means of implementation and support – and the process is to be facilitative and consultative. The Paris Rulebook cautiously (i.e. 'as appropriate') expands the scope of the global stocktake to take into account social and economic

consequences and impacts of response measures, and loss and damage associated with the adverse effects of climate change (UNFCCC, 2019d, paras. 8-10).

The global stocktake is to occur 'in the light of equity and the best available science.' While the focus of the global stocktake is on collective and not individual progress towards the goals of the Agreement, the inclusion of equity in the global stocktake 'leaves the door open for a dialogue on equitable burden sharing' (Rajamani 2016b). The Paris Rulebook seeks to operationalize equity by including consideration of it in the modalities and sources of inputs for the global stocktake (UNFCCC, 2019d, paras 1, 2, 13, 27, 31, 36h and 37g), which will likely result in equity being factored into the outcome of the stocktake (Winkler 2019). The Rulebook does not, however, resolve the tension between the collective nature of the assessment that is authorized by the stocktake and the individual assessments required to determine relative fair share (Zahar 2019; Rajamani and Bodansky 2019).

The global stocktake is seen as crucial to encouraging parties to increase the ambition of their NDCs (Huang 2018; Milkoreit and Haapala 2019) as its outcome 'shall inform Parties in updating and enhancing, in a nationally determined manner, their actions and support' (Art 14.3). The Rulebook provides for the stocktake to draw on a wide variety of inputs sourced from a full range of actors, including 'non-Party stakeholders' (UNFCCC, 2019d, para. 37). However, the Rulebook specifies that the global stocktake will be 'a Party-driven process' (UNFCCC, 2019d, para. 10), will not have an 'individual Party focus', and will include only 'non-policy prescriptive consideration of collective progress' (UNFCCC, 2019d, para. 14).

14.4.2.6 Finance

As highlighted above, the objective of the Paris Agreement includes the goal of '[m]aking finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development' (UNFCCC 2015, Art 2.1(c)). Provision of finance will be critical to achievement of many parties' NDCs, particularly those that are framed in conditional terms (Zhang and Pan 2016; Kissinger et al. 2019). International cooperation on climate finance represents 'a complex and fragmented landscape' with a range of different mechanisms and forums involved (Roberts and Weikmans 2017). These include entities set up under the international climate change regime, such as the UNFCCC financial mechanism, with the Global Environment Facility (GEF) and Green Climate Fund (GCF) as operating entities; special funds, such as the Special Climate Change Fund, the Least Developed Countries Fund (both managed by the GEF), and the Adaptation Fund established under the Kyoto Protocol; the Standing Committee on Finance, a constituted body which assists the COP in exercising its functions with respect to the UNFCCC financial mechanism; and other bodies outside of the international climate change regime, such as the Climate Investment Funds (CIF) administered through multilateral development banks (discussed further below). Pursuant to decisions adopted at the Paris conference and 2018 Katowice meeting, countries agreed that the operating entities of the financial mechanism – GEF and GCF – as well as the Special Climate Change Fund, the Least Developed Countries Fund, the Adaptation Fund and the Standing Committee on Finance, all serve the Paris Agreement (UNFCCC, 2016b, paras 58 and 63, 2019a). The GCF, which became operational in 2015, is expected to become the main compensatory mechanism for transferring public funds, and some private funds, to developing countries to address climate change (Brechin and Espinoza 2017; Antimiani et al. 2017) (see further section 14.5.4 below).

Much of the current literature on climate finance and the Paris Agreement focuses on the obligations of developed countries to provide climate finance to assist the implementation of mitigation and adaptation actions by developing countries. The principal provision on finance in the Paris Agreement is the binding obligation on developed country parties to provide financial resources to assist developing country parties (UNFCCC 2015, Art 9.1). This provision applies to both mitigation and adaptation and is in continuation of developed country parties' existing obligations under the

international climate change regime. This signals that the Paris Agreement finance requirements must be interpreted in light of the UNFCCC (Yamineva 2016). The principal novelty introduced by the Paris Agreement is an expansion in the potential pool of donor countries as article 9.2 encourages 'other parties' to provide or continue to provide such support on a voluntary basis. However, 'developed countries should continue to take the lead in mobilizing climate finance', with a 'significant role' for public funds, and a requirement that such mobilization of finance 'should represent a progression beyond previous efforts' (UNFCCC 2015, Art 9.3). Beyond this there are no new recognized promises (Ciplet et al. 2018). In the Paris Agreement negotiations, parties merely formalized and extended to 2025 previous long-term finance pledges made under the international climate regime, such as the Copenhagen Accord's pledge by developed countries to raise USD 100 billion per year by 2020. The Paris Agreement decision also provided for the CMA to set a new collective quantified goal from a floor of USD 100 billion per year, taking into account the needs and priorities of developing countries (UNFCCC, 2016b, para. 53). This new collective goal on finance is not explicitly limited to developed countries and could therefore encompass finance flows from major developing countries donors (Bodansky et al. 2017). A decision on the initiation of a process for determining a new collective goal on finance has been deferred to 2020 (UNFCCC, 2019b, para. 1; H. Zhang, 2019).

It is widely recognized that the USD 100 billion figure is a fraction of the broader finance and investment needs of mitigation and adaptation embodied in the Paris Agreement (Peake and Ekins 2017). One estimate, based on a review of 160 (I)NDCs, suggests the financial demand for both mitigation and adaptation needs of developing countries could reach US$474 billion by 2030 (Zhang and Pan 2016). Some research has also sought to quantify the climate finance 'gap' resulting from the US withdrawal from the Paris Agreement, with estimates that the GCF funding gap will increase by USD 2 billion, while the long-term finance gap for mobilization of the $100 billion per annum will increase by around USD 5 billion per year (Chai et al. 2017). More broadly there is recognition of the need for better accounting, transparency and reporting rules to allow evaluation of the fulfilment of finance pledges and the effectiveness of how funding is used (Xu et al. 2016; Roberts et al. 2017; Gupta and van Asselt 2019). Some authors see the 'enhanced transparency framework' of the Paris Agreement (see 14.4.2.4 above), and the specific requirements for developed countries to report on financial support and mobilization efforts (articles 9.5 and 9.7), as promising marked improvements (Weikmans and Roberts 2019), including for the fairness of effort-sharing on climate finance provision (Pickering et al. 2015). Others offer a more circumspect view of the transformative capability of these transparency systems (Ciplet et al. 2018).

The more limited literature focusing on the specific finance needs of developing countries, particularly those expressed in NDCs conditional on international climate finance, suggests that once all countries have fully costed their NDCs, the demand for (public and private) finance to support NDC implementation is likely to be orders of magnitude larger than funds available from bilateral and multilateral sources. This could leave 'NDC ambitions in the forest and land use sector in a precarious position, unless more diversified options are pursued to reach climate goals' (Kissinger et al. 2019). In addition, there is a need for fiscal policy reform in developing countries to ensure international climate finance flows are not undercut by public and private finance supporting unsustainable activities (Kissinger et al. 2019). During 2018 Katowice meeting, UNFCCC parties agreed to conduct an assessment of developing countries financial needs and priorities and requested the Standing Committee on Finance to produce a '2020 Needs Report' for presentation at COP26 (UNFCCC 2019g).

14.4.2.7 Capacity-building

Capacity building, a priority for many countries, has primarily been implemented through partnerships, collaboration and different cooperative activities, inside and outside the UNFCCC. Beyond the UNFCCC, other climate cooperation and partnerships activities on capacity building include those organized by the OECD, IFDD (Francophonie Institute for Sustainable Development), UNDP-NCSP programme, UNEP and the World Bank. There are also a number of regional cooperative structures with capacity-building components, including ClimaSouth, Euroclima+, the UN-REDD Programme, the Caribbean Regional Strategic Programme for Resilience, the Caribbean Climate Online Risk and Adaptation Tool, a project on accelerating low carbon and resilient society realization in the Southeast Asian region, the World Health Organization's Global Salm-Surv network and the Africa Adaptation Initiative.

The Paris Agreement urges all parties to cooperate to enhance the capacity of developing countries to implement the Agreement (UNFCCC, 2015, Art. 11.3), with a particular focus on LDCs and SIDs (UNFCCC, 2015, Art. 11.1). The focus of capacity-building activities should be on enabling developing countries to take effective climate change action, given that most developing countries continue to face significant capacity challenges, undermining their ability to effectively or fully carry out the climate actions they intend to pursue (Dagnet et al. 2016). Under the Paris Agreement, capacity-building can take a range of forms, including: facilitating technology development, dissemination and deployment; access to climate finance; education, training and public awareness; and the transparent, timely and accurate communication of information (UNFCCC, 2015, Art. 11.1). Principles guiding capacity-building support are that it should be: country-driven; based on and responsive to national needs; fostering country ownership of parties at multiple levels; guided by lessons learned; and an effective, iterative process that is participatory, cross-cutting and gender-responsive (UNFCCC, 2015, Art. 11.2).

The UNFCCC established the Paris Committee on Capacity-building (UNFCCC, 2016b, para. 71) is designed to play a key role in coordinating capacity-building activities under the Convention. The COP decision accompanying the Paris Agreement established a Capacity Building Initiative for Transparency designed to support developing country parties in meeting the reporting and transparency requirements under Article 13 of the Paris Agreement (Khan et al. 2018).

In its annual synthesis report for 2018, the UNFCCC secretariat stressed the importance of capacity-building for the implementation of the Paris Agreement and NDCs, with focus on measures already in place, regional and cooperative activities, and capacity-building needs for strengthening NDCs (UNFCCC 2019h). The synthesis report compiled information submitted by parties on the implementation of capacity-building in developing countries, highlighting cooperative and regional activities on NDCs, including projects to build capacity for implementation, workshops related to transparency under the Paris Agreement and collaboration to provide coaching and training (UNFCCC 2019h). A number of developing country Parties also highlighted their contributions to South–South cooperation (discussed further at section 14.5.6 below), and identified capacity-building projects undertaken with others (e.g. capacity-building for risk management in Latin America and the Caribbean, improving capacity for MRV through the Alliance of the Pacific and a climate action package launched by Singapore).

14.4.2.8 Technology transfer

Article 10 of the Paris Agreement articulates parties' 'long-term vision on the importance of fully realizing technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions' (UNFCCC, 2015, Art. 10.1). Technology development and the transfer of environmentally sound technologies for climate mitigation have been heavily contested issues between developed and developing countries, and these differences are likely to continue under the Paris Agreement (Oh 2019). The Technology Mechanism under the UNFCCC, which consists of

the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN), also serves the Paris Agreement, subject to guidance of a new 'technology framework' (UNFCCC, 2015, Art. 10.4). The Paris Rulebook further elaborates the guiding principles and 'key themes' for the technology framework, including innovation, implementation, enabling environment and capacity-building, collaboration and stakeholder engagement, and support (UNFCCC 2019b).

14.4.2.9 Forests and REDD+

Article 5 of the Paris Agreement explicitly calls for parties to take action to conserve and enhance sinks and reservoirs of greenhouse gases, including forests, and encourages countries to engage in cooperative approaches to this end. The explicit inclusion of land use sector activities, including forest conservation, is potentially a 'game changer' as it encourages countries to safeguard ecosystems for climate mitigation purposes (Grassi et al. 2017). Analyses of parties (I)NDCs shows pledged mitigation from land use, and forests in particular, provides a quarter of the emission reductions planned by parties and, if fully implemented, would result in forests becoming a net sink of carbon by 2030 (Forsell et al. 2016; Grassi et al. 2017).

A key cooperative approach endorsed by Article 5 is REDD+, which refers to mechanisms established under the UNFCCC for reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (Park et al. 2013). Article 5.2 encourages parties to implement and support the existing framework for REDD+, including through 'results-based payments' i.e. provision of financial payments for verified avoided or reduced forest carbon emissions (Turnhout et al. 2017). The existing REDD+ framework set up under decisions of the UNFCCC COP includes the Warsaw Framework for REDD+, which specifies modalities for measuring, reporting and verifying (MRV) greenhouse gas emissions and removals. This provides an essential tool for linking REDD+ activities to results-based finance (Voigt and Ferreira 2015). Appropriate finance support for REDD+ is also considered critical to move from its inclusion in many countries' NDCs to implementation on the ground (Hein et al. 2018).

Article 5.2 also encourages parties' support for 'alternative policy approaches' to forest conservation and sustainable management such as 'joint mitigation and adaptation approaches.' It reaffirms the importance of incentivizing, as appropriate, non-carbon benefits associated with such approaches (e.g. improvements in the livelihoods of forest-dependent communities, facilitating poverty reduction and sustainable development). This provision, along with the support for non-market mechanisms in Article 6 (discussed below), is seen as an avenue for cooperative joint mitigation-adaptation and non-market REDD+ activities with co-benefits for biodiversity conservation (Gupta and Dube 2018).

14.4.2.10 Voluntary additional cooperation on mitigation

Article 6.1 of the Paris Agreement recognizes the role that cooperative approaches can play, on a voluntary basis, in implementing parties' NDCs 'in order to allow for higher ambition' in their mitigation actions and to promote sustainable development and environmental integrity. It lists a number of specific types of cooperative approaches that come within its ambit, including internationally transferred mitigation outcomes (ITMOs), a 'mechanism to contribute to mitigation and support sustainable development', and a framework for non-market mechanisms.

Article 6.2 suggests ITMOs can originate from a variety of sources including regional carbon markets or REDD+. Parties can use ITMOs to achieve their NDCs but when engaging in this activity shall promote sustainable development, ensure environmental integrity, ensure transparency, including in governance, and apply 'robust accounting' in accordance with CMA guidance to prevent double counting. While this provision, unlike similar provisions in the Kyoto Protocol, does not create an international carbon market, it enables parties to pursue this option should they choose to do so, for example, through the linking of domestic or regional carbon markets (Marcu 2016; Müller and Michaelowa 2019). Article 6.2 could also be implemented in other ways, including direct transfers

between governments, linkage of mitigation policies across two or more parties, sectoral or activity crediting mechanisms, and other forms of cooperation involving public or private entities, or both (Howard 2017).

Assessments of Article 6.2 generally find that ITMOs are likely to result in cost savings in achieving mitigation outcomes, with the potential for cost reductions to enhance ambition and accelerate parties' progression of mitigation pledges across NDC cycles (Mehling 2018; Gao et al. 2016; Fujimori et al. 2016). However, a growing body of research – usually drawing from experience with existing carbon markets and the Kyoto mechanisms – highlights environmental integrity risks associated with using ITMOs under the Paris Agreement given the challenges that the diverse scope, metrics, types and timeframes of NDC targets pose for robust accounting (Schneider and La Hoz Theuer 2019) and the potential for transfers of 'hot air' as occurred under the Kyoto Protocol (La Hoz Theuer et al. 2019). What these studies collectively affirm is that robust governance, including guidance on accounting for ITMOs, will be critical to ensuring environmental integrity (Müller and Michaelowa 2019; Mehling 2018).

Article 6.4 concerns the mitigation mechanism, referred to by some parties as the 'sustainable development mechanism' or SDM. It is a mechanism that has as an output of GHG emissions reductions, which can be used by any party towards its NDC, subject to the limit that emissions reductions cannot be used towards the NDC of the host party if they are used by another party to demonstrate achievement of its NDC. Unlike the CDM, there is no restriction specified regarding which parties can host mitigation projects and which parties can use the resulting emissions reductions towards their NDCs (Marcu 2016). The SDM will operate under the authority and guidance of the CMA, and is to be supervised by a body designated by the CMA in a similar fashion to the CDM.

The SDM also has a mission to foster sustainable development. The decision adopting the Paris Agreement specifies experience with Kyoto mechanisms like the CDM as a basis for the new mitigation mechanism (UNFCCC, 2016b, para. 37(f)). Compared with the CDM under the Kyoto Protocol, which had a climate-centric focus on measuring emissions reductions, the SDM has a more balanced focus on both climate and development objectives, and a stronger political mandate to measure sustainable development impact and to verify that the impacts are 'real, measurable, and long-term' (Olsen et al. 2018). There are also opportunities to integrate human rights in the SDM (Calzadilla 2018; Obergassel et al. 2017). It is further subject to a specific requirement that it must deliver 'an overall mitigation in global emissions,' which operates in addition to the general requirement in Article 6 for cooperation to enhance ambition (Kreibich 2018).

Negotiations over rules to operationalize Article 6 have proven intractable, failing to deliver both at COP-24 in Katowice in 2018, where the rest of the Paris Rulebook was agreed, and in COP-25 in Madrid in 2019. There are entrenched differences between parties on several issues including: whether to permit the carryover and use of Kyoto CDM credits, and AAUs, towards compliance with parties' NDCs, as this would substantially lower the overall mitigation ambition; whether to impose a mandatory share of proceeds on both Article 6.2 and 6.4 mechanisms to fund adaptation, as this would increase the transaction costs; and, whether credits generated under Article 6.4 should be subject to accounting rules under Article 6.2, as lack thereof could result in double counting, and impact the environmental integrity of the entire regime.

14.4.2.11 Implementation and compliance

The Paris Agreement establishes a mechanism to facilitate implementation and promote compliance under Article 15. This mechanism is to operate in a transparent, non-adversarial and non-punitive manner (Voigt 2016; Campbell-Duruflé 2018; Oberthür and Northrop 2018) that distinguishes it from the more stringent compliance procedures of the Kyoto Protocol's Enforcement branch. The Paris Rulebook elaborated the modalities and procedures for the implementation and compliance

mechanism, specifying the nature and composition of the compliance committee, the situations triggering its procedures, and the facilitative measures it can apply which include a 'finding of fact' in limited situations, dialogue, assistance and recommendations (UNFCCC 2019b). This compliance committee, characterized as 'one of a kind' and an 'an important cornerstone' of the Agreement's legitimacy, effectiveness and longevity (Zihua, Voigt, & Werksman, 2019), is designed to facilitate compliance rather than penalize non-compliance.

14.4.2.12 Loss and Damage

The Paris Agreement contains a free-standing article on loss and damage (UNFCCC, 2015, Art. 8), focused on cooperation and facilitation, under which parties have established a clearing house on risk transfer, and a task force on displacement (UNFCCC, 2016b, paras. 48 and 49). The COP decision accompanying the Paris Agreement specifies that 'Article 8 does not involve or provide a basis for any liability or compensation' (UNFCCC, 2016b, para. 51). There is a range of views on the treatment of loss and damage in the Paris Agreement, how responsibility for loss and damage should be allocated (Lees 2017; McNamara and Jackson 2019), and how it could be financed (Roberts et al. 2017; Gewirtzman et al. 2018). Some scholars argue that there are continuing options to pursue compensation and liability in the climate change regime (Mace and Verheyen 2016; Gsottbauer et al. 2018). There have also been efforts to establish accountability of companies—particularly 'carbon majors' (Frumhoff et al. 2015)—for climate damage in domestic courts (Ganguly et al. 2018). In any case, states that have suffered loss and damage can pursue 'state responsibility' claims under general international law. Many small island states entered declarations on acceptance of the UNFCCC and Paris Agreement that they continue to have rights under international law regarding state responsibility for the adverse effects of climate change, and that no provision in these treaties can be interpreted as derogating from any claims or rights concerning compensation and liability due to the adverse effects of climate change.

Box 14.1 Key features of the Paris Agreement

The Paris Agreement that entered into force on 4 November 2016 has 187 Parties to date, but the United States notified its intent to withdraw on 4 November 2019.

The Paris Agreement's overall aim is to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty. This aim is explicitly linked to enhancing implementation of the UNFCCC, including its objective of stabilizing greenhouse gas emissions at safe levels. The Agreement sets three additional goals:

1. *Temperature*: holding the global average temperature increase to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.

2. *Adaptation* and climate resilience: increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production.

3. *Finance*: making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

In order to achieve the long-term temperature goal, parties collectively aim to reach global peaking of emissions as soon as possible and then to undertake rapid reductions in accordance with the best available science. This is designed to reach global net zero emissions in the second half of the century, with the share of emissions reductions effort borne by different parties to be determined on the basis

of equity and in the context of sustainable development and efforts to eradicate poverty. In addition, implementation of the Agreement as a whole is expected to reflect equity and parties' differentiated responsibilities and respective capabilities, in light of different national circumstances.

The core mitigation commitments of parties under the Paris Agreement centre on preparing, communicating and maintaining successive 'nationally determined contributions' (NDCs), the contents of which countries determine for themselves. All parties must have NDCs and pursue domestic mitigation measures with the aim of achieving the objectives of their NDCs, but parties NDCs are neither subject to a review of adequacy nor legally binding. The compliance mechanism is correspondingly facilitative.

The efficacy of the Paris Agreement in achieving its goal is therefore dependent upon three additional elements:

1. *Voluntary ratcheting of NDCs*: Parties must submit a new NDC every 5 years that is in line with the Paris Agreement's expectations of progression over time and reflecting the party's highest possible ambition.

2. *Enhanced transparency framework*: Parties actions to implement their NDCs are subject to international transparency and review requirements, which will generate information that may also be used by domestic constituencies to pressure governments to increase the ambition of their NDCs.

3. *Collective global stocktake*: The global stocktake undertaken every 5 years will review the collective progress of countries in achieving the Paris Agreement's objectives, in light of equity and best available science. The outcome of the global stocktake informs parties in updating and enhancing their subsequent NDCs.

These international processes establish an iterative ambition cycle for the preparation, implementation and review of NDCs, illustrated below.

For developing countries, the Paris Agreement recognizes that increasing mitigation ambition and realizing long-term low-emissions development pathways depends upon the provision of financial resources, capacity building, and technology development and transfer. The Paris Agreement also permits voluntary cooperation between parties in the implementation of their NDCs to allow for higher ambition in their mitigation actions and to promote sustainable development and environmental integrity.

The Paris Agreement establishes a global goal on adaptation, and recognizes the importance of averting, minimizing and addressing loss and damage that arises where mitigation and adaptation efforts are insufficient.

14.4.2.13 Assessments of the Paris Agreement

Given the comparatively recent conclusion of the Paris Agreement, ex post assessments are not yet feasible. Ex ante assessments are necessarily speculative and limited by the lack of credible counterfactuals. Despite these limitations, numerous ex-ante assessments exist of the potential for international cooperation under the Paris Agreement to advance climate change mitigation. These assessments are mixed and reflect uncertainty over the outcomes the Paris Agreement will achieve (Keohane and Oppenheimer 2016; Young 2016; Christoff 2016; Clémençon 2016; Dimitrov et al. 2019). A general divide can be discerned between studies that reach a more pessimistic conclusion and those that take a more optimistic approach. Those expressing pessimism base this assessment on factors such as: US non-cooperation and the resulting gap in mitigation, finance and governance; a

lack of clarity in the expression of obligations and objectives; a lack of concrete plans collectively to achieve the temperature goal; extensive use of soft law provisions, limited incentives to avoid free-riding, and the Agreement's weak enforcement provisions (Kemp 2018; Bang et al. 2016; Thompson 2017; Chai et al. 2017; Lawrence and Wong 2017; Spash 2016; Barrett 2018). Studies reaching a more optimistic conclusion emphasize factors such as: the breadth of participation enabled by self-differentiated NDCs; the 'logic' of domestic climate policies driving greater national ambition; the multiplicity of actors engaged by the Paris Agreement's facilitative architecture; the falling cost of low-carbon technologies; provision for financial, technology and capacity-building support to developing country parties; possibilities for voluntary cooperation on mitigation under Article 6; and the potential for progressive ratcheting up of parties' pledges over time fostered by transparency of reporting and international scrutiny of national justifications of the 'fairness' of contributions (Chan 2016; Victor 2016; Caparrós 2016; Urpelainen and Van de Graaf 2018; Morgan and Northrop 2017; Falkner 2016).

Turning to the assessment criteria articulated in this chapter, the following preliminary assessments of the Paris Agreement can be made.

In relation to the criterion of *environmental effectiveness*, the Paris Agreement covers a broader range of greenhouse gas emissions than the Kyoto Protocol, thus potentially enhancing its performance against this criterion. Unlike the Kyoto Protocol, the Paris Agreement does not explicitly limit its coverage of greenhouse gases and parties may include a wide range of climate mitigation actions in their NDCs. Moreover, the Paris Agreement makes express reference to parties taking action to conserve and enhance 'sinks and reservoirs of greenhouse gases' (art 5). This allows for coverage of AFOLU emissions, both CO_2 and emissions of other Kyoto Annex A gases. A small number of countries, particularly LDCs, include quantified non-CO_2 emissions reductions from the agricultural sector in their NDCs, and many others include agriculture in their economy-wide targets (Richards et al. 2018). Some studies find that agricultural development pathways with mitigation co-benefits can deliver 21–40% of needed mitigation for the 2°C limit, thus necessitating 'transformative technical and policy options' (Wollenberg et al. 2016). Other studies indicate that broader natural climate solutions, including forests, can provide 37% of the cost-effective CO_2 mitigation needed through 2030 for a more than 66% chance of holding warming to below 2°C (Griscom et al. 2017). Moreover, the estimates in Table 4.3 (chapter 4) show that communicated unconditional NDCs imply a reduction of about a 7% of world emissions by 2030, in terms of Kyoto GHG, compared to a scenario where only current policies are in place; and that conditional NDCs could increase this reduction to about 12%. This demonstrates the importance of meeting the targets in the conditional NDCs.

In relation to the criterion of *transformative potential*, there is presently limited empirical data or theoretical analysis on which to assess the Paris Agreement's transformative potential. The linking of the UNFCCC financial apparatus, including the GCF, to the Paris Agreement, and the provisions on technology support and capacity-building, provide potential avenues for promoting increased investment flows into low-carbon technologies and development pathways. However, the extent of the 'investment signal' sent by the Agreement to business is unclear (Kemp 2018). US non-cooperation also poses a significant threat to adequate investment flows through the GCF (Urpelainen and Van de Graaf 2018; Chai et al. 2017). The IPCC's 1.5°C report concluded that pathways limiting global warming to 1.5°C would require systems transitions that are 'unprecedented in terms of scale' (IPCC 2018c). There is limited evidence to suggest that this is underway.

In relation to the criterion of *distributive outcomes,* the Kyoto Protocol performs better than the Paris Agreement in respect of some indicators such as industrialized country leadership, and differentiation in favour of developing countries. The Kyoto Protocol implemented a multilaterally agreed burden sharing arrangement, reflected in Annex-based differentiation in mitigation obligations, while the Paris Agreement relies on NDCs, accompanied by self-assessments of the fairness of these

contributions. At present, mechanisms for promoting equitable burden-sharing and evaluating the fairness of parties' contributions are undefined, although numerous proposals have been developed in the literature (Sheriff 2019; Herrala and Goel 2016; Alcaraz et al. 2019; Robiou du Pont et al. 2017; Ritchie and Reay 2017) (discussed in section 14.4.2.3, above).

In relation to other indicators such as the provision of support, distributive outcomes are heavily dependent on the effectiveness of compensatory mechanisms, such as the GCF, to meet the mitigation and adaptation financing needs of developing countries (Chan et al. 2018a; Antimiani et al. 2017). This is particularly important given that the implementation of the emissions reduction objectives stated in the NDCs implies trade-offs with poverty reduction efforts needed to achieve SDGs (Campagnolo and Davide 2019). Finally, in relation to the promotion of co-benefits, compared with the Kyoto Protocol, the Paris Agreement has enhanced mechanisms for promoting co-benefits (e.g. for biodiversity conservation through the endorsement of REDD+) and linkages to sustainable development (e.g. through the SDM).

On the criterion of *economic performance*, this is potentially enhanced by the capacity for parties to link mitigation policies, therefore improving aggregate cost-effectiveness. ITMOs, allowed for under Article 6 of the Paris Agreement, are regarded as a reasonable vehicle to facilitate linkage (Chan et al. 2018a). A combination of common accounting rules and the absence of restrictive criteria and conditions on the use of ITMOs could accelerate linkage and increase the latitude of parties to scale up the ambition of their NDCs. However, significant question marks remain over how the environmental integrity of traded emissions reductions can be ensured (Mehling 2018). The ability of Article 6 to contribute to the goal of the Paris Agreement will depend on the extent to which the rules ensure environmental integrity and avoid double counting, while utilizing the full potential of cooperative efforts (Schneider et al. 2019).

In relation to the criterion of *institutional strength*, the performance of the Paris Agreement compared with the Kyoto Protocol is enhanced on some indicators but reduced on others. For example, the Paris Agreement has broad participation, with 187 parties thus far who have submitted 185 NDCs. On the other hand, the durability and future ambition of NDCs is potentially threatened by the US withdrawal (Chan et al. 2018a; Pickering et al. 2018). In addition, the trade-off for securing broad participation in the Paris Agreement was greater discretion for parties, vagueness of obligations and a weak compliance system (Keohane and Oppenheimer 2016), elements that reduce institutional strength.

The Paris Agreement's institutional strength in terms of its signalling and guidance function, is arguably high. The Paris Agreement has the potential to interact with complementary approaches to climate governance emerging beyond it (Held and Roger 2018). It may also be used by publics – organized and mobilized in many countries and transnationally – as a point of leverage in domestic politics to encourage countries to take costly mitigation actions (Keohane and Oppenheimer 2016). More broadly, the Paris Agreement's architecture provides flexibility for decentralized forms of governance (Victor 2016; Jordan et al. 2015). The Agreement has served a catalytic and facilitative role in enabling and facilitating climate action from non-state and sub-state actors (Hale 2016; Chan et al. 2016, 2015; Kuyper et al. 2018b; Bäckstrand et al. 2017). Such action could even bridge the ambition gap created by insufficient NDCs from parties (Hsu et al. 2019b). Non-state actors are also playing a role in enhancing the ambition of individual NDCs by challenging their adequacy in national courts (see Chapter 13 and section 14.5.8 below).

The Paris Agreement's institutional strength in terms of 'rules and standards to facilitate collective action' is disputed given the current lack of clear reporting requirements and comparable information in NDCs (Mayer 2019; Pauw et al. 2018; Zihua et al. 2019; Peters et al. 2017), and the extent to which its language, as well as that of the Rulebook, strikes a balance in favour of discretion over prescriptiveness (Rajamani and Bodansky 2019). Similarly, in terms of 'mechanisms to enhance transparency and accountability', although detailed rules relating to transparency have been developed

under the Paris Rulebook, these rules permit parties considerable self-determination in the extent and manner of application (Rajamani and Bodansky 2019). Further the Paris Agreement's compliance committee is facilitative and designed to ensure compliance with the procedural obligations in the Agreement, rather than with the NDCs themselves, which are not subject to obligations of result.

Ultimately, the overall effectiveness of the Paris Agreement depends on its ability to lead to ratcheting up of collective climate action (Bang et al. 2016; Christoff 2016; Dimitrov et al. 2019; Gupta and van Asselt 2019; Young 2016). The design of the Paris Agreement, which has 'nationally determined' contributions at its centre, countenances an initial shortfall in collective ambition on the understanding and expectation that parties will enhance the ambition of their NDCs over time (art. 4). This is essential given the current shortfall in ambition. The pathways reflecting current NDCs, according to various estimates, imply global warming in the range of 3°C by 2100 (UN Environment Programme 2018; UNFCCC 2016b). NDCs will need to be substantially scaled up if the temperature goal of the Paris Agreement is to be met (Rogelj et al. 2016, 2018; Höhne et al. 2017; UN Environment Programme 2019). The Paris Agreement's 'ambition cycle' is designed to trigger such enhanced ambition over time. Some studies find that like-minded climate mitigation clubs can deliver substantial emission reductions (Hovi et al. 2017) and are reasonably stable despite the departure of a major emitter such as the United States (Sprinz et al. 2018), other studies find that conditional commitments in the context of a pledge and review mechanism are unlikely to substantially increase countries' contributions to emissions reductions (Helland et al. 2017), and hence need to be complemented by the adoption of instruments designed differently from the Paris Agreement (Barrett and Dannenberg 2016). In any case, high (but not perfect) levels of mean compliance rates with the Paris Agreement have to be assumed for reaching the 'well below 2°C' temperature goal (Håkon Sælen, Hovi, Jon, Detlef Sprinz 2020). This is by no means assured.

In conclusion, it remains to be seen whether the Paris Agreement—which represents a fundamental shift in architecture from the Kyoto Protocol—will deliver the collective ambition necessary to meet the temperature goal. While the Paris Agreement does not contain strong and stringent obligations of result for major emitters, backed by a coercive compliance system, it establishes binding procedural obligations, lays out a range of normative expectations, and creates mechanisms for regular review, stock taking, and revision of NDCs. In combination with complementary approaches to climate governance, engagement of a wide range of non-state and sub-state actors, and domestic enforcement mechanisms, these have the potential to deliver the necessary collective ambition.

14.4.3 Other relevant non-climate agreements

As a result of the expanding scope of global climate governance, matters relevant to climate change mitigation are addressed by a range of multilateral environmental agreements (MEAs) beyond those of the international climate regime.

The 1987 Montreal Ozone Protocol is the leading example of a non-climate MEA with significant implications for mitigating climate change (Barrett 2008). The Montreal Protocol regulates a number of substances that are both ozone depleting substances (ODS) and GHGs with a significant global warming potential (GWP), including chlorofluorocarbons, halons and hydrochlorofluorocarbons (HCFCs). As a result, implementation of phase-out requirements for these substances under the Montreal Protocol has made a significant contribution to mitigating climate change (Molina et al. 2009). Velders et al estimate that the climate protection achieved by the Montreal Protocol alone was far larger than the reduction target of the first commitment period of the Kyoto Protocol (Velders et al. 2007).

The 2016 Kigali Amendment to the Montreal Protocol applies to the production and consumption of hydrofluorocarbons (HFCs). HFCs, which are widely used as refrigerants (Abas et al. 2018), have

high GWP values ranging from 53 to 14,800 for HFC-23. The Kigali Amendment addresses the risk that the phase-out of HCFCs under the Montreal Protocol and their replacement with HFCs could exacerbate global warming (Akanle 2010; Hurwitz et al. 2016), especially with the predicted growth in HFC usage for applications like air conditioners (Velders et al. 2015). It requires developed country parties to phase-down HFCs by 85% from 2011-2013 levels by 2036. Developing country parties are permitted longer phase-down periods (out to 2045 and 2047), but must freeze production and consumption between 2024 and 2028 (UN 2016; Ripley and Verkuijl 2016). A ban on trade in HFCs with non-parties will come into effect from 1 January 2033. For HFC-23, which is a by-product of HCFC production rather than a ODS, parties are required to report production and consumption data, and to destroy all emissions of HFC-23 occurring as part of HCFCs or HFCs to the extent practicable using approved technologies (Ripley and Verkuijl 2016). Full compliance with the Kigali Amendment is predicted to reduce global HFC emissions by 61% of the global baseline by 2050 (Höglund-Isaksson et al. 2017), with avoided global warming of up to 0.5°C this century (Roberts 2017; Graziosi et al. 2017). However, achievement of this objective is dependent on ratification of the Amendment by key developed countries, such as the United States, and the provision of funds by developed countries through the Protocol's Multilateral Fund to meet developing countries' 'agreed incremental costs' of implementation (Roberts 2017). The Kigali Amendment came into force on 1 January 2019 and has been ratified by 87 of the 196 parties to the Montreal Protocol.

MEAs dealing with transboundary air pollution, such as the Convention on Long-Range Transboundary Air Pollution (LRTAP) and its implementing protocols, which regulate non-GHGs like particulates, nitrogen oxides and ground-level ozone, can also have potential benefits for climate change mitigation (Erickson 2017). Studies have indicated that rigorous air quality controls targeting short-lived climate forcers, like methane, ozone and black carbon, could slow global mean temperature rise by about 0.5°C by mid-century (Schmale et al. 2014). Steps in this direction were taken with 2012 amendments to the LRTAP Gothenburg Protocol to include black carbon, which is an important driver of climate change in the Arctic region (Yamineva and Kulovesi 2018). The amended Protocol, which has 22 parties including the US and EU, entered into force in October 2019. However, its limits on black carbon have been criticized as insufficiently ambitious in light of scientific assessments (Khan and Kulovesi 2018).

Another, recently concluded MEA that may play a role in aiding climate change mitigation is the 2013 Minamata Mercury Convention, which came into force on 16 August 2017. Coal burning for electricity generation represents the second largest source (behind artisanal and small-scale gold mining) of anthropogenic mercury emissions to air (UNEP 2013). Efforts to control and reduce atmospheric emissions of mercury from coal-fired power generation under the Minamata Convention may reduce GHG emissions from this source (Eriksen and Perrez 2014; Selin 2014). For instance, (Giang et al. 2015) have modelled the implications of the Minamata Convention for mercury emissions from coal-fired power generation in India and China, concluding that reducing mercury emissions from present-day levels in these countries is likely to require 'avoiding coal consumption and transitioning toward less carbon-intensive energy sources' (Giang et al. 2015). Parties to the Minamata Convention include five of the six top global CO_2 emitters – China, the United States, the EU, India and Japan (Russia has not ratified the Convention). The Minamata Convention also establishes an Implementation and Compliance Committee to review compliance with its provisions on a 'facilitative' basis (Eriksen and Perrez 2014).

MEAs that require state parties to conserve habitat or to protect certain ecosystems like wetlands may also have co-benefits for climate change mitigation through the adoption of well-planned conservation policies (Phelps et al. 2012; Gilroy et al. 2014). REDD+ activities have been identified as a particular opportunity for achieving climate mitigation objectives while also conserving tropical forest biodiversity, although actual biodiversity co-benefits are dependent on the design and implementation

of REDD+ programs (Panfil and Harvey 2016). Busch et al have found that elements of REDD+ that are most effective for climate change mitigation (e.g. greater finance combined with reference levels which reduce leakage by promoting broad participation across countries with both high and low historical deforestation rates) also offer the greatest benefits for biodiversity conservation (Busch et al. 2011).

14.5 Institutions and instruments for sub-global and/or sectoral specific cooperation

As discussed above, the Paris Agreement sets in place a new framework for international climate policy that some cite as leading to a new era of hybrid multilateralism (Bäckstrand et al. 2017). Whereas international governance had assumed centre stage earlier, the Paris Agreement recognizes the primacy of domestic politics in the governance of climate change. The new architecture also provides more flexibility for recognizing the benefits of working in diverse forms and groups and allowing for more decentralized "polycentric" forms of governance (Victor 2016; Jordan et al. 2015).

A similar evolution can be observed in theoretical analyses, which in general no longer deal with multilateral negotiations over a global agreement. The focus has shifted towards regional or sectoral agreements, or agreements focused on a particular subset of GHGs (Stewart et al. 2017; Falkner 2016; Sabel and Victor 2017). However, these institutions are no longer static, as the key idea is that self-enforcing cooperation can emerge in small groups which can serve as "building blocks" towards global cooperation.

One theoretical basis for this is that of socio-technological transitions. Geels et al. (2019) suggest that the elimination of net greenhouse gas emissions across all sectors of society, within a specific timeframe, requires anticipatory investments in new technologies, which differ substantially across sectors. Cross-sectoral policies, such as economy-wide emissions reduction targets, do not lead to this result, as they often result in delaying action in those sectors where decarbonization is most challenging. They suggest that greater attention to specific technology or performance standards within separate sectors, supplemented with direct technology support, can address this issue, not only at national levels but also in the area of international cooperation. A second theoretical basis comes from club theory. Technology innovation can be transformed easier than climate change mitigation into a club good, as it is possible to exclude non-members of the club. Economic theory of clubs shows that cooperation in clubs is easier that at a global level, under certain conditions (Buchanan 1965). In exchange for curbing their emissions, club participants receive some benefits that they would not receive otherwise (Green 2017). Along these lines, Stewart et al. (2017) consider clubs which are established around producing and disseminating green technology, and Potoski (2017) analyzes voluntary clubs built around a certification system (in both cases developing previous contribution within a logic of building blocks). Similarly, Nordhaus (2015) advocates the creation of climate clubs, focusing on the use of trade penalties to outsiders (Keohane et al. 2017). Using different methods, but with similar outcomes, several studies have shown that cooperation can evolve gradually starting with the actions from a leader, or a group of committed countries (Caparrós and Péreau 2017; Sprinz et al. 2018; Hovi et al. 2016).

14.5.1 International emissions trading mechanisms

In theory, trading carbon assets can reduce the costs of global climate mitigation, by helping facilitate abatement of greenhouse gases at least-cost locations. This could help countries ratchet up their ambitions more than in a situation without such mechanisms (Mehling et al. 2018). Progress as to developing such mechanisms has however so far been moderate and uneven.

As described in previous IPCC reports the 1997 Kyoto Protocol included three international market-based mechanisms, both among Annex I Parties (i.e. International Emissions Trading and Joint Implementation) and between Annex I Parties and non-Annex I countries (i.e. the Clean Development Mechanism) (Grubb 2014; World Bank 2018). Joint Implementation, with projects and credits mainly being developed by Russia, Ukraine and some Eastern European countries, never took off and only a limited number of trades were conducted. International Emissions Trading has been a bit more important, with trades mainly with the Russian and Easters European countries as sellers and Japan as the key buyer. Demand has generally been low (World Bank 2018). As the basis for these credits was mainly post-Communist economic restructuring and not climate policy the credits have been criticized for constituting 'hot air' and not real and additional reductions.

The CDM market has been the most important, with something of a 'gold rush' period between 2005 and 2011, although CDM projects have also been criticized, for lack of 'additionality', problems of baseline determination and uneven geographic coverage (as most projects were in India, China and Brazil) (Michaelowa, A. and Michaelowa 2011; Öko-Institut 2016; Michaelowa, A., Shishlov, I.; Brescia 2019). The EU, the main buyer of credits, tightened its rules and restricted the use of CDM credits in 2011, contributing to a sharp drop in the price of CDM credits in 2012. As the second commitment period of the Kyoto Protocol has yet to be formally initiated, the Doha Amendment not having entered into force, this price has not recovered.

Assessing the effectiveness of international emissions trading mechanisms is a challenge. The CDM has been the most prominent of the mechanisms. In relation to environmental effectiveness, a number of studies raise serious concerns about the independent value of many CDM projects (Michaelowa, A., Shishlov, I.; Brescia 2019). This points to a 'likely low and also uncertain' environmental effectiveness score. In relation to transformative potential, the picture is mixed. On the one hand, the CDM's contribution to capacity building in some developing countries has been lauded as its possible most important achievement (Spalding-Fecher, R., Achanta, A. N., Erickson, P., Haites, E., Lazarus, M., Pahuja, N., Tewari, 2012). On the other hand, the CDM seems also to have led to prioritizing 'low-hanging fruits' over more fundamental measures (e.g. (Akita, J., Imai, H., & Niizawa 2012; Newell, P., & Bumpus 2012). So, an overall 'moderate' score appears reasonable. As to distributive outcomes, as noted, the mechanisms have been criticized for a 'familiarity focus' and steering money into only a handful of key countries (China, India, Brazil). A low to medium score is given here. With regard to economic performance, the mechanism has reportedly lowered compliance costs significantly for the EU and Japan (Spalding-Fecher, R., Achanta, A. N., Erickson, P., Haites, E., Lazarus, M., Pahuja, N., Tewari, 2012). This points to a medium score in this respect. Finally, as to institutional strength, the assessment is mixed: while the experiences from the International Transaction Log (ITL) and the accounting apparatus helped establish a certain administrative capacity in this issue area, there were also governance challenges such as lack of transparency on project decisions.

A relevant and promising new development is the international linkage of existing regional or national emission trading systems. Several emission trading systems are now operational in different jurisdictions, including the EU, Switzerland, China, South Korea, New Zealand, and several US states and Canadian provinces (Wettestad, J. and Gulbrandsen 2018). More systems are in the pipeline, including Mexico and Thailand (ICAP 2019). Some of these jurisdictions have agreed to link their systems (the EU and Switzerland agreed in 2016) and other linkages are being negotiated. (Doda and Taschini 2017; Doda et al. 2019) analyse the potential benefits of these multilateral linkages and demonstrate that these are significant. Over time, the linkages of these emission trading systems can be seen as a building blocks to a strategic enlargement of international cooperation (Mehling 2018; Caparrós and Péreau 2017).

However, it is important to distinguish between theory and practice. The practice of ETS linking so far shows few links having been made and several processes breaking down due to shifts of governments and political preferences (for instance the process between the EU and Australia, and Ontario withdrawing from the WCI). It is worth noting that the linking of carbon markets raises problems of distribution of costs and loss of political control and hence does not offer a politically easy alternative route to a truly international carbon market. Careful, piece-meal and incremental linking may be the most feasible approach forward (Green, J., Sterner, T., & Wagner 2014; Gulbrandsen, L.H., Wettestad, J., Victor 2019). It is premature for any serious assessment of the practice of ETS linking to be conducted. Environmental effectiveness, transformative potential, economic performance, institutional strength and even distributional outcomes can potentially be significant and positive if linking is done carefully (Mehling et al. 2018; Doda and Taschini 2017; Doda et al. 2019), but are all marginal if one focuses on existing experiences.

14.5.2 International sectoral agreements and institutions.

Sectors refer to distinct areas of economic activity, often subject to their own governance regimes; examples include energy production, mobility, and manufacturing. A sectoral agreement could include virtually any type of mitigation commitment. It could establish sectoral emission targets, on either an absolute or an indexed basis. It could also require states (or particular groups of states, if commitments are differentiated) to adopt uniform or harmonized policies and measures for a sector, such as technology-based standards, taxes, or best-practice standards. It could provide for cooperation on technology research or deployment. Or a sectoral agreement could combine a number of approaches (Bodansky 2007).

14.5.2.1 Forestry sector

Since 2008, several, often overlapping, voluntary and non-binding international efforts and agreements have been established to reduce net emissions from the forestry sector. These initiatives have varying levels of private sector involvement and different objectives, targets, and timelines. Some efforts focus on *reducing emissions from deforestation and degradatio*n, while other focus on *negative emissions through restoration* of cleared or degraded landscapes. These initiatives do not elaborate specific policies, procedures, or implementation mechanisms. They merely set targets, frameworks, and milestones, aiming to catalyze further action, investment, and transparency in conservation and consolidate individual country efforts.

The longest standing program in the forestry sector is the UN REDD+ Programme, started in 2008, which aims to reduce forest emissions and enhance carbon stocks in forests while contributing to national sustainable development. These efforts tend to focus on reducing emissions through the creation of protected areas, payments for ecosystem services, and/or land tenure reform (Pirard et al. 2019). The programme supports national REDD+ efforts, inclusion of stakeholders in relevant dialogues, and capacity building toward REDD+ readiness in partner countries. The Forest Carbon Partnership Facility is a related initiative that helps facilitate funding for REDD+ readiness and specific projects. To date the conservation and emissions impacts of REDD+ remain poorly understood (Pirard et al. 2019), but existing evidence suggests that reductions in deforestation from subnational REDD+ initiatives have been minimal (Bos et al. 2017).

Another relevant initiative is the 2015 United Nations Convention to Combat Desertification (UNCCD), which targets land degradation neutrality ("A state whereby the amount and quality of land resources, necessary to support ecosystem functions and services and enhance food security, remains stable or increases within specified temporal and spatial scales and ecosystems*")* (Orr et al. 2017). This overarching goal was recognized as also being critical to reaching the more specific avoided deforestation and degradation and restoration goals of the UNFCCC and UNCBD.

Recent efforts toward reduced emissions from the forestry sector have the overarching goal of reaching zero *gross* deforestation globally (no more clearing of natural forests). The New York Declaration on Forests was the first international pledge to call for a halving of "natural forest" loss by 2020 and the elimination of natural forest loss by 2030 (Streck et al.). It was endorsed at the United Nations Climate Summit in September 2014. By September 2019 the list of NYDF supporters included over 200 actors: national governments, sub-national governments, multi-national companies, groups representing indigenous communities, and non-government organizations. These endorsers have committed to doing their part to achieve the NYDF's ten goals, which further include ending deforestation for agricultural expansion by 2020, reducing deforestation from other sectors, restoring forests, and providing financing for forest action (Forest Declaration 2019). The effectiveness of these agreements, which lack binding rules, can only be judged by the supplementary actions they have catalyzed. The NYDF contributed to the development of a number of other zero-deforestation pledges, including the Amsterdam Declarations by seven European nations to achieve fully sustainable and deforestation-free agro-commodity supply chains in Europe by 2020 and over 150 individual company commitments to not source products associated with deforestation (Lambin et al. 2018; Donofrio et al. 2017). Recent studies indicate that these efforts currently lack the potential to achieve wide-scale reductions in clearing and associated emissions due to low implementation (Garrett et al. 2019), but may have triggered small additional reductions in deforestation in some areas, particularly for soy, and to a lesser extent cattle, in the Brazilian Amazon(Lambin et al. 2018). Though deforestation levels and associated emissions continue to be high, and even increasing in many regions of the world (Curtis et al. 2018), global targets are clearly not being met.

In 2010 the Strategic Plan for Biodiversity 2011–2020 was adopted by the parties of the UN Convention on Biological Diversity (UNCBD) in 2010. This plan included 20 targets known as the Aichi Biodiversity targets(Marques et al. 2014). Of relevance to the forestry sector, Aichi Target 15 sets the goal of enhancing ecosystem resilience and the contribution of biodiversity to carbon stocks though conservation and restoration, including "restoration of at least 15% of degraded ecosystems"(UNCBD 2010). The plan elaborates milestones, including the development of national plans for potential restoration levels and contributions to biodiversity protection, carbon sequestration, and climate adaptation to be integrated into other national strategies, including REDD+.

Recent efforts toward negative emissions through restoration include the Bonn Challenge, the African Forest Landscape Restoration Initiative (AFR 100) and Initiative 20X20. The Bonn Challenge was initiated in 2011 by the Government of Germany and the IUCN to serve as a catalyst to realizing the existing international AFOLU commitments. It sets the target of bringing 150 million hectares (Mha) of the world's deforested and degraded land into restoration by 2020, and 350 Mha by 2030. AFR has the goal of restoring 100 Mha specifically in Africa (Nhlapho 2019), while 20X20 aims to restore 20 Mha in Latin America and the Caribbean (Peimbert 2019). Increasing commitments for restoration have created momentum for restoration interventions (Chazdon et al. 2017; Mansourian et al. 2017; Djenontin et al. 2018). To date 97 Mha have been pledged in Intended Nationally Determined Contributions. Yet only a small part of this goal has actually been achieved. The Bonn Challenge Barometer – a progress-tracking framework and tool to support pledgers - indicates that 27 Mha (InfoFLR 2018) are currently being restored, equivalent to 1.379 billion tonnes CO_2eq sequestered (Dave et al. 2019). A key challenge in scaling up restoration has been how to mobilize sufficient financing (FAO and UNCCD 2015; Djenontin et al. 2018). This underscores the importance of building international financing for restoration (equivalent to the Forest Carbon Partnership Facility focused on avoided deforestation and degradation).

In sum, existing international agreements have had a small impact on reducing emissions from the forestry sector and some success in achieving negative emissions through restoration, but these outcomes are nowhere near levels required to meet the Paris Agreement - turning land use an forests

globally "from a net anthropogenic source during 1990-2010 (1.3 ± 1.1 $GtCO_2eq\ y^{-1}$) to a net sink of carbon by 2030 (up to -1.1 ± 0.5 $GtCO_2eq\ y^{-1}$), and providing a quarter of emission reductions planned by countries"(Grassi et al. 2017). The forestry sector continues to be a large source of emissions that is not even close to being offset by existing restoration initiatives.

14.5.2.2 Energy sector

International cooperation on issues of energy supply and security has a long history. Most of this history, however, has centred on fossil fuels, oil and gas in particular. As Goldthau and Witte (2010) document, the majority of governance effort, outside of oil and gas producing states, was oriented towards ensuring reliable and affordable access to oil and gas imports. For example, the original rationale for creation of the International Energy Agency (IEA), during the oil crisis of 1973-74, was to manage a mechanism to ensure importing countries access to oil (Van de Graaf and Lesage 2009). On the other side of the aisle, oil exporting countries created the international institution of OPEC to enable them to control oil output and prices (Fattouh and Mahadeva 2013). For years, energy governance was seen as a zero-sum game between these poles (Goldthau and Witte 2010). The only international governance agency focusing on low carbon energy sources was the International Atomic Energy Agency, and this organization was primarily concerned with nuclear safety non-proliferation of weapons, rather than promoting a low-carbon energy source (Scheinman 1987).

More recently, however, new institutions have emerged, and existing institutions have realigned their missions, in order to promote capacity raising and global investment in low carbon energy technologies. In 2005 the IEA broadened its mission from one concerned primarily with security of oil supplies, to one also concerned with the sustainability of energy use, including work programs on energy efficiency and clean energy technologies. Included in this work has been the maintenance of databases on alternative energy production and consumption, development of renewable energy scenarios, and performing advisory functions, such as in the context of UNFCCC negotiations (Van de Graaf and Lesage 2009). Nevertheless, the perception that the IEA was primarily interested in promoting the continued use of fossil fuels, and underplaying the potential role of renewable technologies led a number of IEA member states to successfully push for the creation of a parallel organization, the International Renewable Energy Agency (IRENA), which was then established in 2009 (Van de Graaf 2013). An assessment of IRENA's activities in 2015 suggested that the agency could has a positive effect as a result of three core activities: offering advisory services to member states regarding renewable energy technologies and systems; serving as a focal point for data and analysis for renewable energy; and, mobilizing other international institutions, such as multilateral development banks, to promote renewable energy (Urpelainen and Van de Graaf 2015). Similar work has also been conducted by the Committee on Sustainable Energy within the United Nations Economic Commission for Europe. Finally, there have emerged a number of transnational organizations and activities, such as REN21, a global community of renewable energy experts (REN21 2019), and RE100, an NGO led initiative to enlist multilateral companies to shift towards 100% renewable energy in their value chains (RE100 2019).

Whether a result of the above activities or not, multilateral development banks' lending practices have shifted in the direction of renewable energy (Delina 2017). Activities include new sources of project finance, concessional loans, as well as loan guarantees, the latter through the Multilateral Investment Guarantee Agency (MIGA 2019). This appears to matter. For example, Frisari and Stadelmann (2015) find concessional lending by multilateral development banks to solar energy projects in Morocco and India to have reduced overall project costs, due to more attractive financing conditions from additional lenders, as well as reducing the costs to local governments. Labordena et al. (2017b) projected these results into the future, and found that with the drop in financing costs, renewable energy projects serving all major demand centers in sub-Saharan Africa could reach cost parity with

fossil fuels by 2025, whereas without the drop in financing costs associated with concessional findings, this would not be the case.

Despite improvements in the international governance of energy, it still appears that a great deal of this is still concerned with promoting further development of fossil fuels. For example, Gallagher et al. (2018) examine the role of national development finance systems, focusing in particular on China. They find the majority of finance devoted to projects associated either with fossil fuel extraction or with fossil fuel-fired power generation.

There are no empirical analyses of the combined effectiveness of international cooperation in the energy sector. Given the separate analyses reviewed here, it appears that pre-existing governance had a negative overall effect towards achieving the objectives of the Paris Agreement, while more recent progress is having a weakly positive effect. The latter is primarily associated with the criterion of transformative potential, as the new initiatives are primarily associated with improving capacity, financing, and performance of low carbon technologies, rather than engaging in direct regulation that would lead to an observable environmental impact. Such efforts would also contribute to improvements in the institutional strength of national governments in the area of renewable energy development.

14.5.2.3 Transportation sector

Regulations introduced by the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO) have played a role in controlling emissions from international shipping and aviation. Emissions from these elements of the transportation sector are generally excluded from national emissions reduction policies because of the 'international' location of emissions release that makes allocating them to individual nations difficult (Bows-Larkin 2015; Lyle 2018). Aviation emissions currently account for 2-2.5% of global CO_2 emissions (Grote et al. 2014), with total shipping emissions contributing 2.6% global CO_2 emissions (Olmer et al. 2017). Despite increasing efficiency, emissions from both sectors are growing substantially with increasing demand (Bows-Larkin 2015). By 2050, emissions from these sectors combined are projected to reach a level equivalent to 10-32% of the total global emissions consistent with a 2°C pathway (Gençsü and Hino 2015).

The Kyoto Protocol required developed country parties to pursue emissions reductions from aviation and marine bunker fuels by working through IMO and ICAO (Art. 2.2). Although limited progress was made by these organizations on emissions controls in the ensuing decades (Liu 2012), conclusion of the SDGs and Paris Agreement (Martinez Romera 2016), together with unilateral actions such as the EU's inclusion of aviation emissions in its Emissions Trading Scheme (Kulovesi 2012; Gössling and Upham 2009), have prompted greater action. The Paris Agreement neither explicitly addresses emissions from international aviation and shipping, nor repeats the Kyoto Protocol's provision requiring parties to work through ICAO/IMO to address these emissions. This leaves unclear the status of the Kyoto Protocol's article 2.2 directive after 2020, potentially opening up scope for more attention to aviation and shipping emissions under the Paris Agreement, as well as within the IMO and ICAO (Doelle and Chircop 2019).

ICAO has adopted a 'basket' of mitigation measures for the aviation sector consisting of technical and operational measures, sustainable alternative fuels and a market-based measure, known as the Carbon Offset and Reduction Scheme for International Aviation (CORSIA) introduced in 2016 (ICAO 2016). CORSIA includes an aspirational goal to keep global net CO_2 emissions from international aviation from 2020 at the same level, which is to be implemented in phases after 2020. However, it is unclear whether this goal and further emissions reduction in the sector will be possible solely through the use of offsets without additional constraints on demand (Lyle 2018). Other measures adopted by ICAO include an aircraft CO_2 emissions standard that will apply to new aircraft type designs from 2020, and to aircraft type designs already in production as of 2023 (Smith and Ahmad 2018).

The IMO has also considered a range of measures to reduce shipping emissions, with a focus on energy efficiency (Martinez Romera 2016). The IMO's Energy Efficiency Design Index (EEDI) for new ships is intended over a ten-year period to improve energy efficiency by up to 30% in several categories of ships propelled by diesel engines (Smith and Ahmad 2018). However, it is unlikely that the EEDI and other IMO technical and operational measures will be sufficient to produce necessary emissions reduction because of the future growth in international seaborne trade and world population (Shi and Gullett 2018). Consequently, in 2018, the IMO adopted an initial strategy on reduction of GHG emissions from ships, which aims for peaking of emissions as soon as possible and reducing the total annual GHG emissions by at least 50% by 2050 compared to 2008 levels (IMO 2018). The strategy identifies a series of candidate short-term, medium-term and long-term measures for achieving this goal, including possible market-based measures. Further progress on market-based measures faces difficulty in light of conflicts between the CBDR principle of the climate regime and the traditional non-discrimination approach that has guided past IMO regulation (Zhang 2016). Overall, the IMO strategy is seen as a reasonable first step that is ambitious for the industry, although in its next iteration of the strategy to 2023 there is a need to specify concrete implementation measures and to strengthen targets to catch up with the goals of the Paris Agreement (Doelle and Chircop 2019).

14.5.3 International cooperation in science, technology, and innovation

Science, technology and innovation are essential for the design of effective measures to address climate change and, more generally, for economic and social development. The OECD (2012a) finds that single countries alone often cannot provide effective solutions to the global challenges of today, as these cross national borders and affect different actors. However the capacity for scientific and technological innovation is not evenly distributed, particularly across the developed and the developing world. For this reason, many countries have been introducing strategies and policies to enhance international cooperation in science and technology and have made this a priority (Chen et al. 2019; OECD 2012a). Partnerships and international cooperation can play a role in establishing domestic innovation systems, which enable more effective science and technology innovation (de Coninck and Sagar 2015a,b).

International cooperation in science and technology occurs across different levels, with a growing number of international cooperation initiatives aimed at research and collaborative action in technology development. Weart (2012) finds that such global efforts are effective in advancing climate change science due to the international nature of the challenge. Global research programmes and institutions have also provided the scientific basis for major international environmental treaties. For example, the Transboundary Air Pollution Convention and the Montreal Protocol were both informed by scientific assessments based on collaboration and cooperation of scientists across several geographies. Furthermore, the Global Energy Assessment (GEA) (2012) provided the scientific basis and evidence for the 2030 Agenda for Sustainable Development, in particular SDG7 to ensure access to affordable, reliable and sustainable modern energy for all. The GEA drew on the expertise of scientists from over 60 countries and institutions. Several other platforms exist to provide scientists and policymakers an opportunity for joint research and knowledge sharing, such as The World in 2050, an initiative that brings together scientists from some 40 institutions from around the world to provide the science for SDG and Paris Agreement implementation (TWI2050 2018).

Non-state actors are also increasingly collaborating internationally. Such collaborations, referred to as international cooperative initiatives (ICIs), bring together multi-stakeholder groups across industry, communities, and regions and operate both within and outside the UNFCCC process. While a large number of ICIs exist, Bakhriari (2018) finds that the impact on greenhouse gas reduction of these initiatives is hindered due to a lack of coordination between ICIs, overlap with other activities conducted by the UNFCCC and governments, and a lack of monitoring system to measure impact.

Increasing the exchange of information between ICIs, enhancing monitoring systems, and increasing collaborative research in science and technology would help address these issues (Boekholt et al. 2009; Bakhtiari 2018).

At the level of research institutes, there has been a major shift to a more structured and global type of cooperation in research, building on the existing bottom-up, informal and regional (mostly European) cooperation (Georghiou 1998). Wagner et al (2017) find that number of scientific papers that are co-authored internationally has increased from 10 percent to 25 percent, and the amount of countries participating in international research has grown by 58 countries in the period 1990 to 2015. Although only a portion of these scientific papers address the issue of climate change specifically, this growth of scientific collaboration across borders provides a comprehensive view of the conducive environment in which climate science collaboration has grown.

However, there are areas in which international cooperation can be strengthened. Both the Paris Agreement and the 2030 Agenda for Sustainable Development call for more creative forms of international cooperation in science that can help bridge the science and policy interface, and that can provide learning processes and places to deliberate on possible policy pathways across disciplines on a more sustainable and long-lasting basis. Scientific assessments, such as the IPCC and IPBES offer this possibility, but the processes need to be enriched for this to happen more effectively (Kowarsch et al. 2016). This is especially apparent in literature surrounding scenarios, where researchers are collaborating to produce new families of scenarios that aim to be more comprehensive and inclusive of economic, social and environmental dimensions (Riahi et al. 2017; Ebi et al. 2014). These efforts involve researchers and institutions globally, drawing expertise from individuals in both the developed as well as developing world. The IPCC Special Report on Emissions Scenarios (SRES) in 2000, the Representative Concentration Pathways (RCPs) (van Vuuren et al. 2011), and the current collaboration on Shared Socioeconomic Pathways (SSPs) (Riahi et al. 2017; O'Neill et al. 2017) all relied on the successful cooperation of scientists across borders

Rapid advances in technology, major geopolitical changes, shifts in the way research is funded, and more pressures for open access will all have major impacts on international cooperation in science. A report by Elsevier and Ipsos (2019) find that these new developments have the potential, if well managed, to bring positive impacts. Major advances in general purpose technologies such as digital technology will have implications across sectors and have already been disruptive in the energy sector (Skea et al. 2019). Big data, artificial intelligence, blockchain, and augmented reality are opening not only new way of sharing and accessing data and providing new learning tools, but also changing the shape of science and technology (Elsevier and IPSOS MORI 2019). Digital technologies such as nanotechnologies and nanobiotechnology, genetic engineering, synthetic biology, biometrics, and additive manufacturing, all have the potential to open new frontiers in the complex fight against climate change. However, if not well managed, these developments might not be realised by all countries, thus creating a new divide (TWI2050 2018). International cooperation strengthens institutional and policy frameworks in developing countries and builds their innovation systems can aid technology transfer and knowledge to flow to their advantage (de Coninck and Sagar 2015a,b; Niosi 2018).

14.5.4 International governance of SRM and CDR technologies

14.5.4.1 Global governance of solar radiation modification and associated risks

Solar radiation modification (SRM) refers to a range of deliberate attempts to reduce the amount of sunlight absorbed by the planet in order to counteract warming caused by greenhouse gases. SRM proposals include those that increase land and ocean albedo, brighten marine clouds or inject reflective particles into the stratosphere. Several SRM techniques were already discussed in AR5 and SR1.5. In AR6, Working Group I chapters 4 and 5 assess the physical climate system and biogeochemical responses to different SRM approaches (sections 4.6.3 and 5.6.3). SRM has been

suggested as a potential response option within a broader climate risk management strategy in addition to mitigation, carbon dioxide removal and adaptation (Crutzen 2006; Royal Society 2009), for example as a temporary measure to address temperature overshoot (MacMartin et al. 2018). SRM is still at an early stage of research. Assessments rely primarily on modelling efforts, first and foremost in the context of the Geoengineering Model Intercomparison Project GeoMIP6 (Kravitz et al. 2015).

Stratospheric aerosol injection (SAI) – the most researched SRM method – would carry global risks, and since it could potentially be deployed uni- or minilaterally and alter the global mean temperature much faster than any other climate policy measure, it poses significant governance challenges (Parson 2014; Sugiyama et al. 2018; Nicholson et al. 2018; Reynolds 2019). Both benefits (Irvine et al. 2019) and adverse geophysical effects (e.g. on precipitation patterns, crop growth, biodiversity or the ozone layer) (Pitari et al. 2014; Visioni et al. 2017; Trisos et al. 2018) will be unevenly distributed. Perceptions could exacerbate geopolitical conflicts, not the least depending on which countries are part of a deployment coalition (Maas and Scheffran 2012; Zürn and Schäfer 2013). Premature deployment triggered by perceived climate emergencies would create international tensions (Corry 2017; Lederer and Kreuter 2018).

There is broad agreement in the literature that emerging and potentially disruptive SRM technologies should not be governed through comprehensive institutional architectures designed well in advance (Rayner et al. 2013; Sugiyama et al. 2018; Reynolds 2019). Such arrangements would likely prove either too restrictive or too permissive in light of subsequent developments (Bodansky 2013). Accordingly, governance arrangements should co-evolve with respective SRM technologies, aiming to be at least one step ahead of research, development, demonstration, and—potentially—deployment (Parson 2014). A recent literature review (Nicholson et al. 2018) distills four core objectives for near-term polycentric SRM governance: (1) Guard against potential risks and harms; (2) Enable appropriate research and development of scientific knowledge; (3) Legitimize any future research or policy-making through active and informed public and expert community engagement; (4) Ensure that SRM is considered only as a part of a broader portfolio of responses to climate change. Given that risks and potentials of SRM techniques are differing substantially and that their large-scale deployment is highly speculative, there is a wide array of concrete proposals for anticipatory and/or adaptive governance. Regarding options for institutionalization, proposals range from formal integration into existing UN bodies like the UNFCCC (Nicholson et al. 2018) creation of specific, but less formalized global fora (Parson and Ernst 2013) to forms of club governance (Bodansky 2013; Lloyd and Oppenheimer 2014).

Currently, there is no targeted governance for SRM. Some multilateral agreements—such as the UN Convention on Biological Diversity, the Vienna Convention on the Protection of the Ozone Layer, and the Environmental Modification Convention—cover parts, but none is comprehensive (Bodansky 2013; Reynolds 2019). An attempt to pass a resolution on CDR and SRM at the UN Environment Assembly (UNEA) that would have, among others, mandated an assessment of future global governance options, failed recently (Jinnah and Nicholson 2019).

14.5.4.2 Carbon dioxide removal

Carbon dioxide removal (CDR) technologies such as ocean fertilization also pose similar governance challenges. The current governance frameworks for CDR have inadequacies, gaps and limits (Liu and Chen 2015), but there is a need for governance (Pasztor 2017), and potential for global experimentalist governance in this field (Armeni 2015). Instruments such as the London Dumping Convention and its 1996 Protocol, and the CBD have adopted a precautionary approach and imposed moratoria on ocean fertilization, except for small-scale studies or legitimate scientific research (Sands & Peel, 2018). The London Convention/Protocol has also developed an Assessment Framework for Scientific Research Involving Ocean Fertilization (London Convention/Protocol 2010) and in 2013

adopted amendments (which are not yet in force) to regulate marine geoengineering activities, including ocean fertilization. Some question whether there is a need for a facilitative approach to marine geo-engineering, since assumptions about negative emissions are playing a significant role in modelling for future temperature stabilization pathways consistent with the Paris Agreement's temperature goal (McGee et al. 2018). Given the obstacles to the uptake of negative emissions at scale, others, however, challenge these assumptions and argue that even a modest consideration of equity, instead requires, stringent mitigation policy, including curbing energy demand, in the short-term (Larkin et al. 2018).

14.5.5 Multilateral and bilateral development institutions and instruments

14.5.5.1 Bilateral development assistance

The UNFCCC website cites some 20 bilateral development agencies providing support to climate change programs in developing countries. These agencies provide a mix of development cooperation, policy advice and support and financing of climate change projects. Article 11.5 of the Convention states that the developed country Parties may also provide and developing country Parties avail themselves of, financial resources related to the implementation of the Convention through bilateral, regional and other multilateral channels (UNFCCC 2019i). Since the year 2000, the OECD Development Assistance Committee has been tracking trends in climate-related development finance and assistance. The sectors receiving the highest percentage of the funding include the following: energy which is by far the largest; agriculture forestry and fishing follows with a slightly reduced amount; water supply and sanitation, transport and storage, and other multisector support; and, governance and social infrastructure. The statistics do not include references to what percentage of this assistance is used for regional or international programs, as for example in energy regional integration schemes or transboundary environment and ecosystem protection, which must exist. The amount of bilateral development finance allocated to climate change has increased exponentially since the year 2000 (OECD 2019). Both the Paris Agreement and the SDGs reinforce the need to forge strong linkages between climate and development. Both refer to the need to address the growing needs of development while at the same time addressing the challenges of climate change (Fay et al. 2015). This in turn has highlighted the urgent need for greater attention to the relationship between development assistance and finance and climate change (Steele 2015). But the literature on how these programs promote international cooperation is still scarce.

14.5.5.2 Multilateral development institutions

The United Nations Development Program (UNDP) is the largest implementer of climate action among the UN Agencies. Its program to support Nationally Determined Contributions (NDCs) and its support for adaptation and mitigation helps countries integrate climate risks into their development planning and to develop programs to adopt low carbon and climate resilient and sustainable development. Many of these activities promote either transboundary or regional cooperation. Thematic cooperation across countries is also promoted though the global thematic centers (UNDP). Furthermore, the majority of the other agencies are also engaged in activities related to their area of mandate, such as FAO and the impacts of climate on food security, WHO and the impacts of climate on health, UNIDO on the impacts of climate on industry and infrastructure, to name just the few. Most of these also promote cooperation across geographical boundaries. And lastly, there is the UN Office of South-South Cooperation set up to promote cooperation among developing countries, and triangular cooperation (UNOSSC).

The term Multilateral Development Banks (MDBs) includes a large variety and number of institutions. These include global, regional and sub-regional development banks, some 25 in all[1] (Prizzon and Engen 2018) . They play a key role in international cooperation at the global, regional and sub-regional level because of their growing mandates and proximity to policymakers. They are key partners in the growing importance of regional and sub-regional cooperation. For many, climate change is a growing priority and for some, because of the needs of the regions, or sub-regions in which they operate, climate change is embedded in many of their operations (Nakhooda 2011). A large group of them have established a system for tracking climate finance (funding of mitigation and adaptation activities) and for sharing experiences and establishing cooperation (African Development Bank et al. 2017). More recently, there have been calls for focusing not just on climate finance and tracking climate finance, but also in examining how the lending activities of the multilateral development banks contribute to the goals of the Paris Agreement. Arguably, it is only through closer linkages between climate and development that significant inroads can be made in addressing climate change. MDBs can play a major role through the totality of their portfolios (Larsen et al. 2018)

Over time the World Bank has steadily increased its engagement with the climate change issue, in line with a growing realization of the important links between reducing poverty and addressing climate change. A number of initiatives have been taken, mostly in the field of 'carbon finance' (World Bank 2018). These include the Prototype Carbon Fund and several subsequent 'national' funds, the Forest Carbon Partnership Facility, and the Global Gas Flaring Reduction Partnership (Hale, T. and Roger 2014). In addition, several carbon pricing initiatives and partnerships have been established, such as the Partnership for Market Readiness (PMR) in 2010, Networked Carbon Markets (NCM) in 2013, and Carbon Pricing Leadership Coalition (CPLC) in 2015 (World Bank 2018)(World Bank 2019). Furthermore, complementing initiatives such as the NCM and the CPLC the post-2012 phase - with Jim Yon Kim as Bank President from 2012 on - has seen several important climate policy decisions and programs adopted. In 2013 the Bank decided to limit financing of coal power only to 'rare circumstances.' In 2016 a Climate Change Action Plan was adopted, with targets such as helping client countries add 30 gigawatts of renewable energy by 2020. Furthermore, in 2017 the Bank announced it would no longer finance upstream oil and gas from 2019 on except in special circumstances. Then in December 2018 the Bank. along with eight other MDBs, announced a joint framework for aligning their activities with the Paris Agreement, and the World Bank Group also announced a new set of climate targets for 2021-2025, doubling its current 5-year investments to around 200 billion dollars. In January 2019 an Action Plan on Adaptation and Resilience was published, including a goal to increase adaptation finance to 50 billion dollars by 2025.

The operating entity of the UNFCCC's financial mechanism, the Global Environment Facility, manages two special funds, the Special Climate Change Fund (SCCF) and the Least Developed Countries Fund (LDCF) (UNFCCC). In 2010, at COP 16, parties established the Green Climate Fund

[1] Six global development banks that include European Investment Bank (EIB), international Fund for Agricultural Development (IFAD), International Investment Bank (IIB), New Development Bank (NDB), OPEC Fund for International Development (OFID), World Bank Group; six regional development banks that include African Development Bank (AfDB), Asian Development Bank (AsDB), Asian Infrastructure Investment Bank (Asian Infrastructure Investment Bank (AIIB), European Bank for Reconstruction and Development (EBRD), Inter American Development Bank (IADB), and Islamic Development Bank (IsDB); and thirteen sub-regional development banks that include Arab Bank for Economic Development in Africa (BADEA), Arab Fund for Economic and Social Development (AFESD), Black Sea Trade and Development Bank (BSTDB), Caribbean Development Bank (CDB), Central American Bank for Economic Integration (CABEI), Development Bank of the Central African States (BDEAC), Development Bank of Latin America (CAF), East African Development Bank (EADB), Eastern and Southern African Trade and Development Bank (TDB), Economic Cooperation Organization Trade and Development Bank (ETDB), ECOWAS Bank for Investment and Development (EBID), Eurasian Development Bank EDB), West African Development Bank (BOAD).

and in 2011 designated it as another operating entity of the Financial Mechanism. In 2015, the Green Climate Fund was given a special role in supporting the Paris Agreement. It aims to provide funding, balanced between mitigation and adaptation, in the form of either grants, loans, equity, or guarantees to activities that are aligned with the priorities of the countries compatible with the principle of country ownership (Green Climate Fund). The Green Climate Fund faces many challenges. While some see the GCF as an opportunity to transform and rationalize what is now a complex and fragmented climate finance architecture with insufficient resources and overlapping remits (Smita, Nakhooda 2014), others see it as an opportunity to address the frequent tensions which arise between mitigation-focused transformation and national priorities of countries. This tension is at the heart of the principle of country ownership and the need for transformational change (Winkler, Harald and Dubash 2016). Leveraging private funds and investments by the public sector is another expressed aim of the GCF (Green Climate Fund). Given the demand for financial resources, which need to come from many sources, the leveraging of private funds is a crucial task for the GCF. In assessing the effectiveness of the GCF, one needs to consider the extent to which it is successful in leveraging these investments. The establishment of a Private Sector Facility by the GCF, for instance, is seen as a step in the right direction. The current architecture of climate finance is one that is primarily based on north-south, developed-developing country dichotomies. As more and more climate finance flows across developing countries, enhanced by international cooperation, the GCF could also be assessed based on the extent it promotes climate finance between developing countries and in so doing acts as a facilitator of international cooperation (Ha,Sangjung , Hale 2016).

The Organization for Economic Co-operation and Development (OECD) has since 2009 engaged in environmental issues, including climate change. It established the Climate Change Expert Group to promote dialogue on and enhance understanding in the international climate change negotiations, and it has other programs on climate finance as well. The OECD Declaration on Green Growth acknowledges that “green and growth can go hand-in-hand” (OECD 2009). The Green Growth Strategy, presented in the Rio+20 Conference 2012, brings together economic, environmental, social, technological, and development aspects into a comprehensive framework. The strategy proposes a flexible policy framework that can be tailored to different country circumstances and stages of development, and strengthening arrangements for managing global public goods, especially biodiversity and climate (OECD 2011). The OECD Environmental Outlook 2050 addresses the implications of demographic and economic trends over the next decades using model-based projections for four key areas of global concern: climate change, biodiversity, water and the health impacts of environmental pollution (OECD 2012b)

14.5.6 South-South cooperation

South-South (SSC) and triangular (TrC) cooperation are bold, innovative, and rapidly developing means of strengthening cooperation for the achievement of the SDGs (FAO 2018). SSC is gaining momentum in achieving sustainable development and climate actions in developing countries (UN 2017). Through SSC, countries are able to map their capacity needs and knowledge gaps and find sustainable, cost-effective, long-lasting and economically viable solutions (FAO 2019).

There has been a recent resurgence of South-South cooperation (Gray and Gills (2016), signaled inter alia by the South-South Cooperation Action Plan adopted by the UN as a substantive pillar to support the implementation of the UN Climate Change Engagement Strategy 2017 (UNOSC 2017).

Janus, Klingebiel and Hahn (2014) explore the evolving development cooperation and its future governance architecture based on The Global Partnership for Effective Development Cooperation (GPEDC) and The United Nations (UN) Development Cooperation Forum (DCF). Drawing on evidence from the hydropower, solar and wind energy industry in China, Urban (2018) introduces the concept of ‘geographies of transfer and cooperation’ and challenges the North-South technology

transfer and cooperation paradigm for low carbon innovation and climate change mitigation. While North-South technology transfer and cooperation (NSTT) for low carbon energy technology has been implemented for decades, South-South technology transfer and cooperation (SSTT) and South-North technology transfer and cooperation (SNTT) have only recently emerged. Kirchher and Urban (2018) provide a meta-synthesis of the scholarly writings on NSTT, SSTT and SNTT from the past 30 years. The discussion focuses on core drivers and inhibitors of technology transfer and cooperation, outcomes as well as outcome determinants. A case study of transfer of low-carbon energy innovation and its opportunities and barriers, based on first large Chinese-funded and Chinese-built dam in Cambodia is presented by Urban et al. (2015a).

Urban, Zhou, Nordensward and Narain (2015b) explore the role that technology transfer/cooperation from Europe played in shaping firm level wind energy technologies in China and India and discuss the recent technology cooperation between the Chinese, Indian, and European wind firms. The research finds that firm-level technology transfer/cooperation shaped the leading wind energy technologies in China and to a lesser extend in India. Thus, the technology cooperation between China, India, and Europe has become more multi-faceted and increasingly Southern-led.

Rampa, Bilal and Sidiropoulos (2012) focus on the manner in which African states understand and approach new opportunities for cooperation with emerging powers, especially China, India and Brazil, including the crucial issue of whether they seek joint development initiatives with both traditional partners and emerging powers. UN (2018) presents and analyses case studies of SSTT in Asia-Pacific and Latin America and Caribbean regions. Illustrative case studies on TrC can be consulted in Shimoda and Nagasawa (2012), and specific cases on biofuel SSC and TrC in UNCTAD (2012).

In order to maximize its unique contribution to Agenda 2030, southern providers recognize the benefits of measuring and monitoring South–South cooperation, and there is a clear demand for better information from partner countries. Di Ciommo (2017) argues that better data could support monitoring and evaluation, improve effectiveness, explore synergies with other resources, and ensure accountability to a diverse set of stakeholders.

The central argument of the majority of the case studies is that South–South cooperation, which is value-neutral, is contributing to sustainable development and capacity building (Rampa et al. 2012; Shimoda and Nakazawa 2012; UN 2018). An important new development in SSC is that in relation to some technologies the cooperation is increasingly led by Southern countries (for instance, wind energy between Europe, India and China), challenging the classical North–South technology cooperation paradigm. More broadly, parties should ensure the sustainability of cooperation, rather than focusing on short-term goals (Eyben 2013).

The global landscape of development cooperation has changed dramatically in recent years, with countries of the South engaging in collaborative learning models to share innovative, adaptable and cost-efficient solutions to their development and socio-economic-environmental challenges, ranging from poverty and education to climate change. The proliferation of new actors and cross-regional modalities had enriched the understanding and practice of development cooperation and generated important changes in the global development architecture towards a more inclusive, effective, and horizontal development agenda. South-South cooperation will grow in the future. However, there are knowledge gaps in relation to the precise volume, impact, effectiveness and quality of development cooperation from emerging development partners. This gap needs to be plugged, and evidence on such cooperation strengthened.

14.5.7 Trade agreements and regional economic communities

There is a widespread perception that many trade agreements stand in the way of both national- and global-level progress on climate mitigation. Universal tariff reduction and growth in foreign investment flows has increased trade in carbon-intensive and environmentally destructive products,

such as fossil fuels and timber, more than it has for environmental goods (Tamiotti et al. 2009; Griffin et al. 2019). There is, as well, the potential that developed countries with stringent domestic climate policies may adopt trade measures to ameliorate the competitive impacts of those policies vis-à-vis countries with laxer climate mitigation policies, with the WTO-compatibility of such 'response measures' as yet unresolved (Cosbey 2016). Equally, while investment agreements may facilitate flows of foreign investment to support green technology development, more commonly these agreements have protected investor rights at the expense of host countries' environmental and renewable energy policies (Miles 2019).

Trade policies can have an impact on the climate change mitigation efforts of countries, just as policies for addressing climate change can influence trade among countries. This relationship is entering a new phase as significant changes in the policy landscape emerge from the adoption by the United Nations of a universal post-2015 development agenda, sustainable development goals and the Paris Agreement (UNCTAD 2015). These include transmitting and strengthening best practices from recent trade and investment agreements and increasing WTO–UNFCCC cooperation.

Environmental provisions in RTAs have become increasingly far-reaching over time. Early RTAs merely replicated the WTO's environmental provisions. More recent RTAs typically include a full-length chapter entirely devoted to environmental protection, with precise and enforceable obligations on various environmental issue areas. Innovative climate provisions are in some cases more specific and enforceable than those found in the Kyoto Protocol and the Paris Agreement. Nonetheless, these climate provisions offer limited progress because they remain limited to RTAs. Moreover, most RTAs do not provide for third party dispute settlement, and even when they do, few provide for sanctions or remedies in case of violation. Since there are fewer parties involved, strong enforcement mechanisms, and room for policy experimentation, RTAs hold great potential to enhance climate change governance. Yet, the contribution of RTAs to climate governance remains underexplored.

New trade and investment agreements are usually more open to environmental and climate issues. The latest efforts to consider climate change within trade rules are just beginning—and they will have major implications for agriculture markets and food security (Baldos and Hertel 2015; Lilliston 2019). Mattoo and Subramanian (2013) consider four areas: subsidization of green goods and technologies; border tax adjustments related to carbon content; restrictions on the export of fossil fuels; and intellectual property protection of new technologies and products related to climate change. There are additional opportunities for boosting climate-friendly trade flows: removal of tariff and non-tariff barriers on environmental goods and services; approval on non-discriminatory renewable energy subsidies; green procurement; and, explicit limitation of fossil fuel subsidies. Nordhhaus (2015) argues that a uniform tariff mechanism for nonparticipants could increase the participation of countries in climate agreements. Another commercial instrument could be the tariff in relation to the good's carbon content. To truly align the global climate and trade architecture, Heal and Kunreuther (2017) recommend discussing the introduction of a "climate waiver" that would permit countries to impose trade-restrictive climate policy response measures that are in line with Paris Agreement obligations.

In 2018, the European Commission passed a non-binding resolution to only engage in trade talks with countries that are part of the Paris Climate Agreement (Lee and Vaughan 2019). But the EC has wavered in its talks with the Trump administration—which is in the process of withdrawing the U.S. from the Paris Agreement (Sauer 2019). With its wide coverage of economic spheres, the TTIP opens windows of opportunity for advancing action on climate change. In this respect Holzer and Cottier (2015) examine possible avenues and international trade law implications for an alignment of carbon-related standards between the EU and the US. The EU-Singapore FTA recognizes the need for parties take "proper account" of the need to reduce GHG emissions when designing subsidy systems. The CETA also carves out a number of important provisions to support climate action. In deals with Japan

and Mexico, the EU has referenced the Paris deal. The EU is pushing for a clause in any Australia-EU FTA that includes full implementation of the Paris Agreement (Lilliston 2019). The EU has taken a similar position in relation to its partnership agreements with The Forum of the Caribbean Group of African, Caribbean and Pacific (ACP) States (CARIFORUM) and the EuroMediterranean Partnership, as well as the different association agreements signed by the EU.

The Asia-Pacific Economic Cooperation Mechanism (APEC) adopted a Declaration on Climate Change, Energy Security and Clean Development in 2007, and the 21 APEC economies (emitting more than 60% of GHG) began significant efforts to decrease their GHG emissions, to foster the use of green technologies and exchange environmental friendly goods (Ivanova and Cuevas Tello 2016).

NAFTA was formulated as a straight free-trade agreement (FTA), but it also establishes separate side-agreements to deal with environmental and labor concerns. The North American Agreement on Environmental Cooperation (NAAEC), a side agreement to NAFTA, establishes the Commission for Environmental Cooperation (CEC) as its implementation body. Betsill (2007) evaluates the CEC as a site of regional climate governance based on three potential advantages of governance through regional organizations: a small number of actors; opportunities for issue linkage; and, linkage between national and global governance systems. The 2003 United States – Singapore Free Trade Agreement recognizes the links between economic development, social development, and environmental protection.

The Canada-Chile Free Trade Agreement, the Canada-Costa Rica Free Trade Agreement, the Canada Peru Free Trade Agreement, the Oman-US Free Trade Agreement, the US-Colombia Free Trade Agreement and the Chile-US Free Trade Agreement all enshrine commitments to pursue and support policies that promote sustainable development, and environmental and natural resource management. The US-Australia and Australia –Japan FTAs provide that parties will conduct their activities “in a manner consistent with their commitment to high labor standards, sustainable development, and environmental protection.” (Gehring et al. 2013).

In many RTAs, parties include provisions committing to improve and strengthen laws or their enforcement, including regulations addressing climate change, promoting climate finance instruments and carbon markets. Similar provisions are found in the Canada Chile FTA, the Canada-Costa Rica FTA, the Canada-Colombia FTA and the US-Central America-Dominican Republic FTA, among others. Prom (Gehring et al. 2013).

Casola and Freier (2017) analyze the climate change and renewable energy regulations in Argentina and Brazil, as Mercosur's economically and politically most powerful nations, which have shown to be particularly affected by climate change. The authors examine if domestic regulations prioritize sustainable development or energy security, how Mercosur policies influence national decisions, and if common standards leading to a future regional integration in this field can be observed between the two countries.

Moulot (2016) assesses the African regional economic communities, presenting eight case studies, only four of which have specific climate provisions. The Economic Community of West Africa States (ECOWAS) has established common Renewable Energy Policies, while East Africa Community (EAC) has two initiatives: Protocol on Environment and Natural Resources Management and EAC Climate Change. The Nile Basin Initiative (NBI) has The NBI Climate Change Strategy, focusing on transboundary water resources management and The Economic Community of Central Africa States (EC- CAS) has adopted the Regional Strategy of Disaster Management and Adaptation.

Broader models of RTAs, many negotiated more recently, tend to include provisions on further issues, such as investment, labor standards or environmental protection. For example, as a twenty-first-century trade agreement, the Trans-Pacific Partnership Agreement (TPP) presents an important opportunity to address a range of environmental issues, from illegal logging to climate change and to

craft rules that strike an appropriate balance between supporting open trade and ensuring governments can respond to pressing environmental issues (Meltzer 2013).

The synthesis article by Schwerhoff (2016) describes possible positive reaction mechanisms from different fields of economics, some of which have scarcely been linked to climate economics previously. All these mechanisms have a leader, a nation or group of nations, that sets an example with the intention of motivating others to contribute to the public good.

The inclusion and reinforcement of environmental and climate action clauses in RTAs could contribute to global mitigation goals. Thus, the regional efforts of climate action undertaken within regional trade and integration agreements (RTA) can successfully complement the efforts on global level Although deep cooperation remains elusive, many partial efforts could build confidence and lead to larger cuts in emissions (Keohane and Victor 2011, 2016).

14.5.8 Transnational civil society movements and actions

Civil society groups and transnational coalitions have had a long-standing involvement in international climate policy. During the 1990s and early 2000s, the activities of the global climate movement were concentrated in developed countries and largely sought to exercise influence through participation in UNFCCC COPs and side events (Almeida 2019). Beginning in the mid-2000s, the movement began to use more non-institutionalized tactics, such as simultaneous demonstrations across several countries, focusing on a grassroots call for climate justice that grew out of previous environmental justice movements (Almeida 2019). Contemporary climate justice groups mobilize multiple strands of environmental justice movements from the Global North and South, as well as from indigenous and peasant rights movements, and are organized as a decentralized network of semiautonomous, coordinated units (Tormos-Aponte and García-López 2018; Claeys and Delgado Pugley 2017). This polycentric arrangement of the climate justice movement allows simultaneous influence on multiple sites of climate governance, from the local to the global levels (Tormos-Aponte and García-López 2018).

Climate justice has been variously defined, but centres on addressing the disproportionate impacts of climate change on the most vulnerable populations and calls for community sovereignty and functioning (Schlosberg and Collins 2014; Tramel 2016). The climate justice movement held global days of protest in most of the world's countries in 2014 and 2015, and mobilized another large campaign in 2018 (Almeida 2019). The most recent manifestations of the movement are Extinction Rebellion and Fridays for Future, which have each held hundreds of coordinated protests across the globe in 2019 marking out 'the transnational climate justice movement as one of the most extensive social movements on the planet' (Almeida 2019).

Fridays for Future is a children's and youth movement that began in August 2018, inspired by the actions of then 15-year old Greta Thunberg who pledged to strike in front of the Swedish parliament every Friday to protest against a lack of action on climate change in line with the Paris Agreement targets (Fridays for Future 2019). Fridays for Future events worldwide now encompass more than 200 countries and close to 10 million strikers. The movement is unusual for its focus on children and the rights of future generations, with children's resistance having received little previous attention in the literature. Fridays for the Future is regarded as a progressive resistance movement that has quickly achieved global prominence (for example, Thunberg was invited to address governments at the UN Climate Summit in New York in September 2019) and is credited with helping to support the discourse about the responsibility of humanity as a whole for the climate emergency (Holmberg and Alvinius 2019).

Whereas Fridays for Future has focused on periodic protest action, Extinction Rebellion has pursued a campaign based on sustained non-violent direct citizen action that is focused on three key demands: declaration of a climate emergency, acting now to halt biodiversity loss and reduce greenhouse gas

emissions to net zero by 2025, and creation of a citizen's assembly on climate and ecological justice (Extinction Rebellion 2019; Booth 2019). The movement first arose in the UK – where it has claimed credit for adoption of a climate emergency declaration by the UK government – but now has a presence in 45 countries with some 650 groups having formed globally (Gunningham 2019).

Other transnational civil society organizations are also seen to have played an important role in influencing climate policy. For example, 350.org has supported mobilization of youth and university students around a campaign of divestment that has persuaded 985 institutions (including insurance companies, sovereign wealth funds and pension funds) across 37 countries to commit to divesting from fossil fuel companies (Gunningham 2019). Although the direct impacts of the divestment movement have been small (given that replacement investors usually acquire any divested shares), it has had a more significant impact on public discourse by raising the profile of climate change as a financial risk for investors (Bergman 2018).

Climate justice campaigns by transnational civil society movements have often embraced action through the courts. Chapter 13 discusses the growth and policy impact of climate litigation brought by civil society actors in domestic courts. Transnational and international court actions focused on climate change, by contrast, have been relatively few in number (Peel and Lin 2019). However, there have been active discussions about seeking an advisory opinion on states' international obligations regarding the reduction of greenhouse gas emissions from the International Court of Justice (Sands 2016), or bringing a case to the International Tribunal for the Law of the Sea on marine pollution harms caused by climate change (Boyle 2019). The aim of climate litigation is generally to supplement other regulatory efforts by filling gaps and ensuring that interpretations of laws and policies are aligned with climate mitigation goals (Osofsky 2010).

It is too early at this stage to know what the overall impact of transnational civil society climate movements will be for international cooperation on climate change mitigation. The polycentric organization of the movement poses challenges for coordinating between groups operating in different contexts, acting with different strategies and around multiple issues, and lobbying multiple decision-making bodies at various levels of government in a sustainable way (Tormos-Aponte and García-López 2018). Influence may be enhanced through taking advantage of 'movement spillover' (the involvement of activists in more than one movement) (Hadden 2014) and coordination of activities with a range of 'non-state governors,' including cities, sub-national governments, and investor groups (Gunningham 2019). Studies of societal change suggest that once 3.5% of the population are mobilized on an issue, far-reaching change becomes possible (Gladwell 2002) – a tipping point that may be approaching in the case of climate change (Gunningham 2019).

14.5.9 Transnational business and public-private partnerships

An important feature of the evolving international climate policy landscape of the recent years is the entrepreneurship of UN agencies such as UNEP, UNDP and the World Bank in initiating public-private partnerships. (Andonova 2017) calls this 'governance entrepreneurship'. Such partnerships can be defined as 'voluntary agreements between public actors (IOs, states, or sub-state public authorities) and non-state actors (non-governmental organizations (NGOs), companies, foundations, etc.) on a set of governance objectives and norms, rules, practices, and/or implementation procedures and their attainment across multiple jurisdictions and levels of governance' (Andonova 2017):2). Partnerships may carry out different main functions: first, *policy development*; establishing new agreements on norms, rules, or standards among a broader set of governmental and non-governmental actors; second, *enabling implementation and delivery of services*, by combining resources from governmental and non-governmental actors; and, third, *knowledge production and dissemination*, to e.g. the evolution of relevant public policies.

UNEP has initiated a number of public-private-partnership climate change finance initiatives. These are designed to increase the financing for the purposes of disseminating low-carbon technologies to tackle climate change and promote clean energy in many parts of developing countries (UNEP/CPR/142/4 2018; Charlery and Traerup 2019).

The World Bank has established several partnerships since 2010, mainly in the field of carbon pricing. Prominent examples are the Networked Carbon Markets initiative (established 2013; spanning both governmental actors and experts) and the Carbon Pricing Leadership Coalition (established 2015; spanning a wide range of governmental and non-governmental actors, not least within business) (World Bank 2018, 2019). These partnerships deal with knowledge production and dissemination and seek to enable implementation of carbon pricing policies. The leadership role of the international 'heavyweight' World Bank gives these partnerships additional comparative political weight, meaning also a potentially greater involvement of powerful finance ministries/ministers generally involved in Bank matters and meetings.

The World Business Council on Sustainable Development (WBCSD) is a global, CEO-led organization of over 200 leading businesses working together to accelerate the transition to a sustainable world. Member companies come from all business sectors and all major economies, representing a combined revenue of more than USD $8.5 trillion and with 19 million employees. The WBCSD enhances the business case for sustainability through tools, services, models and experiences. It includes a Global Network of almost 70 national business councils across the globe. The overall vision is to create a world where more than 9 billion people are all living well and within the boundaries of our planet, by 2050. Vision 2050, released in 2010, explored what a sustainable world would look like 2050, how such a world could be realized, and the role that business can play in making that vision a reality. A few years later, Action2020 took that Vision and translated it into a roadmap of necessary business actions and solutions (WBCSD 2019). WBCSD focuses on those areas where business operates and can make an impact. They identify six system transformation systems that are critical in this regard: Circular Economy, Climate and Energy, Cities and Mobility, Food and Nature, People and Redefining Value. All have an impact on climate. A new important initiative launched in September of 2008 – the "natural climate solutions", has the objective of leveraging business investment to capture carbon out of the atmosphere. This initiative has quickly built strong cross-sectoral partnerships and is intended to tap into this immense emissions reduction solution potential through natural methods with the help of private investment.

In 2010 FAO delivered the Framework for Assessing and Monitoring Forest Governance. The Framework draws on several approaches currently in use or under development in major forest governance-related processes and initiatives, including the World Bank's Framework for Forest Governance Reform. The Framework builds on the understanding that governance is both the context and the product of the interaction of a range of actors and stakeholders with diverse interests (FAO 2010). For example, UNFCC and UN-REDD program focus on REDD+ and UNEP focus on TEEB institutional mechanisms have been conceptualized as a "win-win-win" for mitigating climate, protecting biodiversity and conserving indigenous culture by institutionalizing payments on carbon sequestration and biodiversity conservation values of ecosystems services from global to local communities. These mechanisms include public-private partnership, and non-governmental organization participation. REDD+ and TEEB allocation policies will be interventions in a highly complex system, and will inevitably involve trade-offs; therefore, it is important to question "win-win-win" discourse (Zia and Kauffman 2018; Goulder et al. 2018). The initial investment and the longer periods of recovery of investment are sometimes barriers to private investment. In this sense, it is important to have government incentives and encourage public-private investment (Ivanova and Lopez 2013).

Another potentially influential type of business partnership is investor coalitions or alliances formed for the purpose of pushing investee companies to adopt stronger measures for stranded asset management and climate change mitigation. MacLeod & Park (2011, p. 55) argue that these transnational groups 'attempt to re-orient and "regulate" the behaviour of business by holding corporations accountable via mechanisms of information sharing, monitoring of environmental impacts, and disclosure of activities related to the corporate climate footprint'. This favours a theory of active ownership (investor engagement with corporate boards) over capital divestment as the optimal pathway to shape the behaviour of corporate actors on climate risk (Kruitwagen et al. 2017; Krueger et al. 2018).

PPP funding for cities expanded rapidly in the 1990s and outpaced official external assistance almost tenfold. Most of the PPP infrastructure investment has been aimed at telecommunications, followed by energy. However, with the exception of the telecommunications sector, PPP investments have generally bypassed low-income countries (Ivanova 2017). It is therefore not surprising that PPPs have added relatively little to the financing of urban capital in developing countries over the past two decades (Bahl and Linn 2014). Liu and Waibel (2010) argue that the inherent risk of urban investment is the main obstacle to increasing the flow of private capital. Nevertheless, there have been cases where PPP investments have exceeded official external aid flows even for water and sanitation, and highly visible projects have been funded with PPPs in selected metropolitan areas of developing countries, including urban rail projects in Bangkok, Kuala Lumpur, and Manila (Liu and Waibel 2010).

In 2017 the Financial Stability Board's Taskforce on Climate-related Financial Disclosures (TCFD) adopted international recommendations for climate risk disclosure (TCFD 2017). These recommendations, which apply to all financial-sector organizations, including banks, insurance companies, asset managers, and asset owners, have received strong support from investor coalitions globally, including Climate Action 100+ (with 300 investors with more than USD $33 trillion in assets under management) and the Global Investor Coalition on Climate Change (a coalition of regional investor groups across Asia, Australia, Europe and North America). One of the key recommendations of the TCFD calls for stress-testing of investment portfolios taking into consideration different climate-related scenarios, including a 2° C or lower scenario. Broad adoption of the TCFD recommendations could provide a basis for decisions by investors to shift assets away from climate-risk exposed assets such as fossil fuel extraction projects (Osofsky et al. 2019). There is strong evidence showing the urgent need for scaling-up climate finance to mitigate greenhouse gases in line with the 2°C target, and to support adaptation to safeguard the international community from the consequences of a changing climate. While public actors have a responsibility to deploy climate finance, it is clear that the contribution from the private sector needs to be significant (Gardiner et al. 2016).

As most of these partnerships are of recent vintage an assessment of its effectiveness is premature. Instead, these partnerships can be assessed on the basis of the three main functions introduced earlier. Starting with *policy development*, i.e. establishing new agreements on norms, rules, or standards among a broader set of governmental and non-governmental actors, this is not the most prominent aspect of partnerships so far, although both the cities' networks and risk disclosure recommendations include some elements of this. The second element, *enabling implementation and delivery of services*, by combining resources from governmental and non-governmental actors, seems to be a more prominent part of the partnerships. Both UNEP financing, the World Business Council on Sustainable Development (WBCSD), the REDD+ and TEEB mechanisms, and PPP funding for cities are examples here. Finally, the third element, *knowledge production and dissemination* in the evolution of relevant public policies, is perhaps the most prominent part of these partnerships, with most of them including such activities. There is a relatively large volume of literature that assesses public private

partnerships in general. And much of this applies to partnerships which, either by design or not, advance climate goals. This literature provides a good starting point for assessing these partnerships as they become operational. These can help assess whether such partnerships are worth the effort in terms of their performance and effectiveness (Junxiao, Liu. 2015), their economic and social value added (Quelin, B.V, Kivleniece, i., Larazzaini 2017), their efficiency (Estache, Antonio, Saussier 2014) and the possible risks associated with them (Darrin, Grimsey and Mervyn 2002).). What is less common, but gradually growing, is an important and more relevant literature on criteria to assess sustainability and impact on climate and development goals. A recent study using a systematic review of business and public administration literature on PPPs concludes that past research rarely incorporates sustainability concepts. The authors propose a research agenda and a series of success factors that, if appropriately managed can contribute to sustainable development, and in so doing contribute to a more solid scientific evaluation of PPPs (Alexander Pinz 2018). There is evidence that with the adoption of the Sustainable Development Goals (SDGs), many of which are directly linked to climate goals, PPPs will become even more prominent as they will be called upon to provide resources, knowledge, expertise, and implementation support in a very ambitious agenda. PPPs in the developing world needs to take into account different cultural and social decision making processes, language differences, and unfamiliar bureaucracy (Gardiner et al. 2016). Having more evidence on what norms and standards in relation to sustainability are used and their governance is essential (Axel 2019). Some recent studies aim to provide systems to assess the impact of PPPs beyond the much-used notion of value for money. One of these recent studies proposes a conceptual model that addresses six dimensions relevant to economic, social and environmental progress. These include resilience and environment, access of services to the population, scalability and replicability, economic impact, inclusiveness, and finally, degree of engagement of stakeholders (Pacual 2019). These systems will most likely continue to evolve.

14.5.10 International co-operation at the sub-national and city levels

Local and regional governments have an important role to play in global climate action, something recognized by the Paris Agreement, and also assessed in Chapter 13 of this report. There are several ways they can be useful. First, subnational governments can contribute insights and experience that provide valuable lessons to national governments, as well as offering needed implementation capacity (GIZ 2017; Leffel 2018). A great deal of policy-making has occurred at the level of city governments in particular. Cities are responsible for more than 70% of global greenhouse gas (GHG) emissions and generate over 80% of global income (World Bank 2010), and many of them have started to take their own initiative in enacting and developing mitigation policies (CDP 2015). Most of these activities aim at the reduction of GHG emissions in the sectors of energy, transportation, urban land use and waste (Bulkeley 2010; Xuemei 2007), and are motivated by concerns not only over climate, but also a consideration of local co-benefits (Rashidi et al. 2017, 2019). Second, sub-national governments can fill the void in policy leadership in cases where national governments are ineffectual, even to the point of claiming leadership and authority with respect to foreign affairs (Leffel 2018).

With respect to their role in formal international cooperation, however, it is unclear what authority, as a non-state actor, they actually have. Several researchers suggest that their role is important in informal ways, given issues about the legitimacy of non-state actors Paris (Chan et al. 2016; Nasiritousi et al. 2016). Bäckstrand et al. (2017) advance the concept of 'Hybrid Multilateralism' (HM) as a heuristic to capture this intensified interplay between state and non-state actors in the new landscape of international climate cooperation. The effectiveness of such non-state government actors should be measured not only by their contribution to mitigation, but also by their success to enhance the accountability, transparency and deliberative quality of the UNFCCC and the Paris Agreement (Hale et al. 2016; Chan et al. 2015; Busby 2016). In the post-Paris era, effectiveness also revolves around how to align non-state and intergovernmental action in a comprehensive framework

that can help achieve low carbon futures (Chan et al. 2016). Such effectiveness has to be complemented also by *normative questions*, applying a set of democratic values: participation, deliberation, accountability, and transparency (Bäckstrand and Kuyper 2017). Such concepts of polycentric governance offer new opportunities for climate action, but it has been argued that it is too early to judge its importance and effects (Jordan et al. 2015).

In addition to their role as non-state actors in formal international cooperation, sub-national governments also engage in transnational cooperation. Several international networks , such as C40, ICLEI, and Mayors for Climate Protection, have played an important role in defining and developing climate-policy initiatives at the city level (Fünfgeld 2015). While the networks differ from each other, they generally are voluntary and non-hierarchical, intended to support the horizontal diffusion of innovative climate policies (Kern and Bulkeley 2009). The literature has addressed the questions of why cities join the networks (Betsill and Bulkeley 2004; Pitt 2010), what recognition benefits cities can expect (Buis 2009; Kern and Bulkeley 2009), and how memberships can provide visibility to leverage international funding (Betsill and Bulkeley 2004; Heinrichs et al., 2013). Membership in the networks has been found to be a significant predictor of cities' adoption of mitigation policies (Rashidi and Patt 2018).

14.6 Synthesis

14.6.1 Changing nature of international cooperation

International cooperation is vital for achieving climate mitigation goals in the context of sustainable development. As in AR5, there is still *robust evidence* and *high agreement* in the literature in that direction. However, the reasons it is vital, and the precise forms of cooperation that are most useful, have evolved since AR5. This reflects many factors: changing geo-politics; a rising level of public attention, activism and demand; increasing, although still inadequate, ambition with respect to mitigation targets; improvements to low-carbon technologies; new empirical evidence and theory with respect to the processes of socio-technological transitions and transformations; an increasing emphasis on national autonomy, and decentralized solutions; and, an expanding evidence base with respect to the effectiveness of multi-level and multi-actor climate governance approaches.

At the time of AR5, the importance of international cooperation was understood to be "principally due to the fact that greenhouse gases (GHGs) mix globally in the atmosphere, making anthropogenic climate change a global commons problem". That in turn suggested the need for a top-down approach: countries agree to be legally bound by specific emissions reduction targets in the knowledge that other countries face similar constraints, and an international governance regime has the capacity to monitor and enforce compliance, as a way of eliminating free riders. The Kyoto Protocol fit this model, and the findings of AR5 suggested the need to negotiate a successor treaty of similar architecture, albeit with greater levels of ambition and participation.

In addition to the global commons nature of the problem, the literature now highlights evidence that an important barrier to achieving decarbonization objectives is the pace at which societies can move from the use of high-carbon to low-carbon technologies. This has aspects of market failure, such as with respect to technology spill overs, which may call for top-down solutions, but also aspects calling for bottom-up and sectoral approaches. With respect to the latter, there is evidence that many industrialized countries have the resources and capacity to engage in a rapid technology turnover, whereas many developing countries do not, and require assistance for rapid decarbonization. The Paris Agreement reflects this new logic. Many developing countries have submitted conditional pledges, where conditionality is typically with respect to international financial, technological and capacity-building support. And, countries have agreed to set a new collective quantified goal prior to

2025 (not explicitly limited to developed countries) to mobilize $100 billion per year, as a floor, to assist developing countries.

14.6.2 Evolving international cooperation instruments

The main development in terms of international climate cooperation has been the negotiation and subsequent operationalization of the Paris Agreement. As we have noted, the Paris Agreement is tailored to the evolving understanding of the climate mitigation challenge as well as shifting political imperatives and constraints. Whether the Paris Agreement will in fact be effective in supporting global action sufficient to achieve its objectives is contested, with competing arguments supporting different views. The strongest critique of the Paris Agreement is that the NDCs themselves fail by a wide margin to add up to the level of aggregate emissions reductions necessary to achieve the objectives of holding global average warming well below 2°C, much less 1.5°C. Arguments in support of Paris are that it puts in place the processes, and generates normative expectations, that nudge NDCs to become progressively more ambitious over time. But then these are met with counterarguments, that even with Paris processes in place, given the logic of iterative, rising levels of ambition over time, this is unlikely to happen within the narrow window of opportunity that exists to avert dangerous levels of global warming. The degree to which countries are willing to increase the ambition of their NDCs over time will be an important indicator of the success of the Paris Agreement; evidence of this will be available by the end of 2020.

An increasing role is also played by other cooperative agreements, trans-national partnerships, and the institutions that support them. This fits both a transitions narrative that cooperation at the sub-global and sectoral levels is necessary to enable specific system transformations, and a recent emphasis in the public goods literature on club goods and a gradual approach to cooperation. There has been little analysis of whether these other agreements are of sufficient scale and scope to ensure that transformations happen quickly enough. Our judgment, appraising them together, is that they are not. First, many agreements, such as those related to trade, may stand in the way of bottom-up mitigation efforts (14.5.7). Second, many sectoral agreements aimed at decarbonization – such as within the air travel sector – have not yet adopted targets comparable in scale, scope or legal character to those of the Paris Agreement (14.5.2.3). Third, there are many sectors for which there are no agreements in place. At the same time, there are some important bright spots, many in the area of trans-national partnerships. A growing number of cities have committed themselves to adopting urban policies that will place them on a path to rapid decarbonization, while learning from each other how to implement successful policies to realize climate goals. An increasing number of large corporations have committed to decarbonizing their industrial processes and supply chains. And, an ever-increasing number of non-state actors are adopting goals and initiating mitigation actions. These goals and actions, some argue, could bridge the mitigation gap created by inadequate NDCs, however there is less transparency of and limited accountability for such actions.

14.6.3 Overall assessment

Where are the major gaps in international cooperation? Earlier in this chapter we identified a set of criteria for assessing the effectiveness of international cooperation, and we return to these now. Our five main criteria are environmental effectiveness, transformative potential, distributive outcomes, economic performance, and institutional strength. Within each criterion are a number of indicators. In Figure 14.1, we provide an overall assessment of the current state of these indicators.

	Environmental effectiveness	Transformative potential	Distributive outcomes	Economic performance	Institutional strength
Strong positive effect	• Non-AFOLU emissions of other Kyoto gases				• Administrative capacity
Weak positive effect	• Non-AFOLU CO_2 emissions • AFOLU sector CO_2 emissions	• Cost / performance frontier • Increased investment flows • Infrastructure expansion • Engineering & institutional capacity	• Developed country leadership • Differentiation in favour of developing countries • Promotion of co-benefits	• Economic efficiency • Cost effectiveness	• Transparency & accountability • Regulative quality
Little effect	• AFOLU non-CO_2 emissions • Non-AFOLU sector emissions of non-Kyoto gases	• Technologies for non-AFOLU negative emissions • Technologies for solar radiation management			
Negative effect					

Figure 14.1 Overall Assessment of Current Levels of International Cooperation

The top row in Figure 14.1, in dark green, represents areas where international cooperation is having a strong positive effect towards achieving the objectives of the Paris Agreement. There are two indicators which we classify here. First, The Kigali Amendments to the Montreal Protocol are having a strongly positive effect on emissions of many of the most serious non-CO_2 gases, supplemented as well by agreements falling under the LRTAP convention (14.5.2.1). Second, one of the indicators associated with institutional strength, administrative capacity, falls into this category. On this indicator, the Paris Agreement is supplemented by a number of other forms of cooperation. There is evidence that trans-national city partnerships have contributed to administrative capacity at the municipal level [14.5.10]. Bilateral development agreements have also focused on building capacity (14.5.5).

The largest number of indicators fall into the second category, where international cooperation is having a weak positive effect. Virtually all NDCs concern emissions of CO_2 from the non-AFOLU sectors; the literature suggests that Paris processes will have some positive effect on the ratcheting up of levels of ambition, although it is too early to say whether the effect will be major or adequate (14.4.2.13). Additionally, the LRTAP and Minamata Mercury Convention appear to be having an effect on further use of coal (14.4.3). There are also sectoral agreements that could provide further support and can be anticipated to have a weakly positive effect, such as for shipping and for aviation

(14.5.2.3). The evidence also suggests that international cooperation is making a weakly positive influence on reducing emissions of CO_2 from the AFOLU sector, driven by several complementary measures. These include the Paris Agreement NDCs, which contain a number of commitments to reduce such emissions (14.4.2.13), supplemented by a number of initiatives covering the forestry sector, including trans-national industrial agreements limiting the marketability of products from unsustainably managed forests (14.5.2.1). Most of the indicators for transformative potentially fall within the weakly positive category, due to a number of factors. The assessment of the Paris Agreement suggests that, presently, it is having limited effect on these indicators, arguably in part because of the announced withdrawal of the United States, which is one of several drivers for potentially transformative technologies. (14.4.2.13). Other agreements and institutions, however, do appear to be having an effect. International cooperation in science and technology is substantial, and arguably pushing the cost/performance frontier for a number of technologies (14.5.3). This is further augmented by cooperative R&D within sectors, such as shipping and aviation (14.5.2.3), as well as South-South cooperation (14.5.6). A number of multilateral institutions, such as the World Bank, are having a positive effect on investment flows, although these would need to be scaled up substantially to have a strongly positive effect (14.5.5, 14.5.7). Much of this is related to infrastructure expansion, which is why the infrastructure indicator is assigned to the weakly positive category as well. South-South cooperation (14.5.6), as well as bilateral development institutions (14.5.5) are having effects on engineering and institutional capacity. These support mechanisms for capacity building, technology transfer, and investment all have an impact with respect to distributional outcomes, and the indicator pertaining to mitigation support. Based on our assessment of the Paris Agreement (14.4.2.13), all three indicators for distributive outcomes fall into the middle category of effectiveness. With respect to economic performance, a number of international mechanisms are leading or could lead to enhanced cost-effectiveness. These include cooperation with respect to international market mechanisms (14.5.1) and voluntary cooperative agreements under the Paris Agreement (14.4.2.13). Economic efficiency can also be classified within this category. There are multiple strands of evidence that international cooperation is having an effect on domestic politics and pushing countries to increase their levels of ambition (14.4.2.13, 14.5.1, 14.5.2.1, 14.5.2.2, 14.5.3, 14.5.8). Since the evidence suggests that the benefits of these higher levels of ambition substantially outweigh their costs, the effect on economic efficiency is positive. However, many of the NDCs are conditional on support pursuant to Article 6 of the Paris Agreement, the final details of which have yet to be agreed. Two of the indicators for institutional strength fall into the weak positive effect category as well. The Paris Agreement focuses heavily on transparency and accountability, with attention to regular reporting not only of emissions, but also of the policies, actions and financial flows that will influence emissions in the future. The Paris Rule Book provides detailed rules for such reporting, but it allows parties considerable discretion in determining the extent to which particular rules apply to them. It is not yet clear to what extent the rules on transparency will generate accountability. However, such rules will likely play a role in developing administrative capacity both at the international and municipal levels (14.4.2.13). With respect to regulative quality, there is evidence that a number of trans-national cooperative mechanisms are leading to some improvements, such as at the municipal level (14.5.10).

There are several areas where international cooperation is having little effect, either due to an absence of attention within existing agreements, or to a need for new agreements, which have not yet been agreed. Falling under the former category are non-CO_2 gases in the AFOLU sector; while several NDCs cover these, the evidence suggests that the commitments are both weak and scarce (14.4.2.13). There is a lack of other agreements, such as with respect to methane emissions from agriculture, that would supplement these (14.5.2.1). Also falling into this category are non-Kyoto gases and forcings, such as black carbon and contrail cirrus clouds. While LRTAP covers some of the former, it is weak with respect to black carbon (14.4.3). The ICAO has yet to tackle issues associated with non-CO_2

radiative forcing from aviation (14.5.2.3). Further, there has been an identified need for international cooperation to play a role in developing and managing transformative technologies such as negative emissions from outside the AFOLU sector, and the solar radiation modification, but there is limited international cooperation in these areas currently (14.5.4).

There are no indicators identified for which the net effect of international cooperation is negative in terms of achieving the objectives of the Paris Agreement. That is not to say that there are not individual forms of cooperation that are negative, but rather that these are balanced by positive forces elsewhere. For example, there is mixed evidence with respect to trade agreements and regional economic communities, including some evidence that these have stifled the ability of countries to enact particular kinds of legislation that would accelerate mitigation efforts (14.5.7). At the same time, there are some instances where these agreements have been modified to facilitate greater national autonomy with respect to mitigation. More importantly, there are other agreements that have equally strong positive effects.

14.7 Gaps in Knowledge and Data

Any assessment of the effectiveness of international cooperation is limited by the methodological challenge of observing sufficient variance in cooperation in order to support inference on effects. There is little in the way of cross-sectional variance, given that most of the governance mechanisms we assess here are global in their geographical coverage. Time series analysis is also of little value, given the other determinants of climate mitigation, including technology costs and the effects of national and sub-national level policies, are rapidly evolving. The only remaining possibility is to compare observations with theory-based counter-factual scenarios.

Many of the international agreements and institutions that we have described in this chapter, in particular the Paris Agreement, are new. The logic and architecture of the Paris Agreement, in particular, is a break from the past, giving us little in the way of prior experience to draw on. It has evolved in response to geo-political and other drivers, that are changing rapidly, and will continue to shape the nature of international cooperation under it and triggered by it. The Paris Agreement is also, in common with other multilateral agreements, a 'living instrument' evolving through interpretative and operationalizing rules, and forms of implementation, that parties continue to negotiate at conferences year on year. It is a constant 'work in progress' and thus challenging to assess at any given point in time. The Paris Agreement also engages a larger set of variables – given its privileging of national autonomy and politics, integration with the sustainable development agenda, and its engagement with actions and actors at multiple levels – than earlier international agreements, which further complicates the task of tracing causality between observed effects and international cooperation through the Paris Agreement.

Our understanding of the effectiveness of international agreements and institutions is driven entirely by theory driven prediction of how the world will evolve, both with these agreements in place and without them. The former predictions in particular are problematic, because governance regimes are complex adaptive systems, making it impossible to predict how they will evolve over time, and hence what their effects will be. Time will cure this in part, as it will generate observations of the world with the new regime in place, which we can compare to the counterfactual situation of the new regime's being absent, which may be a simpler situation to model. But even here our modelling capacity is limited: it may simply never be possible to know with a high degree of confidence whether international cooperation, such as that embodied in the Paris Agreement, is having a significant effect, no matter how much data we accumulate.

Given the importance of theory for guiding assessments of the past and likely future impacts of policies, it is important to note that among the alternative theoretical frameworks for analysis, some have been much more extensively developed in the literature than others. In this chapter we have noted in particular the partial dichotomy between a global-commons framing of climate change and a transitions framing, which include different criteria for assessment. The latter framing is particularly under-developed. Greater development of theories resting in social science disciplines such as economic geography, sociology, and psychology could potentially provide us with a more complete picture of the nature and effectiveness of international cooperation.

Frequently Asked Questions

FAQ 14.1: **Now that the Paris Agreement has entered into force, and it requires countries to develop their own nationally determined emissions reduction contributions, does this mean that international cooperation no longer plays a useful role in achieving long-term climate goals?**

Continued international cooperation remains important. The Paris Agreement has changed the framework for international cooperation, from one built on multilaterally negotiated emissions reduction targets, backed by a compliance mechanism, with an enforcement branch, and penalties for non-compliance, to one relying on nationally determined contributions that are subject to an international oversight system, and bolstered through international support. The international oversight system is designed to generate transparency and accountability for individual emission reduction contributions, and regular moments for stock-taking of these efforts towards global goals. Such enhanced transparency may instill confidence and trust, and foster solidarity among nations. It can also influence domestic politics in these countries, with theory-based arguments that this will lead to greater levels of ambition. Further, for most developing countries, international cooperation and support is important for their mitigation efforts. Such support includes bilateral and multilateral cooperation on low-carbon finance, technology support, capacity building, and enhanced South-South cooperation. It can take place through the implementation of the Paris Agreement, and through a large number of sub-global and sectoral agreements, as well as the actions of transnational organizations (high confidence).

FAQ 14.2: **Is international cooperation working?**

Countries' emissions were in line with their internationally agreed targets – the collective GHG mitigation stabilization target for Annex I countries in the UNFCCC for 2000, and their individual target in the Kyoto Protocol for 2008-12. Neither of these required transformational policy changes, whereas meeting the long-term goals of the Paris Agreement will. International support of the kinds that the Paris Agreement establishes but are yet to be implemented, as well as those embodied in other cooperative agreements at the sub-global and sectoral levels, play an important role in making political, economic, and social conditions more favorable to ambitious mitigation efforts in the context of sustainable development and efforts to eradicate poverty (high confidence). The degree to which countries are willing to increase the ambition of their NDCs over time, which has yet to be observed, will be an important indicator of the success of the Paris Agreement.

FAQ 14.3: **Are there any important gaps in international cooperation, which will need to be filled in order for countries to achieve the objectives of the Paris Agreement, such as holding temperature increase to well below 2°C above pre-industrial levels?**

While international cooperation is contributing to global mitigation efforts, its effects are far from uniform. Cooperation has made a significant contribution to rapidly falling CO_2 emissions in the AFOLU sector, although these gains are not immune to backsliding in some countries. Likewise, international cooperation is leading to rapid reduction in emissions of many non-CO_2 greenhouse gases, such as those covered under the Kigali Amendment to the Montreal Protocol, and it may influence institutional factors vital for achieving the objectives of the Paris Agreement, such as with respect to administrative capacity. In most other respects, international cooperation is making a weak contribution, and there is evidence that further strengthening of cooperation would improve the likelihood of achieving the Paris Agreement objectives. Finalizing the rules to pursue voluntary cooperation in the implementation of NDCs, without compromising environmental integrity, may be key for the success of the Paris Agreement. Finally, there are several areas where international cooperation potentially could, but is not yet making a discernable contribution. These include reducing non-CO_2 emissions from the AFOLU sector, reducing emissions of gases not covered under the Kyoto Protocol, and for developing or managing technologies associated with negative emissions and solar radiation modification.

References

Abas, N., A. R. Kalair, N. Khan, A. Haider, Z. Saleem, and M. S. Saleem, 2018: Natural and synthetic refrigerants, global warming: A review. *Renew. Sustain. Energy Rev.*, **90**, 557–569, https://doi.org/10.1016/J.RSER.2018.03.099.

Abate, R., and A. Greenlee, 2010: Sowing Seeds Uncertain: Ocean Iron Fertilization, Climate Change, and the International Environmental Law Framework. *Pace Environ. Law Rev.*,.

Acemoglu, D., P. Aghion, L. Bursztyn, and D. Hemous, 2012: The Environment and Directed Technical Change. *Am. Econ. Rev.*, **102**, 131–166.

——, ——, and D. Hémous, 2014: The environment and directed technical change in a North-South model. *Oxford Rev. Econ. Policy*, **30**, 513–530, https://doi.org/10.1093/oxrep/gru031.

Adelman, S., 2018: Human Rights in the Paris Agreement: Too Little, Too Late? *Transnatl. Environ. Law*, **7**, 17–36, https://doi.org/10.1017/S2047102517000280.

Adger, W. N., S. Huq, K. Brown, and M. Hulme, 2003: Adaptation to climate change in the developing world. *Prog. Dev. Stud.*, **3**, 179–195.

African Development Bank, Asian Development Bank, Bank, IADB, EBRD, WBG, and Islamic Devt Bank, 2017: *Joint Report of Multilateral Development Banks' Climate Finance*.

Aghion, P., C. Hepburn, A. Teytelboym, and D. Zenghelis, 2014: Path dependence, innovation and the economics of climate change, Working Paper, Centre for Climate Change Economics and Policy/Grantham Research Institute on Climate Change and the Environment Policy Paper & Contributing paper to New Climate Economy.

Akanle, T., 2010: Impact of Ozone Layer Protection on the Avoidance of Climate Change: Legal Issues and Proposals to Address the Problem. *Rev. Eur. Community Int. Environ. Law*, **19**, 239–249, https://doi.org/10.1111/j.1467-9388.2010.00680.x.

Akita, J., Imai, H., & Niizawa, H., 2012: Dynamic bargaining and CDM low hanging fruits with quadratic emissions abatement cost. *Int. Multidiscip. Sci. GeoConference SGEM Surv. Geol. Min. Ecol. Manag.*, **4**, 897–905.

Alcaraz, O., P. Buenestado, B. Escribano, B. Sureda, A. Turon, and J. Xercavins, 2019: The global carbon budget and the Paris agreement. *Int. J. Clim. Chang. Strateg. Manag.*, **11**, 310–325, https://doi.org/10.1108/IJCCSM-06-2017-0127.

Aldy, J. E., W. A. Pizer, and K. Akimoto, 2017: Comparing emissions mitigation efforts across countries. *Clim. Policy*, **17**, 501–515, https://doi.org/10.1080/14693062.2015.1119098.

Alexander Pinz, N. R. & J. T., 2018: Public–private partnerships as instruments to achieve sustainability-related objectives: the state of the art and a research agenda. *Public Manag. Rev.*, **20**, 1–22, https://doi.org/10.1080/14719037.2017.1293143.

Almeida, P., 2019: Climate justice and sustained transnational mobilization. *Globalizations*, **16**, 973–979, https://doi.org/10.1080/14747731.2019.1651518.

Andonova, L. B., 2017: *Governance Entrepreneurs - International Organizations and the Rise of Global Public-Private Partnerships*. Cambridge University Press,.

Antimiani, A., V. Costantini, A. Markandya, E. Paglialunga, and G. Sforna, 2017: The Green Climate Fund as an effective compensatory mechanism in global climate negotiations.

Environ. Sci. Policy, **77**, 49–68, https://doi.org/10.1016/J.ENVSCI.2017.07.015.

Armeni, C., 2015: GLOBAL EXPERIMENTALIST GOVERNANCE, INTERNATIONAL LAW and CLIMATE CHANGE TECHNOLOGIES. *Int. Comp. Law Q.*, **64**, 875–904, https://doi.org/10.1017/S0020589315000408.

Arthur, W. B., 1989: Competing technologies, increasing returns, and lock-in by historical events. *Econ. J.*, **99**, 116–131.

Asheim, G. B., C. B. Froyn, J. Hovi, and F. C. Menz, 2006: Regional versus global cooperation for climate control. *J. Environ. Econ. Manage.*, **51**, 93–109, https://doi.org/10.1016/j.jeem.2005.04.004.

Van Asselt, H., 2016: The Role of Non-State Actors in Reviewing Ambition, Implementation, and Compliance under the Paris Agreement. *Clim. Law*, https://doi.org/10.1163/18786561-00601006.

Austin, J. E., and M. M. Seitanidi, 2012: Collaborative Value Creation. *Nonprofit Volunt. Sect. Q.*, **41**, 726–758, https://doi.org/10.1177/0899764012450777.

Axel, M., 2019: Public-Private Partnerships for Sustainable Development: Exploring their design and Impact on Effectiveness. *Sustainability*, **11**, https://doi.org/10.3390/su11041087.

Bäckstrand, K., and O. Elgström, 2013: The EU's role in climate change negotiations: from leader to 'leadiator.' *J. Eur. Public Policy*, **20**, 1369–1386, https://doi.org/10.1080/13501763.2013.781781.

——, and J. W. Kuyper, 2017: The democratic legitimacy of orchestration: the UNFCCC, non-state actors, and transnational climate governance. *Env. Polit.*, **26**, 764–788, https://doi.org/10.1080/09644016.2017.1323579.

——, ——, B.-O. Linnér, and E. Lövbrand, 2017: Non-state actors in global climate governance: from Copenhagen to Paris and beyond. *Env. Polit.*, **26**, 561–579, https://doi.org/10.1080/09644016.2017.1327485.

Bahl, R. W., and J. F. Linn, 2014: *Governing and Financing Cities in the Developing World*. 1–60 pp.

Bakhtiari, F., 2018: International cooperative initiatives and the United Nations Framework Convention on Climate Change. *Clim. Policy*, **18**, 655–663, https://doi.org/https://doi.org/10.1080/14693062.2017.1321522.

Baldos, U. L. C., and T. W. Hertel, 2015: The role of international trade in managing food security risks from climate change. *Food Secur.*, **7**, 275–290, https://doi.org/10.1007/s12571-015-0435-z.

Baldwin, E., Y. Cai, and K. Kuralbayeva, 2019: To build or not to build? Capital stocks and climate policy. *J. Environ. Econ. Manage.*, **In press**, https://doi.org/10.1016/j.jeem.2019.05.001.

Bang, G., J. Hovi, and T. Skodvin, 2016: The Paris Agreement: Short-Term and Long-Term Effectiveness. *Polit. Gov.*, **4**, 209–218, https://doi.org/10.17645/pag.v4i3.640.

Bansard, J. S., P. H. Pattberg, and O. Widerberg, 2017: Cities to the rescue? Assessing the performance of transnational municipal networks in global climate governance. *Int. Environ. Agreements Polit. Law Econ.*, **17**, 229–246, https://doi.org/10.1007/s10784-016-9318-9.

Barrett, S., 1994: Self-Enforcing International Environmental Agreements. *Oxf. Econ. Pap.*, **46**, 878–894.

——, 2008: Climate treaties and the imperative of enforcement. *Oxford Rev. Econ. Policy*, **24**, 239–258, https://doi.org/10.1093/oxrep/grn015.

——, 2011: *Why Cooperate?: The Incentive to Supply Global Public Goods*.

——, 2018: Choices in the climate commons. *Science (80-.).*, **362**, 1217 LP – 1217, https://doi.org/10.1126/science.aaw2116.

——, and A. Dannenberg, 2016: An experimental investigation into 'pledge and review' in climate negotiations. *Clim. Change*, **138**, 339–351, https://doi.org/10.1007/s10584-016-1711-4.

Battaglini, M., and B. Harstad, 2016: Participation and Duration of Environmental Agreements. *J. Polit. Econ.*, **124**, 160–204, https://doi.org/10.1086/684478.

Bauer, M. W., C. Knill, and S. Eckhard, 2017: *International Bureaucracy: Challenges and Lessons for Public Administration Research*. Palgrave Macmillan UK,.

Benedick, R. E., 1998: *Ozone diplomacy: new directions in safeguarding the planet. Enlarged edition*.

Bergman, N., 2018: Impacts of the Fossil Fuel Divestment Movement: Effects on Finance, Policy and Public Discourse. *Sustainability*, **10**, 2529, https://doi.org/10.3390/su10072529.

Betsill, M. M., 2007: Regional Governance of Global Climate Change: The North American Commission for Environmental Cooperation. *Glob. Environ. Polit.*, **7**, 11–27, https://doi.org/10.1162/glep.2007.7.2.11.

——, and H. Bulkeley, 2004: Transnational Networks and Global Environmental Governance: The Cities for Climate Protection Program. *Int. Stud. Q.*, **48**, 471–493, https://doi.org/10.1111/j.0020-8833.2004.00310.x.

Biermann, F., and B. Siebenhüner, 2009: *Managers of Global Change: The Influence of International Environmental Bureaucracies*. MIT Press,.

Le Blanc, D., 2015: Towards Integration at Last? The Sustainable Development Goals as a Network of Targets. *Sustain. Dev.*, **23**, 176–187, https://doi.org/10.1002/sd,1582.

Bodansky, D., 2007: *International Sectoral Agreements in a Post-2012 Climate Framework*. 30 pp.

——, 2013: The who, what, and wherefore of geoengineering governance. *Clim. Change*, **121**, 539–551, https://doi.org/10.1007/s10584-013-0759-7.

——, 2015: Legally binding versus non-legally binding instruments Daniel. *Geneva Reports on the World Economy*.

——, 2016: The legal character of the Paris agreement. *Rev. Eur. Comp. Int. Environ. Law*, **25**, 142–150, https://doi.org/10.1111/reel.12154.

——, J. Brunnée, and L. Rajamani, 2017: Introduction to International Climate Change Law. *International Climate Change Law*.

Boekholt, P., J. Edler, P. Cunningham, and K. Flanagan, 2009: *Drivers of International Collaboration in Research F*. www.technopolis-group.com (Accessed July 10, 2019).

Booth, E., 2019: Extinction Rebellion: social work, climate change and solidarity. *Crit.*

Radic. Soc. Work, **7**, 257–261, https://doi.org/10.1332/204986019x15623302985296.

Bos, A. B., and Coauthors, 2017: Comparing methods for assessing the effectiveness of subnational REDD+ initiatives. *Environ. Res. Lett.*, **12**, 74007, https://doi.org/10.1088/1748-9326/aa7032.

Bouwer, L. M., and J. C. J. H. Aerts, 2006: Financing climate change adaptation. *Disasters*, **30**, 49–63, https://doi.org/10.1111/j.1467-9523.2006.00306.x.

Bows-Larkin, A., 2015: All adrift: aviation, shipping, and climate change policy. *Clim. Policy*, **15**, 681–702, https://doi.org/10.1080/14693062.2014.965125.

Boykoff, M., and O. Pearman, 2019: Now or Never: How Media Coverage of the IPCC Special Report on 1.5°C Shaped Climate-Action Deadlines. *One Earth*, **1**, 285–288, https://doi.org/10.1016/J.ONEEAR.2019.10.026.

Boyle, A., 2018: Climate Change, the Paris Agreement and Human Rights. *Int. Comp. Law Q.*, https://doi.org/10.1017/S0020589318000222.

Boyle, A., 2019: Litigating climate change under Part XII of the LOSC. *Int. J. Mar. Coast. Law*, **34**, 458–481, https://doi.org/10.1163/15718085-13431097.

Brandi, C., D. Blümer, and J.-F. Morin, 2019: When Do International Treaties Matter for Domestic Environmental Legislation? *Glob. Environ. Polit.*, **19**, 14–44.

Brechin, S. R., and M. I. Espinoza, 2017: A case for further refinement of the Green Climate Fund's 50:50 ratio climate change mitigation and adaptation allocation framework: toward a more targeted approach. *Clim. Change*, **142**, 311–320, https://doi.org/10.1007/s10584-017-1938-8.

Bretschger, L., 2017: Equity and the convergence of nationally determined climate policies. *Environ. Econ. Policy Stud.*, **19**, 1–14, https://doi.org/10.1007/s10018-016-0161-6.

Buchanan, J. M., 1965: An economic theory of clubs. *Economica*, **32**, 1–14, https://doi.org/10.1145/1734263.1734357.

Buis, H., 2009: The role of local government associations in increasing the effectiveness of city-to-city cooperation. *Habitat Int.*, **33**, 190–194, https://doi.org/10.1016/j.habitatint.2008.10.017.

Bulkeley, H., 2010: Cities and the governing of climate change. *Annu. Rev. Environ. Resour.*, **35**, 229–253.

Busby, J., 2016: After Paris: good enough climate governance. *Curr. Hist.*, 3–9.

Busch, J., F. Godoy, W. R. Turner, and C. A. Harvey, 2011: Biodiversity co-benefits of reducing emissions from deforestation under alternative reference levels and levels of finance. *Conserv. Lett.*, **4**, 101–116, https://doi.org/10.1111/j.1755-263X.2010.00150.x.

Calzadilla, P. V., 2018: Human Rights and the New Sustainable Mechanism of the Paris Agreement: A New Opportunity to Promote Climate Justice. *Potchefstroom Electron. Law J.*, **21**, 1–39, https://doi.org/10.17159/1727.

Campagnolo, L., and M. Davide, 2019: Can the Paris deal boost SDGs achievement? An assessment of climate mitigation co-benefits or side-effects on poverty and inequality. *World Dev.*, **122**, 96–109, https://doi.org/10.1016/J.WORLDDEV.2019.05.015.

Campbell-Duruflé, C., 2018: Accountability or Accounting? Elaboration of the Paris Agreement's Implementation and Compliance Committee at cop 23. *Clim. Law*, **8**, 1–38, https://doi.org/10.1163/18786561-00801001.

Caparrós, A., 2016: The Paris Agreement as a step backward to gain momentum: Lessons from and for theory. *Rev. Econ. Polit.*, **126**, 347, https://doi.org/10.3917/redp.263.0347.

——, and J. C. Péreau, 2017: Multilateral versus sequential negotiations over climate change. *Oxf. Econ. Pap.*, **69**, 365–387, https://doi.org/10.1093/oep/gpw075.

——, R. E. Just, and D. Zilberman, 2015: Dynamic Relative Standards versus Emission Taxes in a Putty-Clay Model. *J. Assoc. Environ. Resour. Econ.*, **2**, 277–308, https://doi.org/10.1086/681599.

Carazo, M. P., 2017: Part II Analysis of the Provisions of the Agreement, 6 Contextual Provisions (Preamble and Article 1). *Paris Agreem. Clim. Chang. Anal. Comment.*,.

Carraro, C., 2016: A Bottom-Up, Non-Cooperative Approach to Climate Change Control: Assessment and Comparison of Nationally Determined Contributions (NDCs). *J. Sustain. Dev.*, **9**, 175, https://doi.org/10.5539/jsd.v9n5p175.

Casado-Asensio, J., and R. Steurer, 2014: Integrated strategies on sustainable development, climate change mitigation and adaptation in Western Europe: communication rather than coordination. *J. Public Policy*, **34**, 437–473, https://doi.org/10.1017/S0143814X13000287.

Casola, L., and A. Freier, 2017: El nexo entre cambio climático y energía renovable en el Mercosur. Un análisis comparativo de las legislaciones de Argentina y Brasil. *Rev. Derecho del Estado*, 153, https://doi.org/10.18601/01229893.n40.07.

CDP, 2015: CDP cities 2015.

CESCR, 1991: General comment No. 4: The right to adequate housing. *Committee on Economic, Social and Cultural Rights Sixth session*, E/1992/23.

——, 2002: General Comment No. 15: The right to water. *Substantive Issues Arising in the Implementation of the International Covenant on Economic, Social and Cultural Rights*, E/C.12/2002/11.

——, 2010: Statement on the Right to Sanitation. *Committee on Economic, Social and Cultural Rights Forty-fifth session*, E-C-12-2010-1.

Chai, Q., S. Fu, H. Xu, W. Li, and Y. Zhong, 2017: The gap report of global climate change mitigation, finance, and governance after the United States declared its withdrawal from the Paris Agreement. *Chinese J. Popul. Resour. Environ.*, **15**, 196–208, https://doi.org/10.1080/10042857.2017.1365450.

Chan, G., R. Stavins, and Z. Ji, 2018a: International Climate Change Policy. *Annu. Rev. Resour. Econ.*, **10**, 335–360, https://doi.org/10.1146/annurev-resource-100517-023321.

Chan, N., 2016: Climate Contributions and the Paris Agreement: Fairness and Equity in a Bottom-Up Architecture. *Ethics Int. Aff.*, **30**, 291–301, https://doi.org/10.1017/S0892679416000228.

Chan, S., and Coauthors, 2015: Reinvigorating International Climate Policy: A Comprehensive Framework for Effective Nonstate Action. *Glob. Policy*, **6**, 466–473, https://doi.org/10.1111/1758-5899.12294.

——, C. Brandi, and S. Bauer, 2016: Aligning Transnational Climate Action with International Climate Governance: The Road from Paris. *Rev. Eur. Comp. Int. Environ. Law*, **25**, 238–247, https://doi.org/10.1111/reel.12168.

——, R. Falkner, M. Goldberg, and H. van Asselt, 2018b: Effective and geographically

balanced? An output-based assessment of non-state climate actions. *Clim. Policy*, **18**, 24–35, https://doi.org/10.1080/14693062.2016.1248343.

Charlery, L., and S. L. M. Traerup, 2019: The nexus between nationally determined contributions and technology needs assessments: a global analysis. *Clim. POLICY*, **19**, 189–205, https://doi.org/10.1080/14693062.2018.1479957 Correspondence Address - lindycharlery@gmail.com.

Chazdon, R. L., P. H. S. Brancalion, D. Lamb, L. Laestadius, M. Calmon, and C. Kumar, 2017: A Policy-Driven Knowledge Agenda for Global Forest and Landscape Restoration: A policy-driven agenda for restoration. *Conserv. Lett.*, **10**, 125–132, https://doi.org/10.1111/conl.12220.

Chen, C.-C., and A. Gettelman, 2013: Simulated radiative forcing from contrails and contrail cirrus. *Atmos. Chem. Phys.*, **13**, 12525–12536, https://doi.org/10.5194/acp-13-12525-2013.

Chen, K., Y. Zhang, and X. Fu, 2019: International research collaboration: An emerging domain of innovation studies? *Res. Policy*, **48**, 149–168, https://doi.org/10.1016/J.RESPOL.2018.08.005.

Christensen, J., and A. Olhoff, 2019: *Lessons from a decade of emissions gap assessments*. 1–14 pp.

Christoff, P., 2016: The promissory note: COP 21 and the Paris Climate Agreement. *Env. Polit.*, **25**, 765–787, https://doi.org/10.1080/09644016.2016.1191818.

Di Ciommo, M., 2017: Approaches to measuring and monitoring South-South cooperation. *Dev. Initiat.*, 2–3.

Ciplet, D., K. M. Adams, R. Weikmans, and J. T. Roberts, 2018: The Transformative Capability of Transparency in Global Environmental Governance. *Glob. Environ. Polit.*, **18**, 130–150, https://doi.org/10.1162/glep_a_00472.

Claeys, P., and D. Delgado Pugley, 2017: Peasant and indigenous transnational social movements engaging with climate justice. *Can. J. Dev. Stud.*, **38**, 325–340, https://doi.org/10.1080/02255189.2016.1235018.

Clarke, A., and A. MacDonald, 2016: Outcomes to Partners in Multi-Stakeholder Cross-Sector Partnerships: A Resource-Based View. *Bus. Soc.*, **58**, 298–332, https://doi.org/10.1177/0007650316660534.

——, and E. Ordonez-Ponce, 2017: City scale: Cross-sector partnerships for implementing local climate mitigation plans. *Public Adm. Rev.*,.

Clémençon, R., 2016: The Two Sides of the Paris Climate Agreement: Dismal Failure or Historic Breakthrough? *J. Environ. Dev.*, **25**, 3–24, https://doi.org/10.1177/1070496516631362.

de Coninck, H., and A. Sagar, 2015a: Making sense of policy for climate technology development and transfer. *Clim. Policy*, **15**, 1–11, https://doi.org/https://doi.org/10.1080/14693062.2014.953909.

——, and ——, 2015b: *Technology in the 2015 Paris Climate Agreement and beyond*. 31 pp. https://www.ru.nl/publish/pages/749373/2015_-_technology_in_the_2015_paris_climate_agreement_and_beyond_-_ictsd_issue_paper_no_42.pdf.

Corry, O., 2017: The international politics of geoengineering: The feasibility of Plan B for

tackling climate change. *Secur. Dialogue*, **48**, 297–315, https://doi.org/10.1177/0967010617704142.

Cosbey, A., 2016: *The Trade Implications of the Paris COP21 Agreement*.

Crane, A., and M. M. Seitanidi, 2014: *Social partnerships and responsible business: What, why and how?* 40 pp.

Crutzen, P. J., 2006: Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma? *Clim. Change*, **77**, 211–220, https://doi.org/10.1007/s10584-006-9101-y.

Curtis, P. G., C. M. Slay, N. L. Harris, A. Tyukavina, and M. C. Hansen, 2018: Classifying drivers of global forest loss. *Science (80-.).*, **361**, 1108–1111, https://doi.org/10.1126/science.aau3445.

Dagnet, Y., and Coauthors, 2016: *Staying on Track from Paris: Advancing the Key Issues of the Paris Agreement*. https://www.wri.org/publication/staying-track-paris.

Darrin, Grimsey and Mervyn, L., 2002: Evaluating the risks of public private partnerships for infrastructure project. *Internatioanal J. Public Manag.*, **20**, 107–118, https://doi.org/10.1016/S0263/D0263-7863(00)00040-5.

Dave, R., and Coauthors, 2019: *Second Bonn Challenge progress report: application of the Barometer in 2018*. IUCN, International Union for Conservation of Nature,.

Delina, L., 2017: Multilateral development banking in a fragmented climate system: shifting priorities in energy finance at the Asian Development Bank. *Int. Environ. Agreements Polit. Law Econ.*, **17**, 73–88, https://doi.org/10.1007/s10784-016-9344-7.

DeSombre, E. D., 2000: The Experience of the Montreal Protocol: Particularly Remarkable, and Remarkably Particular. *UCLA J. Envtl. L. Pol'y*, **19**, 49–81.

Dimitrov, R., J. Hovi, D. F. Sprinz, H. Sælen, and A. Underdal, 2019: Institutional and Environmental Effectiveness: Will the Paris Agreement Work? *WIREs Clim. Chang.*, **2019;e583**, https://doi.org/10.1002/wcc.583.

Djenontin, I., S. Foli, and L. Zulu, 2018: Revisiting the Factors Shaping Outcomes for Forest and Landscape Restoration in Sub-Saharan Africa: A Way Forward for Policy, Practice and Research. *Sustainability*, **10**, 906, https://doi.org/10.3390/su10040906.

Doda, B., and L. Taschini, 2017: Carbon Dating: When Is It Beneficial to Link ETSs? *J. Assoc. Environ. Resour. Econ.*, **4**, 701–730, https://doi.org/10.2139/ssrn.2610076.

——, S. Quemin, and L. Taschini, 2019: *Linking Permit Markets Multilaterally*.

Doelle, M., 2016: The Paris Agreement: Historic Breakthrough or High Stakes Experiment? *Clim. Law*, **6**, 1–20, https://doi.org/10.1163/18786561-00601001.

——, 2019: The Heart of the Paris Rulebook: Communicating NDCs and Accounting for Their Implementation. *Clim. Law*, **9**, 3–20.

——, and A. Chircop, 2019: Decarbonizing international shipping: An appraisal of the IMO's Initial Strategy. *Rev. Eur. Comp. Int. Environ. Law*, https://doi-org.ezp.lib.unimelb.edu.au/10.1111/ree, https://doi.org/10.1111/reel.12302.

Donofrio, S., P. Rothrock, and J. Leonard, 2017: *Supply-change: Tracking Corporate Commitments to Deforestation-free Supply Chain*. Forest Trends,.

Dow, K., F. Berkhout, B. L. Preston, R. J. T. Klein, G. Midgley, and M. R. Shaw, 2013:

Limits to adaptation. *Nat. Clim. Chang.*, **3**, 305–307, https://doi.org/10.1038/nclimate1847.

Downs, G. W., D. M. Rocke, P. N. Barsoom, and S. 1996, 1996: Is the Good News About Compliance Good News About Cooperation? *Int. Organ.*, **50**, 379–406.

Duguma, L. A., P. A. Minang, and M. van Noordwijk, 2014: Climate Change Mitigation and Adaptation in the Land Use Sector: From Complementarity to Synergy. *Environ. Manage.*, **54**, 420–432, https://doi.org/10.1007/s00267-014-0331-x.

Duyck, S., 2015: The Paris Climate Agreement and the Protection of Human Rights in a Changing Climate. *Yearb. Int. Environ. Law*, **26**, 3–45, https://doi.org/10.1093/yiel/yvx011.

——, 2019: Delivering on the Paris Promises? Review of the Paris Agreement's Implementing Guidelines from a Human Rights Perspective. *Clim. Law*, **9**, 202–223.

Duyck, S., E. Lennon, W. Obergassel, A. Savaresi, S. Duyck, E. Lennon, W. Obergassel, and A. Savaresi, 2018: Human Rights and the Paris Agreement's Implementation Guidelines: Opportunities to Develop a Rights-based Approach. *Carbon Clim. Law Rev.*, https://doi.org/10.21552/cclr/2018/3/5.

Ebi, K. L., and Coauthors, 2014: A new scenario framework for climate change research: background, process, and future directions. *Clim. Change*, **122**, 363–372, https://doi.org/10.1007/s10584-013-0912-3.

Elsevier, and IPSOS MORI, 2019: *Research futures: Drivers and scenarios for the next decade* |. https://www.ipsos.com/ipsos-mori/en-uk/research-futures-drivers-and-scenarios-next-decade (Accessed July 10, 2019).

Erickson, L. E., 2017: Reducing greenhouse gas emissions and improving air quality: Two global challenges. *Environ. Prog. Sustain. Energy*, **36**, 982–988, https://doi.org/10.1002/ep.12665.

Eriksen, H. H., and F. X. Perrez, 2014: The Minamata Convention: A Comprehensive Response to a Global Problem. *Rev. Eur. Comp. Int. Environ. Law*, **23**, 195–210, https://doi.org/10.1111/reel.12079.

Estache, Antonio, Saussier, S., 2014: Public-Private Partnerships and Efficiency: A short assessment. *CESifo DICE Rep.*, **12**, 8–13.

Extinction Rebellion, 2019: Our Demands. *Extinction Rebellion webpage*,. https://rebellion.earth/ (Accessed December 17, 2019).

Eyben, R., 2013: Building Relationships in Development Cooperation : Traditional Donors and the Rising Powers. *IDS Policy Brief.*,.

Falkner, R., 1998: The Multilateral Ozone Fund of the Montreal Protocol: Institutions for global environmental change. *Glob. Environ. Chang.*, **8**, 171–175, https://doi.org/10.1016/S0959-3780(98)00010-7.

——, 2016: The Paris agreement and the new logic of international climate politics. *Int. Aff.*, **92**, 1107–1125, https://doi.org/10.1111/1468-2346.12708.

FAO, 2010: Managing forests for climate change.

——, 2018: FAO's south-south and triangular cooperation to achieve the sustainable development goals. Fostering partnership among the global South. 16.

——, 2019: South-South and Triangular Cooperation in FAO – Strengthening partnerships to

achieve the SGDs.

——, and G. M. of the UNCCD, 2015: *Sustainable financing for forest and landscape restoration: Opportunities, challenges and the way forward*. 131 pp.

Fattouh, B., and L. Mahadeva, 2013: OPEC: What Difference Has It Made? *Annu. Rev. Resour. Econ.*, **5**, 427–443, https://doi.org/10.1146/annurev-resource-091912-151901.

Fay, M., and Coauthors, 2015: Getting the Finance Flowing. *Decarbonizing Development: Three Steps to a Zero-Carbon Future*, The World Bank, 119–136.

Finus, M., and A. Caparrós, 2015: *Game Theory and International Environmental Cooperation: Essential Readings*. Edward Elgar, 934 pp.

Forest Declaration, 2019: New York Declaration on Forests Progress Assessment.

Forsell, N., O. Turkovska, M. Gusti, M. Obersteiner, M. den Elzen, and P. Havlik, 2016: Assessing the INDCs' land use, land use change, and forest emission projections. *Carbon Balance Manag.*, **11**, 26, https://doi.org/10.1186/s13021-016-0068-3.

Freestone, D., 2010: From Copenhagen to Cancun: Train Wreck or Paradigm Shift? *Environ. Law Rev.*, **12**, 87–93, https://doi.org/10.1350/enlr.2010.12.2.081.

Fridays for Future, 2019: About Fridays for Future. https://www.fridaysforfuture.org/about (Accessed December 17, 2019).

Frisari, G., and M. Stadelmann, 2015: De-risking concentrated solar power in emerging markets: The role of policies and international finance institutions. *Energy Policy*, **82**, 12–22, https://doi.org/https://doi.org/10.1016/j.enpol.2015.02.011.

Froyn, C. B., and J. Hovi, 2008: A climate agreement with full participation. *Econ. Lett.*, **99**, 317–319, https://doi.org/10.1016/j.econlet.2007.07.013.

Frumhoff, P. C., R. Heede, and N. Oreskes, 2015: The climate responsibilities of industrial carbon producers. *Clim. Change*, https://doi.org/10.1007/s10584-015-1472-5.

Fujimori, S., and Coauthors, 2016: Will international emissions trading help achieve the objectives of the Paris Agreement? *Environ. Res. Lett.*, **11**, 104001, https://doi.org/10.1088/1748-9326/11/10/104001.

Fünfgeld, H., 2015: Facilitating local climate change adaptation through transnational municipal networks. *Curr. Opin. Environ. Sustain.*,.

Gajevic Sayegh, A., 2017: Climate justice after Paris: a normative framework. *J. Glob. Ethics*, **13**, 344–365, https://doi.org/10.1080/17449626.2018.1425217.

Gallagher, K. P., R. Kamal, J. Jin, Y. Chen, and X. Ma, 2018: Energizing development finance? The benefits and risks of China's development finance in the global energy sector. *Energy Policy*, **122**, 313–321, https://doi.org/https://doi.org/10.1016/j.enpol.2018.06.009.

Ganguly, G., J. Setzer, and V. Heyvaert, 2018: If at First You Don't Succeed: Suing Corporations for Climate Change. *Oxf. J. Leg. Stud.*, **38**, 841–868, https://doi.org/10.1093/ojls/gqy029.

Gao, S., M. Smits, A. P. J. Mol, and C. Wang, 2016: New market mechanism and its implication for carbon reduction in China. *Energy Policy*, **98**, 221–231, https://doi.org/10.1016/J.ENPOL.2016.08.036.

Gardiner, A., M. Bardout, F. Grossi, and S. Dixson-Declève, 2016: *Public-Private*

Partnerships for Climate Finance. Nordic Council of Ministers,.

Garrett, R. D., and Coauthors, 2019: Criteria for effective zero-deforestation commitments. *Glob. Environ. Chang.*, https://doi.org/10.1016/j.gloenvcha.2018.11.003.

GEA, 2012: *Global Energy Assessment Toward a Sustainable Future*. Cambridge University Press, http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/GEA-Summary-web.pdf (Accessed July 10, 2019).

Geels, F., 2002: Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Res. Policy*, **31**, 1257–1274.

——, B. K. Sovacool, T. Schwanen, and S. Sorrell, 2017: Sociotechnical transitions for deep decarbonization. *Science (80-.).*, **357**, 1242, https://doi.org/10.1126/science.aao3760.

——, S. Sharpe, and D. Victor, 2019: *Accelerating the low carbon transition*. 99 pp.

Gehring, M. W., M.-C. C. Segger, F. de Andrade Correa, P. Reynaud, A. Harrington, and R. Mella, 2013: Climate Change and Sustainable Energy Measures in Regional Trade Agreements (RTAs). *Int. Cent. Trade Sustain. Dev. Geneva*,.

Gençsü, I., and M. Hino, 2015: *Raising Ambition to Reduce International Aviation and Maritime Emissions. Contributing paper for Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate*. http://newclimateeconomy.report/misc/working-papers.

George, C., 2014: *Developments in Regional Trade Agreements and the Environment: 2013 Update*. 28 pp.

Georghiou, L., 1998: Global cooperation in research. *Res. Policy*, **27**, 611–626, https://doi.org/10.1016/S0048-7333(98)00054-7.

Gerlagh, R., and T. O. Michielsen, 2015: Moving targets—cost-effective climate policy under scientific uncertainty. *Clim. Change*, **132**, 519–529, https://doi.org/10.1007/s10584-015-1447-6.

Gewirtzman, J., S. Natson, J. A. Richards, V. Hoffmeister, A. Durand, R. Weikmans, S. Huq, and J. T. Roberts, 2018: Financing loss and damage: reviewing options under the Warsaw International Mechanism. *Clim. Policy*, **18**, 1076–1086, https://doi.org/10.1080/14693062.2018.1450724.

Giang, A., L. C. Stokes, D. G. Streets, E. S. Corbitt, and N. E. Selin, 2015: Impacts of the Minamata Convention on Mercury Emissions and Global Deposition from Coal-Fired Power Generation in Asia. *Environ. Sci. Technol.*, **49**, 5326–5335, https://doi.org/10.1021/acs.est.5b00074.

Gilroy, J. J., P. Woodcock, F. A. Edwards, C. Wheeler, B. L. G. Baptiste, C. A. Medina Uribe, T. Haugaasen, and D. P. Edwards, 2014: Cheap carbon and biodiversity co-benefits from forest regeneration in a hotspot of endemism. *Nat. Clim. Chang.*, **4**, 503–507, https://doi.org/10.1038/nclimate2200.

GIZ, 2017: Enabling subnational climate action through multi-level governance.

Gladwell, M., 2002: *The Tipping Point: How little things can make a big difference. 2000*.

Goldthau, A., and J. Witte, eds., 2010: *Global energy governance: The new rules of the game*. Brookings Institution Press,.

Gollier, C., and J. Tirole, 2015: Negotiating effective institutions against climate change. *Econ. Energy Environ. Policy*, **4**, 5–28, https://doi.org/10.5547/2160-5890.4.2.cgol.

Gomez-Echeverri, L., 2018: Climate and development: enhancing impact through stronger linkages in the implementation of the Paris Agreement and the Sustainable Development Goals (SDGs). *Philos. Trans. R. Soc. A Math. Eng. Sci.*, **376**, 20160444, https://doi.org/10.1098/rsta.2016.0444.

Gordon, H. S., 1954: The Economic Theory of a Common-Property Resource : The Fishery. *J. Polit. Econ.*, **62**, 124–142.

Gössling, S., and P. Upham, 2009: *Climate Change and Aviation. Issues, Challenges and Solutions.*

Goulder, L., M. A. Hafstead, G. Kim, and X. Long, 2018: *Impacts of a Carbon Tax across US Household Income Groups: What Are the Equity-Efficiency Trade-Offs?*

Van de Graaf, T., 2013: Fragmentation in Global Energy Governance: Explaining the Creation of IRENA. *Glob. Environ. Polit.*, **13**, 14–33.

Van de Graaf, T., and D. Lesage, 2009: The International Energy Agency after 35 years: Reform needs and institutional adaptability. *Rev. Int. Organ.*, **4**, 293–317, https://doi.org/10.1007/s11558-009-9063-8.

Grassi, G., J. House, F. Dentener, S. Federici, M. den Elzen, and J. Penman, 2017: The key role of forests in meeting climate targets requires science for credible mitigation. *Nat. Clim. Chang.*, **7**, 220–226, https://doi.org/10.1038/nclimate3227.

Gray, K., and B. K. Gills, 2016: South–South cooperation and the rise of the Global South. *Third World Q.*, **37**, 557–574, https://doi.org/10.1080/01436597.2015.1128817.

Graziosi, F., and Coauthors, 2017: European emissions of the powerful greenhouse gases hydrofluorocarbons inferred from atmospheric measurements and their comparison with annual national reports to UNFCCC. *Atmos. Environ.*, **158**, 85–97, https://doi.org/10.1016/J.ATMOSENV.2017.03.029.

Green, J., Sterner, T., & Wagner, G., 2014: A balance of "bottom–up" and "top–down" in linking climate policies. *Nat. Clim. Chang.*, **12**, 1064–1067.

Green, B. A., 2009: Lessons from the Montreal Protocol: Guidance for the next international climate change agreement. *Environ. Law*, **39**, 253–283, https://doi.org/10.1525/sp.2007.54.1.23.

Green Climate Fund, Green Climate Fund. https://www.greenclimate.fund.

Green, J. F., 2017: The strength of weakness: pseudo-clubs in the climate regime. *Clim. Change*, **144**, 41–52, https://doi.org/10.1007/s10584-015-1481-4.

Griffin, C., D. H. Fisher, A. Haider, K. Dawar, A. Green, and G. Owen, 2019: *Climate change and trade agreements: Friends or foes?* 38 pp. https://pages.eiu.com/rs/753-RIQ-438/images/TradeandClimateChange2019.pdf.

Griscom, B. W., and Coauthors, 2017: Natural climate solutions. *Proc. Natl. Acad. Sci. U. S. A.*, **114**, 11645–11650, https://doi.org/10.1073/pnas.1710465114.

Grote, M., I. Williams, and J. Preston, 2014: Direct carbon dioxide emissions from civil aircraft. *Atmos. Environ.*, **95**, 214–224, https://doi.org/10.1016/J.ATMOSENV.2014.06.042.

Grubb, M., 2014: *Planetary economics: energy, climate change and the three domains of*

sustainable development. Earthscan,.

Gsottbauer, E., R. Gampfer, E. Bernold, and A. M. Delas, 2018: Broadening the scope of loss and damage to legal liability: an experiment. *Clim. Policy*, **18**, 600–611, https://doi.org/10.1080/14693062.2017.1317628.

Gulbrandsen, L.H., Wettestad, J., Victor, D. G. and U. A., 2019: The Political Roots of Diverging Carbon Market Design: implications for linking. *Clim. Policy*, **19**, 427–438.

Gunningham, N., 2019: Averting Climate Catastrophe: Environmental Activism, Extinction Rebellion and coalitions of Influence. *King's Law J.*, **30**, 194–202, https://doi.org/10.1080/09615768.2019.1645424.

Gupta, A., and H. van Asselt, 2019: Transparency in multilateral climate politics: Furthering (or distracting from) accountability? *Regul. Gov.*, https://doi.org/10.1111/rego.12159.

Gupta, H., and L. C. Dube, 2018: Addressing biodiversity in climate change discourse: Paris mechanisms hold more promise. *Int. For. Rev.*, **20**, 104–114, https://doi.org/10.1505/146554818822824282.

Gupta, J., and Coauthors, 2010: Mainstreaming climate change in development cooperation policy: conditions for success. *Making climate change work for us*, M. Hulme and H. Neufeldt, Eds., Cambridge University Press, 319–339.

Ha,Sangjung , Hale, T., 2016: Climate Finance in and between developing countries: an emerging opportunity to build on. *Glob. Policy*, **7**, 102–108, https://doi.org/10.1111/1758-5899.12293.

Hadden, J., 2014: Explaining Variation in Transnational Climate Change Activism: The Role of Inter-Movement Spillover. *Glob. Environ. Polit.*, **14**, 7–25, https://doi.org/10.1162/GLEP_a_00225.

Håkon Sælen, Hovi, Jon, Detlef Sprinz, A. U., 2020: How US Withdrawal Might Influence Cooperation under the Paris Climate Agreement. **209701**, 1–13.

Hale, T. and Roger, C., 2014: Orchestration and transnational climate governance. *Rev. Int. Organ.*, **9**, 59–82.

Hale, T., 2016: "All Hands on Deck": The Paris Agreement and Nonstate Climate Action. *Glob. Environ. Polit.*, **16**, 12–22, https://doi.org/10.1162/GLEP_a_00362.

——, and Coauthors, 2016: Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs). *Clim. Policy*, **6**, 1–15, https://doi.org/10.1080/14693062.2019.1624252.

Hales, R., and B. Mackey, 2017: Carbon budgeting post-COP21: The need for an equitable strategy for meeting CO2e targets. *Pathways to a Sustainable Economy: Bridging the Gap between Paris Climate Change Commitments and Net Zero Emissions*.

Hanger, S., N. Komendantova, B. Schinke, D. Zejli, A. Ihlal, and A. Patt, 2016: Community acceptance of large-scale solar energy installations in developing countries: Evidence from Morocco. *Energy Res. Soc. Sci.*, **14**, https://doi.org/10.1016/j.erss.2016.01.010.

Hardin, G., 1968: The Tragedy of the Commons. *Science (80-.).*, **162**, 1243–1248.

Heal, G., and H. Kunreuther, 2017: An alternative framework for negotiating climate policies. *Clim. Change*, **144**, 29–39, https://doi.org/10.1007/s10584-017-2043-8.

Hein, J., A. Guarin, E. Frommé, and P. Pauw, 2018: Deforestation and the Paris climate agreement: An assessment of REDD + in the national climate action plans. *For. Policy*

Econ., **90**, 7–11, https://doi.org/10.1016/J.FORPOL.2018.01.005.

Heinrichs, D., K. Krellenberg, and M. Fragkias, 2013: Urban Responses to Climate Change: Theories and Governance Practice in Cities of the Global South. *Int. J. Urban Reg. Res.*, **37**, 1865–1878, https://doi.org/10.1111/1468-2427.12031.

Held, D., and C. Roger, 2018: Three Models of Global Climate Governance: From Kyoto to Paris and Beyond. *Glob. Policy*, **9**, 527–537, https://doi.org/10.1111/1758-5899.12617.

Helland, L., J. Hovi, and H. Sælen, 2017: Climate leadership by conditional commitments. *Oxf. Econ. Pap.*, **70**, 417–442, https://doi.org/10.1093/oep/gpx045.

Helm, C., and D. F. Sprinz, 2000: Measuring the Effectiveness of International Environmental Regimes. *J. Conflict Resolut.*, **45**, 630–652.

Herrala, R., and R. K. Goel, 2016: Sharing the emission reduction burden in an uneven world. *Energy Policy*, **94**, 29–39, https://doi.org/10.1016/J.ENPOL.2016.03.028.

Hogl, K., D. Kleinschmit, and J. Rayner, 2016: Achieving policy integration across fragmented policy domains: Forests, agriculture, climate and energy. *Environ. Plan. C Gov. Policy*, **34**, 399–414, https://doi.org/10.1177/0263774X16644815.

Höglund-Isaksson, L., P. Purohit, M. Amann, I. Bertok, P. Rafaj, W. Schöpp, and J. Borken-Kleefeld, 2017: Cost estimates of the Kigali Amendment to phase-down hydrofluorocarbons. *Environ. Sci. Policy*, **75**, 138–147, https://doi.org/10.1016/J.ENVSCI.2017.05.006.

Höhne, N., and Coauthors, 2017: The Paris Agreement: resolving the inconsistency between global goals and national contributions. *Clim. Policy*, https://doi.org/10.1080/14693062.2016.1218320.

——, H. Fekete, M. G. J. den Elzen, A. F. Hof, and T. Kuramochi, 2018: Assessing the ambition of post-2020 climate targets: a comprehensive framework. *Clim. Policy*, **18**, 425–441, https://doi.org/10.1080/14693062.2017.1294046.

Holmberg, A., and A. Alvinius, 2019: Children's protest in relation to the climate emergency: A qualitative study on a new form of resistance promoting political and social change. *Childhood*, 0907568219879970, https://doi.org/10.1177/0907568219879970.

Holzer, K., and T. Cottier, 2015: Addressing climate change under preferential trade agreements: Towards alignment of carbon standards under the Transatlantic Trade and Investment Partnership. *Glob. Environ. Chang.*, **35**, 514–522, https://doi.org/10.1016/j.gloenvcha.2015.06.006.

Hovi, J., D. F. Sprinz, and A. Underdal, 2003a: The Oslo-Potsdam Solution to Measuring Regime Effectiveness: Critique, Response, And Extensions. *Glob. Environ. Polit.*, **3**, 74–96.

——, ——, and ——, 2003b: Regime Effectiveness and the Oslo-Potsdam Solution: A Rejoinder to Oran Young. *Glob. Environ. Polit.*, **3**, 105–107.

——, D. F. Sprinz, H. Sælen, and A. Underdal, 2016: Climate change mitigation: A role for climate clubs? *Palgrave Commun.*, **2**, 1–9, https://doi.org/10.1057/palcomms.2016.20.

——, D. F. Sprinz, H. Sælen, and A. Underdal, 2017: The Club Approach: A Gateway to Effective Climate Co-operation? *Br. J. Polit. Sci.*, **49**, 1071–1096, https://doi.org/https://doi.org/10.1017/S0007123416000788.

Howard, A., 2017: Voluntary Cooperation (Article 6). *The Paris Agreement on climate*

change: Analysis and commentary, D. Klein, M. Pía Carazo, M. Doelle, J. Bulmer, and A. Higham, Eds., p. 178.

La Hoz Theuer, S., L. Schneider, and D. Broekhoff, 2019: When less is more: limits to international transfers under Article 6 of the Paris Agreement. *Clim. Policy*, **19**, 401–413, https://doi.org/10.1080/14693062.2018.1540341.

Hsu, A., and Coauthors, 2019a: A research roadmap for quantifying non-state and subnational climate mitigation action. *Nat. Clim. Chang.*, **9**, 11–17, https://doi.org/10.1038/s41558-018-0338-z.

——, J. Brandt, O. Widerberg, S. Chan, and A. Weinfurter, 2019b: Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs). *Clim. Policy*, **0**, 1–15, https://doi.org/10.1080/14693062.2019.1624252.

Huang, J., 2018: What Can the Paris Agreement's Global Stocktake Learn from the Sustainable Development Goals? *Carbon Clim. Law Rev.*, **12**, 218–228.

Huggins, A., and M. S. Karim, 2016: Shifting Traction: Differential Treatment and Substantive and Procedural Regard in the International Climate Change Regime. *Transnatl. Environ. Law*, **5**, 427–448, https://doi.org/10.1017/S2047102516000170.

Hurwitz, M. M., E. L. Fleming, P. A. Newman, F. Li, and Q. Liang, 2016: Early action on HFCs mitigates future atmospheric change. *Environ. Res. Lett.*, **11**, 114019, https://doi.org/10.1088/1748-9326/11/11/114019.

ICAO, 2016: *Resolution A39-3: Consolidated statement of continuing ICAO policies and practices related to environmental protection – Global Market-based Measure (MBM) scheme*.

ICAP, 2019: *Emissions Trading Worldwide*.

ICSU ISSC, 2015: *Review of Targets for the Sustainable Development Goals: the science perspective*.

IMO, 2018: *Res. MEPC.304(72): Initial IMO Strategy on Reduction of GHG Emissions from Ships*.

InfoFLR, 2018: The Bonn Challenge Barometer. *Int. Union Conserv. Nat.*,.

IPCC, 2014: Climate-Resilient Pathways: Adaptation, Mitigation, and Sustainable Development. *Climate Change 2014 Impacts, Adaptation, and Vulnerability*, C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, and M.D. Mastrandrea, Eds., Cambridge University Press, 1101–1131.

——, 2018a: *Global Warming of 1.5°C*. V. Masson-Delmotte et al., Eds. Cambridge University Press,.

——, 2018b: *Global Warming of 1.5 °C an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change*.

——, 2018c: Summary for Policymakers. *Global Warming of 1.5 °C an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change*.

Irvine, P., K. Emanuel, J. He, L. W. Horowitz, G. Vecchi, and D. Keith, 2019: Halving warming with idealized solar geoengineering moderates key climate hazards. *Nat. Clim. Chang.*, **9**, 295–299, https://doi.org/10.1038/s41558-019-0398-8.

Ivanova, A., 2017: Green financing for cities: current options and future challenges. *Climate Change-Sensitive Cities: Building capacities for urban resilience, sustainability, and equity*, G.C. Delgado, Ed., PINCC-UNAM, 283–306.

——, and C. Lopez, 2013: The energy crisis and the policies for implementation of renewable energies. *Strategies towards a sustainable development in front of the three crisis*, UAM-Iztapalapa & Miguel Angel Porrúa, 267–282.

Ivanova, A., and A. B. Cuevas Tello, 2016: How Climate Action at Regional Level Contributes to the Objectives of the UNFCCC: The APEC Case. *Mod. Econ.*, **07**, 1428–1443, https://doi.org/10.4236/me.2016.712131.

Ivanova, A., A. Bermudez, and A. Martinez, 2015: Climate action plan for the city of La Paz, Baja California Sur, Mexico: a tool for sustainability. *The Sustainable City X*, Vol. 1 of, 439–449.

Iyer, G., C. Ledna, L. Clarke, J. Edmonds, H. McJeon, P. Kyle, and J. H. Williams, 2017: Measuring progress from nationally determined contributions to mid-century strategies. *Nat. Clim. Chang.*, **7**, 871–874, https://doi.org/10.1038/s41558-017-0005-9.

Jacquet, J., and D. Jamieson, 2016: Soft but significant power in the Paris Agreement. *Nat. Clim. Chang.*, **6**, 643–646.

Jaffe, A. B., R. G. Newell, and R. N. Stavins, 2005: A tale of two market failures: Technology and environmental policy. *Ecol. Econ.*, https://doi.org/10.1016/j.ecolecon.2004.12.027.

James, R., F. Otto, H. Parker, E. Boyd, R. Cornforth, D. Mitchell, and M. Allen, 2014: Characterizing loss and damage from climate change. *Nat. Clim. Chang.*, **4**, 938–939, https://doi.org/10.1038/nclimate2411.

Janus, H., S. Klingebiel, and T. C. Mahn, 2014: How to Shape Development Cooperation? The Global Partnership and the Development Cooperation Forum. *SSRN Electron. J.*, https://doi.org/10.2139/ssrn.2408384.

Jeffery, M. L., J. Gütschow, M. R. Rocha, and R. Gieseke, 2018: Measuring Success: Improving Assessments of Aggregate Greenhouse Gas Emissions Reduction Goals. *Earth's Futur.*, **6**, 1260–1274, https://doi.org/10.1029/2018EF000865.

Jinnah, S., and S. Nicholson, 2019: The hidden politics of climate engineering. *Nat. Geosci.*, **12**, 876–879, https://doi.org/10.1038/s41561-019-0483-7.

Jordan, A. J., and Coauthors, 2015: Emergence of polycentric climate governance and its future prospects. *Nat. Clim. Chang.*, **5**, 977–982, https://doi.org/10.1038/nclimate2725.

Junxiao, Liu., et al, 2015: *A new framework for evaluating public-private partnerships*.

Karlsson-Vinkhuyzen, S. I., M. Groff, P. A. Tamás, A. L. Dahl, M. Harder, and G. Hassall, 2018: Entry into force and then? The Paris agreement and state accountability. *Clim. Policy*, **18**, 593–599, https://doi.org/10.1080/14693062.2017.1331904.

Kasperson, R., and J. X. Kasperson, 2001: Climate change, vulnerability, and social justice.

Kemp, L., 2018: A Systems Critique of the 2015 Paris Agreement on Climate. *Pathways to a Sustainable Economy*, Springer International Publishing, 25–41.

Keohane, N., A. Petsonk, and A. Hanafi, 2017: Toward a club of carbon markets. *Clim. Change*, **144**, 81–95, https://doi.org/10.1007/s10584-015-1506-z.

Keohane, R. O., and D. G. Victor, 2011: The Regime Complex for Climate Change. *Perspect. Polit.*, **9**, 7–23, https://doi.org/10.1017/S1537592710004068.

Keohane, R. O., and M. Oppenheimer, 2016: Paris: Beyond the Climate Dead End through Pledge and Review? *Polit. Gov.*, **4**, 142, https://doi.org/10.17645/pag.v4i3.634.

——, and D. G. Victor, 2016: Cooperation and discord in global climate policy. *Nat. Clim. Chang.*, **6**, 570–575, https://doi.org/10.1038/nclimate2937.

Kern, K., and H. Bulkeley, 2009: Cities, Europeanization and Multi-level Governance: Governing Climate Change through Transnational Municipal Networks. *JCMS J. Common Mark. Stud.*, **47**, 309–332, https://doi.org/10.1111/j.1468-5965.2009.00806.x.

Khan, M. R., and J. T. Roberts, 2013: Adaptation and international climate policy. *Wiley Interdiscip. Rev. Clim. Chang.*, **4**, 171–189, https://doi.org/10.1002/wcc.212.

——, J. Timmons Roberts, S. Huq, V. Hoffmeister, and S.-A. Robinson, 2018: Capacity building and transparency under Paris. *The Paris Framework for Climate Change Capacity Building*, 203–222.

Khan, S. A., and K. Kulovesi, 2018: Black carbon and the Arctic: Global problem-solving through the nexus of science, law and space. *Rev. Eur. Comp. Int. Environ. Law*, **27**, 5–14, https://doi.org/10.1111/reel.12245.

Kirchherr, J., and F. Urban, 2018: Technology transfer and cooperation for low carbon energy technology: Analysing 30 years of scholarship and proposing a research agenda. *Energy Policy*, **119**, 600–609, https://doi.org/10.1016/j.enpol.2018.05.001.

Kissinger, G., A. Gupta, I. Mulder, and N. Unterstell, 2019: Climate financing needs in the land sector under the Paris Agreement: An assessment of developing country perspectives. *Land use policy*, **83**, 256–269, https://doi.org/10.1016/J.LANDUSEPOL.2019.02.007.

Knox, J. H., 2016: *Report of the Special Rapporteur on the issue of human rights obligations relating to the enjoyment of a safe, clean, healthy and sustainable environment*. UN Human Rights Council, 31st Sess., Agenda Item pp.

——, 2019: The Paris Agreement as a Human Rights Treaty. *Human Rights and the 21st Century Challenges: Poverty, Conflict and the Environment*.

Kowarsch, M., J. Garard, P. Riousset, D. Lenzi, M. J. Dorsch, B. Knopf, J.-A. Harrs, and O. Edenhofer, 2016: Scientific assessments to facilitate deliberative policy learning. *Palgrave Commun.*, **2**, 16092, https://doi.org/10.1057/palcomms.2016.92.

Kravitz, B., and Coauthors, 2015: The Geoengineering Model Intercomparison Project Phase 6 (GeoMIP6): simulation design and preliminary results. *Geosci. Model Dev.*, **8**, 3379–3392, https://doi.org/10.5194/gmd-8-3379-2015.

Kreibich, N., 2018: *Raising Ambition through Cooperation Using Article 6 to bolsterclimate change mitigation*.

Krueger, P., Z. Sautner, and L. T. Starks, 2018: *The Importance of Climate Risks for Institutional Investors*.

Krugman, P., 2011: History Versus Expectations. *Q. J. Econ.*, **106**, 651–667.

Kruitwagen, L., K. Madani, B. Caldecott, and M. H. W. Workman, 2017: Game theory and

corporate governance: conditions for effective stewardship of companies exposed to climate change risks. *J. Sustain. Financ. Invest.*, **7**, 14–36, https://doi.org/10.1080/20430795.2016.1188537.

Kulovesi, K., 2012: Addressing Sectoral Emissions outside the United Nations Framework Convention on Climate Change: What Roles for Multilateralism, Minilateralism and Unilateralism? *Rev. Eur. Community Int. Environ. Law*, **21**, 193–203, https://doi.org/10.1111/reel.12005.

Kuyper, J., H. Schroeder, and B.-O. Linnér, 2018a: The Evolution of the UNFCCC. *Annu. Rev. Environ. Resour.*, **43**, 343–368, https://doi.org/10.1146/annurev-environ-102017-030119.

Kuyper, J. W., B. O. Linnér, and H. Schroeder, 2018b: Non-state actors in hybrid global climate governance: justice, legitimacy, and effectiveness in a post-Paris era. *Wiley Interdiscip. Rev. Clim. Chang.*, **9**, 1–18, https://doi.org/10.1002/wcc.497.

Kverndokk, S., 2018: Climate Policies, Distributional Effects and Transfers Between Rich and Poor Countries. *Int. Rev. Environ. Resour. Econ.*, **12**, 129–176, https://doi.org/10.1561/101.00000100.

Labordena, M., A. Patt, M. Bazilian, M. Howells, and J. Lilliestam, 2017a: Impact of political and economic barriers for concentrating solar power in Sub-Saharan Africa. *Energy Policy*, **102**, 52–72, https://doi.org/10.1016/j.enpol.2016.12.008.

——, ——, ——, ——, and ——, 2017b: Impact of political and economic barriers for concentrating solar power in Sub-Saharan Africa. *Energy Policy*, **102**, 52–72, https://doi.org/10.1016/j.enpol.2016.12.008.

Lambin, E. F., and Coauthors, 2018: The role of supply-chain initiatives in reducing deforestation. *Nat. Clim. Chang.*, https://doi.org/10.1038/s41558-017-0061-1.

Larkin, A., J. Kuriakose, M. Sharmina, and K. Anderson, 2018: What if negative emission technologies fail at scale? Implications of the Paris Agreement for big emitting nations. *Clim. Policy*, **18**, 690–714, https://doi.org/10.1080/14693062.2017.1346498.

Larsen, G., C. Smith, N. Krishan, and et al, 2018: *Towards Paris Alignment: How the Multilateral Development Banks Can Better Support the Paris Agreement*.

Lawrence, P., and D. Wong, 2017: Soft law in the paris climate agreement: Strength or weakness? *Rev. Eur. Comp. Int. Environ. Law*, **26**, 276–286, https://doi.org/10.1111/reel.12210.

Lederer, M., and J. Kreuter, 2018: Organising the unthinkable in times of crises: Will climate engineering become the weapon of last resort in the Anthropocene? *Organization*, **25**, 472–490, https://doi.org/10.1177/1350508418759186.

Lee, B., and S. Vaughan, 2019: Trade Can be a Driver of Climate Action.

Lees, E., 2017: Responsibility and liability for climate loss and damage after Paris. *Clim. Policy*, **17**, 59–70, https://doi.org/10.1080/14693062.2016.1197095.

Leffel, B., 2018: Subnational Diplomacy, Climate Governance & Californian Global Leadership.

Lilliestam, J., A. Battaglini, C. Finlay, D. Fürstenwerth, A. Patt, G. Schellekens, and P. Schmidt, 2012: An alternative to a global climate deal may be unfolding before our eyes. *Clim. Dev.*, **4**, 1–4, https://doi.org/10.1080/17565529.2012.658273.

Lilliston, B., 2019: When Climate goals and trade rules collide.

Liu, J., 2011: The Cancun Agreements. *Environ. Law Rev.*, **13**, 43–49, https://doi.org/10.1350/enlr.2011.13.1.112.

——, 2012: The Role of ICAO in Regulating the Greenhouse Gas Emissions of Aircraft. *Carbon & Clim. Law Rev.*, **5**, 417–431.

Liu, J. Y., S. Fujimori, and T. Masui, 2017: Temporal and spatial distribution of global mitigation cost: INDCs and equity. *Post-2020 Climate Action: Global and Asian Perspectives*.

Liu, L., and M. Waibel, 2010: Managing Subnational Credit and Default Risks. *Sovereign Debt and the Financial Crisis*, 273–293.

Liu, Z., and Y. Chen, 2015: Impacts, risks, and governance of climate engineering. *Adv. Clim. Chang. Res.*, **6**, 197–201, https://doi.org/10.1016/j.accre.2015.10.004.

Lloyd, I. D., and M. Oppenheimer, 2014: On the Design of an International Governance Framework for Geoengineering. *Glob. Environ. Polit.*, **14**, 45–63, https://doi.org/10.1162/GLEP_a_00228.

Locatelli, B., V. Evans, A. Wardell, A. Andrade, and R. Vignola, 2011: Forests and Climate Change in Latin America: Linking Adaptation and Mitigation. *Forests*, **2**, 431–450, https://doi.org/10.3390/f2010431.

London Convention/Protocol, 2010: *RESOLUTION LC-LP.2 ON THE ASSESSMENT FRAMEWORK FOR SCIENTIFIC RESEARCH INVOLVING OCEAN FERTILIZATION*.

Lyle, C., 2018: Beyond the icao's corsia: Towards a More Climatically Effective Strategy for Mitigation of Civil-Aviation Emissions. *Clim. Law*, **8**, 104–127, https://doi.org/https://doi.org/10.1163/18786561-00801004.

Maas, A., and J. Scheffran, 2012: Climate Conflicts 2.0? Climate Engineering as a Challenge for International Peace and Security. *Sicherheit und Frieden / Secur. Peace*, **30**, 193–200, https://doi.org/10.2307/24233201.

MacDonald, A., A. Clarke, L. Huang, M. Roseland, and M. M. Seitanidi, 2017: Multi-stakeholder Partnerships (SDG #17) as a Means of Achieving Sustainable Communities and Cities (SDG #11). *World Sustainability Series*, 193–209.

Mace, M. J., and R. Verheyen, 2016: Loss, damage and responsibility after COP21: All options open for the Paris agreement. *Rev. Eur. Comp. Int. Environ. Law*, **25**, 197–214, https://doi.org/10.1111/reel.12172.

MacLeod, M., and J. Park, 2011: Financial Activism and Global Climate Change: The Rise of Investor-Driven Governance Networks. *Glob. Environ. Polit.*, **11**, 54–74, https://doi.org/10.1162/GLEP_a_00055.

MacMartin, D. G., K. L. Ricke, and D. W. Keith, 2018: Solar geoengineering as part of an overall strategy for meeting the 1.5°C Paris target. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, **376**, 20160454, https://doi.org/10.1098/rsta.2016.0454.

Maljean-Dubois, S., 2016: The paris agreement: A new step in the gradual evolution of differential treatment in the climate regime? *Rev. Eur. Comp. Int. Environ. Law*, https://doi.org/10.1111/reel.12162.

——, and M. Wemaëre, 2016: The Paris Agreement: A Starting Point towards Achieving Climate Neutrality? *Carbon Clim. Law Rev. CCLR*,.

Mansourian, S., N. Dudley, and D. Vallauri, 2017: Forest Landscape Restoration: Progress in the Last Decade and Remaining Challenges. *Ecol. Restor.*, **35**, 281–288, https://doi.org/10.3368/er.35.4.281.

Marcu, A., 2016: *Carbon Market Provisions in the Paris Agreement (Article 6)*. 26 pp.

Marjanac, S., and L. Patton, 2018: Extreme weather event attribution science and climate change litigation: An essential step in the causal chain? *J. Energy Nat. Resour. Law*, **36**, https://doi.org/10.1080/02646811.2018.1451020.

Marques, A., and Coauthors, 2014: A framework to identify enabling and urgent actions for the 2020 Aichi Targets. *Basic Appl. Ecol.*, **15**, 633–638, https://doi.org/10.1016/j.baae.2014.09.004.

Martinez Romera, B., 2016: The Paris Agreement and the Regulation of International Bunker Fuels. *Rev. Eur. Comp. Int. Environ. Law*, **25**, 215–227, https://doi.org/10.1111/reel.12170.

Mattoo, A., and A. Subramanian, 2013: Four Changes to Trade Rules to Facilitate Climate Change Action CGD Policy Paper 021.

Mayer, B., 2016: Human Rights in the Paris Agreement. *Clim. Law*, https://doi.org/10.1163/18786561-00601007.

——, 2018: International Law Obligations Arising in relation to Nationally Determined Contributions. *Transnatl. Environ. Law*, **7**, 251–275, https://doi.org/10.1017/s2047102518000110.

——, 2019: Transparency Under the Paris Rulebook: Is the Transparency Framework Truly Enhanced? *Clim. Law*, **9**, 40–64.

Mayer, B., and F. Crépeau, 2016: 1. Introduction. *Research Handbook on Climate Change, Migration and the Law*, B. Mayer and F. Crépeau, Eds., Elgar, 1–26.

Mazzucato, M., 2016: From market fixing to market-creating: a new framework for innovation policy. *Ind. Innov.*, **23**, 140–156, https://doi.org/10.1080/13662716.2016.1146124.

Mcadam, J., 2016: Climate Change-related Displacement of Persons. *The Oxford Handbook of International Climate Change Law*, K.R. Gray, R. Tarasofsky, and C. Carlarne, Eds., Oxford University Press, p. 519.

McGee, J., K. Brent, and W. Burns, 2018: Geoengineering the oceans: An emerging frontier in international climate change governance. *Aust. J. Marit. Ocean Aff.*, **10**, 67–80, https://doi.org/10.1080/18366503.2017.1400899.

McNamara, K. E., and G. Jackson, 2019: Loss and damage: A review of the literature and directions for future research. *Wiley Interdiscip. Rev. Clim. Chang.*, **10**, e564, https://doi.org/10.1002/wcc.564.

Mehling, M. A., 2018: *Governing Cooperative Approaches under the Paris Agreement*. https://www.belfercenter.org/sites/default/files/files/publication/mehling-paris-cooperative-approaches-nov-19-2018.pdf.

——, G. E. Metcalf, and R. N. Stavins, 2018: Linking climate policies to advance global mitigation. *Science (80-.).*, **359**, **Issue**, 997–998.

Meltzer, J. P., 2013: The Trans-Pacific Partnership Agreement, the environment and climate change. *Trade Liberalisation and International Co-operation: A Legal Analysis of the*

Trans-Pacific Partnership Agreement, Edward Elgar Publishing, 207–230.

Michaelowa, A., Shishlov, I.; Brescia, D., 2019: Evolution of international carbon markets: lessons for the Paris Agreement. *WIREs Clim. Chang.*,.

Michaelowa, A. and Michaelowa, K., 2011: Climate business for poverty reduction. *Rev. Int. Organ.*, **6**, 259–286.

MIGA, 2019: About MIGA. *2019*,.

Miles, E. L., A. Underdal, S. Andresen, J. Wettestad, J. B. Skjærseth, and E. M. Carlin, 2002: *Environmental Regime Effectiveness: Confronting Theory with Evidence*. The MIT Press,.

Miles, K., 2019: *Research Handbook on Environment and Investment Law*. K. Miles, Ed. Edward Elgar,.

Milkoreit, M., and K. Haapala, 2019: The global stocktake: design lessons for a new review and ambition mechanism in the international climate regime. *Int. Environ. Agreements Polit. Law Econ.*, **19**, 89–106, https://doi.org/10.1007/s10784-018-9425-x.

Milman, A., L. Bunclark, D. Conway, and W. N. Adger, 2013: Assessment of institutional capacity to adapt to climate change in transboundary river basins. *Clim. Change*, **121**, 755–770, https://doi.org/10.1007/s10584-013-0917-y.

Mitchell, R. B., 2006: Part Two: The Effectiveness of International Environmental Regimes Problem Structure, Institutional Design, and the Relative Effectiveness of International Environmental Agreements. *Glob. Environ. Polit.*, **6**, 72–89.

Molina, M., D. Zaelke, K. M. Sarma, S. O. Andersen, V. Ramanathan, and D. Kaniaru, 2009: Reducing abrupt climate change risk using the Montreal Protocol and other regulatory actions to complement cuts in CO₂ emissions. *Proc. Natl. Acad. Sci.*, **106**, 20616 LP – 20621, https://doi.org/10.1073/pnas.0902568106.

Morgan, J., and E. Northrop, 2017: Will the Paris Agreement accelerate the pace of change? *Wiley Interdiscip. Rev. Clim. Chang.*, **8**, e471, https://doi.org/10.1002/wcc.471.

Moulot, J., 2016: *Regional Integration in the Context of Climate Change*. 67 pp. http://www.climate-energysolutions.com/images/fichiers/REGIONAL INTEGRATION IN THE CONTEXT OF CLIMATE CHANGE.pdf.

Müller, B., and A. Michaelowa, 2019: How to operationalize accounting under Article 6 market mechanisms of the Paris Agreement. *Clim. Policy*, **19**, 812–819, https://doi.org/10.1080/14693062.2019.1599803.

Nakhooda, S., 2011: Asia, the multilateral development banks and energy governance. *Glob. Policy*, **2**, 120–132.

Nasiritousi, N., M. Hjerpe, and B.-O. Linnér, 2016: The roles of non-state actors in climate change governance: understanding agency through governance profiles. *Int. Environ. Agreements Polit. Law Econ.*, **16**, 109–126, https://doi.org/10.1007/s10784-014-9243-8.

Newell, P., & Bumpus, A., 2012: The global political ecology of the clean development mechanism. *Glob. Environ. Polit.*, **12**, 49–67.

Nhlapho, T., 2019: African Forest Landscape Restoration Initiative. *AFRICAN UNION Dev. AGENCY-NEPAD*,.

Nicholson, S., S. Jinnah, and A. Gillespie, 2018: Solar radiation management: a proposal for immediate polycentric governance. *Clim. Policy*, **18**, 322–334,

https://doi.org/10.1080/14693062.2017.1400944.

Nilsson, Mans, Griggs, Dave, Visbek, M., 2016: Map the interactions between sustainable development goals. *Nature*, **534**, 320–322.

Niosi, J., 2018: National Systems of Innovation in developing countries. *Innovation Systems, Policy and Management*, Cambridge University Press, 149–177.

Nordhaus, W., 2015: Climate Clubs: Overcoming Free-riding in International Climate Policy. *Am. Econ. Rev.*, **105**, 1339–1370, https://doi.org/10.1257/aer.15000001.

O'Neill, B. C., and Coauthors, 2017: The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. *Glob. Environ. Chang.*, **42**, 169–180, https://doi.org/10.1016/J.GLOENVCHA.2015.01.004.

Obergassel, W., L. Peterson, F. Mersmann, J. Schade, J. A. Hofbauer, and M. Mayrhofer, 2017: Human rights and the clean development mechanism: lessons learned from three case studies. *J. Hum. Rights Environ.*, https://doi.org/10.4337/jhre.2017.01.03.

Oberthür, S., and R. Bodle, 2016: Legal Form and Nature of the Paris Outcome. *Clim. Law*, **6**, 40–57, https://doi.org/10.1163/18786561-00601003.

——, and E. Northrop, 2018: Towards an Effective Mechanism to Facilitate Implementation and Promote Compliance under the Paris Agreement. *Clim. Law*, **8**, 39 References-www.wri.org/our-work/project/proj, https://doi.org/10.1163/18786561-00801002.

——, and Coauthors, 2017: *COP21: Results and Implications for Pathways and Policies for Low Emissions European Societies*. 129 pp.

OECD, 2009: Declaration on Green Growth Adopted at the Meeting of the Council at Ministerial Level on 25 June 2009.

——, 2011: *Towards Green Growth*. OECD,.

——, 2012a: *Meeting global challenges through better governance: international co-operation in science, technology and innovation*.

——, 2012b: *What could the environment look like in 2050?* https://www.oecd.org/env/indicators-modelling-outlooks/49846090.pdf (Accessed October 24, 2019).

——, 2019: Climate Change: OECD DAC External Development Finance Statistics - OECD. http://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm (Accessed December 11, 2019).

Oh, C., 2019: Political Economy of International Policy on the Transfer of Environmentally Sound Technologies in Global Climate Change Regime. *New Polit. Econ.*, **24**, 22–36, https://doi.org/10.1080/13563467.2017.1417361.

Öko-Institut, 2016: How additional is the Clean Development Mechanism? Analysis of the application of current tools and proposed alternatives.

Olmer, N., B. Comer, B. Roy, X. Mao, and D. Rutherford, 2017: *Greenhouse Gas Emissions from Global Shipping, 2013–2015*.

Olmstead, S. M., and R. N. Stavins, 2012: Three Key Elements of a Post-2012 International Climate Policy Architecture. *Rev. Environ. Econ. Policy*, **6**, 65–85, https://doi.org/10.1093/reep/rer018.

Olsen, K. H., C. Arens, and F. Mersmann, 2018: Learning from CDM SD tool experience for

Article 6.4 of the Paris Agreement. *Clim. Policy*, **18**, 383–395, https://doi.org/10.1080/14693062.2016.1277686.

Orr, B. J., and Coauthors, 2017: *Scientific Conceptual Framework for Land Degradation Neutrality*.

Osofsky, H., J. Peel, B. McDonnell, and A. Foerster, 2019: Energy re-investment. *Indiana Law J.*, **94**.

Osofsky, H. M., 2010: The continuing importance of climate change litigation. *Clim. Law*, **1**, 3–29.

Ostrom, E., 2010: Polycentric systems for coping with collective action and global environmental change. *Glob. Environ. Chang.*, **20**, 550–557, https://doi.org/10.1016/j.gloenvcha.2010.07.004.

Pacual, et al, 2019: An evaluation Model for public private partnerships contributing to sustainable development. *Sustainability*, **11**, https://doi.org/10.339/su11082339.

Panfil, S. N., and C. A. Harvey, 2016: REDD+ and Biodiversity Conservation: A Review of the Biodiversity Goals, Monitoring Methods, and Impacts of 80 REDD+ Projects. *Conserv. Lett.*, **9**, 143–150, https://doi.org/10.1111/conl.12188.

Park, M. S., E. S. Choi, and Y.-C. Youn, 2013: REDD+ as an international cooperation strategy under the global climate change regime. *Forest Sci. Technol.*, **9**, 213–224, https://doi.org/10.1080/21580103.2013.846875.

Parson, E. A., 2003: *Protecting the Ozone Layer: Science and Strategy*. Oxford University Press,.

——, 2014: Climate Engineering in Global Climate Governance: Implications for Participation and Linkage. *Transnatl. Environ. Law*, **3**, 89–110, https://doi.org/10.1017/S2047102513000496.

——, and L. N. Ernst, 2013: International Governance of Climate Engineering. *Theor. Inq. Law*, **14**, 307–338, https://doi.org/10.1515/til-2013-015.

Pasztor, J., 2017: The need for governance of climate geoengineering. *Ethics Int. Aff.*, **31**, 419–430, https://doi.org/10.1017/S0892679417000405.

Patt, A., 2015: *Transforming energy: solving climate change with technology policy*. Cambridge University Press,.

——, 2017: Beyond the tragedy of the commons: Reframing effective climate change governance. *Energy Res. Soc. Sci.*, **34**, 1–3, https://doi.org/10.1016/j.erss.2017.05.023.

——, and J. Lilliestam, 2018: The Case against Carbon Prices. *Joule*, **2**, 2494–2498, https://doi.org/10.1016/J.JOULE.2018.11.018.

Pauw, W. P., R. J. T. Klein, K. Mbeva, A. Dzebo, D. Cassanmagnago, and A. Rudloff, 2018: Beyond headline mitigation numbers: we need more transparent and comparable NDCs to achieve the Paris Agreement on climate change. *Clim. Change*, **147**, 23–29, https://doi.org/10.1007/s10584-017-2122-x.

Peake, S., and P. Ekins, 2017: Exploring the financial and investment implications of the Paris Agreement. *Clim. Policy*, **17**, 832–852, https://doi.org/10.1080/14693062.2016.1258633.

Pearse, R., 2017: Gender and climate change. *Wiley Interdiscip. Rev. Clim. Chang.*, **8**, https://doi.org/10.1002/wcc.451.

Peel, J., and J. Lin, 2019: Transnational Climate Litigation: The Contribution of the Global South. *Am. J. Int. Law*, **113**, 679–726, https://doi.org/10.1017/ajil.2019.48.

Peimbert, N., 2019: About Initiative 20X20. *Initiat. 20X20*,.

Peng, J., and Coauthors, 2016: Markedly enhanced absorption and direct radiative forcing of black carbon under polluted urban environments. *Proc. Natl. Acad. Sci. U. S. A.*, **113**, 4266–4271, https://doi.org/10.1073/pnas.1602310113.

Peters, G. P., R. M. Andrew, J. G. Canadell, S. Fuss, R. B. Jackson, J. I. Korsbakken, C. Le Quéré, and N. Nakicenovic, 2017: Key indicators to track current progress and future ambition of the Paris Agreement. *Nat. Clim. Chang.*, **7**, 118–122, https://doi.org/10.1038/nclimate3202.

Peterson, L., and J. Skovgaard, 2019: Bureaucratic politics and the allocation of climate finance. *World Dev.*, **117**, 72–97, https://doi.org/10.1016/J.WORLDDEV.2018.12.011.

Phelps, J., E. L. Webb, and W. M. Adams, 2012: Biodiversity co-benefits of policies to reduce forest-carbon emissions. *Nat. Clim. Chang.*, **2**, 497–503, https://doi.org/10.1038/nclimate1462.

Pickering, J., F. Jotzo, and P. J. Wood, 2015: Sharing the Global Climate Finance Effort Fairly with Limited Coordination. *Glob. Environ. Polit.*, **15**, 39–62, https://doi.org/10.1162/GLEP_a_00325.

——, J. S. McGee, T. Stephens, and S. I. Karlsson-Vinkhuyzen, 2018: The impact of the US retreat from the Paris Agreement: Kyoto revisited? *Clim. Policy*, **18**, 818–827, https://doi.org/10.1080/14693062.2017.1412934.

——, J. S. McGee, S. I. Karlsson-Vinkhuyzen, and J. Wenta, 2019: Global climate governance between hard and soft law: Can the Paris agreement's "Crème Brûleé" approach enhance ecological reflexivity? *J. Environ. Law*, https://doi.org/10.1093/jel/eqy018.

Pirard, R., S. Wunder, A. E. Duchelle, J. Puri, S. Asfaw, M. Bulusu, H. Petit, and M. Vedoveto, 2019: Effectiveness of forest conservation interventions: An evidence gap map. *IEU Learn. Pap. no. 02*, 57.

Pitari, G., and Coauthors, 2014: Stratospheric ozone response to sulfate geoengineering: Results from the Geoengineering Model Intercomparison Project (GeoMIP). *J. Geophys. Res. Atmos.*, **119**, 2629–2653, https://doi.org/10.1002/2013JD020566.

Pitt, D., 2010: The impact of internal and external characteristics on the adoption of climate mitigation policies by US municipalities. *Environ. Plann. C. Gov. Policy*, **28**, 851–871.

Potoski, M., 2017: Green clubs in building block climate change regimes. *Clim. Change*, **144**, 53–63, https://doi.org/10.1007/s10584-015-1517-9.

Prizzon, A., and L. Engen, 2018: *A guide to multilateral development banks*.

Quelin, B.V, Kivleniece, i., Larazzaini, S., 2017: Public-Private Collaboration, Hybridity and Social Value. *J. Manag. Stud.*, 763–792.

Rajamani, L., 2010: The making and unmaking of the Copenhagen accord. *Int. Comp. Law Q.*, **59**, 824–843, https://doi.org/10.1017/S0020589310000400.

——, 2015: The Devilish Details: Key Legal Issues in the 2015 Climate Negotiations. *Mod. Law Rev.*, https://doi.org/10.1111/1468-2230.12145.

——, 2016a: The 2015 Paris Agreement: Interplay between hard, soft and non-obligations. *J.*

Environ. Law, **28**, 337–358, https://doi.org/10.1093/jel/eqw015.

——, 2016b: Ambition and Differentiation in the Paris Agreement: Interpretative Possibilities and Underlying Politics. *Int. Comp. Law Q.*, **65**, 493–514, https://doi.org/10.1017/s0020589316000130.

——, 2018: Human Rights in the Climate Change Regime: From Rio to Paris and Beyond. *Hum. Right to a Heal. Environ.*, **2015**, 236–251.

——, 2019: Integrating Human Rights in the Paris Climate Architecture: Contest, Context, and Consequence. *Clim. Law*, **9**, 180–201.

——, and E. Guérin, 2017: Part I Introductory Chapters, 4 Central Concepts in the Paris Agreement and How They Evolved. *Paris Agreem. Clim. Chang. Anal. Comment.*,.

——, and J. Werksman, 2018: The legal character and operational relevance of the Paris Agreement's temperature goal. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, **376**, https://doi.org/10.1098/rsta.2016.0458.

——, and D. Bodansky, 2019: The Paris Rulebook: Balancing Prescriptiveness with National Discretion. *Int. Comp. Law Q.*, **68**, 1023–1040, https://doi.org/10.1017/S0020589319000320.

Rampa, F., S. Bilal, and E. Sidiropoulos, 2012: Leveraging South–South cooperation for Africa's development. *South African J. Int. Aff.*, **19**, 247–269, https://doi.org/10.1080/10220461.2012.709400.

Rashidi, K., and A. Patt, 2018: Subsistence over symbolism: the role of transnational municipal networks on cities' climate policy innovation and adoption. *Mitig. Adapt. Strateg. Glob. Chang.*, **23**, 507–523, https://doi.org/10.1007/s11027-017-9747-y.

——, M. Stadelmann, and A. Patt, 2017: Valuing co-benefits to make low-carbon investments in cities bankable: The case of waste and transportation projects. *Sustain. Cities Soc.*, **34**, 69–78, https://doi.org/10.1016/J.SCS.2017.06.003.

——, ——, and ——, 2019: Creditworthiness and climate: Identifying a hidden financial co-benefit of municipal climate adaptation and mitigation policies. *Energy Res. Soc. Sci.*, **48**, 131–138, https://doi.org/10.1016/J.ERSS.2018.09.021.

Rayner, S., C. Heyward, T. Kruger, N. Pidgeon, C. Redgwell, and J. Savulescu, 2013: The Oxford Principles. *Clim. Change*, **121**, 499–512, https://doi.org/10.1007/s10584-012-0675-2.

RE100, 2019: RE100 Overview. http://there100.org/re100 (Accessed December 18, 2019).

REN21, 2019: No TitleREN21: Renewables Now! https://www.ren21.net/about-us/who-we-are/ (Accessed December 18, 2019).

Reynolds, J. L., 2019: *The governance of solar geoengineering : managing climate change in the Anthropocene*. 268 pp.

Riahi, K., and Coauthors, 2017: The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. *Glob. Environ. Chang.*, **42**, 153–168, https://doi.org/10.1016/J.GLOENVCHA.2016.05.009.

Richards, M. B., E. Wollenberg, and D. van Vuuren, 2018: National contributions to climate change mitigation from agriculture: allocating a global target. *Clim. Policy*, **18**, 1271–1285, https://doi.org/10.1080/14693062.2018.1430018.

Ripley, K., and C. Verkuijl, 2016: "Ozone Family" Delivers Landmark Deal for the Climate.

Environ. Policy Law, **46**, 371–376.

Ritchie, H., and D. S. Reay, 2017: Delivering the two degree global climate change target using a flexible ratchet framework. *Clim. Policy*, **17**, 1031–1045, https://doi.org/10.1080/14693062.2016.1222260.

Roberts, J. T., and R. Weikmans, 2017: Postface: fragmentation, failing trust and enduring tensions over what counts as climate finance. *Int. Environ. Agreements Polit. Law Econ.*, **17**, 129–137, https://doi.org/10.1007/s10784-016-9347-4.

Roberts, J. T., S. Natson, V. Hoffmeister, A. Durand, R. Weikmans, J. Gewirtzman, and S. Huq, 2017: How Will We Pay for Loss and Damage? *ETHICS POLICY Environ.*, **20**, 208-226 Funding details-Belgian Fund for Scient, https://doi.org/10.1080/21550085.2017.1342963

Roberts, M. W., 2017: Finishing the job: The Montreal Protocol moves to phase down hydrofluorocarbons. *Rev. Eur. Comp. Int. Environ. Law*, **26**, 220–230, https://doi.org/10.1111/reel.12225.

Robiou du Pont, Y., M. L. Jeffery, J. Gütschow, J. Rogelj, P. Christoff, and M. Meinshausen, 2017: Equitable mitigation to achieve the Paris Agreement goals. *Nat. Clim. Chang.*, **7**, 38–43, https://doi.org/10.1038/nclimate3186.

Rogelj, J., and Coauthors, 2010: Analysis of the Copenhagen Accord pledges and its global climatic impacts—a snapshot of dissonant ambitions. *Environ. Res. Lett.*, **5**, 034013, https://doi.org/10.1088/1748-9326/5/3/034013.

——, G. Luderer, R. C. Pietzcker, E. Kriegler, M. Schaeffer, V. Krey, and K. Riahi, 2015: Energy system transformations for limiting end-of-century warming to below 1.5 °C. *Nat. Clim. Chang.*, **5**, 519–527.

——, and Coauthors, 2016: Paris Agreement climate proposals need a boost to keep warming well below 2 °c. *Nature*, **534**, 631–639, https://doi.org/10.1038/nature18307.

Rogelj, J., and Coauthors, 2018: Mitigation pathways compatible with 1.5°C in the context of sustainable development. *Global Warming of 1.5 °C an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change*.

Royal Society, 2009: *Geoengineering the climate: Science, governance and uncertainty*. 84 pp.

Sabel, C. F., and D. G. Victor, 2017: Governing global problems under uncertainty: making bottom-up climate policy work. *Clim. Change*, **144**, 15–27, https://doi.org/10.1007/s10584-015-1507-y.

Sands, P. Q. C., 2016: Climate change and the rule of law: Adjudicating the future in international law. *J. Environ. Law*, **28**, 19–35, https://doi.org/10.1093/jel/eqw005.

——, and J. Peel, 2018: *Principles of International Environmental Law*. 4th ed. Cambridge University Press,.

Sauer, N., 2019: EU committee shelves climate concerns to open US trade talks. *Climate Home News*.

Savaresi, A., 2018: Climate change and human rights: Fragmentation, interplay, and institutional linkages. *Routledge Handbook of Human Rights and Climate Governance*.

Scheinman, L., 1987: *The International Atomic Energy Agrncy and the World Nuclear Order*. Resources for the Future,.

Schleussner, C. F., and Coauthors, 2016: Science and policy characteristics of the Paris Agreement temperature goal. *Nat. Clim. Chang.*, **6**, 827–835, https://doi.org/10.1038/nclimate3096.

Schlosberg, D., and L. B. Collins, 2014: From environmental to climate justice: Climate change and the discourse of environmental justice. *Wiley Interdiscip. Rev. Clim. Chang.*, **5**, 359–374, https://doi.org/10.1002/wcc.275.

Schmale, J., D. Shindell, E. Von Schneidemesser, I. Chabay, and M. Lawrence, 2014: Air pollution: Clean up our skies. *Nature*, **515**, 335–337, https://doi.org/10.1038/515335a.

Schmieg, G., and Coauthors, 2017: Modeling normativity in sustainability: a comparison of the sustainable development goals, the Paris agreement, and the papal encyclical. *Sustain. Sci.*, **13**, https://doi.org/10.1007/s11625-017-0504-7.

Schneider, L., and S. La Hoz Theuer, 2019: Environmental integrity of international carbon market mechanisms under the Paris Agreement. *Clim. Policy*, **19**, 386–400, https://doi.org/10.1080/14693062.2018.1521332.

——, and Coauthors, 2019: Double counting and the Paris Agreement rulebook. *Science (80-.).*, **366**, 180–183, https://doi.org/10.1126/science.aay8750.

Schwerhoff, G., 2016: The economics of leadership in climate change mitigation. *Clim. Policy*, **16**, 196–214, https://doi.org/10.1080/14693062.2014.992297.

Selin, H., 2014: Global Environmental Law and Treaty-Making on Hazardous Substances: The Minamata Convention and Mercury Abatement. *Glob. Environ. Polit.*, **14**, 1–19, https://doi.org/10.1162/GLEP_a_00208.

Sheriff, G., 2019: Burden Sharing under the Paris Climate Agreement. *J. Assoc. Environ. Resour. Econ.*, **6**, 275–318, https://doi.org/10.1086/701469.

Shi, Y., and W. Gullett, 2018: International Regulation on Low-Carbon Shipping for Climate Change Mitigation: Development, Challenges, and Prospects. *Ocean Dev. Int. Law*, **49**, 134–156, https://doi.org/10.1080/00908320.2018.1442178.

Shimoda, Y., and S. Nakazawa, 2012: *Flexible Cooperation for Indonesia's Multi-dimensional Challenges for South-South Cooperation Under A Shared Vision*. 149–172 pp.

Shishlov, I., R. Morel, and V. Bellassen, 2016: Compliance of the Parties to the Kyoto Protocol in the first commitment period. *Clim. Policy*, **16**, 768–782, https://doi.org/10.1080/14693062.2016.1164658.

Sindico, F., 2016: Paris, Climate Change, and Sustainable Development. *Clim. Law*, **6**, 130–141.

Skea, J., R. Van Diemen, M. Hannon, E. Gazis, and A. Rhodes, 2019: *Energy innovation for the twenty-first century: Accelerating the energy revolution*. Edward Elgar Publishing,.

Skjærseth, J. B., O. S. Stokke, and J. Wettestad, 2006: Soft law, hard law, and effective implementation of international environmental norms. *Glob. Environ. Polit.*, **6**, 104–120, https://doi.org/10.1162/glep.2006.6.3.104.

Smit, B., and J. Wandel, 2006: Adaptation, adaptive capacity and vulnerability. *Glob. Environ. Chang.*, **16**, 282–292, https://doi.org/10.1016/j.gloenvcha.2006.03.008.

Smita, Nakhooda, et al, 2014: *Climate Finance - Is it making a difference: A review of the effectiveness of multilateral climate funds*.

Smith, J. J., and M. T. Ahmad, 2018: Globalization's Vehicle: The Evolution and Future of Emission Regulation in the icao and imo in Comparative Assessment. *Clim. Law*, **8**, 70–103, https://doi.org/https://doi.org/10.1163/18786561-00801003.

Sovacool, B. K., and B.-O. Linnér, 2016: The Perils of Climate Diplomacy: The Political Economy of the UNFCCC. *The Political Economy of Climate Change Adaptation*, Palgrave Macmillan UK, 110–135.

Spalding-Fecher, R., Achanta, A. N., Erickson, P., Haites, E., Lazarus, M., Pahuja, N., … Tewari, R., 2012: *Suppressed demand in the clean development mechanism: Conceptual and practical issues*.

Spash, C. L., 2016: This Changes Nothing: The Paris Agreement to Ignore Reality. *Globalizations*, **13**, 928–933, https://doi.org/10.1080/14747731.2016.1161119.

Sprinz, D. F., H. Sælen, A. Underdal, and J. Hovi, 2018: The Effectiveness of Climate Clubs under Donald Trump. *Clim. Policy*, **18**, 828–838, https://doi.org/https://doi.org/10.1080/14693062.2017.1410090.

Stavins, R., and Coauthors, 2014: International Cooperation: Agreements and Instruments. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment of the Intergovernmental Panel on Climate Change*, O.R. Edenhofer et al., Eds., Cambridge University Press, 1001–1082.

Steele, P., 2015: *Development finance and climate finance: Achieving zero poverty and zero emissions*. IIED, 1–31 pp. https://pubs.iied.org/pdfs/16587IIED.pdf.

Stephenson, S. R., N. Oculi, A. Bauer, and S. Carhuayano, 2019: Convergence and Divergence of UNFCCC Nationally Determined Contributions. *Ann. Am. Assoc. Geogr.*, **109**, 1240–1261, https://doi.org/10.1080/24694452.2018.1536533.

Stewart, R. B., M. Oppenheimer, and B. Rudyk, 2017: Building blocks: a strategy for near-term action within the new global climate framework. *Clim. Change*, **144**, 1–13, https://doi.org/10.1007/s10584-017-1932-1.

Streck, C., F. Haupt, S. Roe, K. Behm, A. Kroeger, and I. Schulte, Climate Focus. 2016. Progress on the New York Declaration on Forests: Eliminating Deforestation from the Production of Agricultural Commodities–Goal 2. *forestdeclaration.org*,.

Suckall, N., L. C. Stringer, and E. L. Tompkins, 2015: Presenting Triple-Wins? Assessing Projects That Deliver Adaptation, Mitigation and Development Co-benefits in Rural Sub-Saharan Africa. *Ambio*, **44**, 34–41, https://doi.org/10.1007/s13280-014-0520-0.

Sugiyama, M., A. Ishii, S. Asayama, and T. Kosugi, 2018: *Solar Geoengineering Governance*. Oxford University Press,.

Tamiotti, L., R. Teh, V. Kulaçoğlu, A. Olhoff, B. Simmons, and H. Abaza, 2009: *Trade and Climate Change, A report by the United Nations Environment Programme and the World Trade Organization*. https://www.wto.org/english/res_e/booksp_e/trade_climate_change_e.pdf.

TCFD, 2017: *Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures*.

Thompson, R., 2017: Whither climate change post-Paris? *Anthr. Rev.*, **4**, 62–69, https://doi.org/10.1177/2053019616676607.

Thorgeirsson, H., 2017: Part II Analysis of the Provisions of the Agreement , A . General Overview. *The Paris Agreement on climate change: Analysis and commentary*.

Tormos-Aponte, F., and G. A. García-López, 2018: Polycentric struggles: The experience of the global climate justice movement. *Environ. Policy Gov.*, **28**, 284–294, https://doi.org/10.1002/eet.1815.

Tramel, S., 2016: The Road Through Paris: Climate Change, Carbon, and the Political Dynamics of Convergence. *Globalizations*, **13**, 960–969, https://doi.org/10.1080/14747731.2016.1173376.

Trisos, C. H., G. Amatulli, J. Gurevitch, A. Robock, L. Xia, and B. Zambri, 2018: Potentially dangerous consequences for biodiversity of solar geoengineering implementation and termination. *Nat. Ecol. Evol.*, **2**, 475–482, https://doi.org/10.1038/s41559-017-0431-0.

Trouwborst, A., Trouwborst, and Arie, 2012: Transboundary Wildlife Conservation in A Changing Climate: Adaptation of the Bonn Convention on Migratory Species and Its Daughter Instruments to Climate Change. *Diversity*, **4**, 258–300, https://doi.org/10.3390/d4030258.

Turnhout, E., A. Gupta, J. Weatherley-Singh, M. J. Vijge, J. de Koning, I. J. Visseren-Hamakers, M. Herold, and M. Lederer, 2017: Envisioning REDD+ in a post-Paris era: between evolving expectations and current practice. *Wiley Interdiscip. Rev. Clim. Chang.*, **8**, e425, https://doi.org/10.1002/wcc.425.

TWI2050, 2018: *Transformations to achieve the Sustainable Development Goals. Report prepared by the World in 2050 initiative.*

UN, 2016: *Montreal Protocol, Kigali Amendment*.

——, 2017: *Catalyzing the Implementation of Nationally Determined Contributions in the Context of the 2030 Agenda through South-South Cooperation*. 68 pp. http://www.indiaenvironmentportal.org.in/files/file/ssc_ndc_report.pdf.

——, 2018: *South-South and Triangular Cooperation on Climate Technologies*. 76 pp. http://www.iai.int/admin/site/sites/default/files/2018 SouthSouth and Triangular Climate Tech.pdf.

UN Environment Programme, 2018: *Emissions Gap Report 2018*. https://www.unenvironment.org/resources/emissions-gap-report-2018.

——, 2019: *Emissions Gap Report 2019*. 108 pp.

UNCBD, 2010: *Strategic Plan for Biodiversity2011-2020 and the Aichi Targets: "Living in Harmony with Nature"*. https://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf.

UNCTAD, 2012: *State of South-South and Triangular Cooperation in the Production, Use and Trade of Sustainable Biofuels*. United Nations, https://unctad.org/en/PublicationsLibrary/ditcted2011d10_en.pdf.

——, 2015: *Trade and Climate Change Policy Beyond 2015*. 4 pp. http://unctad.org/en/PublicationsLibrary/presspb2015d8_en.pdf.

UNDP, UNDP Global Policy Centers.

UNEP/CPR/142/4, 2018: Report by the Secretariat on UN Environment Programme's Private Sector Engagement. *142nd meeting of the Committee of Permanent Representatives to the United Nations Environment Programme*.

UNEP, 2013: *Global Mercury Assessment*.

UNFCCC, UNFCCC Topics on Climate Finance.

——, 1992: *United Nations Framework Convention on Climate Change*.

——, 1997: *Kyoto Protocol*.

——, 2012: Report of the Conference of the Parties on its seventeenth session, held in Durban from 28 November to 11 December 2011. *Conference of the Parties*, Durban, UNFCCC, 2.

——, 2014: Warsaw international mechanism for loss and damage associated with climate change impacts. *Report of the Conference of the Parties on its nineteenth session, held in Warsaw from 11 to 23 November 2013: Decisions adopted by the Conference of the Parties*, Warsaw, 6.

——, 2015: *Paris Agreement*.

——, 2016a: Decision 1/CP.21 Adoption of the Paris Agreement. *Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015*, FCCC/CP/2015/10/Add.1.

——, 2016b: *Aggregate effect of the intended nationally determined contributions: an update*.

——, 2019a: Dec. 4/CMA.1 Further guidance in relation to the mitigation section of decision 1/CP.21. *Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on the third part of its first session, held in Katowice from 2 to 15 December 2018. Addendum 1. Part two: Action taken by the Conference of the Parties s*, 6.

——, 2019b: Decisions adopted by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement ('Paris Rulebook'). *Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on the third part of its first session, held in Katowice from 2 to 15 December 2018*, FCCC/PA/CMA/2018/3/Add.1.

——, 2019c: Dec. 18/CMA.1 Modalities, procedures and guidelines for the transparency framework for action and support referred to in Article 13 of the Paris Agreement. *Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on the third part of its first session, held in Katowice from 2 to 15 December 2018*, FCCC/PA/CMA/2018/3/Add.2.

——, 2019d: Dec. 19/CMA.1 Matters relating to Article 14 of the Paris Agreement and paragraphs 99–101 of decision 1/CP.21. *Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on the third part of its first session, held in Katowice from 2 to 15 December 2018*, FCCC/PA/CMA/2018/3/Add.2.

——, 2019e: Dec. 13/CMA.1 Matters relating to the Adaptation Fund. *Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on the third part of its first session, held in Katowice from 2 to 15 December 2018*, 2.

——, 2019f: Dec. 14/CMA.1 Setting a new collective quantified goal on finance in accordance with decision 1/CP.21, paragraph 53. *Report of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement on the third part of its first session, held in Katowice from 2 to 15 December 2018*, 3.

——, 2019g: Dec. 4/CP.24 Report of the Standing Committee on Finance. *Report of the*

Conference of the Parties on its twenty-fourth session, held in Katowice from 2 to 15 December 2018 Addendum Part two: Action taken by the Conference of the Parties at its twentyfourth session, 14.

——, 2019h: *Implementation of the framework for capacity-building in developing countries. Synthesis report by the secretariat*. 22 pp.

——, 2019i: Bilateral and Multilateral Funding | UNFCCC. https://unfccc.int/topics/climate-finance/resources/multilateral-and-bilateral-funding-sources (Accessed December 11, 2019).

UNGA, 1948: *The Universal Declaration of Human Rights*.

——, 1966a: *International Covenant on Civil and Political Rights*.

——, 1966b: *international Covenant on Economic, Social and Cultural Rights*.

UNOSC, 2017: United Nations Action Plan on South-South Climate Cooperation (2017-2021).

UNOSSC, South-South and Triangular Cooperation.

Urban, F., 2018: China's rise: Challenging the North-South technology transfer paradigm for climate change mitigation and low carbon energy. *Energy Policy*, **113**, 320–330, https://doi.org/10.1016/j.enpol.2017.11.007.

——, G. Siciliano, K. Sour, P. D. Lonn, M. Tan-Mullins, and G. Mang, 2015a: South-South Technology Transfer of Low-Carbon Innovation: Large Chinese Hydropower Dams in Cambodia. *Sustain. Dev.*, **23**, 232–244, https://doi.org/10.1002/sd.1590.

——, Y. Zhou, J. Nordensvard, and A. Narain, 2015b: Firm-level technology transfer and technology cooperation for wind energy between Europe, China and India: From North–South to South–North cooperation? *Energy Sustain. Dev.*, **28**, 29–40, https://doi.org/10.1016/j.esd.2015.06.004.

Urpelainen, J., 2011: Can Unilateral Leadership Promote International Environmental Cooperation? *Int. Interact.*, **37**, 320–339, https://doi.org/10.1080/03050629.2011.596018.

——, and T. Van de Graaf, 2015: The International Renewable Energy Agency: a success story in institutional innovation? *Int. Environ. Agreements Polit. Law Econ.*, **15**, 159–177, https://doi.org/10.1007/s10784-013-9226-1.

——, and ——, 2018: United States non-cooperation and the Paris agreement. *Clim. Policy*, **18**, 839–851, https://doi.org/10.1080/14693062.2017.1406843.

Velders, G. J. M., S. O. Andersen, J. S. Daniel, D. W. Fahey, and M. McFarland, 2007: The importance of the Montreal Protocol in protecting climate. *Proc. Natl. Acad. Sci. U. S. A.*, **104**, 4814–4819, https://doi.org/10.1073/pnas.0610328104.

——, D. W. Fahey, J. S. Daniel, S. O. Andersen, and M. McFarland, 2015: Future atmospheric abundances and climate forcings from scenarios of global and regional hydrofluorocarbon (HFC) emissions. *Atmos. Environ.*, **123**, 200–209, https://doi.org/10.1016/J.ATMOSENV.2015.10.071.

Victor, D., 2011: *Global Warming Gridlock*. Cambridge University Press, 392 pp.

Victor, D. G., 2016: What the Framework Convention on Climate Change Teaches Us About Cooperation on Climate Change. *Polit. Gov.*, **4**, 133, https://doi.org/10.17645/pag.v4i3.657.

——, K. Raustiala, and E. B. Skolnikoff, 1998: *The Implementation and Effectiveness of International Environmental Commitments: Theory and Practice*. D.G. Victor, K. Raustiala, and E.B. Skolnikoff, Eds. MIT Press,.

Visioni, D., G. Pitari, and V. Aquila, 2017: Sulfate geoengineering: a review of the factors controlling the needed injection of sulfur dioxide. *Atmos. Chem. Phys.*, **17**, 3879–3889, https://doi.org/10.5194/acp-17-3879-2017.

Voigt, C., 2016: The compliance and implementation mechanism of the Paris agreement. *Rev. Eur. Comp. Int. Environ. Law*, **25**, 161–173, https://doi.org/10.1111/reel.12155.

——, and F. Ferreira, 2015: The Warsaw Framework for REDD+: Implications for National Implementation and Access to Results-Based Finance. *Carbon Clim. Law Rev.*, **2**, 113.

——, and ——, 2016a: 'Dynamic Differentiation': The Principles of CBDR-RC, Progression and Highest Possible Ambition in the Paris Agreement. *Transnatl. Environ. Law*, **5**, 285–303, https://doi.org/10.1017/s2047102516000212.

——, and ——, 2016b: Differentiation in the Paris Agreement. *Clim. Law*, **6**, 58–74, https://doi.org/10.1163/18786561-00601004.

van Vuuren, D. P., J. A. Edmonds, M. Kainuma, K. Riahi, and J. Weyant, 2011: A special issue on the RCPs. *Clim. Change*, **109**, 1–4, https://doi.org/10.1007/s10584-011-0157-y.

Waage, J., and Coauthors, 2015: Governing Sustainable Development Goals: interactions, infrastructures, and institutions. *Thinking Beyond Sectors for Sustainable Development*, Ubiquity Press, 79–88.

Wagner, C. S., T. A. Whetsell, and L. Leydesdorff, 2017: Growth of international collaboration in science: revisiting six specialties. *Scientometrics*, **110**, 1633–1652, https://doi.org/10.1007/s11192-016-2230-9.

Watkiss, P., M. Benzie, and R. J. T. Klein, 2015: The complementarity and comparability of climate change adaptation and mitigation. *Wiley Interdiscip. Rev. Clim. Chang.*, **6**, 541–557, https://doi.org/10.1002/wcc.368.

WBCSD, 2019: About us. https://www.wbcsd.org/Overview/About-us%0D (Accessed December 12, 2019).

WCED, 1987: *Our Common Future*. Oxford University Press,.

Weart, S. R., 2012: The evolution of international cooperation in climate science. *J. Int. Organ. Stud.*, **3**, 41–59.

Weikmans, R., and J. T. Roberts, 2019: The international climate finance accounting muddle: is there hope on the horizon? *Clim. Dev.*, **11**, 97–111, https://doi.org/10.1080/17565529.2017.1410087.

——, H. van Asselt, and J. T. Roberts, 2019: Transparency requirements under the Paris Agreement and their (un)likely impact on strengthening the ambition of nationally determined contributions (NDCs). *Clim. Policy*, **0**, 1–16, https://doi.org/10.1080/14693062.2019.1695571.

Weiss, E. B., and H. K. Jacobson, 1998: *Engaging Countries: Strengthening Compliance with International Environmental Accords*. MIT Press,.

Werksman, J., 2010: Legal symmetry and legal differentiation under a future deal on climate. *Clim. Policy*, **10**, 672–677, https://doi.org/10.3763/cpol.2010.0150.

Wettestad, J. and Gulbrandsen, L. H., 2018: *The Evolution of Carbon Markets: Design and*

Diffusion. Routledge,.

Wilder, M., C. A. Scott, N. P. Pablos, R. G. Varady, G. M. Garfin, and J. McEvoy, 2010: Adapting Across Boundaries: Climate Change, Social Learning, and Resilience in the U.S.–Mexico Border Region. *Ann. Assoc. Am. Geogr.*, **100**, 917–928, https://doi.org/10.1080/00045608.2010.500235.

Winkler, Harald and Dubash, N. K., 2016: Who determines transformational change in development and climate finance? *Clim. Policy*, **16**, 783–791.

Winkler, H., 2019: Putting equity into practice in the global stocktake under the Paris Agreement. *Clim. Policy*, **0**, 1–9, https://doi.org/10.1080/14693062.2019.1680337.

——, B. Mantlana, and T. Letete, 2017: Transparency of action and support in the Paris Agreement. *Clim. Policy*, **17**, 853–872, https://doi.org/10.1080/14693062.2017.1302918.

——, N. Höhne, G. Cunliffe, T. Kuramochi, A. April, and M. J. de Villafranca Casas, 2018: Countries start to explain how their climate contributions are fair: More rigour needed. *Int. Environ. Agreements Polit. Law Econ.*, https://doi.org/10.1007/s10784-017-9381-x.

Wolf, S., C. Jaeger, J. Mielke, F. Schuetze, and R. Rosen, 2019: Framing 1.5°C - Turning an Investment Challenge into a Green Growth Opportunity. *SSRN Electron. J.*, https://doi.org/10.2139/ssrn.3324509.

Wollenberg, E., and Coauthors, 2016: Reducing emissions from agriculture to meet the 2 °C target. *Glob. Chang. Biol.*, **22**, 3859–3864, https://doi.org/10.1111/gcb.13340.

World Bank, 2010: Cities and Climate Change: An Urgent Agenda. *World Bank Gr.*,.

——, 2018: *Carbon Markets for Greenhouse Gas Emission Reduction in a Warming World*.

——, 2019: *State and Trends of Carbon Pricing*. http://documents.worldbank.org/curated/en/191801559846379845/State-and-Trends-of-Carbon-Pricing-2019.

Xu, Y., Z. Dong, and Y. Wang, 2016: Establishing a measurement, reporting, and verification system for climate finance in post-Paris agreement period. *Chinese J. Popul. Resour. Environ.*, **14**, 235–244, https://doi.org/10.1080/10042857.2016.1258802.

Xuemei, B., 2007: Integrating Global Environmental Concerns into Urban Management. *J. Ind. Ecol.*, **11**, 15–29.

Yamineva, Y., 2016: Climate Finance in the Paris Outcome: Why Do Today What You Can Put Off Till Tomorrow? *Rev. Eur. Comp. Int. Environ. Law*, **25**, 174–185, https://doi.org/10.1111/reel.12160.

——, and K. Kulovesi, 2018: Keeping the Arctic White: The Legal and Governance Landscape for Reducing Short-Lived Climate Pollutants in the Arctic Region. *Transnatl. Environ. Law*, **7**, 201–227, https://doi.org/10.1017/S2047102517000401.

Young, O. R., 2001: Inferences and Indices: Evaluating the Effectiveness of International Environmental Regimes. *Glob. Environ. Polit.*, **1**, 99–121.

——, 2003: Determining Regime Effectiveness: A Commentary on the Oslo-Potsdam Solution. *Glob. Environ. Polit.*, **3**, 97–104.

——, 2011: Effectiveness of International Environmental Regimes: Existing Knowledge, Cutting-Edge Themes, and Research Strategies. *Proc. Natl. Acad. Sci.*, **108**, 19853–19860, https://doi.org/10.1073/pnas.1111690108.

——, 2013: Sugaring Off: Enduring Insights From Long-Term Research on Environmental Governance. *Int. Environ. Agreements Polit. Law Econ.*, **13**, 87–105, https://doi.org/10.1007/s10784-012-9204-z.

Young, O. R., 2016: The Paris Agreement: Destined to Succeed or Doomed to Fail? *Polit. Gov.*, **4**, 124–132, https://doi.org/10.17645/pag.v4i3.635.

Zahar, A., 2019: Collective Progress in the Light of Equity Under the Global Stocktake. *Clim. Law*, **9**, 101–121, https://doi.org/10.1163/18786561-00901006.

Zhang, H., 2016: Towards global green shipping: the development of international regulations on reduction of GHG emissions from ships. *Int. Environ. Agreements Polit. Law Econ.*, **16**, 561–577.

Zhang, H., 2019: Implementing Provisions on Climate Finance Under the Paris Agreement. *Clim. Law*, **9**, 21–39.

Zhang, W., and X. Pan, 2016: Study on the demand of climate finance for developing countries based on submitted INDC. *Adv. Clim. Chang. Res.*, **7**, 99–104, https://doi.org/10.1016/J.ACCRE.2016.05.002.

Zia, A., and S. Kauffman, 2018: The Limits of Predictability in Predefining Phase Spaces of Dynamic Social–Ecological Systems: "Command and Control" Versus "Complex Systems"-Based Policy Design Approaches to Conserve Tropical Forests. *J. Policy Complex Syst.*, **4**, https://doi.org/10.18278/jpcs.4.2.9.

Zihua, G., C. Voigt, and J. Werksman, 2019: Facilitating Implementation and Promoting Compliance With the Paris Agreement Under Article 15: Conceptual Challenges and Pragmatic Choices. *Clim. Law*, **9**, 65–100.

Zürn, M., and S. Schäfer, 2013: The Paradox of Climate Engineering. *Glob. Policy*, **4**, n/a-n/a, https://doi.org/10.1111/gpol.12004.

TARGET 15 - Technical Rationale extended (provided in document COP/10/INF/12/Rev.1).