WG III contribution to the Sixth Assessment Report

List of corrigenda to be implemented

The corrigenda listed below will be implemented in the Chapter during copy-editing.

CHAPTER 14

Document (Chapter, Annex, Supp. Material)	Page (Based on the final pdf FGD version)	Line	Detailed information on correction to make
Chapter 14	81	15	Another aspect is finance; Gallagher et al. (2018) examine the role of national development finance systems, focusing in particular on China. While there has been a great deal of finance devoted to renewable energy, they find the majority of finance devoted to projects associated either with fossil fuel extraction or with fossil fuel-fired power generation. Delete: "focusing in particular on China."
Chapter 14	81	18-19	Ascensão et al. (2018) similarly suggest that activities associated with the Belt and Road Initiative could play a role in slowing down mitigation efforts in developing countries. Delete sentence
Chapter 14	Front	5	Agus P. Sari

Chapter 14: International cooperation

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

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

Contributing Authors: Mustafa Babiker (Saudi Arabia), Govindasamy Bala (India), Christopher Bataille (Canada), Paolo Bertoldi (Italy), Felix Creutzig (Germany), Heleen de Coninck (the Netherlands), Navroz K. Dubash (India), Rachael Garett (Switzerland/the United States of America), Oliver Geden (Germany), Veronika Ginzburg (the Russian Federation), Michael Grubb (United Kingdom), Erik Haites (Canada), Ben Hinder (United Kingdom), Janna Hoppe (Switzerland), Yong-Gun Kim (Republic of Korea), Katharine J. Mach (the United States of America), Gregory Nemet (the United States of America), Kilian Raiser (Germany), Yamina Saheb (France), Sonia I. Seneviratne (Switzerland), Raphael Slade (United Kingdom), Masahiro Sugiyama (Japan), Christopher H. Trisos (Republic of South Africa), Maarten van Aalst (the Netherlands), Harro van Asselt (the Netherlands)

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

Chapter Scientist: Zyaad Boodoo (Mauritius)

Date of Draft: 1/11/2021

Table of Contents

Executive summary

International cooperation is having positive and measurable results (*high confidence*). The Kyoto Protocol led to measurable and substantial avoided emissions, including in 20 countries with Kyoto first commitment period targets that have experienced a decade of declining absolute emissions. It also built national capacity for GHG accounting, catalysed the creation of GHG markets, and increased investments in low-carbon technologies (medium confidence). Other international agreements and institutions have led to avoided CO_2 emissions from land-use practices, as well as avoided emissions of some non-CO_2 greenhouse gases (*medium confidence*). {14.3, 14.5, 14.6}

New forms of international cooperation have emerged since AR5 in line with an evolving understanding of effective mitigation policies, processes, and institutions. Both new and pre-existing forms of co-operation are vital for achieving climate mitigation goals in the context of sustainable development (*high confidence*). While previous IPCC assessments have noted important synergies between the outcomes of climate mitigation and achieving sustainable development objectives, there now appear to be synergies between the two processes themselves (*medium confidence*). Since AR5, international cooperation has shifted towards facilitating national level mitigation action through numerous channels. Now including both processes established under the UNFCCC regime and through regional and sectoral agreements and organisations. {14.2, 14.3, 14.5, 14.6}

Participation in international agreements and transboundary networks is associated with the adoption of climate policies at the national and sub-national levels, as well as by non-state actors (*high confidence*). International cooperation helps countries achieve long-term mitigation targets when it supports development and diffusion of low-carbon technologies, often at the level of individual sectors, which can simultaneously lead to significant benefits in the areas of sustainable development and equity (*medium confidence*). {14.2, 14.3, 14.5, 14.6}

International cooperation under the UN climate regime has taken an important new direction with the entry into force of the 2015 Paris Agreement, which strengthened the objective of the UN climate regime, including its long-term temperature goal, while adopting a different architecture to that of the Kyoto Protocol to achieve it (*high confidence*). The core national commitments under the Kyoto Protocol have been legally binding quantified emission targets for developed countries tied to well-defined mechanisms for monitoring and enforcement. By contrast, the commitments under the Paris Agreement are primarily procedural, extend to all parties, and are designed to trigger domestic policies and measures, enhance transparency, and stimulate climate investments, particularly in developing countries, and to lead iteratively to rising levels of ambition across all countries (*high confidence*). Issues of equity remain of central importance in the UN climate regime, notwithstanding shifts in the operationalisation of 'common but differentiated responsibilities and respective capabilities' from Kyoto to Paris (*high confidence*). {14.3}

There are conflicting views on whether the Paris Agreement's commitments and mechanisms will lead to the attainment of its stated goals. Arguments in support of the Paris Agreement are that the processes it initiates and supports will in multiple ways lead, and indeed have already led, to rising levels of ambition over time. The recent proliferation of national mid-century net-zero GHG targets can be attributed in part to the Paris Agreement (*medium confidence*). Moreover, its processes and commitments will enhance countries' abilities to achieve their stated level of ambition, particularly among developing countries (*medium confidence*). Arguments against the Paris Agreement are that it lacks a mechanism to review the adequacy of individual Parties' nationally determined contributions (NDCs), that collectively current NDCs are inconsistent in their level of ambition with achieving the Paris Agreement's temperature goal, that its processes will not lead to sufficiently rising levels of ambition in the NDCs, and that NDCs will not be achieved because the targets, policies and measures they contain are not legally binding at the international level (*medium confidence*). To some extent, arguments on both sides are aligned with different analytic frameworks, including assumptions about the main barriers to mitigation that international cooperation can help overcome (*medium confidence*). The extent to which countries increase the ambition of their NDCs and ensure they are effectively implemented will depend in part on the successful implementation of the support mechanisms in the Paris Agreement, and in turn will determine whether the goals of the Paris Agreement are met (*high confidence*). {14.2, 14.3, 14.4}

International cooperation outside the UNFCCC processes and agreements provides critical support for mitigation in particular regions, sectors and industries, for particular types of emissions, and at the sub- and trans-national levels (*high confidence*). Agreements addressing ozone depletion, transboundary air pollution, and release of mercury are all leading to reductions in the emissions of specific greenhouse gases (*high confidence*). Cooperation is occurring at multiple governance levels including cities. Transnational partnerships and alliances involving non-state and sub-national actors are also playing a growing role in stimulating low-carbon technology diffusion and emissions reductions (*medium confidence*). Such transnational efforts include those focused on climate litigation; the impacts of these are unclear but promising. Climate change is being addressed in a growing number of international agreements operating at sectoral levels, as well as within the practices of many multilateral organisations and institutions (*high confidence*). Sub-global and regional cooperation, often described as climate clubs, can play an important role in accelerating mitigation, including the potential for reducing mitigation costs through linking national carbon markets, although actual examples of these remain limited (*high confidence*). {14.2, 14.4, 14.5, 14.6}

International cooperation will need to be strengthened in several key respects in order to support mitigation action consistent with limiting temperature rise to well below 2°C in the context of sustainable development and equity *(high confidence)*. Many developing countries' NDCs have components or additional actions that are conditional on receiving assistance with respect to finance, technology development and transfer, and capacity building, greater than what has been provided to date (*high confidence*). Sectoral and sub-global cooperation is providing critical support, and yet there is room for further progress. In some cases, notably with respect to aviation and shipping, sectoral agreements have adopted climate mitigation goals that fall far short of what would be required to achieve the temperature goal of the Paris Agreement (*high confidence*). Moreover, there are cases where international cooperation may be hindering mitigation efforts, namely evidence that trade and investment agreements, as well as agreements within the energy sector, impede national mitigation efforts (*medium confidence*). International cooperation is emerging but so far fails to fully address transboundary issues associated with solar radiation modification and carbon dioxide removal (*high confidence*) {14.2, 14.3, 14.4, 14.5, 14.6}

14.1 Introduction

This chapter assesses the role and effectiveness of international cooperation in mitigating climate change. Such cooperation includes multilateral global cooperative agreements among nation states such as the 1992 United Nations Framework Convention on Climate Change (UNFCCC), and its related legal instruments, the 1997 Kyoto Protocol and the 2015 Paris Agreement, 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, this chapter assesses the role of transnational agreements and cooperative arrangements between non-state and sub-national actors, including municipal governments, private-sector firms and industry consortia, and civil society organisations. This chapter does not assess international cooperation within the European Union, as this is covered in Chapter 13 of this report.

Past IPCC assessment reports have discussed 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 include attention to climate clubs (groups of countries and potentially non-state actors that can work together to achieve particular objectives), and the effects of framing the global climate change mitigation challenge as one of accelerating a socio-technical transition or transformation, shifting development pathways accordingly, in addition to (or rather than) solving a global commons problem. This chapter draws from theory to identify a set of criteria by which to assess the effectiveness of existing forms of international cooperation.

The rest of this chapter describes existing cooperative international agreements, institutions, and initiatives with a view to clarifying how they operate, what effects they have, and ultimately, whether they work. At the heart of this international institutional architecture lies the Paris Agreement, which sets the overall approach for international cooperation under the UNFCCC at the global level. In many ways, the Paris Agreement reshapes the structure of such cooperation, from one oriented primarily towards target setting, monitoring, and enforcement, to one that is oriented towards supporting and enabling nationally determined actions (including targets), monitoring as well as catalysing non-state and sub-national actions at multiple levels of governance. In addition to the Paris Agreement, many forms of cooperation 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 non-state actors. The chapter ends with an overall assessment of the effectiveness of current international cooperation and identifies areas that would benefit from improved and enhanced action.

14.1.1 Key findings from AR5

AR5 found that two characteristics of climate change make international cooperation essential: that it is a global commons problem that needs to be addressed in a coordinated fashion at the global scale; and that given the global diversity with respect to opportunities for and cost of mitigation, there are economic efficiencies associated with cooperative solutions (13.2.1.1). Consequently, AR5 found evidence to suggest that climate policies that are implemented across geographical regions would be more effective in terms of both their environmental consequences and their economic costs (13.13, 13.6, 14.4). AR5 also suggested that regional cooperation could offer opportunities beyond what countries may be able to achieve by themselves. These opportunities are due to geographic proximity, shared infrastructure and policy frameworks, trade, and cross-border investments, and examples included renewable energy pools across borders, networks of energy infrastructure and coordinated forestry policies (1.2, 6.6,15.2, 14.2). AR5 also suggested that policy linkages exist across regional, national, and sub-national scales (13.3.1, 13.5.1.3). For these reasons, AR5 suggested that although the UNFCCC remains the primary international forum for climate negotiations, many other institutions engaged at the global, regional, and local levels do and should play an active role (1.3.3.1,13.4.1.4,13.5). AR5 also noted that the inclusion of climate change issues across a variety of forums often creates institutional linkages between mitigation and adaptation (13.3,13.4.13.5). In addition to centralised cooperation and governance, with a primary focus on the UNFCCC and its associated institutions, AR5 noted the emergence of new transnational climate-related institutions of decentralised authority such as public-private sector partnerships, private sector governance initiatives, transnational NGO programs, and city-led initiatives (13.2,13.3.1,13.12). It noted that these have resulted in a multiplicity of cooperative efforts in the form of multilateral agreements, harmonised national policies and decentralised but coordinated national and regional policies (13.4.1, 13.3.2, 14.4). Finally, it suggested that international cooperation may also have a role in promoting active engagement of the private sector in technological innovation and cooperative efforts leading to technology transfer and the development of new technologies (13.3, 13.9, 13.12).

14.1.2 Developments since AR5

14.1.2.1 Negotiation of the Paris Agreement

The key development since AR5 has been the negotiation and adoption of the Paris Agreement, which, building on the UNFCCC, introduces a new approach to global climate governance. This new approach, as discussed below (Section 14.3.1.1), is driven by the need to engage developing countries in emissions reductions beyond those they had taken on voluntarily under the Cancun Agreements, 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 (Section 14.3.1.2).

14.1.2.2 2030 Agenda for Sustainable Development and the Sustainable Development Goals

It has long been clear that a failure to mitigate climate change would exacerbate existing poverty, accentuate vulnerability and worsen inequality (IPCC 2014), but there is an emerging attempt to harmonise mitigation actions with those oriented towards social and economic development. A key development since AR5 is the adoption in 2015 of the 2030 Agenda for Sustainable Development, which contains 17 Sustainable Development Goals (SDGs). This Agenda offers an aspirational narrative, coherent framework and actionable agenda 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 these dimensions of sustainable development are inter-dependent (Nilsson et al. 2016), and, as such it is difficult if not impossible to achieve economic and social gains while neglecting environmental concerns, including climate change (Le Blanc 2015). The SDGs are closely linked to the Paris Agreement, adopted a few weeks later. There is a growing body of literature that examines the interlinkages between SDGs, including SDG 13 (taking urgent action to combat climate change) and others, concluding that without a proper response to climate change, success in many of the other SDGs would be difficult if not impossible (Weitz et al. 2018; ICSU ISSC 2015; Le Blanc 2015; Nilsson et al. 2016). Likewise, failure to achieve the SDGs will have a detrimental effect on the ability to limit climate change to manageable levels. Initiatives such as The World in 2050 (TWI2050 2018), a large research initiative by a global consortium of research and policy institutions, work on the premise that pursuing climate action and sustainable development in an integrated and coherent way, based on a sound understanding of development pathways and dynamics, is the strongest approach to enable countries to achieve their objectives in both agreements.

14.1.2.3 IPCC Special Reports

Further key developments since AR5 include the release of three IPCC special reports. The first of these assessed the differential impacts of limiting climate change to 1.5°C global average warming compared to 2°C warming, indicated the emissions reductions necessary and enabling conditions to stay within this limit (IPCC 2018a). While the events that have unfolded since the report are not yet comprehensively documented in literature, arguably the report has led to a renewed perception of the urgency of climate mitigation (Wolf et al. 2019). In particular, the report appears to have crystalised media coverage in some parts of the world around a need to reduce emissions to net zero by 2050 (whether of GHGs or CO_2), rather than delaying such reductions until the latter half of the century, as had been previously understood and indicated in the Paris Agreement. Its release is hence one factor explaining the rise in transnational climate mobilisation efforts (Boykoff and Pearman 2019). It has also played a role, in addition to the Paris Agreement (Geden 2016a), in the numerous announcements, pledges and indications by governments, including by all G-7 countries, of their adoption of net zero GHG targets for 2050. The other two special reports focused on ocean and the cryosphere (IPCC 2019), and the potential of land-related responses to contribute to adaptation and mitigation (IPCC 2020). There has been no literature directly tying the publication of these latter two reports to changes in international cooperation. However, the 25th UNFCCC Conference of Parties in Madrid in 2019 convened a dialogue on ocean and climate change to consider how to strengthen mitigation and adaptation action in this context (UNFCCC 2019a, para 31).

14.2 Evaluating international cooperation

This section describes recent insights from social-science theory that can shed light on the need for and ideal structure of international cooperation. This section starts by describing developments in framing the underlying problem, move towards a body of theory describing the benefits of multilateral sub-global action, and ends with a theory-based articulation of criteria to assess the effectiveness of international cooperation.

14.2.1 Framing concepts for assessment of the Paris Agreement

Previous IPCC reports have framed international climate cooperation, and indeed climate mitigation more generally, primarily as addressing a global commons problem (Stavins et al. 2014). In this report, by contrast, multiple framings are considered. Chapter 1 introduces four analytic frameworks: aggregated economic approaches such as cost-benefit analysis, which maps onto the global commons framing; ethical approaches; analysis of transitions and transformations; and psychology and politics of changing course. Here, we highlight some of the findings that are of relevance to international cooperation.

When applied to the international context, the public good (or global commons) framing stresses that the incentives for mitigation at the global level are greater than they are for any single country, since the latter does not enjoy the benefits of its own mitigation efforts that accrue outside its own borders (Patt 2017; Stavins et al. 2014). This framing does not preclude countries engaging in mitigation, even ambitious mitigation, but it suggests that these countries' level of ambition and speed of abatement would be greater if they were part of a cooperative agreement.

Theoretical economists have shown that reaching such a global agreement is difficult, due to countries' incentives to freeride, namely benefit from other countries' abatement efforts while failing to abate themselves (Barrett 1994; Gollier and Tirole 2015). Numerical models that integrate game theoretic concepts, whether based on optimal control theory or on dynamic programming, consistently confirm this insight, at least in the absence of transfers (Germain et al. 2003; Lessmann et al. 2015; Chander 2017). Recent contributions suggest that regional or sectoral agreements, or agreements focused on a particular subset of GHGs, can be seen as building blocks towards a global approach (Asheim et al.

2006; Froyn and Hovi 2008; Sabel and Victor 2017; Stewart et al. 2017). In a dynamic context, this gradual approach through building blocks can alleviate the free-riding problem and ultimately lead to global cooperation (Caparrós and Péreau 2017). Much of this literature is subsumed under the concept of "climate clubs," described in the next section. Other developments based on dynamic game theory suggest that the free-riding problem can be mitigated if the treaties do not prescribe countries' levels of green investment and the duration of the agreement, as countries can credibly threaten potential free-riders with a short-term agreement where green investments will be insufficient due to the hold-up problem (Battaglini and Harstad 2016). Finally, thresholds and potential climate catastrophes have also been shown, theoretically and numerically, to reduce free-riding incentives, especially for countries that may become pivotal in failing to avoid the threshold (Barrett 2013; Emmerling et al. 2020).

In addition to mitigation in the form of emissions abatement, innovation in green technologies also has public good features, leading for the same reasons to less innovation than would be globally ideal (Jaffe et al. 2005). Here as well, theory suggests that there are benefits from cooperation on technology development at the regional or sectoral levels, but also that cooperation on technology, especially for breakthrough technologies, may prove to be easier than for abatement (El-Sayed and Rubio 2014; Rubio 2017). In a dynamic context, 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 (Acemoglu et al. 2012; Aghion et al. 2014), 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 1991). 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 subsidising clean energy research) (Acemoglu et al. 2012; Aghion et al. 2014). This result is exacerbated by the irreversibility of energy investments and the extremely long periods of operation of the typical energy investment (Caparrós et al. 2015; Baldwin et al. 2020).

While the public goods and global commons framing concentrates on free-riding incentives as the primary barrier to mitigation taking place at a pace that would be globally optimal, other factors arise across the four analytic frameworks. For example, within the political framework, Beiser-McGrath and Bernauer (2021) highlight that not just the incentive to free-ride, but also the knowledge that another major emitter is free-riding, could lessen a country's political incentive to mitigate. Aklin and Mildenberger (2020) present evidence to suggest that distributive conflict within countries, rather than free riding across countries, is the primary barrier to ambitious national level action. Another barrier could be a lack of understanding and experience with particular policy approaches; there is evidence that participation in cooperative agreements could facilitate information exchange across borders and lead to enhanced mitigation policy adoption (Rashidi and Patt 2018).

The analytic approach focusing on transitions and transformation focuses on path dependent processes as an impediment to the shift to low-carbon technologies and systems. Cross-chapter box 12 on Transition Dynamics (Chapter 16) summarizes the key points of this literature. This chapter describes how the two framings focus on different indicators of progress, and potentially different types of cooperative action within the international context. This chapter highlights in later sections conflicting views on whether the Paris Agreement is likely to prove effective (section 14.3.3.2). To some extent, the dichotomy of views aligns with the two framings: analysis implicitly aligned with the global commons framing is negative about the Paris architecture, whereas that aligned with the transitions framing is more positive (Kern and Rogge 2016; Roberts et al. 2018; Patt 2017).

Within the 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 2017; Hanna and Victor 2021). The fact that the sum of all countries' emissions has continued to grow (IPCC 2018a), even as there has been a global recognition that they should decline, is seen as being consistent with the absence of a strong global agreement. Within this framing, there is traditionally an emphasis on treaties' containing self-enforcing agreements (Olmstead and Stavins 2012), ideally through binding commitments, as a way of dealing with the overarching problem of free-ridership (Barrett 1994; Finus and Caparrós 2015; Tulkens 2019). However, as discussed above, the emphasis has now shifted to a gradual cooperation approach, either regional or sectoral, as an alternative way of dealing with free-riding incentives (Caparrós and Péreau 2017; Sabel and Victor 2017; Stewart et al. 2017). The gradual linkage of emission trading systems (discussed in Section 14.4.4), goes in the same direction. There is also literature suggesting that the diversity of the countries involved may in fact be an asset to reduce the free-rider incentive (Pavlova and De Zeeuw 2013; Finus and McGinty 2019), which argues in favour of a system where all countries, irrespectively of their income levels, are fully involved in mitigation, unlike the Kyoto Protocol and in line with the Paris Agreement. Finally, recent efforts have discussed potential synergies between mitigation and adaptation efforts in a strategic context (Bayramoglu et al. 2018) (see Section 14.5.1.2) In general, current efforts go beyond considering climate policy as a mitigation-only issue, much in line with the discussion about linkages between climate change and sustainable development policies described in detail in Chapters 1 and 4 of this report.

In the transitions framing, by contrast, global emissions levels are viewed as the end (and often greatly delayed) result of a large number of transformative processes. International cooperation may be effective at stimulating such processes, even if a change in global emissions is not yet evident, implying that short-term changes in emissions levels may be a misleading indicator of progress towards long-term goals (Patt 2017). Hanna and Victor (2021) suggest a particular focus on technical advances and deployment patterns in niche low carbon technologies, such as wind and solar power, and electric vehicles. However, this is one among many suggestions: the literature does not identify a single clear indicator to use, and there are many metrics of technological progress and transformation, described in Chapter 16, Section 16.3.3 of this report. These can include national level emissions among countries participating in particular forms of cooperation, as well as leading indicators of such emissions such as changes in low-carbon technology deployment and cost.

Just as the transition framing highlights indicators of progress other than global emissions, it de-emphasises the importance of achieving cost-effectiveness with respect to global emissions. Hence, this strand of the literature does not generally support the use of international carbon markets, suggesting that these can delay transformative processes within countries that are key drivers of technological change (Cullenward and Victor 2020). For similar reasons, achieving cross-sectoral cost-effectiveness, a goal of many carbon markets, is not seen as a high priority. Instead, within the transitions framing the emphasis with respect to treaty design is often on providing mechanisms to support parties' voluntary actions, such as with financial and capacity-building support for new technologies and technology regimes (Geels et al. 2019). The transitions literature also highlights impediments to transformation as being sector specific, and hence the importance of international cooperation addressing sector-specific issues (Geels et al. 2019). While such attention often starts with promoting innovation and diffusion of low-carbon technologies that are critical to a sector's functioning, it often ends with policies aimed at phasing out the high-carbon technologies once they are no longer needed (Markard 2018). In line with this, many scholars have suggested value in supply-side international agreements, aimed at phasing out the production and use of fossil fuels (Collier and Venables 2014; Piggot et al. 2018; Asheim et al. 2019; Newell and Simms 2020).

Analytic approaches centred on equity and development figure prominently within this report, with many of the key concepts addressed in Chapter 4. Primarily the focus is on aligning climate policy at the international level with efforts to shift development pathways towards improved quality of life and greater sustainability (see cross chapter box 5 on shifting sustainable development pathways, Chapter 4). There are also overlaps between the equity framework and the others. Within the global commons framing, the emphasis is on international carbon markets to reduce the costs from climate policies, and as way of generating financial flows to developing countries (Michaelowa et al. 2019a). The transitions framing, while focused empirically primarily on industrialized countries, nevertheless aligns with an understanding of climate mitigation taking place within a wider development agenda; in many cases it is a lack of development that creates a barrier to rapid system transformation, which international cooperation can address (Delina and Sovacool 2018)(see also Cross-chapter Box 12).

14.2.2 Climate clubs and building blocks

A recent development in the literature on international climate governance has been increased attention to the potential for climate clubs (Victor 2011). Hovi et al. (2016) define these "as any international actor group that (1) starts with fewer members than the UNFCCC has and (2) aims to cooperate on one or more climate change-related activities, notably mitigation, adaptation, climate engineering or climate compensation." While providing public goods (such as mitigation), they also offer member-only benefits (such as preferential tariff rates) to entice membership. In practice, climate clubs are sub-global arrangements, and formal agreement by interstate treaty is not a prerequisite. Actors do not have to be states, although in the literature on climate clubs states have hitherto dominated. The literature has an essentially static dimension that focuses on the incentives for actors to join such a club, and a dynamic one, which focuses on the "building blocks" for global cooperative agreements.

The literature focusing on the static aspects of clubs highlight that they represent "coalitions of the willing" (Falkner 2016a; Gampfer 2016; Falkner et al. 2021), which offer a package of benefits, part of which are pure public goods (available also to non-club members), and others are club benefits that are only available to members (Hovi et al. 2016). The members-only or excludable part can be a system of transfers within the club to compensate the countries with higher costs. For example, the benefit from participating in the club can be to have access to a common emissions trading system, which in general is more attractive the larger the diversity of the countries involved, although this is not a general result as discussed in detail in Doda and Taschini (2017). However, as costs and effort sharing agreements are unsuccessful in a static context (Barrett 1994), mainly due to free-rider incentives, several studies have proposed using tariffs on trade or other forms of sanctions to reduce incentives for free-riding (Helm and Sprinz 2000; Eyland and Zaccour 2012; Anouliès 2015; Nordhaus 2015; Al Khourdajie and Finus 2020). For example, Nordhaus (2015) uses a coalition formation game model to show that a uniform percentage tariff on the imports of nonparticipants into the club region (at a relatively low tariff rate of about 2%) can induce high participation within a range of carbon price values. More recently, Al Khourdajie and Finus (2020) show that border carbon adjustments and an open membership policy can lead to a large stable climate agreement, including full participation. Table 14.1 presents a number of key results related to climate clubs from a static context.

Table 14.1 Key climate club static modelling results

	Aakre et al. (2018)	(Nordhaus 2015)	(Hovi et al. 2017; Sprinz et al. 2018)	(Sælen et al. 2020; Sælen 2020)
Scope	Transboundary black carbon and methane in the Arctic	Global emissions	Global emissions	Global emissions
Modelling method	TM5-FASST model ("reduced-form air quality and impact evaluation tool")	C-DICE (coalition formation game based on a static version of the multiregional	Agent-based model	Agent-based model

		DICE-RICE optimisation model)		
Border tax adjustment	No	Yes	No	No
Key results	Black carbon can be more easily controlled than methane, based on self-interest; inclusion of non-Arctic Council major polluters desirable to control pollutants	For non-participants in mitigation efforts, modest tariffs on trade are advised to stabilize coalition formation for emission reductions	Climate clubs can substantially reduce GHG emissions, provided club goods are present. The (potential) departure of a single major actor (e.g., USA) reduces emissions coverage, yet is rarely fatal to the existence of the club	The architecture of the Paris Agreement will achieve the 2°C goal only under a very fortunate constellation of parameters. Potential (e.g., US) withdrawal further reduces these chances considerably

In a dynamic context, the literature on climate clubs highlights the co-called 'building blocks' approach (Stewart et al. 2013a,b, 2017). This is a bottom-up strategy designed to create an array of smaller-scale, specialised initiatives for transnational cooperation in particular sectors and/or geographic areas with a wide range of participants. As part of this literature, Potoski and Prakash (2013) provide a conceptual overview of voluntary environmental clubs, showing that many climate clubs do not require demanding obligations for membership and that a substantial segment thereof are mostly informational (Weischer et al. 2012; Andresen 2014). Also crafted onto the building blocks approach, Potoski (2017) demonstrates the theoretical potential for green certification and green technology clubs. Green (2017) further highlights the potential of "pseudo-clubs" with fluid membership and limited member benefits to promote the diffusion and uptake of mitigation standards. Falkner et al. (2021) suggest a typology of normative, bargaining, and transformational clubs. Before the adoption of the Paris Agreement, some literature suggested that the emergence of climate clubs in parallel to the multilateral climate regime would lead to "forum shopping", with states choosing the governance arrangement that best suits their interests (McGee and Taplin 2006; van Asselt 2007; Biermann et al. 2009; Oh and Matsuoka 2017). However, more recent literature suggests that climate clubs complement rather than challenge the international regime established by the UNFCCC (van Asselt and Zelli 2014; Draguljić 2019; Falkner 2016a).

In this dynamic context, one question is whether to negotiate a single global agreement or to start with smaller agreements in the hope that they will eventually evolve into a larger agreement. It has been debated extensively in the context of free trade whether a multilateral (global) negotiating approach is preferable to a regional approach, seen as a building block towards global free trade. Aghion et al. (2007) analysed this issue formally for trade, showing that a leader would always choose to move directly to a global agreement. In the case of climate change, it appears that even the mildest form of club discussed above (an efforts and costs sharing agreement, as in the case of the linkage of emissions trading systems) can yield global cooperation following a building-blocks approach, and that the sequential path relying on building-blocks may be the only way to reach global cooperation over time (Caparrós and Péreau 2017). While the existence of a nearly universal agreement such as the Paris

Agreement may arguably have rendered this discussion less relevant, the Paris Agreement co-exists, and will likely continue to do so, with a multitude of sectoral and regional agreements, meaning that this discussion is still relevant for the evolution of these complementary regimes.

Results based on an agent-based model suggest that climate clubs results in major emission reductions if there is a sufficiently high provision of the club good and if initial membership by several states with sufficient emissions weight materializes. Such configurations allow the club to grow over time to enable effective global action (Hovi et al. 2017). The departure of a major emitter (specifically the United States) triggered a scientific discussion on the stability of the Paris Agreement. Sprinz et al. (2018) explore whether climate clubs are stable against a leader willing to change its status, e.g., from leader to follower or even completely leaving the climate club, finding in most cases such stability to exist. Related studies on the macroeconomic incentives for climate clubs by Paroussos et al. (2019) show that climate clubs are reasonably stable, both internally and externally (i.e., no member willing to leave and no new member willing to join), and climate clubs that include obligations in line with the 2°C goal combined with financial incentives can facilitate technology diffusion. The authors also show that preferential trade arrangements for low-carbon goods can reduce the macroeconomic effects of mitigation policies. Aakre et al. (2018) show numerically that small groups of countries can limit black carbon in the Arctic, driven mainly for reasons of self-interest, yet reducing methane requires larger coalitions due to its larger geographical dispersal and require stronger cooperation.

14.2.3 Assessment criteria

This section identifies a set of criteria for assessing the effectiveness of international cooperation, which is applied later in the chapter. Lessons from the implementation of other multilateral environmental agreements (MEAs) can provide some guidance. There is considerable literature on this topic, most of which predates AR5, and which will therefore not be covered in detail. 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 (Downs et al. 1996; Victor et al. 1998; Weiss and Jacobson 1998). 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).

Many have pointed to the Montreal Protocol, addressing stratospheric ozone loss, as an example of a successful treaty because of its ultimate environmental effectiveness, and relevance for solving climate change. Scholarship emerging since AR5 emphasises that the Paris Agreement has a greater ‘bottom-up’ character than many other MEAs, including the Montreal or Kyoto Protocols, allowing for more decentralised ‘polycentric’ forms of governance that engage diverse actors at the regional, national and sub-national levels (Ostrom 2010; Jordan et al. 2015; Falkner 2016b; Victor 2016). Given the differences in architecture, 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 incentivise private sector engagement in transnational climate governance (Chan et al. 2018).

While environmental outcomes and economic performance have been long-standing criteria for assessment of effectiveness, the other elements deserve some note. It is the case that the achievement of climate objectives, such as limiting global average warming to 1.5 – 2°C, will require the transition from high- to low-carbon technologies, and the transformation of the sectors and social environments within which those technologies operate. 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, activities that contribute to transformative potential include technology transfer and financial support for low-carbon infrastructure, especially where the latter is not tied to immediate emissions reductions. Assessing the transformative potential of international cooperation takes these factors into account. Equity and distributive outcomes are of central importance to the climate change debate, and hence for evaluating the effects of policies. Equity encompasses the notion of distributive justice which refers to the distribution of goods, burdens, costs and benefits, as well as procedural-related issues (Kverndokk 2018).

Finally, the literature on the performance of other MEAs highlights the importance of institutional strength, which can include regulative quality, mechanisms to enhance transparency and accountability, and administrative capacity. Regulative quality includes guidance and signalling (Oberthür et al. 2017), as well as clear rules and standards to facilitate collective action (Oberthür and Bodle 2016). The literature is clear that legally binding obligations (which require the formal expression of state consent) and non-binding recommendations can each be appropriate, depending on the particular circumstances (Skjærseth et al. 2006), and indeed it has been argued that for climate change non-binding recommendations may better fit the capacity of global governance organisations (Victor 2011). Mechanisms to enhance transparency and accountability are essential to collect, protect, and analyse relevant data about parties' implementation of their obligations, and to identify and address challenges in implementation (Kramarz and Park 2016; Kinley et al. 2020). 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 (Andler and Behrle 2009; Bauer et al. 2017).

In addition to building on the social science theory just described, we recognise that it is also important to strike a balance between applying the same standards developed and applied to international cooperation in AR5, and maintaining consistency with other chapters of this report (primarily Chapters 1, 4, 13, and 15). Table 14.2 presents a set of criteria that do this, and which are then applied later in the chapter.

Table 14.2 Criteria for assessing effectiveness of international cooperation

Criterion	Description
Environmental outcomes	To what extent does international cooperation lead to identifiable environmental benefits, namely the reduction of economy-wide and sectoral emissions of greenhouse gases from pre-existing levels or 'business as usual' scenarios?
Transformative potential	To what extent does international cooperation contribute to the enabling conditions for transitioning to a zero-carbon economy and sustainable development pathways at the global, national, or sectoral levels?
Distributive outcomes	To what extent does international cooperation lead to greater equity with respect to the costs, benefits, and burdens of mitigation actions, taking into account current and historical contributions and circumstances?
Economic performance	To what extent does international cooperation promote the achievement of economically efficient and cost-effective mitigation activities?
Institutional strength	To what extent does international cooperation create the institutional framework needed for the achievement of internationally agreed-upon goals, and contribute to national, sub-national, and sectoral institutions needed for decentralised and bottom-up mitigation governance?

14.3 The UNFCCC and the Paris Agreement

14.3.1 The UN climate change regime

14.3.1.1 Instruments & Milestones

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. The UNFCCC categorises parties into Annex I and Annex II. Annex I parties, comprising developed country parties, have a goal to return, individually or jointly, their GHG emissions to 1990 levels by 2000. Annex II parties, comprising developed country parties except for those with economies in transition, have additional obligations relating to the provision of financial and technology support. All parties, including developing country parties, characterised as non-Annex-I parties, have reporting obligations, as well as obligations to take policies and measures on mitigation and adaptation. The UNFCCC also establishes the institutional building blocks for global climate governance. Both the 1997 Kyoto Protocol and the 2015 Paris Agreement are distinct but 'related legal instruments' in that only parties to the UNFCCC can be parties to these later instruments.

The Kyoto Protocol specifies GHG emissions reduction targets for the 2008-2012 commitment period for countries listed in its Annex B (which broadly corresponds to 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 for Annex B parties, as well as initiated a process under the UNFCCC to consider long-term cooperation among all parties.

At COP 13 in Bali in 2007, parties adopted the *Bali Action Plan* that launched negotiations aimed at an agreed outcome enhancing the UNFCCC's 'full, effective and sustained implementation'. The agreed outcome 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 with no formal legal status under the UNFCCC, it reflected significant progress on several fronts and set in place the building blocks for the Paris Agreement, namely: setting a goal of limiting global temperature increase to below 2°C; calling on all countries to put forward mitigation pledges; establishing broad new terms for the reporting and verification of countries' actions; setting a goal of mobilising USD100 billion a year by 2020 from a wide variety of sources, public and private, bilateral and multilateral, including alternative sources of finance; and, calling for the establishment of a new Green Climate Fund and Technology Mechanism (Rogelj et al. 2010; Rajamani 2010; UNFCCC 2010a). One hundred and forty states endorsed the Copenhagen Accord, with 85 countries entering pledges to reduce their emissions or constrain their growth by 2020 (Christensen and Olhoff 2019).

At COP 16 in Cancun in 2010, parties adopted a set of decisions termed the *Cancun Agreements* that effectively formalised the core elements of the Copenhagen Accord, and the pledges states made, under the UNFCCC. The Cancun Agreements were regarded as an interim arrangement through to 2020, and parties left the door open to further negotiations, in line with negotiations launched in 2005, toward a legally binding successor to the Kyoto Protocol (Freestone 2010; Liu 2011a). Collectively the G-20 states are on track to meeting the mid-level of their Cancun pledges, although there is uncertainty about some individual pledges. However, there is significant gap between annual emissions expected under full implementation of pledges and the level consistent with the 2°C goal (Christensen and Olhoff 2019).

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 2012, Dec. 1, para. 2). At the 2012 Doha climate conference, parties adopted a second commitment period for the Kyoto Protocol, running from 2013-2020. The Doha amendment entered into force in 31 December 2020. Given the subsequent adoption of the Paris Agreement, the Kyoto Protocol is unlikely to continue beyond 2020 (Bodansky et al. 2017a). At the end of the compliance assessment period under the Kyoto Protocol, Annex B parties were in full compliance with their targets for the first commitment period; in some cases through the use of the Protocol's flexibility mechanisms (Shishlov et al. 2016).

Although both the Kyoto Protocol and Paris Agreement are under the UNFCCC, they are generally seen as representing fundamentally different approaches to international cooperation on climate change (Held and Roger 2018; Falkner 2016b). The Paris Agreement has been characterised as a 'decisive break' from the Kyoto Protocol (Keohane and Oppenheimer 2016). Some note that the mitigation efforts under the Kyoto Protocol take the form of targets that, albeit based on national self-selection, were part of the multilateral negotiation process, whereas under the Paris Agreement parties make nationally determined contributions. The different approaches have been characterised by some as a distinction between a 'top down' and 'bottom up' approach (Bodansky and Rajamani 2016; Bodansky et al. 2016; Chan et al. 2016; Doelle 2016) but others disagree with such a characterisation pointing to continuities within the regime, for example, in terms of rules for reporting and review, and crossover and use of common institutional arrangements (Depledge 2017; Allan 2019). Some note, in any case, that the Kyoto Protocol's core obligations are substantive obligations of result, while many of the Paris Agreement's core obligations are procedural obligations, complemented by obligations of conduct (Rajamani 2016a; Mayer 2018a).

The differences between and continuities in the three treaties that comprise the UN climate regime are summarised in Table 14.3 below. The Kyoto targets apply only to Annex I parties, but the procedural obligations relating to NDCs in the Paris Agreement apply to all parties, with flexibilities in relation to some obligations 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 is maintained by the Secretariat, but to which parties can upload their own NDCs. The Kyoto Protocol allows Annex B parties to use three market-based mechanisms – the Clean Development Mechanism (CDM), Joint Implementation and International Emissions Trading – to fulfil a part of their GHG targets. The Paris Agreement recognizes that parties may choose to cooperate voluntarily on markets, in the form of cooperative approaches under Article 6.2, and a mechanism with international oversight under Article 6.4, subject to guidance and rules that are yet to be adopted. These rules relate to integrity and accounting (La Hoz Theuer et al. 2019). Article 5 also provides explicit endorsement of REDD+. 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 (through the withdrawal of benefits such as participation in market-based mechanisms), with its national system requirements, and 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 14.3 Continuities in and differences between the UNFCCC, Paris Agreement and the Kyoto Protocol

Feature	UNFCCC	Kyoto Protocol	Paris Agreement
Objective	To stabilize GHGs in the atmosphere at a level that would prevent	Primarily mitigation-focused (although in pursuit of the	Mitigation in line with a long-term temperature goal, adaptation and finance goals, as well as

	dangerous anthropogenic interference with the climate system, in a time frame to protect food security, enable natural ecosystem adaptability and permit economic development in a sustainable manner	UNFCCC objective)	sustainable development and equity (also, in pursuit of the UNFCCC objective)
Architecture	'Framework' agreement with agreement on principles such as CBDRRC, division of countries into Annexes, with different groups of countries with differentiated commitments.	Differentiated targets, based on national offers submitted to the multilateral negotiation process, and multilaterally negotiated common metrics	Nationally determined contributions subject to transparency, multilateral consideration of progress, common metrics in inventories and accounting.
Coverage of mitigation-related commitments	Annex I Parties with a GHG stabilization goal, all Parties to take policies and measures	UNFCCC Annex I/Kyoto Annex B parties only	All parties
Targets	GHG stabilization goal for Annex I parties ('quasi target')	Legally binding, differentiated mitigation targets inscribed in treaty	Non-binding (in terms of results) contributions incorporated in parties' NDCs, and provisions including those relating to highest possible ambition, progression and common but differentiated responsibilities and respective capabilities, in light of different national circumstances
Timetable	Aim to return to 1990 levels of GHGs by 2000	Two commitment periods (2008-2012; 2013-2020)	Initial NDCs for timeframes from 2020 running through 2025 or 2030 with new or updated NDCs every five years, and

			encouragement to submit long-term low GHG emission development strategies
Adaptation	Parties to cooperate in preparing for adaptation to the impacts of climate change	Parties to formulate and implement national adaptation measures, share of proceeds from CDM to fund adaptation	Qualitative global goal on adaptation to enhance adaptative capacity and resilience, and reduce vulnerability, parties to undertake national adaptation planning and implementation
Loss and Damage	Not covered	Not covered	Cooperation and facilitation to enhance understanding, action and support for loss and damage, including through the Warsaw International Mechanism on Loss and Damage under the UNFCCC
Transparency	National communications from parties, with differing content and set to differing timeframes for different categories of parties	Reporting and review – Annex B parties only	Enhanced transparency framework and five-yearly global stocktake for a collective assessment of progress towards goals – all parties
Support	Annex II commitments relating to provision of finance, development and transfer of technology to developing countries	Advances UNFCCC Annex II commitments relating to provision of finance, development and transfer of technology to developing countries	Enhances reporting in relation to support, expands the base of donors, and tailors support to the needs and capacities of developing countries
Implementation	National implementation, communication on implementation	Market mechanisms (international emissions trading, joint implementation, CDM)	Voluntary cooperation on mitigation (through market-based and non-market approaches); encouragement of REDD+ (guidance and rules under negotiation)

Compliance	Multilateral consultative process, never adopted	Compliance committee with facilitative and enforcement branches; sanctions for non-compliance	Committee to promote compliance and facilitate implementation; no sanctions

14.3.1.2 Negotiating Context and Dynamics

The 2015 Paris Agreement was negotiated in a starkly different geopolitical context to that of the 1992 UNFCCC and the 1997 Kyoto Protocol (Streck and Terhalle 2013; Ciplet et al. 2015). The ‘rupturing binary balance of superpowers’ of the 1980s had given way to a multipolar world with several distinctive trends: emerging economies began challenging US dominance (Ciplet et al. 2015); industrialised countries' emissions peaked in the 2010s and started declining, while emissions from emerging economies began to grow (Falkner 2019); the EU stretched eastwards and became increasingly supra-national (Kinley et al. 2020); disparities within the group of developing countries increased (Ciplet et al. 2015); and the role of non-state actors in mitigation efforts has grown more salient (Bäckstrand et al. 2017; Kuyper et al. 2018b; Falkner 2019). The rise of emerging powers, many of whom now have ‘veto power’, however, some noted, did not detract from the unequal development and inequality at the heart of global environmental politics (Hurrell and Sengupta 2012).

In this altered context, unlike in the 1990s when the main cleavages were between the EU and the US (Hurrell and Sengupta 2012), US-China ‘great power politics’ came to be seen as determinative of outcomes in the climate change negotiations (Terhalle and Depledge 2013). The US-China joint announcement (Whitehouse 2014), for instance, before the 2014 Lima climate conference, brokered the deal on differentiation that came to be embodied in the Paris Agreement (Ciplet and Roberts 2017; Rajamani 2016a). Others have identified, on the basis of economic standing, political influence, and emissions levels, three influential groups - the first comprising the US with Japan, Canada, and Russia, the second comprising the EU and the third comprising China, India and Brazil (Brenton 2013). The emergence of the Major Economies Fora (MEF), among other climate clubs (discussed in Section 14.2.2) reflects this development (Brenton 2013). It also represents a ‘minilateral’ forum, built on a recognition of power asymmetries, in which negotiating compromises are politically tested and fed into multilateral processes (Falkner 2016a).

Beyond these countries, in the decade leading up to the Paris climate negotiations, increasing differences within the group of developing countries divided the 134-strong developing country alliance of the G-77/China into several interest-based coalitions (Vihma et al. 2011; Bodansky et al. 2017b). A division emerged between the vulnerable least developed and small island states on the one side and rapidly developing economies, the BASIC (Brazil, South Africa, India and China) on the other, as the latter are ‘decidedly not developed but not wholly developing’ (Hochstetler and Milkoreit 2013). This ‘fissure’ in part led to the High Ambition Coalition in Paris between vulnerable countries and the more progressive industrialised countries (Ciplet and Roberts 2017). A division also emerged between the BASIC countries (Hurrell and Sengupta 2012), that each have distinctive identities and positions (Hochstetler and Milkoreit 2013). In the lead up to the Paris negotiations, China and India formed the Like-Minded Developing Countries (LMDCs) with OPEC and the Bolivarian Alliance for the Peoples of our Americas (ALBA) countries, to resist the erosion of differentiation in the regime. Yet, the ‘complex and competing’ identities of India and China, with differing capacities, challenges and self-images, have also influenced the negotiations (Rajamani 2017; Ciplet and Roberts 2017). Other developing countries’ coalitions also played an important role in striking the final deal in Paris. The

Alliance of Small Island States (AOSIS), despite their lack of structural power, played a leading role, in particular in relation to the inclusion of the 1.5°C long term temperature goal in the UN climate regime (Agueda Corneloup and Mol 2014; Ourbak and Magnan 2018). The Association of the Latin American and Caribbean Countries (AILAC) that emerged in 2012 also played a decisive role in fostering ambition (Edwards et al. 2017; Watts and Depledge 2018).

Leadership is essential to reaching international agreements and overcoming collective action problems (Parker et al. 2015). The Paris negotiations were faced, as a reflection of the multipolarity that had emerged, with a 'fragmented leadership landscape' with the US, EU, and China being perceived as leaders at different points in time and to varying degrees (Parker et al. 2014; Karlsson et al. 2012). Small island states are also credited with demonstrating 'moral leadership'(Agueda Corneloup and Mol 2014), and non-state and sub-national actors are beginning to be recognised as pioneers and leaders (Wurzel et al. 2019). There is also a burgeoning literature on the emergence of diffused leadership and the salience of followers (Busby and Urpelainen 2020; Parker et al. 2014).

It is in the context of this complex, multipolar and highly differentiated world - with a heterogeneity of interests, constraints and capacities, increased contestations over shares of the carbon and development space, as well as diffused leadership - that the Paris Agreement was negotiated. This context fundamentally influenced the shape of the Paris Agreement in particular on issues relating to its architecture, 'legalisation' (Karlas 2017) and differentiation (Bodansky et al. 2017b; Kinley et al. 2020), all of which are discussed below.

14.3.2 Elements of the Paris Agreement relevant to mitigation

The 2015 Paris Agreement to the UNFCCC, which entered into force on 4 November 2016, and has 192 Parties as of date, 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, especially in the initial part of its four-year negotiating process (Rajamani 2015; Maljean-Dubois and Wemaëre 2016; Klein et al. 2017; Bodansky et al. 2017b), the Paris Agreement is a treaty containing provisions of differing levels of "bindingness" (Bodansky 2016; Rajamani 2016b; Oberthür and Bodle 2016). 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 on factors such as the normative content of the provision, the precision of its terms, the language used, and the oversight mechanisms in place (Werksman 2010; Bodansky 2015; Oberthür and Bodle 2016; Rajamani 2016b). Assessed on these criteria, the Paris Agreement contains the full spectrum of provisions, from hard to soft law (Pickering et al. 2019; Rajamani 2016b) and even 'non-law', provisions that do not have standard-setting or normative content, but which play a narrative-building and context-setting role (Rajamani 2016b). The Paris Agreement, along with the UNFCCC and the Kyoto Protocol, can be interpreted in light of the customary international law principle of harm prevention according to which states must exercise due diligence in seeking to prevent activities within their jurisdiction from causing extraterritorial environmental harm (Mayer 2016a; Maljean-Dubois 2019).The key features of the Paris Agreement are set out in Box 14.1.

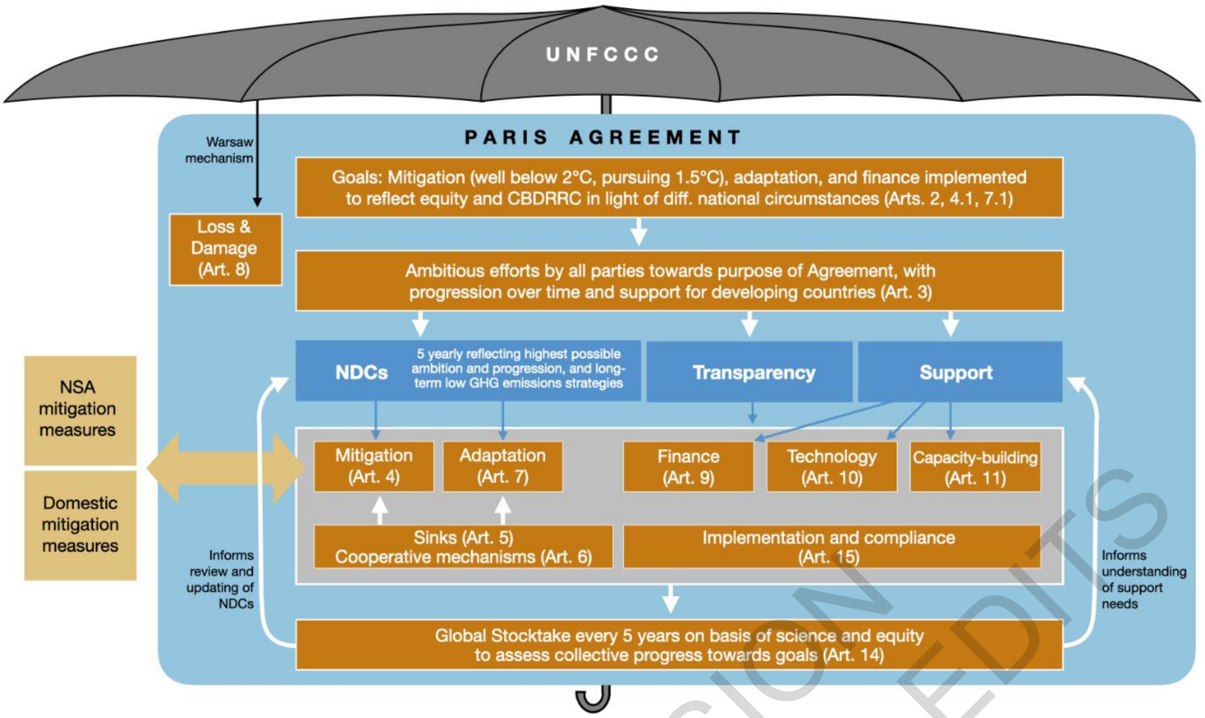


Figure 14.1 Key features of the Paris Agreement. Arrows illustrate the interrelationship between the different features of the Paris Agreement, in particular between the Agreement's goals, required actions (through NDCs, support (finance, technology and capacity-building), transparency framework and global stocktake process. The figure also represents points of interconnection with domestic mitigation measures, whether taken by state parties or by non-state actors (NSAs). This figure is illustrative rather than exhaustive of the features and interconnections.

Figure 14.1 illustrates graphically the key features of the Paris Agreement. The Paris Agreement is based on a set of binding procedural obligations requiring parties to 'prepare, communicate, and maintain' 'nationally determined contributions' (NDCs) (UNFCCC 2015a, Art. 4.2) every five years (UNFCCC 2015a, Art. 4.9). These obligations are complemented by: (1) an 'ambition cycle' that expects parties, informed by five-yearly global stocktakes (Art 14), to submit successive NDCs representing a progression on their previous NDCs (UNFCCC 2015a; Bodansky et al. 2017b), and (2) an 'enhanced transparency framework' that places extensive informational demands on parties, tailored to capacities, and establishes review processes to enable tracking of progress towards achievement of NDCs (Oberthür and Bodle 2016). In contrast to the Kyoto Protocol with its internationally inscribed targets and timetable for emissions reduction for developed countries, the Paris Agreement contains nationally determined contributions embedded in an international system of transparency and accountability for all countries (Doelle 2016; Maljean-Dubois and Wemaëre 2016) accompanied by a shared global goal, in particular in relation to a temperature limit.

14.3.2.1 Context and purpose

The preamble of the Paris Agreement lists several factors that provide the interpretative context for the Agreement (Carazo 2017; Bodansky et al. 2017b), 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 2016b). 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, 'when taking action to address human rights', take into account 'their respective obligations on human rights' (UNFCCC 2015a, preambular recital 14), a first for an environmental treaty (Knox 2016). The 'respective obligations' referred to in the Paris Agreement could potentially include those relating to the right to life (UNGA 1948, Art. 3, 1966, Art. 6), right to health (UNGA 1966b, Art. 12), right to development, 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, including as applied in the context of indigenous peoples (UNGA 1966a,b, Art. 1). In addition, climate impacts contribute to displacement and migration (Mayer and Crépeau 2016; McAdam 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; Duyck et al. 2018; Rajamani 2018; Savaresi 2018; Knox 2019). Notwithstanding proposals from some parties and stakeholders to mainstream and operationalise human rights in the climate regime post-Paris (Duyck et al. 2018), and references to human rights in COP decisions, the 2018 Paris Rulebook contains limited and guarded references to human rights (Duyck 2019; Rajamani 2019) (see Section 14.5.1.2). In addition to the reference to human rights, the preamble also notes the importance of 'ensuring the integrity of all ecosystems, including oceans and the protection of biodiversity' which provides opportunities for integrating and mainstreaming other environmental protections.

The overall purpose of international cooperation through the Paris Agreement is to enhance the implementation of the UNFCCC, including its objective of stabilising atmospheric GHG concentrations 'at a level that would prevent dangerous anthropogenic interference with the climate system' (UNFCCC 1992, Art. 2). The Paris Agreement aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, by inter alia '[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 2015a, Art. 2(1)(a)). There is an ongoing structured expert dialogue under the UNFCCC in the context of the second periodic review of the long-term global goal (the first was held between 2013-2015) aimed at enhancing understanding of the long-term global goal, pathways to achieving it, and assessing the aggregate effect of steps taken by parties to achieve the goal.

Some authors interpret the Paris Agreement's temperature goal as a single goal with two inseparable elements, the well below 2°C goal pressing towards 1.5°C (Rajamani and Werksman 2018), but others interpret the goal as a unitary one of 1.5°C with minimal overshoot (Mace 2016). Yet others interpret 1.5° C as the limit within the long-term temperature goal, and that it 'signals an increase in both the margin and likelihood by which warming is to be kept below 2°C (Schleussner et al. 2016). Although having a long-term goal has clear advantages, the literature highlights the issue of credibility, given the lengthy timeframe involved (Urpelainen 2011), and stresses that future regulators may have incentives to relax current climate plans, which could have a significant effect on the achieved GHG stabilisation level (Gerlagh and Michielsen 2015).

As the risks of adverse climate impacts, even with a 'well below' 2°C increase, are substantial, the purpose of the Paris Agreement extends to increasing adaptive capacity and fostering climate resilience (UNFCCC 2015a, Art. 2(1)(b)), as well as redirecting investment and finance flows (UNFCCC 2015a, Art (2)(1)(c); Thorgeirsson 2017). The finance and adaptation goals are not quantified in the Paris Agreement itself but the temperature goal and the pathways they generate may, some argue, 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 resolves to set a new collective quantified finance goal prior to 2025 (not explicitly limited to developed countries), with USD100 billion yr^{-1} as a floor (UNFCCC 2016a, para. 53; Bodansky et al. 2017b). Article 2 also references sustainable development and poverty eradication, and thus implicitly underscores the need to integrate the SDGs in the implementation of the Paris Agreement (Sindico 2016).

The Paris Agreement's purpose 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 2015a, Art. 2.2). This provision generates an expectation that parties will implement the agreement to reflect CBDRRC, and is not an obligation to do so (Rajamani 2016a). 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 2016a). 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 2016a; 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 2015a, 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 GHG emissions 'in the second half of the century'. Some argue this implies a need to reach net zero GHG emissions in the third quarter of the 21st century (Rogelj et al. 2015; IPCC 2018b; ch2, table 2.4; cross-chapter box 3 on net zero targets). To reach net zero CO_2 around 2050, in the short-term global net human-caused CO_2 emissions would need to fall by about 45% - 60% from 2010 levels by 2030 (IPCC 2018b). Achieving the Paris Agreement's Article 4.1 aim potentially implies imply that global warming will peak and then follow a gradually declining path, potentially to below 1.5°C warming (Rogelj et al. 2021).

Albeit non-binding, Article 4.1 has acted as a catalyst for several national net-zero GHG targets, as well net zero CO_2 and GHG targets across local governments, sectors, businesses, and other actors (Day et al. 2020). There is a wide variation in the targets that have been adopted – in terms of their legal character (policy statement, executive order or national legislation), scope (GHGs or CO_2) and coverage (sectors or economy-wide). National net-zero targets could be reflected in the long-term strategies that states are urged to submit under Article 4.19, but only a few states have submitted such strategies thus far. 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 2019b, Annex I, para. 7), Parties could in this context include information on how their short-term actions align with their long-tern net zero GHG or CO_2 targets thereby enhancing the credibility of their long-term goals.

At last count 131 countries had adopted or had net zero targets (whether of carbon or GHG) in the pipeline, covering 72% of global emissions. If these targets are fully implemented some estimate that this could bring temperature increase down to 2-2.4°C by 2100 as compared to current policies which are estimated to lead to a temperature increase of 2.9–3.2 °C, and NDCs submitted to the Paris Agreement which are estimated to lead to a temperature increase of 2.4-2.9°C (Höhne et al. 2021).

It is worth noting that Article 4.1 recognizes that 'peaking will take longer for developing countries' and that the balance between emissions and removals needs to be on the 'basis of equity, and in the context of sustainable development and efforts to eradicate poverty.' This suggests that not all countries are expected to reach net zero GHG emissions at the same time, or in the same manner. If global cost-effective 1.5 °C and 2 °C scenarios from integrated assessment models are taken, without applying an equity principle, the results suggest that domestic net zero GHG and CO_2 emissions would be reached a decade earlier than the global average in Brazil and the USA and later in India and Indonesia (van Soest et al. 2021). By contrast if equity principles are taken into account, countries like Canada and the EU would be expected to phase-out earlier than the cost-optimal scenarios indicate, and countries like China and Brazil could phase out emissions later, as well as other countries with lower per-capita emissions (van Soest et al. 2021). Some suggest that the application of such fairness considerations could bring forward the net zero GHG date for big emitting countries by up to 15 to 35 years as compared to the global least-cost scenarios (Lee et al. 2021b). In any case, reaching net-zero GHG emissions requires to some extent the use of carbon dioxide removal (CDR) methods as there are important sources of non-CO_2 GHGs, such as methane and nitrous oxide, that cannot be fully eliminated resorting to carbon dioxide removal (CDR) methods (IPCC 2018b). However, there are divergent views on different CDR methods, policy choices determine the degree to which and the type of CDR methods that are considered and there is a patchwork of applicable regulatory instruments. There are also uncertainties and governance challenges associated with CDR methods which render tracking progress against net zero GHG emissions challenging (Mace et al. 2021). Researchers have noted that given the key role of CDR in net-zero targets and 1.5 °C compatible pathways, and the fact that it presents 'significant costs to current and future generations,' it is important to consider what an equitable distribution of CDR might look like (UNFCCC 2019c; Day et al. 2020; Lee et al. 2021b).

14.3.2.2 NDCs, progression and ambition

Each party to the Paris Agreement has a procedural obligation to 'prepare, communicate and maintain' successive NDCs 'that it intends to achieve.' Parties have a further procedural obligation to 'pursue domestic mitigation measures' (UNFCCC 2015a, Art. 4.2). These procedural obligations are coupled with an obligation of conduct to make best efforts to achieve the objectives of NDCs (Rajamani 2016a; Mayer 2018b). Many states have adopted climate policies and laws, discussed in Chapter 13, and captured in databases (LSE 2020).

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 2015a, Art. 4.4), as well as 'progression' and 'highest possible ambition' reflecting 'common but differentiated responsibilities and respective capabilities in light of different national circumstances' (Art 4.3). There is 'a firm expectation' that for every five-year cycle a party puts forward a new or updated NDC that is 'more ambitious than their last' (Rajamani 2016a). 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 2015a, Art. 4.9), all parties have an obligation to 'provide the information necessary for clarity, transparency and understanding' (UNFCCC 2015a, Art. 4.8). These requirements are further elaborated in the Paris Rulebook (Doelle 2019; UNFCCC 2019b). This includes 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 2019b, Annex I, para 1). 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 2019b, Annex I, para 6). However, parties are required to provide the enumerated information only 'as applicable' to their NDC (UNFCCC 2019b, 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 by 2020, such quantifiable information 'may' be included, 'as appropriate', signalling a softer requirement, although parties are 'strongly encouraged' to provide this information (UNFCCC 2019b, Annex I, para 9).

Parties' first NDCs submitted to the provisional registry maintained by the UNFCCC Secretariat vary in terms of target type, reference year or points, time frames, and scope and coverage of GHGs. A significant number of NDCs include adaptation, and several NDCs have conditional components, for instance, being conditional on the use of market mechanisms or on the availability of support (UNFCCC 2016b). There are wide variations across NDCs. Uncertainties are generated through interpretative ambiguities in the assumptions underlying NDCs, (Rogelj et al. 2017). According to the assessment in this report, current policies lead to median global GHG emissions of 63 $GtCO_2$-eq with a full range of 57-70 by 2030 and unconditional and conditional NDCs to 59 (55-65) and 56 (52-61) $GtCO_2$-eq, respectively (Chapter 4, Table 4.1). Many omit important mitigation sectors, provide little detail on financing implementation, and are not effective in meeting assessment and review needs (Pauw et al. 2018). Although, it is estimated that the land-use sector could contribute as much as 20% of the full mitigation potential of all the intended NDC targets (Forsell et al. 2016) , there are variations in how the land-use component is included, and the related information provided, leading to large uncertainties on whether and how these will contribute to the achievement of the NDCs (Grassi et al. 2017; Obergassel et al. 2017a; Benveniste et al. 2018; Fyson and Jeffery 2019; Forsell et al. 2016). All these variations make it challenging to aggregate the efforts of countries and compare them to each other (Carraro 2016). 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 discretion in the formulation of NDCs (Rajamani and Bodansky 2019; Weikmans et al. 2020).

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 (Iyer et al. 2017; Jeffery et al. 2018). 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 multiple indicators that reflect the different viewpoints of the parties under the UNFCCC (Aldy et al. 2017; Höhne et al. 2018). These different approaches are described in greater depth in Chapter 4, section 4.2.2.

It is clear, however, that the NDCs communicated by parties for the 2020-2030 period are insufficient to achieve the temperature goal (den Elzen et al. 2016; Rogelj et al. 2016; Schleussner et al. 2016; Robiou du Pont and Meinshausen 2018; UNEP 2018a; Alcaraz et al. 2019; UNEP 2019, 2020), and the emissions gap is larger than ever (Christensen and Olhoff 2019) (see Chapter 4). The IPCC 1.5ºC Report notes that pathways that limit global warming to 1.5°C with no or limited overshoot show up to 40-50% reduction of total GHG emissions from 2010 levels by 2030, and that current pathways reflected in the NDCs are consistent with cost-effective pathways that result in a global warming of about 3°C by 2100 ((IPCC 2018b) SPM, D.1.1). Analysis by the UNFCCC Secretariat of the second round of those NDCs submitted until into October 2021 suggests that 'total global GHG emission level, taking into account full implementation of all the latest NDCs (including their conditional elements), implies possibility of global emissions peaking before 2030'. However, such total global GHG emission level in 2030 is still expected to be 15.9% above the 2010 level. This 'implies an urgent need for either a significant increase in the level of ambition of NDCs between now and 2030 or a significant overachievement of the latest NDCs, or a combination of both.' (UNFCCC 2021a).

Many NDCs with conditional elements may not be feasible as the conditions are not clearly defined and existing promises of support are insufficient (Pauw et al. 2020). Moreover, 'leadership by conditional commitments' (when some states promise to take stronger commitments if others do so as well), and the system of pledge-and-review, may lead to decreasing rather than deeper contributions over time

(Helland et al. 2017). Some note, however, that many of the NDCs are conservative and may be overachieved, that 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 NDCs with and without conditional elements are implemented, net land use, land use change and forestry emissions will decrease in 2030 compared to 2010 levels, but large uncertainties remain on how Parties estimate, project and account for emissions and removals from this sector (Forsell et al. 2016; Fyson and Jeffery 2019). 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 GHGs, 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%.

In this context, it should be noted that many NDCs have been formulated with conditional elements, and such NDCs require international cooperation on finance, technology and capacity-building (Kissinger et al. 2019), potentially including through Article 6 in the form of bilateral agreements and market mechanisms (UNFCCC 2016b). More broadly, some argue that there is a 'policy inconsistency' between the facilitative, 'bottom up' architecture of the Paris Agreement, and both the setting of the long-term temperature goal, as well as expectations that it will be delivered (Geden 2016b). As Figure 14.2 shows, there is a large share of additional effort needed to reach a 1.5ºC compatible path by 2030 (and even a 2ºC compatible path). International coordination and cooperation are crucial in enhancing the ambition of current pledges, as countries will be more willing to increase their ambition if matched by other countries (coordination) and if cost-minimising agreements between developed and developing countries, through Article 6 and other means, are fully developed (cooperation) (Sælen 2020).

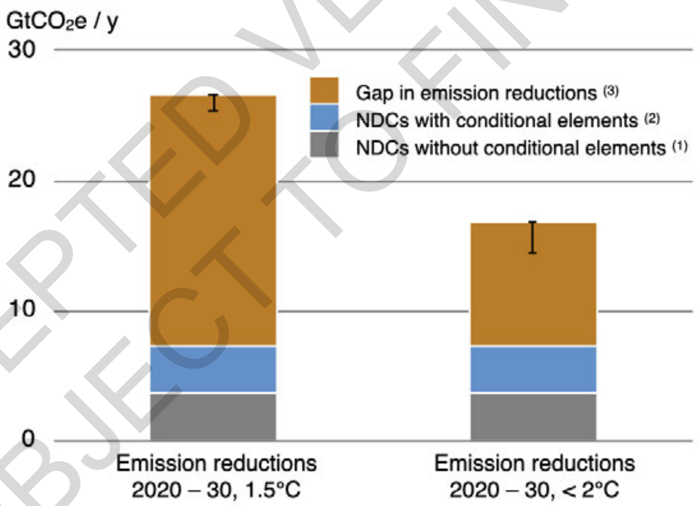


Figure 14.2 The role of international cooperation in the reductions in annual emissions by 2030 needed to follow a 1.5°C (respectively < 2°C) cost-effective path from 2020 onwards. The figure represents the additional contribution of pledges included in the NDCs over current policies at the global level, and the remaining gap in emission reductions needed to move from current policies to cost-effective long-term mitigation pathways for limiting warming to 1.5°C with low (<0.1°C) overshoot (50% chance), respectively for limiting warming to 2°C (66% chance). Median values are used, showing the confidence interval for the total effort. See Figure 1 in Cross-Chapter Box 4, and Tables 4.2 and 4.3 for details. (1) The grey share represents NDCs with abatement efforts pledged without any conditions (called "unconditional" in the literature). They are based mainly on domestic abatement actions, although countries can use international cooperation to meet their targets. (2) The blue share represents NDCS with conditional components. They require international cooperation, for example bilateral agreements under article 6, financing or monetary and/or technological transfers. (3) The remaining gap in emission reductions – the orange share – can potentially be achieved through national and international actions.

International coordination of more ambitious efforts promotes global ambition and international cooperation provides the cost-saving basis for more ambitious NDCs.

14.3.2.3 NDCs, fairness and equity

The Paris Agreement encourages Parties, while submitting their NDCs, to explain how these are 'fair and ambitious' (UNFCCC 2015a, 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 (Rajamani and Bodansky 2019; UNFCCC 2019b paras 7a and 9, Annex, paras 6(a) and (b)). Although equity within nations and between communities is also important, much of the literature on fairness and equity in the context of NDCs focuses on equity between nations.

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). At least some of the indicators Parties have identified in their NDCs as justifying the 'fairness' of their contributions, such as a 'small share of global emissions', 'cost-effectiveness' and assumptions that privilege current emissions levels ('grandfathering') are not, according to one group of scholars, in accordance with principles of international environmental law (Rajamani et al. 2021) . Moreover, the NDCs reveal long-standing institutional divisions and divergent climate priorities between Annex I and non-Annex I Parties, suggesting that equity and fairness concerns remain salient (Stephenson et al. 2019). Fairness concerns also affect the share of carbon dioxide removal (CDR) responsibilities for major emitters if they delay near-term mitigation action (Fyson et al. 2020).

It is challenging, however, to determine 'fair shares', and address fairness and equity in a world of voluntary climate contributions (Chan 2016a), in particular, since these contributions are insufficient (see above Section 14.3.2.2.). Self-differentiation in contributions has also led to fairness and equity being discussed in terms of individual nationally determined contributions rather than between categories of countries (Chan 2016a). In the climate change regime, one option is for Parties to provide more rigorous information under the Paris Agreement 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 operationalised these principles, and explain their mitigation targets in terms of the portion of the appropriated global budget (Hales and Mackey 2018).

Equity is critical to addressing climate change, including through the Paris Agreement (Klinsky et al. 2017), however, since the political feasibility of developing equity principles within the climate change regime is low, the onus is on mechanisms and actors outside the regime to develop these (Lawrence and Reder 2019). Equity and fairness concerns are being raised in national and regional courts that are increasingly being asked to determine if the climate actions pledged by states are adequate in relation to their fair share (The Supreme Court of the Netherlands 2019; European Court of Human Rights 2020; German Constitutional Court 2021), as it is only in relation to such a 'fair share' that the adequacy of a state's contribution can be assessed in the context of a global collective action problem (see chapter 13.5.5 for a discussion of national climate litigation). Some domestic courts have stressed that as climate change is a global problem of cumulative impact, all emissions contribute to the problem regardless of their relative size and there is a clear articulation under the UNFCCC and Paris Agreement for developed countries to 'take the lead' in addressing GHG emissions (Preston 2020). Given the limited avenues for multilateral determination of fairness, several researchers have argued that the onus is on the scientific community to generate methods to assess fairness (Herrala and Goel 2016; Lawrence and Reder 2019). Peer-to-peer comparisons also potentially 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 (Hales and Mackey 2018; Alcaraz et al. 2019), which may occur through the transparency processes (Hales and Mackey 2018); quantifying national emissions allocations using different equity approaches, including those reconciling finance and emissions rights distributions (Robiou du Pont et al. 2017); combining equity concepts in a bottom-up manner using different sovereign approaches (Robiou du Pont and Meinshausen 2018), 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 organising 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. 2016). Some of the equity approaches rely on 'grandfathering' as an allocation principle, which some argue has led to 'cascading biases' against developing countries (Kartha et al. 2018), and is morally 'perverse' (Caney 2011). While no country's NDC explicitly supports the grandfathering approach, many countries describe as 'fair and ambitious' NDCs that assume grandfathering as the starting point (Robiou du Pont et al. 2017). It is worth noting that the existence of multiple metrics associated with a range of equity approaches, has implications for how the ambition and 'fair' share of each state is arrived at, some average out multiple approaches and indicators (Hof et al. 2012; Meinshausen et al. 2015; Robiou du Pont and Meinshausen 2018), others exclude indicators and approaches that do not, in their interpretation, accord with principles of international environmental law (Rajamani et al. 2021). One group of scholars have suggested that utilitarianism offers a 'ethically minimal and conceptually parsimonious' benchmark that promotes equity, climate and development (Budolfson et al. 2021).

14.3.2.4 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, among other things, to track progress in implementing and achieving mitigation contributions (UNFCCC 2015a, Art. 13). This transparency framework builds on the processes that already exist under the UNFCCC. The transparency framework under the Paris Agreement s 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 2015a, Art. 13.7) biennially (UNFCCC 2016a, para. 90). The Paris Rulebook requires all Parties to submit their national inventory reports using the 2006 IPCC Guidelines (UNFCCC 2019b, 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 2019k, Annex, para 65), a significant concession to national sovereignty (Rajamani and Bodansky 2019). The Rulebook phases in common reporting requirements for developed and developing countries (except LDCs and SIDS) at the latest by 2024 (UNFCCC 2019k, para. 3), but offers flexibilities in 'scope, frequency, and level of detail of reporting, and in the scope of the review' for those developing countries that need it in light of their capacities (UNFCCC 2019k, Annex, 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 2015a, Art. 9.7).

The information provided by Parties in biennial transparency 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 from making 'political judgments' or reviewing the 'adequacy or appropriateness' of a party's NDC, domestic actions, or support provided (UNFCCC 2019k, 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). There are also limits to the extent that the enhanced transparency framework will reduce ambiguities, and associated uncertainties, for instance, in how LULUCF is incorporated into the NDCs (Fyson and Jeffery 2019) and lead to increased ambition (Weikmans et al. 2020). More broadly, there has been 'weak' translation of transparency norms into accountability (Ciplet et al. 2018). Hence, the Paris Agreement's effectiveness in ensuring NDCs are achieved will depend on additional accountability pathways at the domestic level involving political processes and civil society engagement (Jacquet and Jamieson 2016; van Asselt 2016; Campbell-Duruflé 2018a; Karlsson-Vinkhuyzen et al. 2018).

14.3.2.5 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 2015a, 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 outlines the scope of the global stocktake to include social and economic consequences and impacts of response measures, and loss and damage associated with the adverse effects of climate change (UNFCCC 2019f, 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 enables a discussion on equitable burden sharing (Rajamani 2016a; Winkler 2020), and for equity metrics to be factored in (Robiou du Pont and Meinshausen 2018). The Paris Rulebook includes consideration of the modalities and sources of inputs for the global stocktake (UNFCCC 2019f, paras 1, 2, 13, 27, 31, 36h and 37g), which arguably will result in equity being factored into the outcome of the stocktake (Winkler 2020). The Rulebook does not, however, some argue, resolve the tension between the collective nature of the assessment that is authorised by the stocktake and the individual assessments required to determine relative 'fair share' (Rajamani and Bodansky 2019; Zahar 2019).

The global stocktake is seen as crucial to encouraging parties to increase the ambition of their NDCs (Huang 2018; Hermwille et al. 2019; 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) (Rajamani 2016a; Friedrich 2017; Zahar 2019). 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 2019f, para. 37). However, the Rulebook specifies that the global stocktake will be 'a Party-driven process' (UNFCCC 2019f, para. 10), will not have an 'individual Party focus', and will include only 'non-policy prescriptive consideration of collective progress' (UNFCCC 2019f, para. 14).

14.3.2.6 Conservation of sinks and reservoirs, including forests

Article 5 of the Paris Agreement calls for parties to take action to conserve and enhance sinks and reservoirs of greenhouse gases, including biomass in terrestrial, coastal, and marine ecosystems, and encourages countries to take action to support the REDD+ framework under the Convention. The explicit inclusion of land use sector activities, including forest conservation, is potentially, while cautiously, a 'game changer' as it encourages countries to safeguard ecosystems for climate mitigation purposes (Grassi et al. 2017). Analyses of parties' 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 action endorsed by Article 5 is REDD+, which refers to initiatives 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. It remains an evolving concept and some identified weaknesses are being addressed, including the issues of scale (project-based vs sub-national jurisdictional approach), problems with leakage, reversal, benefit sharing, as well as safeguards against potential impacts on local and indigenous communities. Nevertheless, REDD+ shows several innovations under the climate regime with regard to international cooperation. The legal system for REDD+ manages to reconcile flexibility (creating consensus) and legal security. It shows a high standard of effectiveness (Dellaux 2017).

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). Since public finance for REDD+ is limited, private sector participation is expected by some to leverage REDD+ (Streck and Parker 2012; Henderson et al. 2013; Pistorius and Kiff 2015; Seymour and Busch 2016; Ehara et al. 2019). 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 incentivising, 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).

14.3.2.7 Cooperative approaches

Article 6 of the Paris Agreement provides for voluntary cooperative approaches. Its potential importance in terms of project-based cooperation should be viewed against the background of key lessons from the market-based mechanisms under the Kyoto Protocol, particularly the Clean Development Mechanism (CDM). The CDM has been used for implementing bilateral strategies and unilateral (non-market) actions for instance in India (Phillips and Newell 2013), hence arguably covering all the mechanisms now included in Article 6 of the Paris Agreement. As we describe in section 14.3.3.1, below, ex-post evaluation of the Kyoto market mechanisms, in particular the CDM, have been at-best mixed. However, Article 6 goes beyond the project-based approach followed by the CDM, as hinted by the emerging landscape of activities based on Article 6 (Greiner et al. 2020), such as the bilateral treaty signed under the framework of Article 6 in October 2020 by Switzerland and Peru (see section 14.4.4).

This experience from the CDM is relevant to the implementation of Article 6 (4) of the Paris Agreement. It addresses a number of specific types of cooperative approaches, including those involving the use of internationally transferred mitigation outcomes (ITMOs) towards NDCs, a 'mechanism to contribute to mitigation and support sustainable development', and a framework for non-market approaches such as many aspects of REDD+.

Article 6.1 recognises 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. Article 6.2 indicates that ITMOs can originate from a variety of sources, and that parties using ITMOs to achieve their NDCs 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 Article 17 of 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 the potential of Article 6.2 generally find that ITMOs are likely to result in cost reductions in achieving mitigation outcomes, with the potential for such reductions to enhance ambition and accelerate parties' progression of mitigation pledges across NDC cycles (Fujimori et al. 2016; Gao et al. 2016; Mehling 2019). However, studies applying insights from the CDM highlight 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). These studies collectively affirm that robust governance on accounting for ITMOs, and for reporting and review, will be critical to ensuring the environmental integrity of NDCs making use of them (Mehling 2019; Müller and Michaelowa 2019).

Article 6.4 concerns the mitigation mechanism, with some similarities to the Kyoto Protocol's CDM. Unlike the CDM, there is no restriction on which parties can host mitigation projects and which parties can use the resulting emissions reductions towards their NDCs (Marcu 2016). This central mechanism will operate under the authority and guidance of the CMA, and is to be supervised by a body designated by the CMA (Marcu 2016).

The Article 6.4 central mechanism is intended to promote mitigation while fostering sustainable development. The decision adopting the Paris Agreement specifies experience with Kyoto market mechanisms as a basis for the new mitigation mechanism (UNFCCC 2016a, para. 37(f)). Compared with the CDM under the Kyoto Protocol, the central mechanism 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 into the central mechanism (Obergassel et al. 2017b; Calzadilla 2018). It is further subject to the requirement that it must deliver 'an overall mitigation in global emissions,' which is framed by the general objectives of Article 6 for cooperation to enhance ambition (Kreibich 2018).

Negotiations over rules to operationalise Article 6 have thus far 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. Ongoing points of negotiation have included: whether to permit the carryover and use of Kyoto CDM credits and AAUs into the Article 6.4 mechanism, whether to impose a mandatory share of proceeds on Article 6.2 mechanism to fund adaptation, like for Article 6.4; and whether and how credits generated under Article 6.4 should be subject to accounting rules under Article 6.2 (Michaelowa et al. 2020a).

14.3.2.8 Finance flows

Finance is the first of three means of support specified under the Paris Agreement to accomplish its objectives relating to mitigation (and adaptation) (UNFCCC 2015a, Art. 14.1). This sub-section discusses the provision made in the Paris Agreement for international cooperation on finance. Section

14.4.1 below considers broader cooperative efforts on public and private finance flows for climate mitigation, including by multilateral development banks and through instruments such as green bonds.

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 2015a, Art 2.1(c)). Alignment of financial flows, and in some cases provision of finance will be critical to the achievement of many parties' NDCs, particularly those that are framed in conditional terms (Zhang and Pan 2016; Kissinger et al. 2019) (see further Chapter 15 on investment and finance).

International cooperation on climate finance represents 'a complex and fragmented landscape' with a range of different mechanisms and forums involved (Pickering et al. 2017; 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 (the role of these banks in climate finance is discussed further in Section 14.4.1 below).

Pursuant to decisions adopted at the Paris and Katowice conferences, parties 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 2016a, paras 58 and 63, 2019e,g). The GCF, which became operational in 2015, is the largest dedicated international climate change fund and plays a key role in channelling financial resources to developing countries (Antimiani et al. 2017; Brechin and Espinoza 2017).

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 2015a, Art 9.1). This provision applies to both mitigation and adaptation and is in continuation of existing developed country parties' obligations under the UNFCCC. This signals that the Paris Agreement finance requirements must be interpreted in light of the UNFCCC (Yamineva 2016). The novelty introduced by the Paris Agreement is a further 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, 'as part of the global effort, developed countries should continue to take the lead in mobilising climate finance', with a 'significant role' for public funds, and an expectation that such mobilisation of finance 'should represent a progression beyond previous efforts' Beyond this there are no new recognised promises (Ciplet et al. 2018). In the Paris Agreement parties formalized the continuation of the existing collective mobilization goal to raise 100 billion a year through 2025 in the context of meaningful mitigation actions and transparency on implementation. The Paris Agreement decision also provided for the CMA by 2025 to set a new collective quantified goal from a floor of USD100 billion yr^{-}, taking into account the needs and priorities of developing countries (UNFCCC 2016a, para. 53). This new collective goal on finance is not explicitly limited to developed countries and could therefore encompass finance flows from developing countries' donors (Bodansky et al. 2017b). Deliberations on setting a new collective quantified goal on finance is expected to be initiated at COP26 in 2021 (UNFCCC 2019g,e; Zhang 2019).

It is widely recognised that the USD100 billion yr^{-1} 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 USD474 billion yr^{-1} by 2030 (Zhang and Pan 2016). The OECD reports that climate finance provided and mobilised by developed countries was USD79.6 billion in 2019. This finance included four components: bilateral public, multilateral public (attributed to developed countries), officially supported export credits and mobilised private finance (OECD 2021) (See also Chapter 15.3.2, and Box 15.4).

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; Jachnik et al. 2019; Roberts et al. 2021; Gupta and van Asselt 2019). There is also a concern about climate finance being new and additional though the Paris Agreement does not make an explicit reference to it, nor is there a clear understanding of what constitutes new and additional (UNFCCC 2018; Carty et al. 2020; Mitchell et al. 2021). Some authors see the 'enhanced transparency framework' of the Paris Agreement (see Section 14.3.2.4 above), and the specific requirements for developed countries to provide, biennially, indicative quantitative and qualitative information as well as report on financial support and mobilisation 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. For some sectors, such as forestry and land-use, this could leave 'NDC ambitions ... 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 the 2018 Katowice conference, UNFCCC Parties requested the Standing Committee on Finance to prepare, every four years, a report on the determination of the needs of developing country Parties related to implementing the Convention and the Paris Agreement, for consideration by parties at COP26 (UNFCCC 2019c).

14.3.2.9 Technology development and transfer

Technology development and transfer is the second of three 'means of implementation and support' specified under the Paris Agreement to accomplish its objectives relating to mitigation (and adaptation) (UNFCCC 2015a, Art. 14.1). This sub-section discusses the provision made in the Paris Agreement for international cooperation on technology development and transfer. Section 14.4.2 below considers broader cooperative efforts on technology development and transfer under the UNFCCC. Both sections complement the discussion in Chapter 16.6 on the role of international cooperation in fostering transformative change.

The importance of technology as a means of implementation for climate mitigation obligations under the Paris Agreement is evident from parties' NDCs. Of the 168 NDCs submitted as of June 2019, 109 were expressed as conditional upon support for technology development and transfer, with 70 parties requesting technological support for both mitigation and adaptation, and 37 parties for mitigation only (Pauw et al. 2020). Thirty-eight LDCs (79%) and 29 SIDS made their NDCs conditional on technology transfer, as did 50 middle-income countries (Pauw et al. 2020).

While technology is seen as a key means of implementation and support for Paris Agreement commitments, the issue of technology development and the transfer of environmentally sound technologies for climate mitigation was heavily contested between developed and developing countries in the Paris negotiations, and these differences are likely to persist as the Paris Agreement is implemented (Oh 2019). Contestations continued in negotiations for the Paris Rulebook, particularly regarding the meaning of technological innovation, which actors should be supported, and how support should be provided by the UNFCCC (Oh 2020a).

Article 10 of the Paris Agreement articulates a shared 'long-term vision on the importance of fully realising technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions' (UNFCCC, 2015, Art. 10.1). All parties are required 'to strengthen cooperative action on technology development and transfer' (UNFCCC, 2015, Art. 10.2). In addition, support, including financial support, 'shall be provided' to developing country parties for the implementation of Article 10, 'including for strengthening cooperative action on technology development and transfer at different stages of the technology cycle, with a view to achieving a balance between support for mitigation and adaptation' (UNFCCC, 2015, Art. 10.6). Available information on efforts related to support on technology development and transfer for developing country parties is also one of the matters to be taken into account in the global stocktake (UNFCCC, 2015, Art. 10.6) (see Section 14.3.2.5 above).

The Paris Agreement emphasises that efforts to accelerate, encourage and enable innovation are 'critical for an effective long-term global response to climate change and promoting economic growth and sustainable development' and urges that they be supported, as appropriate, by the Technology Mechanism and Financial Mechanism of the UNFCCC (UNFCCC, 2015, Art. 10.5). This support should be directed to developing country parties 'for collaborative approaches to research and development, and facilitating access to technology, in particular for early stages of the technology cycle' (UNFCCC, 2015, Art. 10.5). Inadequate support for R&D, particularly in developing countries, has been identified in previous studies of technology interventions by international institutions as a key technology innovation gap that might be addressed by the Technology Mechanism (Coninck and Puig 2015).

To support parties' cooperative action, the Technology Mechanism, established in 2010 under the UNFCCC (see further Section 14.4.2 below), will serve the Paris Agreement, subject to guidance of a new 'technology framework' (UNFCCC, 2015, Art. 10.4). The latter was strongly advocated by the African group in the negotiations for the Paris Agreement (Oh 2020a), and was adopted in 2018 as part of the Paris Rulebook, with implementation entrusted to the component bodies of the Technology Mechanism. The guiding principles of the framework are coherence, inclusiveness, a results-oriented approach, a transformational approach and transparency. Its 'key themes' include innovation, implementation, enabling environment and capacity-building, collaboration and stakeholder engagement, and support (UNFCCC 2019e, Annex). A number of 'actions and activities' are elaborated for each thematic area. These include: enhancing engagement and collaboration with relevant stakeholders, including local communities and authorities, national planners, the private sector and civil society organisations, in the planning and implementation of Technology Mechanism activities; facilitating parties undertaking, updating and implementing technology needs assessments (TNAs) and aligning these with NDCs; and enhancing the collaboration of the Technology Mechanism with the Financial Mechanism for enhanced support for technology development and transfer. As regards TNAs, while some developing countries have already used the results of their TNA process in NDC development, other countries might benefit from following the TNA process, including its stakeholder involvement, and multi-criteria decision analysis methodology, to strengthen their NDCs (Hofman and van der Gaast 2019).

14.3.2.10 Capacity-building

Together with finance, and technology development and transfer, capacity-building is the third of 'the means of implementation and support' specified under the Paris Agreement (see UNFCCC 2015a, Art.

14.1). Capacity-building has primarily been implemented through partnerships, collaboration and different cooperative activities, inside and outside the UNFCCC. This sub-section discusses the provision made in the Paris Agreement for international cooperation on capacity-building. Section 14.4.3 below considers broader cooperative efforts on capacity-building within the UNFCCC.

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 a focus on measures already in place, regional and cooperative activities, and capacity-building needs for strengthening NDCs (UNFCCC 2019h). Of the 168 NDCs submitted as of June 2019, capacity-building was the most frequently requested type of support (113 of 136 conditional NDCs) (Pauw et al. 2020). The focus of capacity-building activities is on enabling developing countries to take effective climate change action, given that many 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). Content analysis of NDCs shows that capacity-building for adaptation is prioritised over mitigation for developing countries, with the element of capacity-building most indicated in NDCs being research and technology (Khan et al. 2020). In addition, developing countries' needs for education, training and awareness-raising for climate change mitigation and adaptation feature prominently in NDCs, particularly those of LDCs (Khan et al. 2020). Differences are evident though between capacity-building needs expressed in the NDCs of LDCs (noting that Khan et al's review was limited to NDCs in English) compared with those of upper-middle income developing countries as categorised by the World Bank (World Bank 2021); the latter have more focus on mitigation with an emphasis on technology development and transfer (Khan et al. 2020).

The Paris Agreement urges all parties to cooperate to enhance the capacity of developing countries to implement the Agreement (UNFCCC 2015a, Art. 11.3), with a particular focus on LDCs and SIDS (UNFCCC 2015a, Art. 11.1). Developed country parties are specifically urged to enhance support for capacity-building actions in developing country Parties (UNFCCC 2015a, Art. 11.3). Article 12 of the Paris Agreement addresses cooperative measures to enhance climate change education, training, public awareness, public participation and public access to information, which can also be seen as elements of capacity-building (Khan et al. 2020). Under the Paris Rulebook, efforts related to the implementation of Article 12 are referred to as 'Action for Climate Empowerment' and parties are invited to develop and implement national strategies on this topic, taking into account their national circumstances (UNFCCC 2019i, para. 6). Actions to enhance climate change education, training, public awareness, public participation, public access to information, and regional and international cooperation may also be taken into account by parties in the global stocktake process under Article 14 of the Paris Agreement (UNFCCC 2019i, para. 9).

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 2015a, Art. 11.1; see also 14.3.2.4 on 'Transparency' above). 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 2015a, Art. 11.2). Parties undertaking capacity-building for developing country parties must 'regularly communicate on these actions or measures.' Developing countries parties have a soft requirement ('should') to communicate progress made on implementing capacity-building plans, policies, actions or measures to implement the Paris Agreement (UNFCCC 2015a, Art. 11.4).

Article 11.5 provides that capacity-building activities 'shall be enhanced through appropriate institutional arrangements to support the implementation of this Agreement, including the appropriate institutional arrangements established under the Convention that serve this Agreement'. The COP decision accompanying the Paris Agreement established the Paris Committee on Capacity-building, with the aim to 'address gaps and needs, both current and emerging, in implementing capacity-building in developing country Parties and further enhancing capacity-building efforts, including with regard to coherence and coordination in capacity-building activities under the Convention' (UNFCCC 2016a, para. 71). The activities of the Committee are discussed further in Section 14.4.3 below. The relevant COP decision also established the Capacity Building Initiative for Transparency (UNFCCC 2016a, para. 84), which is managed by the GEF and designed to support developing country parties in meeting the reporting and transparency requirements under Article 13 of the Paris Agreement (Robinson 2018).

Studies on past capacity-building support for climate mitigation offer some lessons for ensuring effectiveness of arrangements under the Paris Agreement. For example, Umemiya et al. (2020) suggest the need for a common monitoring system at the global level, and evaluation research at the project level to achieve more effective capacity building support. Khan et al. (2020) articulate 'four key pillars' of a sustainable capacity-building system for implementation of NDCs in developing countries: universities in developing countries as institutional hubs; strengthened civil society networks and partnerships; long-term programmatic finance support; and consideration of a capacity-building mechanism under the UNFCCC – paralleling the Technology Mechanism – to marshal, coordinate and monitor capacity-building activities and resources.

14.3.2.11 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 2018b; 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 2019e). The compliance committee is focused on ensuring compliance with a core set of binding procedural obligations (UNFCCC 2019j, Annex, Para. 22). This compliance committee, characterised as 'one of its kind' and an 'an important cornerstone' of the Agreement's legitimacy, effectiveness and longevity (Zihua et al. 2019), is designed to facilitate compliance rather than penalise non-compliance.

START BOX 4.1 HERE

Box 14.1 Key features of the Paris Agreement relevant to mitigation.

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 in Article 2 of stabilising greenhouse gas emissions at a level that would 'prevent dangerous anthropogenic interference with the climate system'. The Agreement sets three 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 aim to reach global peaking of emissions as soon as possible, recognising that peaking will take longer for developing countries, and then to undertake rapid reductions in accordance with the best available science. This is designed to reach global net zero GHG emissions in the second half of the century, with the emissions reductions effort 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' common but 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 (at an individual level) nor to legally binding obligations of result. The compliance mechanism is correspondingly facilitative.

The Paris Agreement establishes a global goal on adaptation, and recognises the importance of averting, minimising and addressing loss and damage associated with the adverse effects of climate change.

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

1. *Ratcheting of NDCs*: Parties must submit a new or updated NDC every 5 years that is in line with the Paris Agreement's expectations of progression over time and the party's highest possible ambition, reflecting common but differentiated responsibilities and respective capabilities in light of different national circumstances.

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 and peers to pressure governments to increase the ambition of their NDCs.

3. *Collective global stocktake*: The global stocktake undertaken every 5 years, starting in 2023, will review the collective progress of countries in achieving the Paris Agreement's goals, 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, communication, implementation and review of NDCs.

For developing countries, the Paris Agreement recognises that increasing mitigation ambition and realising long-term low-emissions development pathways can be bolstered by the provision of financial resources, capacity building, and technology development and transfer. In continuation of existing obligations under the Convention, developed countries are obliged to provide financial assistance to developing countries with respect to mitigation and adaptation. The Paris Agreement also recognizes that Parties may choose to voluntarily cooperate in the implementation of their NDCs to allow for higher ambition in their mitigation and adaptation actions and to promote sustainable development and environmental integrity.

END BOX 4.1 HERE

14.3.3 Effectiveness of the Kyoto Protocol and the Paris Agreement

14.3.3.1 Ex-post assessment of the Kyoto Protocol's effects

Previous assessment reports have assessed the Kyoto Protocol with respect to each of the criteria identified in this chapter. However, at the time of AR5, it was premature to assess the impact of Kyoto on emissions, as this data had not been entirely compiled yet. Since AR5, a number of studies have done so. Chapter 2 of this report lists 24 countries that have sustained absolute emissions reductions for at least a decade, of which 20 are countries that had Kyoto targets for the first commitment period. Most studies have concluded that Kyoto did cause emissions reductions. Such studies find a positive, statistically significant impact on emission reductions in Annex I countries (Kim et al. 2020), Annex B countries (Grunewald and Martínez-Zarzoso 2012; Kumazawa and Callaghan 2012; Grunewald and Martínez-Zarzoso 2016; Maamoun 2019), or all countries respectively (Aichele and Felbermayr 2013; Iwata and Okada 2014). Overall, countries with emission reduction obligations emit on average less CO_2 than similar countries without emission reduction obligations – with estimates ranging from 3-50% (Grunewald and Martínez-Zarzoso 2012, 2016). Maamoun (2019) estimates that the Kyoto Protocol reduced GHG emissions of Annex B countries by 7% on average below a no-Kyoto scenario over 2005 - 2012. Aichele and Felbermayr (2013) conclude that Kyoto reduced CO_2 and GHG emissions by 10% compared to the counterfactual. By contrast, Almer and Winkler (2017) find no evidence for binding emission targets under Kyoto inducing significant and lasting emission reductions for any of the Annex B or non-Annex B countries. The authors identify both negative and positive associations between Kyoto and emissions for several countries in several years, but no coherent picture emerges. Hartl (2019) calculates a Kyoto leakage share in global carbon dioxide trade of 4.3% for 2002-2009.

In terms of transformative potential, the Kyoto Protocol has been found to increase international patent applications for renewable energy technologies, especially in the case of solar energy technologies and especially in countries with more stringent emission reduction targets, and has even led to an increase in patent applications in developing countries not obliged to reduce emissions under Kyoto (Miyamoto and Takeuchi 2019). Kyoto also had a positive and statistically significant impact on the cost-effectiveness of renewable energy projects, as well as renewable energy capacity development as it stimulated the introduction of domestic renewable energy policies (Liu et al. 2019).

The issue of institutional strength of Kyoto has been analysed by many authors, and much of this has been assessed in previous assessment reports. Since AR5, several papers question the environmental efficacy of the Kyoto Protocol based on its institutional design (Rosen 2015; Kuriyama and Abe 2018). Particular attention has focused on Kyoto's market mechanisms (Erickson et al. 2014; Kollmuss et al. 2015).

As described in previous IPCC reports and above, the 1997 Kyoto Protocol included three international market-based mechanisms. These operated 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 CDM) (Grubb et al. 2014; World Bank 2018). Joint Implementation led to limited volumes of emissions credit transactions, mostly from economies in transition but also some Western European countries; International Emissions Trading also led only to limited transaction volumes (Shishlov et al. 2016).

Of the Kyoto Protocol's mechanisms, the CDM market has led to a greater amount of activity, with a 'gold rush' period between 2005 and 2012. The main buyer of CDM credits were private companies surrendering them within the European Union (EU) Emissions Trading System (ETS). Once the EU tightened its rules and restricted the use of CDM credits in 2011, there was a sharp drop in the price of CDM credits in 2012. This price never recovered, as the demand for CDM was very weak after 2012, in part because of the difficulties encountered in securing the entry into force of the Doha Amendment (Michaelowa et al. 2019b).

Assessing the effectiveness of Kyoto's market mechanisms is challenging, and the results have been mixed. (Aichele and Felbermayr 2013; Iwata and Okada 2014; Kuriyama and Abe 2018). Kuriyama and Abe (2018) assessed emission reduction quantities taking into account heightened criteria for additionality. They identified annual energy-related emissions reductions of 49 $MtCO_2e\ y^{-1}$ flowing from the CDM, and non-energy related emissions reductions of 177 $MtCO_2e\ y^{-1}$. Others have pointed to issues associated with non-energy related emission reductions that suggest the latter estimate may be of questionable reliability, while also noting that regulatory tightening led later CDM projects to perform better with respect to the additionality criterion (Michaelowa et al. 2019b). The CDM's contribution to capacity building in some developing countries has been identified as possibly its most important achievement (Spalding-Fecher et al. 2012; Gandenberger et al. 2015; Murata et al. 2016; Dong and Holm Olsen 2017; Lindberg et al. 2018; Xu et al. 2016). There is evidence that the CDM lowered compliance costs for Annex 1 countries by at least USD3.6 billion (Spalding-Fecher et al. 2012). In host countries, the CDM led to the establishment of national approval bodies and the development of an ecosystem of consultants and auditors (Michaelowa et al. 2019b) .

On the negative side, there are numerous findings that the CDM, especially at first, failed to lead to additional emissions cuts in host countries, meaning that the overall effect of CDM projects was to raise global emissions. Cames et al. (2016) concluded that over 70% of CDM projects led to emissions reductions that were likely less than projected, including the absence of additional reductions, while only 7% of projects led to actual additional emissions reductions that had a high likelihood of meeting or exceeding the ex-ante estimates. The primary reason the authors gave was the associated with the low price for CDM credits; this meant that the contribution of the CDM to project finance was negligible, suggesting that most CDM projects would have been built anyway. A meta-analysis of ex-post studies of global carbon markets, which include the CDM, found net combined effects on emission to be negligible (Green 2021). Across, the board, CDM projects have been criticised for lack of 'additionality', problems of baseline determination, uneven geographic coverage (Michaelowa and Michaelowa 2011a; Cames et al. 2016; Michaelowa et al. 2019b), as well as failing to address human rights concerns (Schade and Obergassel 2014).

14.3.3.2 Effectiveness of the Paris Agreement

Given the comparatively recent conclusion of the Paris Agreement, evidence is still being gathered to assess the effectiveness of the Paris Agreement in practice, in particular, since its long-term effectiveness hinges on states communicating more ambitious nationally determined contributions in successive cycles over time. Assessments of the Paris Agreement on paper are necessarily speculative and limited by the lack of credible counterfactuals. Despite these limitations, numerous 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 (Christoff 2016; Clémençon 2016; Young 2016; Dimitrov et al. 2019; Raiser et al. 2020; Keohane and Oppenheimer 2016). There is a divide between studies that do not expect a positive outcome from the Paris Agreement and those that do. The former base this assessment on factors such as: 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 (i.e. non legally-binding) provisions; limited incentives to avoid free-riding; and the Agreement's weak enforcement provisions (Allan 2019), as well as US non-cooperation under the Trump administration and the resulting gap in mitigation, finance and governance (Bang et al. 2016; Spash 2016; Tulkens 2016; Chai et al. 2017; Lawrence and Wong 2017; Thompson 2017; Barrett 2018; Kemp 2018). Studies expecting a positive outcome emphasise 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 (Caparrós 2016; Morgan and Northrop 2017; Urpelainen and Van de Graaf 2018; Hale 2020; Tørstad 2020; Chan 2016a; Falkner 2016b; Victor 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 exceeds the Kyoto Protocol in terms of coverage of GHGs and participation of states in mitigation actions. In terms of coverage of GHGs, the Kyoto Protocol limits its coverage to a defined basket of gases identified in its Annex A (Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6), as well as nitrogen trifluoride (NF_3)). The Paris Agreement does not specify the coverage of gases, thus parties may cover the full spectrum of GHGs in their NDCs as encouraged by the accounting provisions in Annex II to Decision 18/CMA.1 (or conversely choose to exclude important mitigation sectors) and there is also the possibility to include other pollutants such as short-lived climate forcers like black carbon. Article 4.4 calls on developed countries to undertake economy-wide emissions reduction targets with the expectation that developing country parties will also move to introduce these over time. Moreover, the Paris Agreement makes express reference to Parties taking action to conserve and enhance 'sinks and reservoirs of greenhouse gases' (Article 5). As under the UNFCCC and Kyoto Protocol, this allows for coverage of AFOLU emissions, both CO_2 and emissions of other Kyoto Annex A gases, as well as other forms of carbon dioxide removal, including methane (Pekkarinen 2020). A few 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 'well below 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).

As the estimates in Table 4.3 (Chapter 4) demonstrate, communicated unconditional NDCs, if achieved, lead to a reduction of about 7% of world emissions by 2030 in relation to the Kyoto GHGs, and NDCs with conditional elements increase this reduction to about 12% (den Elzen et al. 2016). Although there are uncertainties in the extent to which countries will meet the conditional elements of their NDCs, the experience with the Cancun pledges has been positive, as countries will collectively meet their pledges by 2020, and even individual pledges will be met in most cases, although arguably helped by the COVID-19 pandemic (UNEP 2020). In any case, the main challenge that remains is to close the emissions gap, the difference between what has been pledged and what is needed to achieve by 2030 to reach a 1.5º C compatible path (respectively 2º C) (Roelfsema et al. 2020; UNEP 2020, see also Cross-chapter Box 4 in Chapter 4). In terms of participation of states in mitigation actions, the Paris Agreement performs better than the Kyoto Protocol. The latter contains mitigation targets only for developed countries listed in its Annex B, while the Paris Agreement extends binding procedural obligations in relation to mitigation contributions to all states. It is noted, however, that the Paris Agreement represented a weakening of commitments for those industrialised countries that were parties to the Kyoto Protocol, although a strengthening for those that were not, and for developing countries (Oberthür and Groen 2020). Finally, some analysts have suggested that the recent proliferation of national mid-century net-zero targets – currently 127 countries have considered or adopted such targets – can be attributed, at least in part, to participation in the Paris Agreement and having agreed to its Article 4 (Climate Action Tracker 2020a; Day et al. 2020).

In relation to the criterion of *transformative potential*, there is, as yet, limited empirical data or theoretical analysis on which to assess the Paris Agreement's transformative potential. 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 2018b). There is limited evidence to suggest that this is underway, although there are arguments made that Paris has the right structure to achieve this. 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, as (Labordena et al. 2017) show in the case of solar energy development in Africa. Similarly, Kern and Rogge (2016) argue that the Paris Agreement's global commitment towards complete decarbonisation may play a critical role in accelerating underlying system transitions, by sending a strong signal as to the actions needed by national governments and other international support. Victor et al. (2019) argue that international cooperation that enhances transformative potential needs to operate at the sectoral level, as the barriers to transformation are highly specific to each sector; the Paris Agreement's broad consensus around a clear level of ambition sends a strong signal on what is needed in each sector, but on its own will do little unless bolstered with sectoral-specific action (Geels et al. 2019). On the less optimistic side, it is noted that the extent of the 'investment signal' sent by the Agreement to business is unclear (Kemp 2018), and it is also unclear to what extent the Paris Agreement is fostering investment in break-through technologies. United States non-cooperation from 2017 to 2020 posed a significant threat to adequate investment flows through the GCF (Chai et al. 2017; Urpelainen and Van de Graaf 2018).

In relation to the criterion of *distributive outcomes*, the Paris Agreement performs well in some respects but less well in others, and its performance relative to the Kyoto Protocol is arguably lower in respect of some indicators such as industrialised country leadership, and differentiation in favour of developing countries. While the Kyoto Protocol implemented a multilaterally agreed burden sharing arrangement set out in the UNFCCC and reflected in Annex-based differentiation in mitigation obligations, the Paris Agreement relies on NDCs, accompanied by self-assessments of the fairness of these contributions; some of these do not accord with equity principles of international environmental law, although it is worth noting that the Kyoto Protocol was also not fully consistent with such principles. At present, mechanisms in the Paris Agreement for promoting equitable burden-sharing and evaluating the fairness of parties' contributions are undefined, although numerous proposals have been developed in the literature (Ritchie and Reay 2017; Herrala and Goel 2016; Robiou du Pont et al. 2017; Alcaraz et al. 2019; Sheriff 2019) (discussed in Section 14.3.2.3, above). Zimm and Nakicenovic (2020) analysed the first set of NDCs, and concluded that they would result in a decrease in the inequality of per capita emissions across countries. In relation to other indicators such as the provision of support, the distributive outcomes of the Paris Agreement are dependent on the availability of support through mechanisms such as the GCF to meet the mitigation and adaptation financing needs of developing countries (Antimiani et al. 2017; Chan et al. 2018). One study suggests 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), while other studies offer evidence that the immediate economic, environmental, and social benefits of mitigation in line with developing countries' NDCs exceed those NDCs' costs, and ultimately align the the SDGs (Antwi-Agyei et al. 2018; Vandyck et al. 2018; Caetano et al. 2020) (see Chapter 17). In relation to the promotion of co-benefits the Paris Agreement has enhanced mechanisms for promoting co-benefits (e.g. in some cases for biodiversity conservation through the endorsement of REDD+ initiatives and activities) and linkages to sustainable development (e.g. through the Article 6.4 mechanism). Finally, in its preambular text the Paris Agreement endorses both a human rights perspective and the concept of just transitions, creating potential hooks for further elaboration and expansion of these principles in mitigation actions.

On the criterion of *economic performance*, the Paris Agreement's performance is potentially enhanced by the capacity for parties to link mitigation policies, therefore improving aggregate cost-effectiveness. Voluntary cooperation under Article 6 of the Paris Agreement could facilitate such linkage of mitigation policies (Chan et al. 2018). 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 2019). 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 utilising the full potential of cooperative efforts (Schneider et al. 2019; Michaelowa et al. 2019a).

In relation to the criterion of *institutional strength*, the Paris Agreement's signalling and guidance function is, however, 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 – organised and mobilised 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 decentralised forms of governance (Jordan et al. 2015; Victor 2016) (see further Section 14.5 below). The Agreement has served a catalytic and facilitative role in enabling and facilitating climate action from non-state and sub-state actors (Chan et al. 2015; Hale 2016; Chan et al. 2016; Bäckstrand et al. 2017; Kuyper et al. 2018b). Such action could potentially 'bridge' the ambition gap created by insufficient NDCs from parties (Hsu et al. 2019b). The 2018 UNEP Emissions Gap Report estimates that if 'cooperative initiatives are scaled up to their fullest potential', the impact of non-state and sub-national actors could be up to 15-23 $GtCO_2eq\ yr^{-1}$ by 2030 compared to current policy, which could bridge the gap (Lui et al. 2021). However, at present such a contribution is limited (Michaelowa and Michaelowa 2017; UNEP 2018a). 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 14.5.3 below).

The Paris Agreement's institutional strength in terms of 'rules and standards to facilitate collective action' is disputed given the current lack of comparable information in NDCs (Peters et al. 2017; Pauw et al. 2018; Mayer 2019; Zihua et al. 2019), 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), and may not lead to further ambition (Weikmans et al. 2020). 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. The Paris Agreement does, however, seek to support the building of transparency-related capacity of developing countries, potentially triggering institutional capacity-building at the national, sub-national and sectoral level (see 14.3.2.7).

Ultimately, the overall effectiveness of the Paris Agreement depends on its ability to lead to ratcheting up of collective climate action to meet the long-term global temperature goal (Bang et al. 2016; Christoff 2016; Young 2016; Dimitrov et al. 2019; Gupta and van Asselt 2019). As noted above, there is some evidence that this is already occurring. The design of the Paris Agreement, with 'nationally determined' contributions at its centre, countenances an initial shortfall in collective ambition in relation to the long-term global temperature goal on the understanding and expectation that Parties will enhance the ambition of their NDCs over time (Article 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 (UNFCCC 2016b; UNEP 2018a) (Chapter 4, Box 3). NDCs will need to be substantially scaled up if the temperature goal of the Paris Agreement is to be met (Rogelj et al. 2018, 2016; Höhne et al. 2017, 2018; UNEP 2020). 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 (Sælen 2020; Sælen et al. 2020). This is by no means assured.

In conclusion, it remains to be seen whether the Paris Agreement 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 demanding 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-national actors, and domestic enforcement mechanisms, these have the potential to deliver the necessary collective ambition and implementation. Whether it will do so, remains to be seen.

START CROSS-CHAPTER BOX 10 HERE

Cross-Chapter Box 10: Policy Attribution - Methodologies for estimating the macro-level impact of mitigation policies on indices of GHG mitigation

Authors: Mustafa Babiker (Saudi Arabia), Paolo Bertoldi (Italy), Christopher Bataille (Canada), Felix Creutzig (Germany), Navroz K. Dubash (India), Michael Grubb (United Kingdom), Erik Haites (Canada), Ben Hinder (United Kingdom), Janna Hoppe (Switzerland), Yong-Gun Kim (Republic of Korea), Gregory Nemet (the United States of America), Anthony Patt (Switzerland), Yamina Saheb (France), Raphael Slade (United Kingdom)

This report notes both a growing prevalence of mitigation policies over the past quarter century (Chapter 13), and 'signs of progress' including various quantified indices of GHG mitigation (Chapter 2, Table 2.4). Even though policies implemented and planned to date are clearly insufficient for meeting the Paris long-term temperature goals, a natural question is to what extent the observed macro-level changes (global, national, sectoral, technological) can be attributed to policy developments. This Assessment Report is the first to address that question. This box describes the methods for conducting such 'attribution analysis' as well as its key results, focusing on the extent to which polices have affected three main types of 'outcome indices':

• **GHG emissions**: emissions volumes and trends at various levels of governance including sub- and supra-national levels, and within and across sectors.

• **Proximate emission drivers:** trends in the factors that drive emissions, distinguished through decomposition analyses, notably: energy/GDP intensity and carbon/energy intensity (for energy-related emissions); indices of land use such as deforestation rates (for LULUCF/AFOLU); and more sector-specific component drivers such as the floor area per capita, or passenger kilometres per capita.

• **Technologies:** developments in key low-carbon technologies that are likely to have a strong influence on future emissions trends, notably levels of new investment and capacity expansions, as well as technology costs, with a focus on those highlighted in Chapter 2 Figure 2.30.

Policy attribution examines the extent to which emission-relevant outcomes on these indices – charted for countries, sectors and technologies, particularly in Chapter 2 and the sectoral chapters – may be reasonably attributed to policies implemented prior to the observed changes. Such policies include regulatory instruments such as energy efficiency programmes or technical standards and codes, carbon pricing, financial support for low-carbon energy technologies and efficiency, voluntary agreements, and regulation of land use practices. The sectoral chapters give more detail along with some accounts of policy, whilst trends in mitigation policy adoption are summarised in Chapter 13.

In reviewing hundreds of scientific studies cited in this report, the impacts of adopted policies on observed outcomes were assessed. The vast majority of these studies examine particular instruments in particular contexts, as covered in the sectoral chapters and Chapter 13; only a few have appraised global impacts of policies, directly or plausibly inferred (the most significant are cited in the figure in this box). Typically, studies consider 'mitigation policies' to be those adopted with either a primary objective of reducing GHG emissions or emissions reductions as one among multiple objectives.

Policies differ in design, scope, and stringency, may change over time as they require amendments or new laws, and often partially overlap with other instruments. Overall, the literature indicates that policy mixes are, theoretically and empirically, more effective in reducing emissions, stimulating innovation, and inducing behavioural change than stand-alone policy instruments (Chapter 5 section 5.6; Chapter 13, section 13.7) (Rosenow et al. 2017; Sethi et al. 2020; Best and Burke 2018). Nevertheless, these factors complicate analysis, because they give rise to the potential for double counting emissions reductions that have been observed, and which separate studies can attribute to different policy instruments.

Efforts to attribute observed outcomes to a policy or policy mix is also greatly complicated by the influence of many exogenous factors, including fossil fuel prices and socio-economic conditions. Likewise, technological progress can result from both exogenous causes, such as 'spillover' from other sectors, and policy pressure. Further, other policies, such as fossil fuel subsidies as well as trade-related policies, can partially counteract the effect of mitigation policies by increasing the demand for energy or carbon-intensive goods and services. In some cases, policies aimed at development, energy security, or air quality have climate co-benefits, while others increase emissions.

Studies have applied a number of methods to identify the actual effects of mitigation policies in the presence of such confounding factors. These include statistical attribution methodologies, including experimental and quasi-experimental design, instrumental variable approaches, and simple correlational methods. Typically, the relevant mitigation metric is the outcome variable, while measures of policies and other factors act as explanatory variables. Other methodologies include aggregations and extrapolations from micro-level data evaluation, and inference from combining multiple lines of analysis, including expert opinion. Additionally, the literature contains reviews, many of them systematic in nature, that assess and aggregate multiple empirical studies.

With these considerations in mind, multiple lines of evidence, based upon the literature, support a set of high-level findings, as illustrated in the figure in this box, as follows.

1. **GHG Emissions.** There is robust evidence with a high level of agreement that mitigation policies have had a discernible impact on emissions. Several lines of evidence indicate that mitigation policies have led to avoided global emissions to date by several billion tonnes CO_2-eq annually. The figure in this box shows a selection of results giving rise to this estimate.

As a starting point, one methodologically sophisticated econometric study links global mitigation policies (defined as climate laws and executive orders) to emission outcomes; it estimates emission savings of 5.9 $GtCO_2$ yr^{-1} in 2016 compared to a no-policy world (Eskander and Fankhauser 2020, see Chapter 13.6.2).

A second line of evidence derives from analyses of the Kyoto Protocol. Countries which took on Kyoto Protocol targets accounted for about 24% of global emissions during the first commitment period (2008-12). The most recent robust econometric assessment (Maamoun 2019) estimates that these countries cut GHG emissions by about 7% on average over 2005-2012, rising over the period to around 12% (1.3 $GtCO_2e$ yr^{-1}) *relative to a no-Kyoto scenario.* This is consistent with estimates of Grunewald and Martinez (2016) of about 800 $MtCO_2e$ yr^{-1} averaged to 2009. Developing countries emission reduction projects through the CDM (defined in article 12 of the Kyoto Protocol) were certified as growing to over 240 $MtCO_2e$ yr^{-1} by 2012 (UNFCC 2021c). With debates about the full extent of 'additionality', academic assessments of savings from the CDM have been slightly lower with particular concerns around some non-energy projects (see Chapter 14.3.3.1).

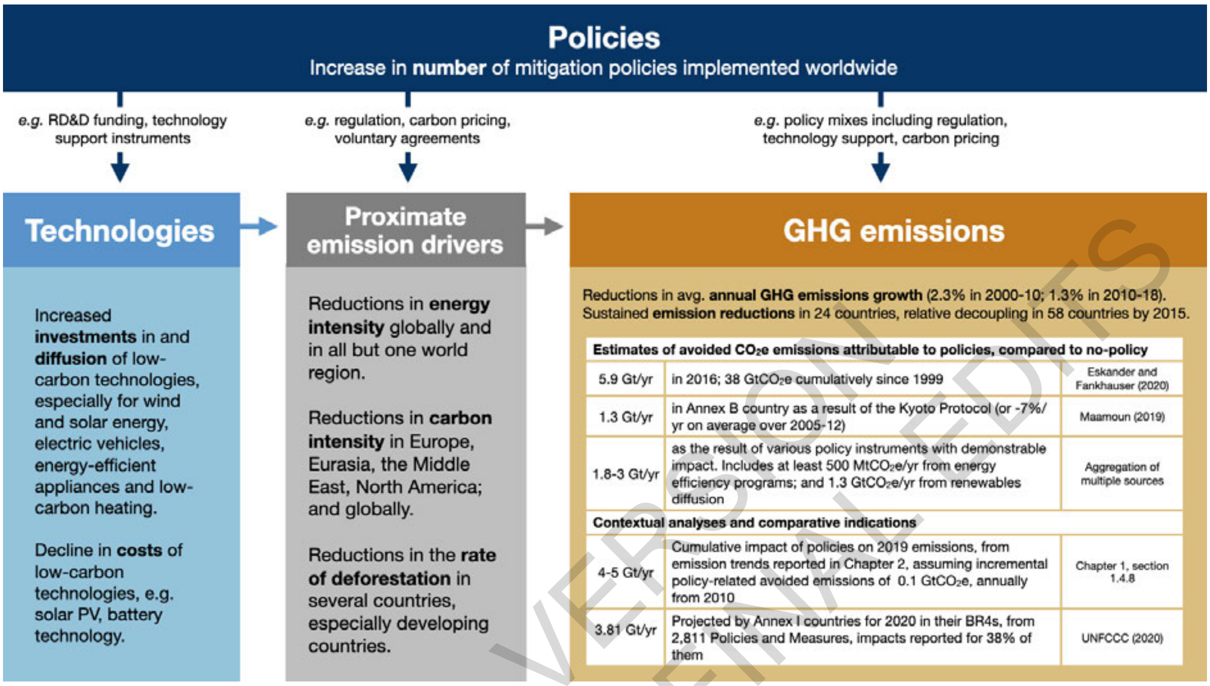
A third line of evidence derives from studies that identify policy-related, absolute reductions from historical levels in particular countries and sectors through decomposition analyses (e.g., Lamb et al. 2021; Le Quéré et al. 2019), or evaluate the impact of particular policies, such as carbon pricing systems. From a wide range of estimates in the literature (see Chapters 2.8.2.2 and 13.6), many evaluations of the EU ETS suggest that it has reduced emissions by around 3% to 9% relative to unregulated firms and/or sectors (Schäfer 2019; Colmer et al. 2020), whilst other factors, both policy (energy efficiency and renewable support) and exogenous trends, played a larger role in the overall reductions seen (Haites 2018).

These findings derived from the peer-reviewed literature are also consistent with two additional sets of analysis. The first set concerns trends in emissions, drawing directly from Chapters 6-11 and Chapter 2, showing that global annual emission growth has slowed as evidenced by annual emission increments of 0.55 $GtCO_2e$ yr^{-1} between 2011 and 2019 compared to 1.014 $GtCO_2e$ yr^{-1} in 2000-08. This suggests avoided emissions of 4-5 Gt yr^{-1} (see also Chapter 1, Figure 1.1d). The second set concerns emissions reductions projected by Annex I governments for 2020 in their fourth biennial reports to the UNFCCC. It is important to note that these are mostly projected annual savings from implemented policies (not *ex-post* evaluations), and there are considerable differences in countries' estimation methodologies. Nevertheless, combining estimates from 38% of the total of 2,811 reported policies and measures yields an overall estimate of 3.81$GtCO_2e$ yr^{-1} emission savings (UNFCCC 2020d).

2. **Proximate emission drivers.** With less overt focus on emissions, studies of trends in energy efficiency, carbon intensity, or deforestation often point to associated policies. The literature s includes an increasing number of studies on demonstrable progress in developing countries. For example, South and South-East Asia have seen energy intensity in buildings improving at ca. 5 – 6% yr^{-1} since 2010 (Chapter 2, Figure 2.22). In India alone, innovative programmes in efficient air conditioning, LED lighting, and industrial efficiency are reported as saving around 25 Mtoe in 2019-2020, thus leading to avoided emissions of over 150 $MtCO_2$ yr^{-1} (see Chapter 16, box 16.3; Malhotra et al. 2021). Likewise, reductions in deforestation rates in several South and Central American and Asian countries are at least partly attributable to ecosystem payments, land use regulation, and internal efforts (Chapter 7.6.2). Finally, the policy-driven displacement of fossil fuel combustion by renewables in energy has led to reductions in carbon intensity in several world regions (Chapters 2 and 6).

3. **Technologies.** The literature indicates unambiguously that the rapid expansion of low-carbon energy technologies is substantially attributable to policy (Chapter 6.7.5, Chapter 16.5). Technology-specific adoption incentives have led to a greater use of less carbon-intensive (e.g. renewable electricity) and less energy-intensive (especially in transport and buildings) technologies. As Chapters 2 and 6 of this report note, modern renewable energy sources currently satisfy over 9% of global electricity demand, and this is largely attributable to policy. There are no global-level studies estimating the avoided emissions due to renewable energy support policies, but there are methods that have been developed to link renewable energy penetration to avoided emissions, such as that of IRENA (2021). Using that method, and assuming that 70% of modern renewable energy expansion has been policy-induced, yields

an estimate of avoided emissions of 1.3 $GtCO_2e\ yr^{-1}$ in 2019. Furthermore, observed cost reductions are the result of policy-driven capacity expansion as well as publicly funded R&D, in individual countries and globally. These correspond with induced effects on number of patents, 'learning curve' correlations with deployed capacity, and cost component and related case study analyses (Kavlak et al. 2018; Nemet 2019; Popp 2019; Grubb et al. 2021).



Cross-Chapter Box 10, Figure 1: Policy impacts on key outcome indices: GHG emissions, proximate emission drivers, and technologies, including several lines of evidence on GHG abatement attributable to policies.

END CROSS-CHAPTER BOX 10 HERE

14.4 Supplementary means and mechanisms of implementation

As discussed above, the Paris Agreement sets in place a new framework for international climate policy albeit one that is embedded in the wider climate regime complex (Coen et al. 2020). Whereas international governance had earlier assumed centre stage, the Paris Agreement recognises the salience of domestic politics in the governance of climate change (Kinley et al. 2020). The new architecture also provides more flexibility for recognising the benefits of working in diverse forms and groups and allows for more decentralised "polycentric" forms of governance (Jordan et al. 2015; Victor 2016). The next two sections address this complementarity between the Paris Agreement and other agreements and institutions.

The Paris Agreement identifies a number of pathways, or means of implementation, towards accomplishing rapid mitigation and the achieving of its temperature goal: finance; capacity building; technology and innovation; and, cooperative approaches and markets (see sections 14.3.2.7-14.3.2.10 above). In this section, we examine each of these means and mechanisms of implementation, and the agreements and institutions lying outside of the Paris Agreement that contribute to each. In the following Section, 14.5, we examine the agreements and institutions playing other governance roles: regulating activities in particular sectors; linking climate mitigation with other activities such as adaptation; and, stimulating and coordinating the actions of non-state actors at a global scale.

Figure 14.3 maps out the interlinkages described in the text of the sections 14.4 and 14.5. It is an incomplete list, but illustrates clearly that across multiple types of governance, there are multiple instruments or organisations with activities connected to the different governance roles associated with the Paris Agreement and the UNFCCC more generally.

Type	Instrument / Organization	Mitigation	Transparency	Sinks	Markets	Finance	Technology	Capacity building
Global treaties	Montreal Protocol	14.5.1.1				14.5.1.1		
	CBD	14.5.1.1		14.5.2.1				
	UNCCD			14.5.2.1				14.5.2.1
	Minimata Mercury Convention	14.5.1.1						
United Nations Programmes and Specialised Agencies	UN REDD+ programme	14.5.1.1		14.5.2.1		14.5.2.1		14.4.3
	UNEP	14.5.1.1						14.4.3
	UNDP							14.4.3
	UNIDO							14.4.1.2
	UNOSSC							14.4.1.2
	FAO			14.5.2.1				14.4.1.2
	ICAO	14.5.2.3			14.5.2.3		14.5.2.3	
	IMO	14.5.2.3	14.5.2.3				14.5.2.3	
Other global organisations	IEA						14.5.2.2	
	IRENA					14.5.2.2	14.5.2.2	14.5.2.2
	MDBs	14.4.1.2	14.4.1.2	14.5.4	14.4.4	14.4.1.2		14.4.3
Regional, multi- and bilateral agreements	LRTAP	14.5.1.1						
	MIGA					14.5.2.2		
	PPCA	14.5.2.2						
	Regional trade agreements	14.5.1.3			14.5.1.3		14.5.1.3	
	Bilateral development programs				14.4.4	14.4.1.1	14.4.1.1	14.4.3
	International science programmes						14.4.2	
	South South Cooperation					14.5.1.4	14.5.1.4	14.4.3
Non-state transnational actors	Global city networks	14.5.5		14.5.5		14.5.5	14.5.5	14.5.5
	Environmental NGOs	14.5.2.2	14.5.4			14.5.3		
	Social movements	14.5.3		14.5.3				
	Business partnerships	14.5.4	14.5.4			14.5.4	14.5.4	14.5.4

Figure 14.3 Climate governance beyond the UNFCCC. The figure shows those relationships, marked in blue, between international governance activities, described in the text, that relate to activities of the UNFCCC and Paris Agreement.

14.4.1 Finance

International cooperation on climate finance is underpinned by various articles of the UNFCCC including Articles 4.3, 4.4, 4.5, 4.7 and 11.5 (UNFCCC 1992). This was further amplified through the commitment by developed countries in the Copenhagen Accord and the Cancun Agreements to mobilise jointly through various sources USD100 billion yr^{-1} by 2020 to meet the needs of the developing countries (UNFCCC 2010b). This commitment was made in the context of meaningful mitigation action and transparency of implementation. As mentioned earlier in Section 14.3.2.8, in the Paris Agreement the binding obligation on developed country parties to provide financial resources to assist developing country parties applies to both mitigation and adaptation (UNFCCC 2015a, Art. 9.1). In 2019, climate finance provided and mobilised by developed countries was in the order of USD79.6 billion, coming from different channels including bilateral and multilateral channels, and also through mobilisation of the private sector attributable to these channels (OECD 2021). A majority (two-thirds) of these flows targeted mitigation action exclusively (see also Chapter 15). These estimates, however, have been criticised on various grounds, including that they are an overestimate and do not represent climate specific net assistance only; that in grant equivalence terms the order of magnitude is lower; and the questionable extent of transparency of information on mobilised private finance, as well as the direction of these flows (Carty et al. 2020). On balance, such assessments need to be viewed in the context of the original commitment, the source of the data and the evolving guidance, and modalities and procedures from the UNFCCC processes. As mentioned in Chapter 15, the measurement of climate finance flows continues to face definitional, coverage and reliability issues despite progress made by various data providers and collators (see section 15.3.2 in Chapter 15).

The multiplicity of actors providing financial support has resulted in a fragmented international climate finance architecture as indicated in Section 14.3.2.8. It is also seen as a system which allows for speed, flexibility and innovation (Pickering et al. 2017). However, the system is not yet delivering adequate flows given the needs of developing countries (see Section 14.3.2.8). An early indication of these self-assessed needs is provided in the conditional NDCs. Of the 136 conditional NDCs submitted by June 2019, 110 have components or additional actions conditioned on financing support for mitigation and 79 have components or additional actions for support for adaptation (Pauw et al. 2020). While the Paris Agreement did not explicitly countenance conditionality for actions in developing countries, it is generally understood that the ambition and effectiveness of climate ambition in these countries is dependent on financial support (Voigt and Ferreira 2016b).

14.4.1.1 Bilateral finance

The Paris Agreement and the imperative for sustainable development reinforce the need to forge strong linkages between climate and development (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).

The UNFCCC website cites some 20 bilateral development agencies providing support to climate change programs in developing countries (UNFCCC 2020a). These agencies provide a mix of development cooperation, policy advice and support and financing for climate change projects. Since the year 2000, the OECD Development Assistance Committee has been tracking trends in climate-related development finance and assistance. The amount of bilateral development finance with climate relevance has increased substantially since 2000 (OECD 2019a). For 2019, it was reported to be USD28.8 billion in direct finance and USD2.6 billion through export credit agencies. Further, another USD34.1 billion of the climate finance provided through multilateral channels is attributable to the developed countries (OECD 2021). The OECD methodology has been critiqued as it uses Rio markers the limitations of which could lead to erroneous reporting and assessment of finance provided as well as the mitigation outcome (Michaelowa and Michaelowa 2011b; Weikmans and Roberts 2019). This issue is to be addressed through the modalities, procedures and guidance under the Enhanced Transparency Framework of the Paris Agreement (see Section 14.3.2.4), through the mandate to Subsidiary Body for Scientific and Technological Advice (SBSTA) to develop Common Tabular Formats (CTFs) for the reporting of information on, *inter alia*, financial support provided, mobilised and received (UNFCCC 2019k). Until then, the Biennial Assessment Report prepared by the Standing Committee on Finance provides the best available information on financial support.

14.4.1.2 Multilateral finance

Multilateral Development Banks (MDBs) comprise six global development banks that include the European Investment Bank (EIB), International Fund for Agricultural Development (IFAD), International Investment Bank (IIB), New Development Bank (NDB), OPEC Fund for International Development (OFID), and the World Bank Group, six regional development banks that include the African Development Bank (AfDB), Asian Development Bank (AsDB), Asian Infrastructure Investment Bank (AIIB), European Bank for Reconstruction and Development (EBRD), Inter-American Development Bank (IADB), and the Islamic Development Bank (IsDB), and thirteen sub-regional development banks that include the 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), and the West African Development Bank (BOAD). Together 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 (Engen and Prizzon 2018). 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.

In 2015, twenty representative MDBs and members of the International Development Finance Club unveiled five voluntary principles to mainstream climate action in their investments, including commitment to climate strategies, managing climate risks, promoting climate smart objectives, improving climate performance and accounting for their own actions (World Bank 2015a; Institute for Climate Economics 2017). The members subscribing to these principles have since grown to 44 in January 2020. 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).

The MDBs as a cohort have been collaborating and coordinating in reporting on climate financing since 2012 following a commitment made in 2012 at the Rio +20 summit (MDB 2012). This has engendered other forms of collaboration among the MDBs, including: commitments to collectively total at least USD65 billion annually by 2025 in climate finance, with USD50 billion for low and middle income economies; to mobilise a further USD40 billion annually by 2025 from private sector investors, including through the increased provision of technical assistance, use of guarantees, and other de-risking instruments; and to commit to helping clients deliver on the goals of the Paris Agreement; building a transparency framework on impact of MDBs' activities and enabling clients to move away from fossil fuels (Asian Development Bank 2019). While the share of MDBs in direct climate financing is small, their role in influencing national development banks and local financial institutions, and leveraging and crowding in private investments in financing sustainable infrastructure, is widely recognised (NCE 2016). However, with this recognition there is also an exhortation to do more to align with the goals of the Paris Agreement, including a comprehensive examination of their portfolios beyond investments that directly support climate action to also enabling the long-term net zero GHG emissions trajectory (Cochran and Pauthier 2019; Larsen et al. 2018). Further, a recent assessment has shown that MDBs perform relatively better in mobilising other public finance than private co- financing (Thwaites 2020). In addition, the banks have launched or are members of significant initiatives such as the Climate and Clean Air Coalition (CCAC) to reduce short lived climate pollutants, the Carbon Pricing Leadership Coalition (CPLC), the Coalition for Climate Resilient Investment (CCRI) and the Coalition of Finance Ministers for climate action. These help to spur action at different levels, from economic analysis, to carbon financing and convenors of finance and development ministers for climate action, with leadership of many of these initiatives led by the World Bank.

The multilateral climate funds also have a role in the international climate finance architecture. This includes, as mentioned in Section 14.3.2.8, those established under the UNFCCC's financial mechanism, its operating entities, the Global Environment Facility (GEF), which also manages two special funds, the Special Climate Change Fund (SCCF) and the Least Developed Countries Fund (LDCF); the Green Climate Fund (GCF), also an operating entity of the financial mechanism which in 2015, was given a special role in supporting the Paris Agreement. The GCF aims to provide funding at scale, balanced between mitigation and adaptation, using various financial instruments including grants, loans, equity, guarantees or others to activities that are aligned with the priorities of the countries compatible with the principle of country ownership (GCF 2011). The GCF faces many challenges. While some see the GCF as an opportunity to transform and rationalise what is now a complex and fragmented climate finance architecture with insufficient resources and overlapping remits (Nakhooda et al. 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 and Dubash 2016).

Leveraging private funds and investments by the public sector, taking risks to unlock climate action are also expressed strategic aims of the GCF.

The UN system is also supporting climate action through much needed technical assistance and capacity building, which is complementary to the financial flows insofar as it enables countries with relevant tools and methodologies to assess their needs, develop national climate finance roadmaps, establish relevant institutional mechanisms to receive support and track it, enhance readiness to access financing, and include climate action across relevant national financial planning and budgeting processes (UN 2017a). The United Nations Development Programme (UNDP) is the largest implementer of climate action among the UN Agencies, with others, such as the Food and Agriculture Organisation (FAO), United Nations Environment Programme (UNEP), United Nations Industrial Development Organisation (UNIDO), and United Nations Office for South-South Cooperation (UNOSSC), providing relevant support.

The current architecture of climate finance is one that is primarily based on north-south, developed-developing country dichotomies. The Paris Agreement, however, has clearly recognised the role of climate finance flows across developing countries, thereby enhancing the scope of international cooperation (Voigt and Ferreira 2016b). Estimates of such flows, though, are not readily available. According to one estimate in 2020 the flows among non-OECD countries were of the order of USD29 billion (CPI 2021).

14.4.1.3 Private sector financing

There is a growing recognition of the importance of mobilising private sector financing including for climate action (World Bank 2015b; Michaelowa et al. 2020b). An early example of the mobilisation of the private sector in a cooperative mode for mitigation outcomes is evidenced from the Clean Development Mechanism of the Kyoto Protocol and the linking with the European Union’s Emissions Trading Scheme, both triggered by relevant provisions in the Kyoto Protocol (see Section 14.4.4) and lessons learnt from this are relevant for development of market mechanisms in the post Paris Agreement period (Michaelowa et al. 2019b). In 2019/2020, on an average for the two years, public and private climate financing was on the order of USD632 billion, of which USD310 billion originated from the private sector. However, as much as 76% of the (overall) finance stayed in the country of origin. This trends holds true also for private finance (CPI 2021). Figure 14.4 depicts the international climate finance flows totalling USD161 billion reported in 2020, about 19% were private flows. For (international) mitigation financing flows of USD116 billion, the share provided by private sources was 24%.

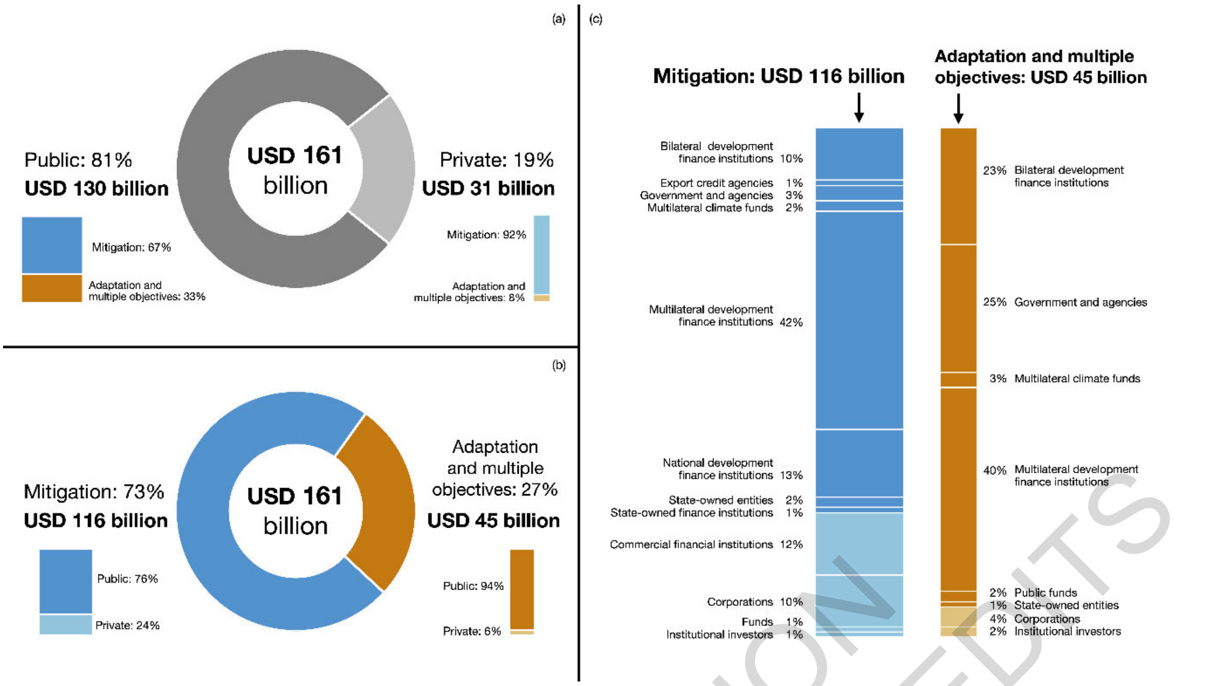


Figure 14.4 International Finance Flows. Total international climate financial flows for 2020 were USD161 billion. By comparison, public sector bilateral and multilateral finance in 2017 for fossil fuel development, including gas pipelines, was roughly USD4 billion. Part (a) disaggregates total financial flows according to public and private sources, and indicates the breakdown between mitigation on the one hand, and adaptation and multiple objectives on the other, within each source. Part (b) disaggregates total financial flows according to intended purpose, namely mitigation or adaptation and multiple objectives, and disaggregates each type according to source. Part (c) provides additional detail on the relative contributions of different public and private sources. Sources: (CPI 2021; OECD 2021).

Foreign direct investments and its greening is seen as a channel for increasing cooperation. An assessment of the greenfield foreign direct investment in different sectors shows the growing share of renewable energy at USD92.2 billion (12% of the volume and 38% of the number of projects) (FDI Intelligence 2020). Coal, oil and gas sectors maintain the top spot for capital investments globally. Over the last decade there is growing issuance of green bonds with non-financial private sector issuance gaining ground (Almeida 2020). While it is questionable if green bonds have a significant impact on shifting capital from non-sustainable to sustainable investments, they do incentivise the issuing organisations to enhance their green ambition and have led to an appreciation within capital markets of green frameworks and guidelines and signalling new expectations (Maltais and Nykvist 2020). In parallel, institutional investors including pension funds are seeking investments that align with the Paris Agreement (IIGCC 2020). However, the readiness of institutional investors to make this transition is arguable (OECD 2019b; Ameli et al. 2020). This evidence suggests that international private financing could play an important role but this potential is yet to be realised (see Chapter 15).

14.4.2 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 (de Coninck and Sagar 2015a). The OECD finds that single countries alone often cannot provide effective solutions to today's global challenges, as these cross national borders and affect different actors (OECD 2012). Madani (2020) shows how conflict, including international sanctions, can reduce science and innovation capacity, which is not evenly distributed, particularly across the developed and the developing world. For this reason, many countries have introduced strategies and policies to enhance international cooperation in science and technology (Chen et al. 2019). 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 2015b,a).

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 Long-Range Transboundary Air Pollution Convention and the Montreal Protocol were both informed by scientific assessments based on collaboration and cooperation of scientists across several geographies (Andresen et al. 2000). 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. Lui et al. (2021) find that such initiatives could make a major contribution to global emissions reduction, Bakhtiari (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; Wagner et al. (2017) found significant increases in both the proportion of papers written by author teams from multiple countries, and in the number of countries participating in such collaboration, over the time period 1990 - 2013. 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 help bridge the science and policy interface, and 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 processes need to be enriched for this to happen more effectively (Kowarsch et al. 2016)

A particular locus for international cooperation on technology development and innovation is found within institutions and mechanisms of the UN climate regime. The UNFCCC, in Article 4.1(c), calls on 'all parties' to 'promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases' and places responsibility on developed country parties to 'take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to environmentally sound technologies and know-how to other parties, particularly developing country parties, to enable them to implement the provisions of the Convention' (UNFCCC 1992, Art. 4.5). The issue of technology development and transfer has continued to receive much attention in the international climate policy domain since its initial inclusion in the UNFCCC in 1992 – albeit often overshadowed by dominant discourses around market-based mechanisms – and its role in reducing GHG emissions and adapting to the consequences of climate change 'is seen as becoming ever more critical' (de Coninck and Sagar 2015a). Milestones in the development of international cooperation on climate technologies under the UNFCCC have included: (1) the development of a technology transfer framework and establishment of the Expert Group on Technology Transfer (EGTT) under the Subsidiary Body for Scientific and Technological Advice (SBSTA) in 2001; (2) recommendations for enhancing the technology transfer framework put forward at the Bali Conference of the Parties in 2007 and creation of the Poznan strategic program on technology transfer under the Global Environmental Facility (GEF); and (3) the establishment of the Technology Mechanism by the Conference of the Parties in 2010 as part of the Cancun Agreements (UNFCCC 2010b). The Technology Mechanism is presently the principal avenue within the UNFCCC for facilitating cooperation on the development and transfer of climate technologies to developing countries (UNFCCC 2015b). As discussed in Section 14.3.2.9 above, the Paris Agreement tasks the Technology Mechanism also to serve the Paris Agreement (UNFCCC 2015b, Art. 10.3).

The Technology Mechanism consists of the Technology Executive Committee (TEC) (replacing the EGTT), as its policy arm, and the Climate Technology Centre and Network (CTCN), as its implementation arm (UNFCCC 2015b). The TEC focuses on identifying and recommending policies that can support countries in enhancing and accelerating the development and transfer of climate technologies (UNFCCC 2020b). The CTCN facilitates the transfer of technologies through three core services: (1) providing technical assistance at the request of developing countries; (2) creating access to information and knowledge on climate technologies; and (3) fostering collaboration and capacity-building (CTCN 2020a). The CTCN 'network' consists of a diverse set of climate technology stakeholders from academic, finance, non-government, private sector, public sector, and research entities, together with more than 150 National Designated Entities, which serve as CTCN national focal points. Through its network, the CTCN seeks to mobilise policy and technical expertise to deliver technology solutions, capacity-building and implementation advice to developing countries (CTCN 2020b). At the Katowice UNFCCC Conference of the Parties in 2018, the TEC and CTCN were requested to incorporate the technology framework developed pursuant to Article 10 of the Paris Agreement into their respective workplans and programmes of work (UNFCCC 2019f).

The Joint Annual Report of the TEC and CTCN for 2019 indicated that, as of July 2019, the CTCN had engaged with 93 developing country parties regarding a total of 273 requests for technical assistance, including 11 multi-country requests. Nearly three-quarters (72.9%) of requests received by the CTCN had a mitigation component, with two-thirds of those mitigation requests related to either renewable energy or energy efficiency. Requests for decision-making or information tools are received most frequently (28% of requests), followed by requests for technology feasibility studies (20%) and technology identification and prioritisation (18%) (TEC and CTCN 2019).

The CTCN is presently funded from 'various sources, ranging from the [UNFCCC] Financial Mechanism to philanthropic and private sector sources, as well as by financial and in-kind contributions from the co-hosts of the CTCN and from participants in the Network' (TEC and CTCN 2019, para. 97). Oh (2020b) describes the institution as 'mainly financially dependent on bilateral donations from developed countries and multilateral support'. Nevertheless, inadequate funding of the CTCN poses a problem for its effectiveness and capacity to contribute to implementation of the Paris Agreement. A 2017 independent review of the CTCN identified 'limited availability of funding' as a key constraint on its ability to deliver services at the expected level and recommended that '[b]etter predictability and security over financial resources will ensure that the CTCN can continue to successfully respond to its

COP mandate and the needs and expectations of developing countries' (Ernst & Young 2017, para. 84). The 2019 Joint Report of the TEC and CTCN indicates that resource mobilisation for the Network remains a challenge (TEC and CTCN 2019, pp. 23-24).

The importance of 'financial support' for strengthening cooperative action on technology development and transfer was recognised in Article 10.6 of the Paris Agreement. The technology framework established by the Paris Rulebook specifies actions and activities relating to the thematic area of 'support' as including: (a) enhancing the collaboration of the Technology Mechanism with the Financial Mechanism; (b) identifying and promoting innovative finance and investment at different stages of the technology cycle; (c) providing enhanced technical support to developing country parties, in a country-driven manner, and facilitating their access to financing for innovation, enabling environments and capacity-building, developing and implementing the results of TNAs, and engagement and collaboration with stakeholders, including organisational and institutional support; and (d) enhancing the mobilisation of various types of support, including pro bono and in-kind support, from various sources for the implementation of actions and activities under each key theme of the technology framework.

Notwithstanding the technology framework's directive for enhanced collaboration of the Technology and Financial Mechanisms of the UNFCCC, linkages between them, and particularly to the GCF, continue to engender political contestation between developing and developed countries (Oh 2020b). Developing countries sought to address concerns over the unsustainable funding status of the CTCN by advocating linkage through a funding arrangement or financial linkage, whereas developed countries favour the design of an institutional linkage maintaining the different and separate mandates of the CTCN and the GCF (Oh 2020a,b). With no resolution reached, the UNFCCC COP requested the Subsidiary Body for Implementation, at its fifty-third session, to take stock of progress in strengthening the linkages between the Technology Mechanism and the Financial Mechanism with a view to recommending a draft decision for consideration and adoption by the Glasgow COP, scheduled for 2021 (UNFCCC 2019l).

14.4.3 Capacity Building

International climate cooperation has long focused on supporting developing countries in building capacity to implement climate mitigation actions. While there is no universally agreed definition of capacity-building and the UNFCCC does not define the term (Khan et al. 2020), elements of capacity-building can be discerned from the Convention's provisions on education and training programmes (UNFCCC 1992, Art. 6), as well as the reference in Article 9(2)(d) of the UNFCCC to the Subsidiary Body for Scientific and Technological Advice (SBSTA) providing support for 'endogenous capacity-building in developing countries.'

Capacity-building is generally conceived as taking place at three levels: individual (focused on knowledge, skills and training), organisational/institutional (focusing on organisational performance and institutional cooperation) and systemic (creating enabling environments through regulatory and economic policies (Khan et al. 2020; UNFCCC 2021b). In its annual synthesis report for 2018, the UNFCCC secretariat 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 in Section 14.5.1.4 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 measurement, reporting and verification (MRV) through the Alliance of the Pacific and a climate action package launched by Singapore).

Beyond the UNFCCC, other climate cooperation and partnership activities on capacity building include climate-related bilateral cooperation and those organised by the OECD, IFDD (Francophonie Institute for Sustainable Development), UNDP-NCSP programme, UNEP and the World Bank.

Climate-related bilateral cooperation provides important human and institutional capacity building supports for climate change actions and activities in developing countries, particularly through developed countries' bilateral cooperation structures, such as the French Development Agency (AFD), the German Development Agency (The Deutsche Gesellschaft für Internationale Zusammenarbeit – GIZ), the Japanese International Cooperation Agency (JICA) and others.

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 realisation in the Southeast Asian region, the World Health Organisation's Global Salm-Surv network, the Red Iberoamericana de Oficinas de Cambio Climático network and the Africa Adaptation Initiative. Many climate-related capacity-building initiatives, including those coordinated or funded by international or regional institutions, are implemented at the national and sub-national level, often with the involvement of universities, consultancy groups and civil society actors.

It is also noted that comprehensive support is provided by the GCF to developing countries (GCF, 2020). This support is made available and accessible for all developing countries through three different GCF tools: the Readiness Programme, the Project Preparation Facility, and the funding of transformative projects and programmes. The goal of the Readiness Programme is to strengthen institutional capacities, governance mechanisms, and planning and programming competencies in support of developing countries' transformational long-term climate policies (GCF, 2020). Despite a decades-long process of capacity-building efforts under many development and environmental regimes, including the UNFCCC, progress has been uneven and largely unsuccessful in establishing institution-based capacity in developing countries (Robinson 2018). In an effort to improve capacity-building efforts within the UNFCCC, in 2015, the Paris Committee on Capacity-building (PCCB) was established by the COP decision accompanying the Paris Agreement as the primary body for enhancing capacity-building efforts, including by improving coherence and coordination in capacity-building activities (UNFCCC 2016a, para. 71). The activities of the Committee include the provision of guidance and technical support on climate change training and capacity building, raising awareness and sharing climate information and knowledge. During 2020, the PCCB was able, despite the Covid-19 situation, to hold its 4th meeting, implement and assess its 2017-2020 work plan, and develop and agree on its future roadmap (2021-2024) (UNFCCC Subsidiary Body for Implementation 2020). Non-governmental organisations such as the Coalition on Paris Agreement Capacity-building provide expert input to the PCCB.

Quantifying the contribution of capacity-building efforts to climate mitigation is acknowledged to be 'difficult, if not impossible' (Hsu et al. 2019a). Nonetheless, such activities 'may play a valuable role in building a foundation for future reductions' by providing 'necessary catalytic linkages between actors' (Hsu et al. 2019a).

14.4.4 Cooperative mechanisms and markets

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), particularly if mechanisms are scaled up from projects and programmes (Michaelowa et al. 2019b). Progress as to developing such mechanisms has however so far been moderate and uneven.

Of the three international market-based mechanisms under the 1997 Kyoto Protocol discussed in Section 14.3.2.7, and in previous IPCC reports, only the CDM or a similar mechanism may have a role to play under the Paris Agreement, although the precise terms are yet to be decided.

Article 6, also discussed in Section 14.3.2.7, is the main framework to foster enhanced cooperation within the Paris Agreement. Although there is an emerging global landscape of activities based on Article 6 (Greiner et al. 2020), such as the bilateral treaty signed under the framework of Article 6 in October 2020 by Switzerland and Peru, the possibilities of bilateral cooperation are yet to be fully exploited. As discussed above, adequate accounting rules are key to the success of Article 6. Sectoral agreements are also a promising cooperative mechanism, as discussed in Section 14.5.2. In fact, both bilateral and sectoral agreements have the potential to enhance the ambition of the parties involved and can eventually serve as building blocks towards more comprehensive agreements (see the discussion in Section 14.2.2).

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, Kazakhstan and several US states and Canadian provinces (Wettestad and Gulbrandsen 2018). More systems are in the pipeline, including Mexico and Thailand (ICAP 2019). The link between the EU and Switzerland entered into force in January 2020 and other linkages are being negotiated. Scholars analyse the potential benefits of these multilateral linkages and demonstrate that these can be significant (Doda et al. 2019; Doda and Taschini 2017). Over time, the linkages of national emission trading systems can be seen as building blocks to a strategic enlargement of international cooperation (Caparrós and Péreau 2017; Mehling 2019). The World Bank has emerged as an important lynchpin and facilitator of knowledge-building and sharing of lessons about the design and linking of carbon markets, through initiatives such as the Partnership for Market Readiness, Networked Carbon Markets and the Carbon Pricing Leadership Coalition (Wettestad et al. 2021).

However, it is important to distinguish between theory and practice. The practice of ETS linking so far demonstrates a few attempts that did not result in linkages due to shifts of governments and political preferences (for instance the process between the EU and Australia, and Ontario withdrawing from the WCI) (Bailey and Inderberg 2018). 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 et al. 2014; Gulbrandsen et al. 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 (Doda and Taschini 2017; Mehling et al. 2018; Doda et al. 2019), but are all marginal if one focuses on existing experiences (Haites 2016; Schneider et al. 2017; Spalding-Fecher et al. 2012; La Hoz Theuer et al. 2019; Schneider et al. 2019).

14.4.5 International Governance of SRM and CDR

While Solar Radiation Modification (SRM) and Carbon Dioxide Removal (CDR) were often referred to as 'geoengineering' in earlier IPCC reports and in the literature, IPCC SR1.5 started to explore SRM and CDR more thoroughly and to highlight the differences between – but also within – both approaches more clearly. This section assesses international governance of both SRM and CDR, recognizing that CDR, as a mitigation option, is covered elsewhere in this report, whereas SRM is not. Chapter 12 of this report covers the emerging national, sub-national and non-state governance of CDR, while chapters 6, 7 and 12 also assess the mitigation potential, risks and co-benefits of some CDR options. Chapters 4 and 5 of the WGI Report assess the physical climate system and biogeochemical responses to different SRM and CDR methods. The Cross Working Group Box 5 on SRM (WGII, Chapter 16 and Cross-Working Group Box 4 in WGIII below) gives a brief overview of solar radiation modification methods, risks, benefits, ethics and governance.

START CROSS-WORKING GROUP BOX 4 HERE

Cross-Working Group Box in WGII and Cross-Working Group Box 4 in WGIII

Cross-Working Group Box 4: Solar Radiation Modification (SRM)

Authors: Govindasamy Bala (India), Heleen de Coninck (the Netherlands), Oliver Geden (Germany), Veronika Ginzburg (the Russian Federation), Katharine J. Mach (the United States of America), Anthony Patt (Switzerland), Sonia I. Seneviratne (Switzerland), Masahiro Sugiyama (Japan), Christopher H. Trisos (Republic of South Africa), Maarten van Aalst (the Netherlands)

Proposed Solar Radiation Modification Schemes

This cross-working group box assesses Solar Radiation Modification (SRM) proposals, their potential contribution to reducing or increasing climate risk, as well as other risks they may pose (categorised as risks from responses to climate change in the IPCC AR6 risk definition in 1.2.1.1), and related perception, ethics and governance questions.

SRM refers to proposals to increase the reflection of shortwave radiation (sunlight) back to space to counteract anthropogenic warming and some of its harmful impacts (de Coninck et al. 2018) (Cross-Working Group Box 4; WGI Chapter 4 and Chapter 5). A number of SRM options have been proposed, including: Stratospheric Aerosol Interventions (SAI), Marine Cloud Brightening (MCB), Ground-Based Albedo Modifications (GBAM), and Ocean Albedo Change (OAC). Although not strictly a form of SRM, Cirrus Cloud Thinning (CCT) has been proposed to cool the planet by increasing the escape of longwave thermal radiation to space and is included here for consistency with previous assessments (de Coninck et al. 2018). SAI is the most-researched proposal. Modeling studies show SRM could reduce surface temperatures and potentially ameliorate some climate change risks (with more confidence for SAI than other options), but SRM could also introduce a range of new risks.

There is high agreement in the literature that for addressing climate change risks SRM cannot be the main policy response to climate change and is, at best, a supplement to achieving sustained net zero or net negative CO_2 emission levels globally (de Coninck et al. 2018; MacMartin et al. 2018; Buck et al. 2020; National Academies of Sciences Engineering and Medecine 2021). SRM contrasts with climate change mitigation activities, such as emission reductions and CDR, as it introduces a ‘mask’ to the climate change problem by altering the Earth’s radiation budget, rather than attempting to address the root cause of the problem, which is the increase in GHGs in the atmosphere. In addition, the effects of proposed SRM options would only last as long as a deployment is maintained— e.g. requiring ca. yearly injection of aerosols in the case of SAI as the lifetime of aerosols in the stratosphere is 1-3 years (Niemeier et al. 2011) or continuous spraying of sea salt in the case of MCB as the lifetime of sea salt aerosols in the atmosphere is only about 10 days—which contrasts with the long lifetime of CO_2 and its climate effects, with global warming resulting from CO_2 emissions likely remaining at a similar level for a hundred years or more (MacDougall et al. 2020) and long-term climate effects of emitted CO_2 remaining for several hundreds to thousands of years (Solomon et al. 2009).

Which scenarios?

The choice of SRM deployment scenarios and reference scenarios is crucial in assessment of SRM risks and its effectiveness in attenuating climate change risks (Keith and MacMartin 2015; Honegger et al. 2021a). Most climate model simulations have used scenarios with highly stylized large SRM forcing to fully counteract large amounts of warming in order to enhance the signal-to-noise ratio of climate responses to SRM (Kravitz et al. 2015; Sugiyama et al. 2018a; Krishnamohan et al. 2019).

The effects of SRM fundamentally depend on a variety of choices about deployment (Sugiyama et al. 2018b), including: its position in the portfolio of human responses to climate change (e.g., the magnitude of SRM used against the background radiative forcing), governance of research and potential deployment strategies, and technical details (latitude, materials, and season, among others, see WGI Chapter 4.6.3.3). The plausibility of many SRM scenarios is highly contested and not all scenarios are equally plausible because of socio-political considerations (Talberg et al. 2018), as with, for example, CDR (Fuss et al. 2014, 2018). Development of scenarios and their selection in assessments should reflect a diverse set of societal values with public and stakeholder inputs (Sugiyama et al. 2018a; Low and Honegger 2020), as depending on the focus of a limited climate model simulation, SRM could look grossly risky or highly beneficial (Pereira et al. 2021).

In the context of reaching the long-term global temperature goal of the Paris Agreement, there are different hypothetical scenarios of SRM deployment: early, substantial mitigation with no SRM, more limited or delayed mitigation with moderate SRM, unchecked emissions with total reliance on SRM, and regionally heterogeneous SRM. Each scenario presents different levels and distributions of SRM benefits, side effects, and risks. The more intense the SRM deployment, the larger is the likelihood for the risks of side effects and environmental risks (e.g., Heutel et al., 2018). Regional disparities in climate hazards may result from both regionally-deployed SRM options such as GBAM, and more globally uniform SRM such as SAI (Jones et al. 2018; Seneviratne et al. 2018). There is an emerging literature on smaller forcings of SAI to reduce global average warming, for instance, to hold global warming to 1.5°C or 2°C alongside ambitious conventional mitigation (Jones et al. 2018; MacMartin et al. 2018), or bring down temperature after an overshoot (Tilmes et al. 2020). If emissions reductions and CDR are deemed insufficient, SRM may be seen by some as the only option left to ensure the achievement of the Paris Agreement's temperature goal by 2100.

Cross-Working Group Box 4, Table 1: SRM options and their potential climate and non-climate impacts. Description, potential climate impacts, potential impacts on human and natural systems, and termination effects of a number of SRM options: Stratospheric Aerosol Interventions (SAI), Marine Cloud Brightening (MCB), Ocean Albedo Change (OAC), Ground-Based Albedo Modifications (GBAM), and Cirrus Cloud Thinning (CCT).

SRM option	SAI	MCB	OAC	GBAM	CCT
Description	Injection of reflective aerosol particles directly into the stratosphere or a gas which then converts to aerosols that reflect sunlight	Spraying sea salt or other particles in marine clouds, making them more reflective	Increase surface albedo of the ocean (e.g., by creating microbubbles or placing reflective foam on the surface)	Whitening roofs, changes in land use management (e.g., no-till farming, bioengineering to make crop leaves more reflective), desert albedo enhancement, covering glaciers with reflective sheeting	Seeding to promote nucleation of cirrus clouds, reducing optical thickness and cloud lifetime to allow more outgoing longwave radiation to escape to space
Potential climate impacts *other*	Change precipitation and runoff	Change in land-sea contrast in	Change in land-sea contrast in	Changes in regional precipitation	Changes in temperature and

than reduced warming	pattern; reduced temperature and precipitation extremes; precipitation reduction in some monsoon regions; decrease in direct and increase in diffuse sunlight at surface; changes to stratospheric dynamics and chemistry; potential delay in ozone hole recovery; changes in surface ozone and UV radiation	temperature and precipitation, regional precipitation and runoff changes	temperature and precipitation, regional , precipitation and runoff changes.	pattern, regional extremes and regional circulation	precipitation pattern, altered regional water cycle, increase in sunlight reaching the surface
Potential impacts on human and natural systems	Changes in crop yields, changes in land and ocean ecosystem productivity, acid rain (if using sulphate), reduced risk of heat stress to corals	Changes in regional ocean productivity, changes in crop yields, reduced heat stress for corals, changes in ecosystem productivity on land, sea salt deposition over land	Unresearched	Altered photosynthesis, carbon uptake and side effects on biodiversity	Altered photosynthesis and carbon uptake
Termination effects	Sudden and sustained termination would result in rapid warming, and abrupt changes to water cycle. Magnitude of termination depends on the degree of warming offset.	Sudden and sustained termination would result in rapid warming, and abrupt changes to water cycle. Magnitude of termination depends on the degree of warming offset.	Sudden and sustained termination would result in rapid warming. Magnitude of termination depends on the degree of warming offset.	GBAM can be maintained over several years without major termination effects because of its regional scale of application. Magnitude of termination depends on the degree of warming offset.	Sudden and sustained termination would result in rapid warming. Magnitude of termination depends on the degree of warming offset.
References (also see main text of this box)	(Visioni et al. 2017) Tilmes et al. (2018) Simpson et al. (2019)	Latham et al. (2012) Ahlm et al. (2017) Stjern et al. (2018)	Evans et al. (2010) Crook et al. (2015)	Davin et al. (2014) Crook et al. (2015) Zhang et al. (2016)	Storelvmo and Herger (2014) Crook et al. (2015)

				Field et al. (2018) Seneviratne et al. (2018)	Jackson et al. (2016) Duan et al. (2020) Gasparini et al. (2020)

SRM risks to human and natural systems and potential for risk reduction

Since AR5, hundreds of climate modelling studies have simulated effects of SRM on climate hazards (Kravitz et al. 2015; Tilmes et al. 2018). Modelling studies have shown SRM has the potential to offset some effects of increasing GHGs on global and regional climate, including the increase in frequency and intensity of extremes of temperature and precipitation, melting of Arctic sea ice and mountain glaciers, weakening of Atlantic meridional overturning circulation, changes in frequency and intensity of tropical cyclones, and decrease in soil moisture (WGI, Chapter 4). However, while SRM may be effective in alleviating anthropogenic climate warming either locally or globally, it would not maintain the climate in a present-day state nor return the climate to a pre-industrial state (climate averaged over 1850-1900, See WGI Chapter 1, Box 1.2) in all regions and in all seasons even when used to fully offset the global mean warming (*high confidence*); WGI Chapter 4}. This is because the climate forcing and response to SRM options are different from the forcing and response to GHG increase. Because of these differences in climate forcing and response patterns, the regional and seasonal climates of a world with a global mean warming of 1.5 or 2°C achieved via SRM would be different from a world with similar global mean warming but achieved through mitigation (MacMartin et al. 2018). At the regional scale and seasonal timescale there could be considerable residual climate change and/or overcompensating change (e.g., more cooling, wetting or drying than just what's needed to offset warming, drying or wetting due to anthropogenic greenhouse gas emissions), and there is low confidence in understanding of the climate response to SRM at the regional scale (WGI, Chapter 4).

SAI implemented to partially offset warming (e.g., offsetting half of global warming) may have potential to ameliorate hazards in multiple regions and reduce negative residual change, such as drying compared to present-day climate, that are associated with fully offsetting global mean warming (Irvine and Keith 2020), but may also increase flood and drought risk in Europe compared to unmitigated warming (Jones et al. 2021). Recent modelling studies suggest it is conceptually possible to meet multiple climate objectives through optimally designed SRM strategies (WGI, Chapter 4). Nevertheless, large uncertainties still exist for climate processes associated with SRM options (e.g. aerosol-cloud-radiation interaction) (WGI, Chapter 4) (Kravitz and MacMartin 2020).

Compared with climate hazards, many fewer studies have examined SRM risks—the potential adverse consequences to people and ecosystems from the combination of climate hazards, exposure and vulnerability—or the potential for SRM to reduce risk (Curry et al. 2014; Irvine et al. 2017). Risk analyses have often used inputs from climate models forced with stylized representations of SRM, such as dimming the sun. Fewer have used inputs from climate models that explicitly simulated injection of gases or aerosols into the atmosphere, which include more complex cloud-radiative feedbacks. Most studies have used scenarios where SAI is deployed to hold average global temperature constant despite high emissions.

There is *low confidence* and large uncertainty in projected impacts of SRM on crop yields due in part to a limited number of studies. Because SRM would result in only a slight reduction in CO_2 concentrations relative to the emission scenario without SRM (Chapter 5, WGI), the CO_2 fertilization effect on plant productivity is nearly the same in emissions scenarios with and without SRM. Nevertheless, changes in climate due to SRM are likely to have some impacts on crop yields. A single study indicates MCB may reduce crop failure rates compared to climate change from a doubling of CO_2 pre-industrial concentrations (Parkes et al. 2015). Models suggest SAI cooling would reduce crop productivity at higher latitudes compared to a scenario without SRM by reducing the growing season length, but benefit crop productivity in lower latitudes by reducing heat stress (Pongratz et al. 2012; Xia et al. 2014; Zhan et al. 2019). Crop productivity is also projected to be reduced where SAI reduces rainfall relative to the scenario without SRM, including a case where reduced Asian summer monsoon rainfall causes a reduction in groundnut yields (Xia et al. 2014; Yang et al. 2016). SAI will increase the fraction of diffuse sunlight, which is projected to increase photosynthesis in forested canopy, but will reduce the direct and total available sunlight, which tends to reduce photosynthesis. As total sunlight is reduced, there is a net reduction in crop photosynthesis with the result that any benefits to crops from avoided heat stress may be offset by reduced photosynthesis, as indicated by a single statistical modeling study (Proctor et al. 2018). SAI would reduce average surface ozone concentration (Xia et al. 2017) mainly as a result of aerosol-induced reduction in stratospheric ozone in polar regions, resulting in reduced downward transport of ozone to the troposphere (Pitari et al. 2014; Tilmes et al. 2018). The reduction in stratospheric ozone also allows more UV radiation to reach the surface. The reduction in surface ozone, together with an increase in surface UV radiation, would have important implications for crop yields but there is *low confidence* in our understanding of the net impact.

Few studies have assessed potential SRM impacts on human health and wellbeing. SAI using sulfate aerosols is projected to deplete the ozone layer, increasing mortality from skin cancer, and SAI could increase particulate matter due to offsetting warming, reduced precipitation and deposition of SAI aerosols, which would increase mortality, but SAI also reduces surface-level ozone exposure, which would reduce mortality from air pollution, with net changes in mortality uncertain and depending on aerosol type and deployment scenario (Effiong and Neitzel 2016; Eastham et al. 2018; Dai et al. 2020). However, these effects may be small compared to changes in risk from infectious disease (e.g., mosquito-borne illnesses) or food security due to SRM influences on climate (Carlson et al. 2020). Using volcanic eruptions as a natural analog, a sudden implementation of SAI that forced the ENSO system may increase risk of severe cholera outbreaks in Bengal (Trisos et al. 2018; Pinke et al. 2019). Considering only mean annual temperature and precipitation, SAI that stabilizes global temperature at its present-day level is projected to reduce income inequality between countries compared to the highest warming pathway (RCP8.5) (Harding et al. 2020). Some integrated assessment model scenarios have included SAI (Arino et al. 2016; Emmerling and Tavoni 2018; Heutel et al. 2018; Helwegen et al. 2019; Rickels et al. 2020) showing the indirect costs and benefits to welfare dominate, since the direct economic cost of SAI itself is expected to be relatively low (Moriyama et al. 2017; Smith and Wagner 2018). There is a general lack of research on the wide scope of potential risk or risk reduction to human health, wellbeing and sustainable development from SRM and on their distribution across countries and vulnerable groups (Carlson et al. 2020; Honegger et al. 2021a).

SRM may also introduce novel risks for international collaboration and peace. Conflicting temperature preferences between countries may lead to counter-geoengineering measures such as deliberate release of warming agents or destruction of deployment equipment (Parker et al. 2018). Game-theoretic models and laboratory experiments indicate a powerful actor or group with a higher preference for SRM may use SAI to cool the planet beyond what is socially optimal, imposing welfare losses on others although this cooling does not necessarily imply excluded countries would be worse off relative to a world of unmitigated warming (Ricke et al. 2013; Weitzman 2015; Abatayo et al. 2020). In this context counter-geoengineering may promote international cooperation or lead to large welfare losses (Helwegen et al. 2019; Abatayo et al. 2020).

Cooling caused by SRM would increase the global land and ocean CO_2 sinks (*medium confidence*), but this would not stop CO_2 from increasing in the atmosphere or affect the resulting ocean acidification under continued anthropogenic emissions (*high confidence*) (WGI Chapter 5).

Few studies have assessed potential SRM impacts on ecosystems. SAI and MCB may reduce risk of coral reef bleaching compared to global warming with no SAI (Latham et al. 2013; Kwiatkowski et al. 2015), but risks to marine life from ocean acidification would remain, because SRM proposals do not reduce elevated levels of anthropogenic atmospheric CO_2 concentrations. MCB could cause changes in marine net primary productivity by reducing light availability in deployment regions, with important fishing regions off the west coast of South America showing both large increases and decreases in productivity (Partanen et al. 2016; Keller 2018).

There is large uncertainty in terrestrial ecosystem responses to SRM. By decoupling increases in atmospheric greenhouse gas concentrations and temperature, SAI could generate substantial impacts on large-scale biogeochemical cycles, with feedbacks to regional and global climate variability and change (Zarnetske et al. 2021). Compared to a high CO_2 world without SRM, global-scale SRM simulations indicate reducing heat stress in low latitudes would increase plant productivity, but cooling would also slow down the process of nitrogen mineralization which could decrease plant productivity (Glienke et al. 2015; Duan et al. 2020). In high latitude and polar regions SRM may limit vegetation growth compared to a high CO_2 world without SRM, but net primary productivity may still be higher than pre-industrial climate (Glienke et al. 2015). Tropical forests cycle more carbon and water than other terrestrial biomes but large areas of the tropics may tip between savanna and tropical forest depending on rainfall and fire (Beer et al. 2010; Staver et al. 2011). Thus, SAI-induced reductions in precipitation in Amazonia and central Africa are expected to change the biogeography of tropical ecosystems in ways different both from present-day climate and global warming without SAI (Simpson et al. 2019; Zarnetske et al. 2021). This would have potentially large consequences for ecosystem services (Chapter 2 and Chapter 9). When designing and evaluating SAI scenarios, biome-specific responses need to be considered if SAI approaches are to benefit rather than harm ecosystems. Regional precipitation change and sea salt deposition over land from MCB may increase or decrease primary productivity in tropical rainforests (Muri et al. 2015). SRM that fully offsets warming could reduce the dispersal velocity required for species to track shifting temperature niches whereas partially offsetting warming with SAI would not reduce this risk unless rates of warming were also reduced (Trisos et al. 2018; Dagon and Schrag 2019). SAI may reduce high fire risk weather in Australia, Europe and parts of the Americas, compared to global warming without SAI (Burton et al. 2018). Yet SAI using sulfur injection could shift the spatial distribution of acid-induced aluminum soil toxicity into relatively undisturbed ecosystems in Europe and North America (Visioni et al. 2020). For the same amount of global mean cooling, SAI, MCB, and CCT would have different effects on gross and net primary productivity because of different spatial patterns of temperature, available sunlight, and hydrological cycle changes (Duan et al. 2020). Large-scale modification of land surfaces for GBAM may have strong trade-offs with biodiversity and other ecosystem services, including food security (Seneviratne et al. 2018). Although existing studies indicate SRM will have widespread impacts on ecosystems, risks and potential for risk reduction for marine and terrestrial ecosystems and biodiversity remain largely unknown.

A sudden and sustained termination of SRM in a high CO_2 emissions scenario would cause rapid climate change (*high confidence*; WGI Chapter 4). More scenario analysis is needed on the potential likelihood of sudden termination (Kosugi 2013; Irvine and Keith 2020). A gradual phase-out of SRM combined with emission reduction and CDR could avoid these termination effects (*medium confidence*) (MacMartin et al. 2014; Keith and MacMartin 2015; Tilmes et al. 2016). Several studies find that large and extremely rapid warming and abrupt changes to the water cycle would occur within a decade if a sudden termination of SAI occurred (McCusker et al. 2014; Crook et al. 2015). The size of this 'termination shock' is proportional to the amount of radiative forcing being masked by SAI. A sudden termination of SAI could place many thousands of species at risk of extinction, because the resulting rapid warming would be too fast for species to track the changing climate (Trisos et al. 2018).

Public perceptions of SRM

Studies on the public perception of SRM have used multiple methods: questionnaire surveys, workshops, and focus group interviews (Burns et al. 2016; Cummings et al. 2017). Most studies have been limited to Western societies with some exceptions. Studies have repeatedly found that respondents are largely unaware of SRM (Merk et al. 2015). In the context of this general lack of familiarity, the publics prefer carbon dioxide removal (CDR) to SRM (Pidgeon et al. 2012), are very cautious about SRM deployment because of potential environmental side effects and governance concerns, and mostly reject deployment for the foreseeable future. Studies also suggest conditional and reluctant support for research, including proposed field experiments, with conditions of proper governance (Sugiyama et al. 2020). Recent studies show that the perception varies with the intensity of deliberation (Merk et al. 2019), and that the public distinguishes different funding sources (Nelson et al. 2021). Limited studies for developing countries show a tendency for respondents to be more open to SRM (Visschers et al. 2017; Sugiyama et al. 2020), perhaps because they experience climate change more directly (Carr and Yung 2018). In some Anglophone countries, a small portion of the public believes in chemtrail conspiracy theories, which are easily found in social media (Tingley and Wagner 2017; Allgaier 2019). Since researchers rarely distinguish different SRM options in engagement studies, there remains uncertainty in public perception.

Ethics

There is broad literature on ethical considerations around SRM, mainly stemming from philosophy or political theory, and mainly focused on SAI (Flegal et al. 2019). There is concern that publicly debating, researching and potentially deploying SAI could involve a 'moral hazard', with potential to obstruct ongoing and future mitigation efforts (Morrow 2014; Baatz 2016; McLaren 2016), while empirical evidence is limited and mostly at the individual, not societal, level (Burns et al. 2016; Merk et al. 2016, 2019). There is low agreement whether research and outdoors experimentation will create a 'slippery slope' toward eventual deployment, leading to a lock-in to long-term SRM, or can be effectively regulated at a later stage to avoid undesirable outcomes (Hulme 2014; Parker 2014; Callies 2019; McKinnon 2019). Regarding potential deployment of SRM, procedural, distributive and recognitional conceptions of justice are being explored, (Svoboda and Irvine 2014; Svoboda 2017; Preston and Carr 2018; Hourdequin 2019). With the SRM research community's increasing focus on distributional impacts of SAI, researchers have started more explicitly considering inequality in participation and inclusion of vulnerable countries and marginalized social groups (Flegal and Gupta 2018; Whyte 2018; Táíwò and Talati 2021), including considering stopping research (Stephens and Surprise 2020; National Academies of Sciences Engineering and Medecine 2021). There is recognition that SRM research has been conducted predominantly by a relatively small number of experts in the Global North, and that more can be done to enable participation from diverse peoples and geographies in setting research agendas and research governance priorities, and undertaking research, with initial efforts to this effect (e.g., Rahman et al. 2018), noting unequal power relations in participation could influence SRM research governance and potential implications for policy (Winickoff et al. 2015; Frumhoff and Stephens 2018; Whyte 2018; Biermann and Möller 2019; McLaren and Corry 2021; National Academies of Sciences Engineering and Medecine 2021; Táíwò and Talati 2021).

Governance of research and of deployment

Currently, there is no dedicated, formal international SRM governance for research, development, demonstration, or deployment (see WGIII Chapter 14). Some multilateral agreements—such as the UN Convention on Biological Diversity or the Vienna Convention on the Protection of the Ozone Layer—indirectly and partially cover SRM, but none is comprehensive and the lack of robust and formal SRM governance poses risks (Ricke et al. 2013; Talberg et al. 2018; Reynolds 2019a). While governance objectives range broadly, from prohibition to enabling research and potentially deployment (Sugiyama et al. 2018b; Gupta et al. 2020), there is agreement that SRM governance should cover all interacting stages of research through to any potential, eventual deployment with rules, institutions, and norms (Reynolds 2019b). Accordingly, governance arrangements are co-evolving with respective SRM technologies across the interacting stages of research, development, demonstration, and—potentially—deployment (Rayner et al. 2013; Parker 2014; Parson 2014). Stakeholders are developing governance already in outdoors research; for example, for MCB and OAC experiments on the Great Barrier Reef (McDonald et al. 2019). Co-evolution of governance and SRM research provides a chance for responsibly developing SRM technologies with broader public participation and political legitimacy, guarding against potential risks and harms relevant across a full range of scenarios, and ensuring that SRM is considered only as a part of a broader portfolio of responses to climate change (Stilgoe 2015; Nicholson et al. 2018). For SAI, large-scale outdoor experiments even with low radiative forcing could be transboundary and those with deployment-scale radiative forcing may not be distinguished from deployment, such that (MacMartin and Kravitz 2019) argue for continued reliance on modeling until a decision on whether and how to deploy is made, with modeling helping governance development. For further discussion of SRM governance see Chapter 14, WGIII.

END CROSS-WORKING GROUP BOX 4 HERE

14.4.5.1 Global governance of solar radiation modification and associated risks

Solar Radiation Modification, in the literature also referred to as 'solar geoengineering', refers to the intentional modification of the Earth's shortwave radiative budget, such as by increasing the reflection of sunlight back to space, with the aim of reducing warming. Several SRM options have been proposed, including Stratospheric Aerosol Injection (SAI), Marine Cloud Brightening (MCB), Ground-Based Albedo Modifications, and Ocean Albedo Change (OAC). SRM has been discussed as a potential response option within a broader climate risk management strategy, as a supplement to emissions reduction, carbon dioxide removal and adaptation (Crutzen 2006; Shepherd 2009; Caldeira and Bala 2017; Buck et al. 2020), for example as a temporary measure to slow the rate of warming (Keith and MacMartin 2015) or address temperature overshoot (MacMartin et al. 2018; Tilmes et al. 2020). SRM assessments of potential benefits and risks still primarily rely on modelling efforts and their underlying scenario assumptions (Sugiyama et al. 2018a), for example in the context of the Geoengineering Model Intercomparison Project GeoMIP6 (Kravitz et al. 2015). Recently, small-scale MCB and OAC experiments started to take place on the Great Barrier Reef (McDonald et al. 2019).

Stratospheric aerosol intervention (SAI) – the most researched SRM method – poses significant international governance challenges since it could potentially be deployed uni- or minilaterally and alter the global mean temperature much faster than any other climate policy measure, at comparatively low direct costs (Parson 2014; Nicholson et al. 2018; Smith and Wagner 2018; Sugiyama et al. 2018b; Reynolds 2019a). While being dependent on the design of deployment systems, both geophysical benefits and adverse effects would potentially be unevenly distributed (WGI Chapter 4). Perceived local harm 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), but also because immediate attribution of climatic impacts to detected SAI deployment would not be possible. Uncoordinated or poorly researched deployment by a limited number of states, triggered by perceived climate emergencies, could create international tensions (Corry 2017; Lederer and Kreuter 2018). An additional risk is that of rapid temperature rise following an abrupt end of SAI activities (Parker and Irvine 2018; Rabitz 2019).

While there is room for national and even sub-national governance of SAI – for example on research (differentiating indoor from open-air) (Jinnah et al. 2018; Hubert 2020) and public engagement (Bellamy and Lezaun 2017; Flegal et al. 2019) – international governance of SAI faces the challenge that comprehensive institutional architectures designed too far in advance could prove either too restrictive or too permissive in light of subsequent political, institutional, geophysical and technological developments (Sugiyama et al. 2018a; Reynolds 2019a). Views on governance encompass a broad range, from aiming to restrict to wanting to enable research and potentially deployment; in between these poles, other suggest authors stress the operationalization of the precautionary approach: preventing deployment until specific criteria regarding scientific consensus, impact assessments and governance issues are met (Tedsen and Homann 2013; Wieding et al. 2020). Many scholars suggest that governance arrangements ought to co-evolve with respective SRM technologies (Parker 2014), including that it stay at least one step ahead of research, development, demonstration, and—potentially—deployment (Rayner et al. 2013; Parson 2014). With the modelling community's increasing focus on showing that, and in what ways, SAI could help to minimise climate change impacts in the Global South, the SRM governance literature has come to include considerations of how SAI could contribute to global equity (Horton and Keith 2016; Flegal and Gupta 2018; Hourdequin 2018).

Given that risks and potential benefits of SRM proposals differ substantially and their large-scale deployment is highly speculative, there is a wide array of concrete proposals for near-term anticipatory or adaptive governance. Numerous authors suggest a wide range of governance principles; (Nicholson et al. 2018) encapsulate most of these in suggesting a list of four: (1) Guard against potential risks and harm; (2) Enable appropriate research and development of scientific knowledge; (3) Legitimise any future research or policymaking through active and informed public and expert community engagement; (4) Ensure that SRM is considered only as a part of a broader, mitigation-centred portfolio of responses to climate change. Regarding international institutionalisation, options range from formal integration into existing UN bodies like the UNFCCC (Nicholson et al. 2018) or the Convention on Biological Diversity (CBD) (Bodle et al. 2014) to the creation of specific, but less formalised global fora (Parson and Ernst 2013) to forms of club governance (Lloyd and Oppenheimer 2014; Bodansky 2013). Recent years have also seen the emergence of transnational non-state actors focusing on SRM governance, primarily expert networks and NGOs (Horton and Koremenos 2020).

Currently, there is no targeted international law relating to SRM, although some multilateral agreements—such as the Convention on Biological Diversity, the UN Convention on the Law of the Sea, the Environmental Modification Convention, or the Vienna Convention on the Protection of the Ozone Layer and its Montreal Protocol—contain provisions applicable to SRM (Jinnah and Nicholson 2019; Bodansky 2013; Reynolds 2019a).

14.4.5.2 Carbon Dioxide removal

Carbon dioxide removal refers to a cluster of technologies, practices, and approaches that remove and sequester carbon dioxide from the ocean and atmosphere and durably store it in geological, terrestrial, or ocean reservoirs, or in products (see Table 12.6). In contrast to SRM, CDR does not necessarily impose transboundary risks, except insofar as misleading accounting of its use and deployment could give a false picture of countries' overall mitigation efforts. CDR is clearly a form of climate change mitigation, and as described in chapter 12 is needed to counterbalance residual GHG emissions that may prove hard to abate (e.g., from industry, aviation or agriculture) in the context of reaching net zero emissions both globally – in the context of Article 4 of the Paris Agreement – and nationally. CDR could also later be used for reducing atmospheric CO_2 concentrations by providing net negative emissions on the global level (Fuglestvedt et al. 2018; Bellamy and Geden 2019). Despite the common feature of removing carbon dioxide, technologies like afforestation/reforestation, soil carbon sequestration, bioenergy with carbon capture and storage (BECCS), direct air capture with carbon storage, enhanced weathering, ocean alkalinity enhancement or ocean fertilisation are very different, as are the governance challenges. Chapter 12 highlights the sustainable development risks associated with land and water use that are connected to the biological approaches to CDR. As a public good which largely lacks incentives to be pursued as a business case, most types of CDR require a suite of dedicated policy instruments that address both near-term needs as well as long-term continuity at scale (Honegger et al. 2021b).

CDR methods other than afforestation/reforestation and soil carbon sequestration have only played a minor role in UNFCCC negotiations so far (Fridahl 2017; Rumpel et al. 2020). To accelerate, and indeed better manage CDR globally, stringent rules and practices regarding emissions accounting, MRV and project-based market mechanisms have been proposed (Honegger and Reiner 2018; Mace et al. 2018). Given their historic responsibility, it can be expected that developed countries would carry the main burden of researching, developing, demonstrating and deploying CDR, or finance such projects in other countries (Pozo et al. 2020; Fyson et al. 2020). McLaren et al. (2019) suggest that there is a rationale for separating the international commitments for net negative emissions from those for emission reductions.

Specific regulations CDR options have been limited to those posing transboundary risks, namely the use of ocean fertilization. In a series of separate decisions from 2008 - 13, the London Convention / Protocol parties limited ocean fertilization activities to only those of a research character, and in 2012 the CBD made a non-legally binding decision to do the same, further requiring such research activities to be limited scale, and carried out under controlled conditions, until more knowledge is gained to be able to assess the risks (GESAMP 2019; Burns and Corbett 2020). In doing so they have taken a precautionary approach (Sands & Peel, 2018). The London Convention/Protocol has also developed an Assessment Framework for Scientific Research Involving Ocean Fertilisation (London Convention/Protocol 2010) and in 2013 adopted amendments (which are not yet in force) to regulate marine carbon dioxide removal activities, including ocean fertilisation.

14.5 Multi-level, multi-actor governance

The Paris Agreement sets in place a new framework for international climate policy (Paroussos et al. 2019), which some cite as evidence of 'hybrid multilateralism' (Savaresi 2016; Christoff 2016; Bäckstrand et al. 2017). While a trend of widening involvement of non-state actors was evident prior to conclusion of the Paris Agreement, particularly at UNFCCC COPs, the 'new landscape of international climate cooperation' features an 'intensified interplay between state and non-state actors,' including civil society and social movements, business actors, and subnational or substate actors, such as local governments and cities (Bäckstrand et al. 2017, p. 562). This involvement of other actors beyond states in international climate cooperation is facilitated by the Paris Agreement's 'hybrid climate policy architecture' (Bodansky et al. 2016) (Section 14.3.1.1 above), which acknowledges the primacy of domestic politics in climate change and invites the mobilisation of international and domestic pressure to make the Agreement effective (Falkner 2016b). In this landscape, there is greater flexibility for more decentralised 'polycentric' forms of climate governance and recognition of the benefits of working in diverse forms and groups to realise global climate mitigation goals (Oberthür 2016; Jordan et al. 2015) (see also Chapter 1, 1.9) .

Increasing attention has focused on the role of multi-level, multi-actor cooperation among actors, groupings and agreements beyond the UNFCCC climate regime as potential 'building blocks' towards enhanced international action on climate mitigation (Falkner 2016a; Caparrós and Péreau 2017; Potoski 2017; Stewart et al. 2017). This can include agreements on emissions and technologies at the regional or sub-global level; what scholars often refer to as climate club' (Nordhaus 2015; Hovi et al. 2016; Green 2017; Sprinz et al. 2018). One forum through which such agreements are often discussed, in support of UNFCCC objectives, are high-level meetings of political leaders, such of the G7 and G20 states (Livingston 2016). It also includes cooperation on narrower sets of issues than are found within the Paris Agreement; for instance, other international environmental agreements dealing with a particular subset of GHGs; linkages with, or leveraging of, efforts or agreements in other spheres such as adaptation, human rights or trade; agreements within particular economic sectors; or transnational initiatives involving global cooperative efforts by different types of non-state actors. Cooperative efforts in each of these forums are reviewed in the following sections of the chapter. Section 14.5.1 discusses international cooperation at multiple governance levels (global, sub-global and regional); Section 14.5.2 discusses cooperation with international sectoral agreements and institutions such as in the forestry, energy and transportation sectors; and Sections 14.5.3-14.5.5 discuss transnational cooperation across civil society and social movements, business partnerships and investor coalitions, and between sub-national entities and cities, respectively.

A key idea underpinning this analysis is that decomposition of the larger challenge of climate mitigation into 'smaller units' may facilitate more effective cooperation (Sabel and Victor 2017) and complement cooperation in the UN climate regime (Stewart et al. 2017). However, it is recognised that significant uncertainty remains over the feasibility and costs of these efforts (Sabel and Victor 2017), as well as whether they ultimately strengthen progress on climate mitigation in the multilateral climate arena (Falkner 2016a).

14.5.1 International cooperation at multiple governance levels

14.5.1.1 Role of other environmental agreements

International cooperation on climate change mitigation takes place at multiple governance levels, including under 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) (See also Section 9.9.7.1). Velders et al. (2007) found that over the period from 1990 to 2010, the reduction in GWP100-weighted ODS emissions expected with compliance to the provisions of the Montreal Protocol was 8 $GtCO_2eq\ yr^{-1}$, an amount substantially greater than the first commitment period Kyoto reduction target. Young et al. (2021) suggest that the Montreal Protocol may also be helping to mitigate climate change through avoided decreases in the land carbon sink.

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 a high GWP100 of 14600 for HFC-23, and are not ODS (See also Section 9.9.7.1). 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). In this way it creates a cooperative rather than a conflictual relationship between addressing ozone depletion and the climate protection goals of the UNFCCC regime (Hoch et al. 2019). The Kigali Amendment 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 (Ripley and Verkuijl 2016; UN 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 an 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 from 2020 onwards using approved technologies (Ripley and Verkuijl 2016).

Full compliance with the Kigali Amendment is predicted to reduce HFC emissions by 61% of the global baseline by 2050 (Höglund-Isaksson et al. 2017), with avoided global warming in 2100 due to HFCs from a baseline of 0.3-0.5°C to less than 0.1°C (WMO 2018). Examining the interplay of the Kigali Amendment with the Paris Agreement, Hoch et al. (2019) show how the Article 6 mechanisms under the Paris Agreement could generate financial incentives for HFC mitigation and related energy efficiency improvements. Early action under Article 6 of the Paris Agreement could drive down baseline levels of HFCs for developing countries (calculated in light of future production and consumption in the early and mid-2020s) thus generating long-term mitigation benefits under the Kigali Amendment (Hoch et al. 2019). However, achievement of the objectives of the Kigali Amendment is dependent on its ratification 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 118 of the 198 parties to the Montreal Protocol.

MEAs dealing with transboundary air pollution, such as the Convention on Long-Range Transboundary Air Pollution (CLRTAP) 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 CLRTAP Gothenburg Protocol (initially adopted in 1999) 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 28 parties including the US and EU, entered into force in October 2019. However, its limits on black carbon have been criticised as insufficiently ambitious in light of scientific assessments (Khan and Kulovesi 2018). There is still a non-negligible uncertainty in the assessment of radiative forcing of each Short-Lived Climate Forcers (SLCFs), and the results of AR6-WGI have been updated since AR5. For example, the assessment of Emission-based Radiative Forcing from Black Carbon emissions was revised downward in AR6 (AR6-WGI-6.4.2). When discussing co-benefits with MEAs related to transboundary air pollution, attention should be paid to the uncertainty in radiative forcing of SLCFs and the update of relevant scientific knowledge.

Another 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 (such as the Convention on Biological Diversity) or to protect certain ecosystems like wetlands (such as the Ramsar Wetlands Convention) 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). At a theoretical level, REDD+ activities have been identified as a particular opportunity for achieving climate mitigation objectives while also conserving tropical forest biodiversity and ecosystem services. Elements of REDD+ that promise greatest effectiveness 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). However, actual biodiversity and ecosystem service co-benefits are dependent on the design and implementation of REDD+ programmes (Ehara et al. 2014; Panfil and Harvey 2016), with limited empirical evidence to date of emissions reductions from these programmes (Newton et al. 2016; Johnson et al. 2019), and concerns about whether they meet equity and justice considerations (Schroeder and McDermott 2014) (See also Chapter 7, section 7.6.1).

14.5.1.2 Linkages with sustainable development, adaptation, loss and damage, and human rights

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.

The IPCC defines adaptation as: 'in human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effect; human intervention may facilitate adjustment to expected climate and its effects' (See Annex I: Glossary).

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 present and future exposure to specific climate risks (Adger et al. 2003), mainstream climate information into existing planning efforts (Gupta et al. 2010; van der Voorn et al. 2012, 2017), 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 - and potential strategies for resolving them (Locatelli et al. 2011; Casado-Asensio and Steurer 2014; Duguma et al. 2014; Suckall et al. 2015; Watkiss et al. 2015; van der Voorn et al. 2020). In a strategic context, this issue has been analyzed in Bayramoglu et al. (2018), Eisenack and Kähler (2016) and Ingham et al. (2013), among others. Bayramoglu et al. (2018) analyze the strategic interaction between mitigation, as a public good, and adaptation, essentially a private good, showing that the fear that adaptation will reduce the incentives to mitigate carbon emissions may not be justified. On the contrary, adaptation can reduce free-rider incentives (lead to larger self-enforcing agreements), yielding higher global mitigation levels and welfare, if adaptation efforts cause mitigation levels between different countries to be complements instead of strategic substitutes (on the conditions for adaptation and mitigation to be substitutes or complements, see (Ingham et al. 2013).

Distinct from project or programmatic level activities, however, international cooperation for adaptation operates to provide finance and technical assistance (Bouwer and Aerts 2006). In most cases it involves transboundary actions, such as in the case of transboundary watershed management (Wilder et al. 2010; Milman et al. 2013; van der Voorn et al. 2017). 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 mitigation and adaptation 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). 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 industrialised countries and international green funds. 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. 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, there are only few papers that examine this issue. Stua (2017a,b) explores the relevance of the so-called 'share of proceeds' included in Article 6 of the Paris Agreement as a key tool for leveraging adaptation though mitigation actions.

There are recognised 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. Roberts et al. (2014) focused on ‘loss and damage’, essentially those climate change impacts which cannot be avoided through adaptation. The Paris Agreement contains a free-standing article on loss and damage (UNFCCC 2015a), focused on cooperation and facilitation, under which parties have established a clearing house on risk transfer, and a task force on displacement (UNFCCC 2016a). The COP decision accompanying the Paris Agreement specifies that ‘Article 8 does not involve or provide a basis for any liability or compensation’ (UNFCCC 2016a). There is 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 (Gewirtzman et al. 2018; Roberts et al. 2017). 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’ —for climate damage in domestic courts (Ganguly et al. 2018; Benjamin 2021). For states that have suffered loss and damage there is also the option to pursue ‘state responsibility’ claims under customary international law and international human rights law (Wewerinke-Singh 2018; Wewerinke-Singh and Salili 2020).

One scholar argues that climate impacts are ‘incremental violence structurally over-determined by international relations of power and control’ that affect most those who have contributed the least to GHG emissions (Dehm 2020). Calls for compensation or reparation for loss and damage are therefore a demand for climate justice (Dehm 2020). 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.

The adoption in 2013 of the Warsaw International Mechanism on Loss and Damage as part of the United Nations Framework Convention on Climate Change (UNFCCC) occurred despite the historic opposition of the United States to this policy. Vanhala and Hestbaek (2016) examine the roles of ‘frame contestation’ (contestations over different framings of loss and damage, whether as ‘liability and compensation’ or ‘risk management and insurance’ or other) and ambiguity in accounting for the evolution and institutionalisation of the loss and damage norm within the UNFCCC. However, there is little international agreement on the scope of loss and damage programmes, and especially how they would be funded and by whom (Gewirtzman et al. 2018). Moreover, non-economic loss and damage (NELD) forms a distinct theme that refers to the climate-related losses of items both material and non-material that are not commonly traded in the market, but whose loss is still experienced as such by those affected. Examples of NELD include loss of cultural identity, sacred places, human health and lives (Serdeczny 2019). The Santiago Network is part of the Warsaw International Mechanism, to catalyse the technical assistance of relevant organisations, bodies, networks and experts, for the implementation of relevant approaches to avert, minimise and address loss and damage at the local, national and regional level, in developing countries that are particularly vulnerable to the adverse effects of climate change (UNFCCC 2020c).

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 scale of adaptation ultimately needed and the lower the scale of loss and damage anticipated. 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 (Otto et al. 2017; Skeie et al. 2017; Marjanac and Patton 2018; Patton 2021) and while it has the potential to address the thorny issue of causation, and thus compensation (Stuart-Smith et al. 2021), it could also be used to develop strategies for climate resilience (James et al. 2014).

There are also direct links between mitigation and sustainable development. The international agendas for mitigation and 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 (Victor 2011; Patt 2015). 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' NDCs, 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. 2017; Dzebo et al. 2019). These studies typically converge on the fact that financial assistance flowing from developed to developing countries enhances any possible synergies or lessens the conflicts. However, mitigation measures can also have negative impacts on gender equality, and peace and justice (Dzebo et al. 2019). The IMF has also taken on board the climate challenge and is examining the role of fiscal and macroeconomic policies to address the climate challenge for supporting its members with appropriate policy responses.

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). The literature also stresses 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 emphasised 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). An assessment of thematic policy coherence between the voluntary domestic contributions regarding the Paris Agreement and the 2030 Agenda should be integrated in national policy cycles for sustainable and climate policy-making to identify overlaps, gaps, mutual benefits and trade-offs in national policies (Janetschek et al. 2020).

It is only since 2008 that the relationship between climate change and human rights has become a focus of international law and policy making. It is not just climate impacts that threaten the enjoyment of human rights but also the mitigation responses to climate change that affect human rights (Shi et al. 2017). The issue of human rights–climate change linkages was first taken up by the UN Human Rights Council (HRC) in 2008, but has since rapidly gained ground with UN human rights treaty bodies issuing comments (e.g. (Human Rights Committee 2018)), recommendations (e.g. (Committee on the Elimination of Discrimination against Women 2018)) and even a joint statement (e.g. (Office of the High Commissioner for Human Rights 2019)) on the impacts of climate change on the enjoyment of human rights. Climate change effects and related disasters have the potential to affect human rights broadly, for instance, by giving rise to deaths, disease or malnutrition (right to life, right to health), threatening food security or livelihoods (right to food), impacting upon water supplies and compromising access to safe drinking water (right to water), destroying coastal settlements through storm surge (right to adequate housing), and in some cases forcing relocation as traditional territories become uninhabitable (UNGA 2019). In addition, the right to a healthy environment, recognized in 2021 as an autonomous right at the international level by the Human Rights Council (UN Human Rights Council 2021), arguably extends to a right to a 'safe climate' shaped in part by the Paris Agreement (UNGA 2019).

As the intersections between climate impacts and human rights have become increasingly clear, litigants have begun to use human rights arguments, with a growing receptivity among courts towards such arguments in climate change cases (Peel and Osofsky 2018; Savaresi and Auz 2019; Macchi and van Zeben 2021). In the landmark Urgenda climate case in 2019, the Dutch Supreme Court interpreted the European Convention on Human Rights in light of customary international law and the UN climate change regime and ordered the state to reduce greenhouse gas emissions by 25% by 2020 compared to 1990 (The Supreme Court of the Netherlands 2019). In the Neubauer case in 2021, the German Federal Constitutional Court ordered the German legislature, in light of its obligations, including on rights protections, to set clear provisions for reduction targets from 2031 onward by the end of 2022 (German Constitutional Court 2021). There are cases in the Global South as well (Peel and Lin 2019; Setzer and Benjamin 2020), with the Supreme Court in Nepal in its 2018 decision in Shrestha, ordering the government to amend its existing laws and introduce a new consolidated law to address climate mitigation and adaptation as this would protect the rights to life, food, and a clean environment, and give effect to the 2015 Paris Agreement (The Supreme Court of Nepal 2018). There are dozens of further cases in national and regional courts, increasingly based on human rights claims. and this trend is only likely to grow (Beauregard et al. 2021; Shi et al. 2017; Peel and Osofsky 2018). These cases face procedural hurdles, such as standing, as well as substantive difficulties, for instance, with regard to the primarily territorial scope of state obligations to protect human rights (Mayer 2021; Boyle 2018), however, there are increasing instances of successful outcomes across the world.

14.5.1.3 Trade agreements

As discussed in AR5, policies to open up trade can have a range of effects on GHG emissions, just as mitigation policies can influence trade flows among countries. Trade rules may impede mitigation action by limiting countries' discretion in adopting trade-related climate policies, but they also have the potential to stimulate the international adoption and diffusion of mitigation technologies and policies (Droege et al. 2017).

The mitigation impacts of trade agreements are difficult to ascertain, and the limited evidence is mixed. Examining the effects of three free trade agreements (FTAs) – Mercosur, the North American Free Trade Agreement (NAFTA) and the Australia-United States Free Trade Agreement – on GHG emissions, (Nemati et al. 2019) find that these effects depend on the relative income levels of the countries involved, and that FTAs between developed and developing countries may increase emissions in the long run. However, studies also suggest that FTAs incorporating specific environmental or climate-related provisions can help reduce GHG emissions (Baghdadi et al. 2013; Sorgho and Tharakan 2020).

Investment agreements, which are often integrated in FTAs, seek to encourage the flow of foreign investment through investment protection. While international investment agreements hold potential to increase low-carbon investment in host countries (PAGE 2018), these agreements have tended to protect investor rights, constraining the latitude of host countries in adopting environmental policies (Miles 2019). Moreover, international investment agreements may lead to 'regulatory chill', which may lead to countries refraining from or delaying the adoption of mitigation policies, such as phasing out fossil fuels (Tienhaara 2018). More contemporary investment agreements seek to better balance the rights and obligations of investors and host countries, and in theory offer greater regulatory space to host countries (UNCTAD 2019), although it is unclear to what extent this will hold true in practice.

In their NDCs, parties mention various trade-related mitigation measures, including import bans, standards and labelling schemes, border carbon adjustments (BCAs; see also Chapter 13), renewable energy support measures, fossil fuel subsidy reform, and the use of international market mechanisms (Brandi 2017). Some of these 'response measures' (Chan 2016b) may raise questions concerning their consistency with trade agreements of the World Trade Organisation (WTO). Non-discrimination is one of the foundational rules of the WTO. This means, among others, that 'like' imported and domestic products are not treated differently ('national treatment') and that a WTO member should not discriminate between other members ('most-favoured-nation treatment'). These principles are elaborated in a set of agreements on the trade in goods and services, including the General Agreement on Tariffs and Trade (GATT), the General Agreement on Trade in Services (GATS), the Agreement on Technical Barriers to Trade (TBT), and the Agreement on Subsidies and Countervailing Measures (ASCM).

Several measures that can be adopted as part of carbon pricing instruments to address carbon leakage concerns have been examined in the light of WTO rules. For instance, depending on the specific design, the free allocation of emissions allowances under an ETS could be considered a subsidy inconsistent with the ASCM (Rubini and Jegou 2012; Ismer et al. 2021). The WTO compatibility of another measure to counter carbon leakage, BCAs, has also been widely discussed (Box 14.2). Alternatives to BCAs, such as consumption charges on carbon-intensive materials (Pollitt et al. 2020), can be consistent with WTO law, as they do not involve discrimination between domestic and foreign products based on their carbon intensity (Ismer and Neuhoff 2007; Tamiotti 2011; Pauwelyn 2013; Holzer 2014; Ismer and Haussner 2016; Cosbey et al. 2019; European Commission 2019; Mehling et al. 2019; Porterfield 2019; Ismer et al. 2020).

START BOX 14.2 HERE

Box 14.2 Border carbon adjustments and international climate and trade cooperation

Analyses of the WTO compatibility of BCAs (Hillman 2013; Trachtman 2017; Ismer and Neuhoff 2007; Tamiotti 2011; Pauwelyn 2013; Holzer 2014; Cosbey et al. 2019; Mehling et al. 2019; Porterfield 2019) gained new currency following the legislative proposal to introduce a 'carbon border adjustment mechanism' in the EU (European Commission 2021). BCAs can in principle be designed and implemented in accordance with international trade law, but the details matter (Tamiotti et al. 2009). To increase the likelihood that a BCA will be compatible with international trade law, studies suggest that it would need to: have a clear environmental rationale (i.e. reduce carbon leakage); apply to imports and exclude exports; consider the actual carbon intensity of foreign producers; account for the mitigation efforts by other countries; and provide for fairness and due process in the design and implementation (Trachtman 2017; Pauwelyn 2013; Cosbey et al. 2019; Mehling et al. 2019).

BCAs may also raise concerns regarding their consistency with international climate change agreements (Hertel 2011; Davidson Ladly 2012; Ravikumar 2020). To mitigate these concerns, BCAs could include special provisions (e.g. exemptions) for LDCs, or channel revenues from the BCA to developing countries to support low-carbon and climate-resilient development (Grubb 2011; Springmann 2013; Mehling et al. 2019). Moreover, international dialogue on principles and best practices guiding BCAs could help to ensure that such measures do not hinder international cooperation on climate change and trade (Bernasconi-Osterwalder and Cosbey 2021).

END BOX 14.2 HERE

Other regulatory measures may also target the GHG emissions associated with the production of goods (Dobson 2018). These measures include bans on carbon-intensive materials, emissions standards for the production process of imported goods, and carbon footprint labels (Kloeckner 2012; Holzer and Lim 2020; Gerres et al. 2021). The compatibility of such measures with trade agreements remains subject to debate. While non-discriminatory measures targeting the emissions from a product itself (e.g. fuel efficiency standards for cars) are more likely to be allowed than measures targeting the production process of a good (Green 2005), some studies suggest that differentiation between products based on their production process may be compatible with WTO rules (Benoit 2011; McAusland and Najjar 2015). (Mayr et al. 2020) find that sustainability standards targeting the emissions from indirect land-use change associated with the production of biofuels may be inconsistent with the TBT Agreement. Importantly, trade rules express a strong preference for the international harmonisation of standards over unilateral measures (Delimatsis 2016).

Renewable energy support measures may be at odds with the ASCM, the GATT, and the WTO Agreement on Trade-Related Investment Measures. In WTO disputes, measures adopted in Canada, India, and the United States to support clean energy generation were found to be inconsistent with WTO law due to the use of discriminatory local content requirements, such as the requirement to use domestically produced goods in the production of renewable energy (Cosbey and Mavroidis 2014; Kulovesi 2014; Lewis 2014; Wu and Salzman 2014; Charnovitz and Fischer 2015; Shadikhodjaev 2015; Espa and Marín Durán 2018).

Some measures may both lower trade barriers and potentially bring about GHG emission reductions. An example is the liberalisation of trade in environmental goods (Hu et al. 2020). In 2012, the APEC economies agreed to reduce tariffs for a list of 54 environmental goods (including e.g. solar cells; but excluding e.g. biofuels or batteries for electric vehicles). However, negotiations on an Environmental Goods Agreement under the WTO stalled in 2016 due in part to disagreement over which goods to include (de Melo and Solleder 2020). Another example is fossil fuel subsidy reform, which may reduce GHG emissions (Jewell et al. 2018; Chepeliev and van der Mensbrugghe 2020; Erickson et al. 2020) and lower trade distortions (Burniaux et al. 2011; Moerenhout and Irschlinger 2020). However, fossil fuel subsidies have largely remained unchallenged before the WTO due to legal and political hurdles (Asmelash 2015; De Bièvre et al. 2017; Meyer 2017; Steenblik et al. 2018; Verkuijl et al. 2019).

With limited progress in the multilateral trading system, some studies suggest that regional FTAs hold potential for strengthening climate governance. In some cases, climate-related provisions in such FTAs can go beyond provisions in the Kyoto Protocol and Paris Agreement, addressing for instance cooperation on carbon markets or electric vehicles (Gehring et al. 2013; van Asselt 2017; Morin and Jinnah 2018; Gehring and Morison 2020). However, Morin and Jinnah (2018) find that these provisions are at times vaguely formulated, not subject to third-party dispute settlement, and without sanctions or remedy in case of violations. Moreover, such provisions are not widely used in FTAs, and they are not adopted by the largest GHG emitters. For instance, the 2019 United States-Mexico-Canada Agreement, NAFTA's successor, does not include any specific provisions on climate change, although it could implement cooperative mitigation actions through its Commission for Environmental Cooperation (Laurens et al. 2019).

A trend in international economic governance has been the adoption of 'mega-regional' trade agreements involving nations responsible for a substantial share of world trade, such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), the EU-Canada

Comprehensive Economic and Trade Agreement (CETA), and the Regional Comprehensive Economic Partnership (RCEP) in East Asia. Given the size of the markets covered by these agreements, they hold potential to diffuse climate mitigation standards (Meltzer 2013; Holzer and Cottier 2015). While CETA includes climate-related provisions and parties have made a broad commitment to implement the Paris Agreement (Laurens et al. 2019), and the CPTPP includes provisions promoting cooperation on clean energy and low-emissions technologies, the RCEP does not include specific provisions ont climate change.

Studies have discussed various options to minimise conflicts, and strengthen the role of trade agreements in climate action, although the mitigation benefits and distributional effects of these options have yet to be assessed. Some options require multilateral action, including: (1) the amendment of WTO agreements to accommodate climate action; (2) the adoption of a 'climate waiver' that temporarily relieves WTO members from their obligations; (3) a 'peace clause' through which members commit to refraining from challenging each other's measures; (4) an 'authoritative interpretation' by WTO members of ambiguous WTO provisions; (5) improved transparency of the climate impacts of trade measures; (6) the inclusion of climate expertise in WTO disputes; and (7) intensified institutional coordination between the WTO and UNFCCC (Hufbauer et al. 2009; Epps and Green 2010; Bacchus 2016; Droege et al. 2017; Das et al. 2019). In addition, issue-specific suggestions have been put forward, such as reinstating an exception for environmentally motivated subsidies under the ASCM (Horlick and Clarke 2017).

Options can also be pursued at the plurilateral and regional level. Several studies suggest that climate clubs (see Section 14.2.2) could employ trade measures, such as lower tariffs for climate-related goods and services, or BCAs, to attract club members (Nordhaus 2015; Brewer et al. 2016; Keohane et al. 2017; Stua 2017a; Banks and Fitzgerald 2020). Another option is to negotiate a new agreement addressing both climate change and trade. Negotiations between six countries (Costa Rica, Fiji, Iceland, New Zealand, Norway, Switzerland) were launched in 2019 on a new Agreement on Climate Change, Trade and Sustainability (ACCTS), which, if successfully concluded, would liberalise trade in environmental goods and services, create new rules to remove fossil fuel subsidies, and develop guidelines for voluntary eco-labels (Steenblik and Droege 2019). At the regional level, countries could further opt for the inclusion of climate provisions in the (re)negotiation of FTAs (Yamaguchi 2020; Morin and Jinnah 2018). Moreover, the conduct of climate impact assessments of FTAs could help identify options to achieve both climate and trade objectives (Porterfield et al. 2017). In their assessment of the feasibility of various options for reform, Das et al. (2019) find that the near-term feasibility of options that require consensus at the multilateral level (notably amendments of WTO agreements) is low. By contrast, options involving a smaller number of parties, as well as options that can be implemented by WTO members on a voluntary basis, face fewer constraints.

For international investment agreements, various other suggestions have been put forward to accommodate climate change concerns. These include incorporating climate change through ongoing reform processes, such as reform of investor-state dispute settlement under the UN Commission on International Trade Law (UNCITRAL); modernisation of the Energy Charter Treaty; the (re)negotiation of international investment agreements; and the adoption of a specific treaty to promote investment in climate action (Brauch et al. 2019; Tienhaara and Cotula 2020; Yamaguchi 2020; Cima 2021).

14.5.1.4 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 2017b). 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). In the UN Climate Change

Engagement Strategy 2017 (UNOSC 2017), South-South Cooperation Action Plan is identified as a substantive pillar to support.

In 2019, the role of South-South and triangular cooperation was further highlighted with the BAPA+40 Outcome document (UN 2019), noting outstanding contributions to alleviating global inequality, promoting sustainable development and climate actions, promoting gender equality and enriching multilateral mechanisms. Furthermore, the role of triangular cooperation was explicitly recognized in the document reflecting its increasingly relevant role in the implementation of the SDGs (UN 2019).

There has been a recent resurgence of South-South cooperation. Gray and Gills (Gray and Gills 2016), signalled 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). (Liu et al. 2017a) explored prospects for South–South cooperation for large-scale ecological restoration, which is an important solution to mitigate climate change. Emphasis is given to experience and expertise sharing, co-financing, and co-development of new knowledge and know-how for more effective policy and practice worldwide, especially in developing and newly industrialised countries.

Janus et al. (2014) explore 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 technology 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. Kirchherr 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 Hensengerth (2017).

Hensengerth (2017) 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 extent in India. Thus, the technology cooperation between China, India, and Europe has become multi-faceted and increasingly Southern-led.

Rampa et al. (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 Nakazawa (2012), and specific cases on biofuel SSC and TrC in UNCTAD (2012).

The central argument in the majority of these 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 Belt and Road Initiative (BRI) is a classic example of a recent

SSC Initiative led by China. According to a joint study by Tsinghua University and Vivid Economics the 126 countries in the BRI region, excluding China, currently account for about 28% of global GHG emissions, but this proportion may increase to around 66% by 2050 if the carbon intensity of these economies only decreases slowly (according to historical patterns shown by developing countries). In this context it is important to highlight that China has already outlined a vision for a green BRI, and recently increased its commitment through the Green Investment Principles (GIP) initiative, announcing a new international coalition to improve sustainability and promote green infrastructure (Jun and Zadek 2019).

Information on triangular cooperation is more readily available than on South-South cooperation though some UN organisations such as UNDP and FAO have established platforms for the latter which also includes climate projects. Further, although there are many South-South cooperation initiatives involving the development and transfer of climate technologies the understanding of the motivations, approaches and designs is limited and not easily accessible. There is no dedicated platform for South-South and triangular cooperation on climate technologies. Hence, it is still too early to fully assess the achievements in the field of climate action (UNFCCC and UNOSSC 2018). In order to maximise its unique contribution to Agenda 2030, southern providers recognise 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. Besharati et al. (2017) present a framework of 20 indicators, organised in five dimensions that researchers and policy makers can use to access the quality and effectiveness of SSC and its contribution to sustainable development.

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, while it is complimentary to North-South cooperation. 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.

14.5.2 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 commitment with implications for mitigation. 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 harmonised policies and measures for a sector, such as technology-based standards, taxes, or best-practice standards, as well as providing for cooperation on technology research or deployment.

14.5.2.1 Forestry, land-use and REDD+

Since 2008, several, often overlapping, voluntary and non-binding international efforts and agreements have been adopted 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 degradation, while other focus on the enhancement of sinks through restoration of cleared or degraded landscapes. These initiatives do not elaborate specific policies, procedures, or implementation mechanisms. They set targets, frameworks, and milestones, aiming to catalyse further action, investment, and transparency in conservation and consolidate individual country efforts.

After the UN-sponsored Tropical Forestry Action Plan (Winterbottom 1990; Seymour and Busch 2016), among the longest standing programs in the forestry sector are the World Bank-sponsored F Forest Carbon Partnership Facility in 2007, which helps facilitate funding for REDD+ readiness and specific projects, in addition to preparing countries for results-based payments and future carbon markets while securing local communities' benefits managed sub-nationally, and the UN REDD+ Programme initiated in 2008, which aims to reduce forest emissions and enhance carbon stocks in forests while contributing to national sustainable development in developing countries, after the 2007 COP13 in Bali formally adopted REDD+ in the UNFCCC decisions and incorporated it in the Bali Plan of Action. As discussed above, Article 5 of the Paris Agreement encourages parties to take action to implement and support REDD+. 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 UNREDD+ programme supports national REDD+ efforts, inclusion of stakeholders in relevant dialogues, and capacity building toward REDD+ readiness in partner countries. To date the conservation and emissions impacts of REDD+ remain misunderstood (Pirard et al. 2019), but while existing evidence suggests that reductions in deforestation from subnational REDD+ initiatives have been limited (Bos et al. 2017) it shows an increasing prominence (Maguire et al. 2021). Additionally, the Green Climate Fund has carried out results-based payments within REDD+. Eight countries have so far received significant funding (GCF 2021). The shift in the REDD+ focus from ecosystem service payment to domestic policy realignments and incentive structure has changed the way REDD+ was developed and implemented (Brockhaus et al. 2017). Large-scale market resources have not fully materialised as a global carbon market system that explicitly integrates REDD+ remains under development (Angelsen 2017). Public funding for REDD+ is also limited (Climate Focus 2017). Leading up to the adoption of the Paris Agreement, the governments of Germany, Norway, and the United Kingdom formed a partnership in 2014 called 'GNU' to support results-based financing for REDD+, with Norway emerging as one of, if not the single largest major donor for REDD+ through its pledge in 2007 of approximately USD3 billion annually. Norway pledged USD1 billion for Brazil in 2008 and the same for Indonesia in 2010 (Schroeder et al. 2020). Meanwhile, REDD+ Early Movers was established with support from Germany, and the Central African Forest Initiative (CAFI), a collaborative partnership between the European Union, Germany, Norway, France, and the United Kingdom. It supports six central African countries in fighting deforestation.

More recently, the Lowering Emissions by Accelerating Forest Finance (LEAF) Coalition was established, consisting of the governments of Norway, the UK, and the US and initially nine companies in accelerating REDD+ with a jurisdictional approach. LEAF uses the Architecture for REDD+ Transaction, The REDD+ Environmental Excellence Standard (ART-TREES), is coordinated by Emergent, a non-profit intermediary between tropical countries and the private sector. Three jurisdictions in Brazil and two countries have already submitted concept notes to ART to receive results-based payments. REDD+ initiatives with a jurisdictional approach have also been adopted in various markets, such as the CORSIA (Maguire 2021). In addition to Brazil, Indonesia has attracted significant interest as a host country for REDD+. Indonesia ranks second, after Brazil, as the largest producer of deforestation-related GHG emissions (Zarin et al. 2016), but it has committed to a large reduction of deforestation in its NDC (Government of Indonesia 2016). Australia has collaborated on scientific research and emission reduction monitoring (Tacconi 2017). It took a while, however, before emission reductions were witnessed (Meehan et al. 2019). The expansion of commodity plantations, however, conflict with reduction ambitions (Anderson et al. 2016; Irawan et al. 2019) In addition to implementation at the site and jurisdictional levels, legal enforcement (Tacconi et al. 2019) as well as policy and regulatory reforms (Ekawati et al. 2019) appears to be needed.

Another relevant initiative is one under the 2015 United Nations Convention to Combat Desertification (UNCCD), which targets land degradation neutrality i.e., '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 recognised as also being critical to reaching the more specific avoided deforestation and degradation and restoration goals of the UNFCCC and UNCBD. The Land Degradation Neutrality (LDN) initiative from UNCCD includes target setting programmes (TSP) that assist countries by providing practical tools and guidance for the establishment of the voluntary targets and formulate associated measures to achieve LDN and accelerate implementation of projects (Chasek et al. 2019). Today, 124 countries have committed to their LDN national targets (UNCCD 2015). The LDN Fund is an investment vehicle launched in UNCCD COP 13 in 2017, which exists to provide long-term financing for private projects and programmes for countries to achieve their LDN targets. According to the UNCCD, most of the funds will be invested in developing countries.

Recent efforts towards the enhancement of sinks from the forestry sector have the overarching goal of reaching zero *gross* deforestation globally, i.e., eliminating the clearing of all natural forests. The New York Declaration on Forests (NYDF) was the first international pledge to call for a halving of natural forest loss by 2020 and the complete elimination of natural forest loss by 2030 (Climate Focus 2016). 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 organisations. These endorsers have committed to doing their part to achieve the NYDF's ten goals, which include ending deforestation for agricultural expansion by 2020, reducing deforestation from other sectors, restoring forests, and providing financing for forest action (Forest Declaration 2019). These goals are assessed and tracked through the NYDF Progress Assessment, which includes NYDF Assessment Partners that collect data, generate analysis, and release the finding based on the NYDF framework and goals.

The effectiveness of these agreements, which lack binding rules, can only be judged by the supplementary actions they have catalysed. The NYDF contributed to the development of several 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 (Donofrio et al. 2017; Lambin et al. 2018). Recent studies indicate that these efforts currently lack the potential to achieve wide-scale reductions in clearing and associated emissions due to weak implementation (Garrett et al. 2019), although in some cases in Indonesia and elsewhere the commodity supply chain sustainability drive appears to contribute to lowering deforestation (Wijaya et al. 2019; Chain Reaction Research 2020; Schulte et al. 2020). The NYDF 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), but these effects were temporary, as efforts are being actively reversed and deforestation has increased again significantly. Deforestation rates have escalated in Brazil, with the rate in June 2019 (the first dry-season month in the new administration) up 88% over the 2018 rate in the same month (INPE 2019). Curtis et al. (2018) find global targets are clearly not being met. More recent increase in deforestation rate remains to be assessed. NYDF confirms that the initiative did not reach its zero-deforestation goal (NYDF Assessment Partners 2020).

In 2010, the parties to the CBD adopted the Strategic Plan for Biodiversity 2011–2020 which 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+. In 2020, however, the CBD found that while progress was evident for the majority of the Aichi Biodiversity Targets, it was not sufficient for the achievement of the targets by 2020 (CBD 2020).

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, initiated in 2011 by the Government of Germany and the IUCN, is intended to catalyse the existing international AFOLU commitments. It aims to bring 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 (AUDA-NEPAD 2019), while 20X20 aims to restore 20 Mha in Latin America and the Caribbean (Anderson and 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 has been pledged in NDCs. Yet only a small part of this goal has 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 $GtCO_2eq$ sequestered (Dave et al. 2019). A key challenge in scaling up restoration has been to mobilise sufficient financing (Liagre et al. 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 AFOLU sector and some success in achieving the enhancement of sinks through restoration. However, these outcomes are nowhere near levels required to meet the Paris Agreement temperature goal –which would require turning land use and forests globally from a net anthropogenic source during 1990-2010 to a net sink of carbon by 2030, and providing a quarter of emission reductions planned by countries (Grassi et al. 2017). The AFOLU sector has so far contributed only modestly to net mitigation (see Chapter 7).

14.5.2.2 Energy sector

International cooperation on issues of energy supply and security has a long and complicated history. There exists a plethora of institutions, organisations, and agreements concerned with managing the sector. There have been efforts to map the relevant actors, with authors in one case identifying six primary organisations (Kérébel and Keppler 2009), in another sixteen (Lesage et al. 2010), and in a third fifty (Sovacool and Florini 2012). At the same time, very little of that history has had climate mitigation as its core focus. Global energy governance has encompassed five broad goals – security of energy supply and demand, economic development, international security, environmental sustainability, and domestic good governance – and as only one of these provides an entry point for climate mitigation, effort in this direction has often been lost (van de Graaf and Colgan 2016). To take one example, during the 1980s and 1990s a combination of bilateral development support and lending practices from multilateral development banks pushed developing countries to adopt power market reforms consistent with the Washington Consensus: towards liberalised power markets and away from state-owned monopolies. The goals of these reforms did not include an environmental component, and among the results was new investment in fossil-fired thermal power generation (Foster and Rana 2020).

As Goldthau and Witte (2010) document, the majority of governance efforts, outside of oil and gas producing states, was oriented towards ensuring reliable and affordable access for oil and gas imports. For example, the original rationale for the 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 influence oil output, thereby stabilising prices and revenues for exporting countries (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, with a dual mission of promoting nuclear energy and nuclear weapons non-proliferation (Scheinman 1987).

More recently, however, new institutions have emerged, and existing institutions have realigned their missions, in order to promote capacity building and global investment in low carbon energy technologies. Collectively, these developments may support the emergence of a nascent field of global sustainable energy governance, in which a broad range of global, regional, national, sub-national and non-state actors, in aggregate, shape, direct and implement the low carbon transition through climate change mitigation activities, which produce concomitant societal benefits (Bruce 2018). Beginning in the 1990s, for example, the IEA began to broaden its mission from one concerned primarily with security of oil supplies, which encompassed conservation of energy resources, to one also concerned with the sustainability of energy use, including work programs on energy efficiency and clean energy technologies and scenarios (van de Graaf and Lesage 2009). Scholars have suggested that it was the widespread perception that the IEA was primarily interested in promoting the continued use of fossil fuels, and underplaying the potential role of renewable technologies, that led a number of IEA member states to successfully push for the creation of a parallel organisation, 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 has a positive effect related to 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, mobilising other international institutions, such as multilateral development banks, promoting renewable energy (Urpelainen and Van de Graaf 2015). The United Nations, including its various agencies such as the Committee on Sustainable Energy within the United Nations Economic Commission for Europe, has also played a role in the realignment of global energy governance towards mitigation efforts. As a precursor to SDG 7, the United Nations initiated in 2011 the *Sustainable Energy for All* initiative, which in addition to aiming for universal access to modern energy services, included the goals of doubling the rate of improvement in energy efficiency, and doubling by 2030 the share of renewable energy in the global energy mix (Bruce 2018).

Sub-global agreements have also started to emerge, examples of issue-specific climate clubs. In 2015, seventy solar-rich countries signed a framework agreement dedicated towards promoting solar energy development (ISA 2015). In 2017 the Powering Past Coal Alliance was formed, uniting a set of states, businesses, and non-governmental organisations around the goal of eliminating coal-fired power generation by 2050 (Jewell et al. 2019; Blondeel et al. 2020). Scholars have argued that greater attention to supply-side agreements such as this – focusing on reducing and ultimately eliminating the supply of carbon-intensive energy sources – would strengthen the UNFCCC and Paris Agreement (Collier and Venables 2014; Piggot et al. 2018; Asheim et al. 2019; Newell and Simms 2020). Chapter 6 of this report, on energy systems, notes the importance of regional cooperation on electric grid development, seen as necessary to enable higher shares of solar and wind power penetration (RGI 2011). Finally, a number of transnational organisations and activities have emerged, 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), a point also raised in Chapter 15 of this Assessment Report. Activities include new sources of project finance, concessional loans, as well as loan guarantees, the latter through the Multilateral Investment Guarantee Agency (Multilateral Investment Guarantee Agency 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. (2017) projected these results into the future, and found that with the drop in financing costs, renewable energy projects serving all major demand centres in sub-Saharan Africa could reach cost parity with fossil fuels by 2025, whereas without the drop in financing costs associated with concessional lending, this would not be the case. Similarly, Creutzig et al. (2017) suggest that greater international attention to finance could be instrumental in the full development of solar energy.

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. One aspect of this is the development of international legal norms. A large number of bilateral and multilateral agreements, including the 1994 Energy Charter Treaty, include provisions for using a system of investor-state dispute settlement (ISDS) designed to protect the interests of investors in energy projects from national policies that could lead their assets to be stranded. Numerous scholars have pointed to ISDS being able to be used by fossil-fuel companies to block national legislation aimed at phasing out the use of their assets (Bos and Gupta 2019; Tienhaara 2018). Another aspect is finance; Gallagher et al. (2018) examine the role of national development finance systems, focusing in particular on China. While there has been a great deal of finance devoted to renewable energy, they find the majority of finance devoted to projects associated either with fossil fuel extraction or with fossil fuel-fired power generation. Ascensão et al. (2018) similarly suggest that activities associated with the Belt and Road Initiative could play a role in slowing down mitigation efforts in developing countries.

Given the complexity of global energy governance, it is impossible to make a definitive statement about its overall contribution to mitigation efforts. Three statements, do however, appear to be robust. First, prior to the emergence of climate change on the global political agenda, international cooperation in the area of energy was primarily aimed at expanding and protecting the use of fossil energy, and these goals were entrenched in a number of multilateral organisations. Second, since the 1990s, international cooperation has gradually taken climate mitigation on board as one of its goals, seeing a realignment of many pre-existing organisations priorities, and the formation of a number of new international arrangements oriented towards the development renewable energy resources. Third, the realignment is far from complete, and there are still examples of international cooperation having a chilling effect on climate mitigation, particularly through financing and investment practices, including legal norms designed to protect the interests of owners of fossil assets.

14.5.2.3 Transportation

The transportation sector has been a particular focus of cooperative efforts on climate mitigation that extend beyond the sphere of the UNFCCC climate regime. A number of these cooperative efforts involve transnational public-private partnerships, such as the European-based Transport Decarbonisation Alliance, which brings together countries, regions, cities and companies working towards the goal of a 'net-zero emission mobility system before 2050' (TDA 2019). Other efforts are centred in specialised UN agencies, such as the International Civil Aviation Organisation (ICAO) and the International Maritime Organisation (IMO).

Measures introduced by the ICAO and IMO have addressed CO_2 emissions from international shipping and aviation. Emissions from these parts of the transportation sector are generally excluded from national emissions reduction policies and NDCs because the 'international' location of emissions release makes allocation to individual nations difficult (Bows-Larkin 2015; Lyle 2018; Hoch et al. 2019). The measures adopted by ICAO take the form of standards and recommended practices that are adopted in national legislation. IMO publishes 'regulations' but does not have a power of enforcement, with non-compliance a responsibility of flag states that issue a ship's 'MARPOL' certificate.

As discussed in Chapter 2 and Figure SPM.4, international aviation currently accounts for approximately 1% of global GHG emissions, with international shipping contributing 1.2% of global GHG emissions. These international transport emissions are projected to be between approximately 60-

220% of global emissions of CO_2 in 2050, as represented by the four main illustrative model pathways in SR1.5 (Rogelj et al. 2018; UNEP 2020) Notably, however, the climate impact of aviation emissions is estimated to be 2-4 times higher due to non-CO_2 effects (Terrenoire et al. 2019; Lee et al. 2021a). Increases in trans-Arctic shipping and tourism activities with sea ice loss are also forecast to have strong regional effects due to ships' gas and particulate emissions (Stephenson et al. 2018).

The Kyoto Protocol required Annex I parties to pursue emissions reductions from aviation and marine bunker fuels by working through IMO and ICAO (UNFCCC 1997, Art. 2.2). Limited progress was made by these organisations on emissions controls in the ensuing decades (Liu 2011b), but greater action was prompted by conclusion of the SDGs and Paris Agreement (Martinez Romera 2016), together with unilateral action, such as the EU's inclusion of aviation emissions in its Emissions Trading Scheme (ETS) (Dobson 2020).

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 (Hoch et al. 2019). This leaves unclear the status of the Kyoto Protocol's article 2.2 directive after 2020 (Martinez Romera 2016; Dobson 2020), potentially opening up scope for more attention to aviation and shipping emissions under the Paris Agreement (Doelle and Chircop 2019). Some commentators have suggested that emissions from international aviation and shipping should be part of the Paris Agreement (Gençsü and Hino 2015; Traut et al. 2018), and shipping and aviation industries themselves may prefer emissions to be treated under an international regime rather than a nationally-oriented one (Gilbert and Bows 2012). In the case of shipping emissions, there is nothing in the Paris Agreement to prevent a party from including international shipping in some form in its NDC (Doelle and Chircop 2019) Under the Paris Rulebook, parties "should report international aviation and marine bunker fuel emissions as two separate entries and should not include such emissions in national totals but report them distinctly, if disaggregated data are available" (UNFCCC 2019d).

ICAO has an overarching climate goal to "limit or reduce the impact of aviation greenhouse gas emissions on the global climate" with respect to international aviation. In order to achieve this, ICAO has two global aspirational goals for the international aviation sector, of 2% annual fuel efficiency improvement through 2050 and carbon neutral growth from 2020 onwards (ICAO 2016). In order to achieve these global aspirational goals, ICAO is pursuing a 'basket' of mitigation measures for the aviation sector consisting of technical and operational measures, such as a CO_2 emissions standard for new aircraft adopted in 2016, measures on sustainable alternative fuels and a market-based measure, known as the Carbon Offset and Reduction Scheme for International Aviation (CORSIA), which the triennial ICAO Assembly of 193 Member States resolved to establish in 2016 (ICAO 2016). In line with the 2016 ICAO Assembly Resolution that established CORSIA, in mid-2018, the ICAO's 36-member state governing Council adopted a series of Standards and Recommended Practices (SARPs), now contained in Annex 16, Volume IV of the Chicago Convention (1944), as a common basis for CORSIA's implementation and enforcement by each state and its aeroplane operators. From 1 January 2019, the CORSIA SARPs require states and their operators to undertake an annual process of monitoring, verification, and reporting of emissions from all international flights, including to establish CORSIA's emissions baseline (ICAO 2019).

Based on this emissions data, CORSIA's carbon offsetting obligations commence in 2021, with 3-year compliance cycles, including a pilot phase in 2021-2023. States have the option to participate in the pilot phase and the subsequent voluntary 3-year cycle in 2024-2026. CORSIA becomes mandatory from 2027 onwards for states whose share in the total international revenue tonnes per kilometre (RTK) is above a certain threshold (Hoch et al. 2019). Under CORSIA, aviation CO_2 emissions are not capped, but rather emissions that exceed the CORSIA baseline are compensated through use of 'offset units' from emissions reduction projects in other industries (Erling 2018). However, it is unclear whether the goal of carbon neutral growth and further CO_2 emissions reduction in the sector will be sufficiently incentivised solely through the use of such offsets in combination with ICAO's manufacturing standards, programs, and state action plans, without additional measures being taken, for example, constraints on demand (Lyle 2018). If countries such as China, Brazil, India and Russia do not participate in CORSIA's voluntary offsetting requirements this could significantly undermine its capacity to deliver fully on the sectoral goal by limiting coverage of the scheme to less than 50% of international aviation CO_2 emissions in the period 2021-2026 (Climate Action Tracker 2020b; Hoch et al. 2019). In addition, a wide range of offsets are approved as 'eligible emissions units' in CORSIA, including several certified under voluntary carbon offset schemes, which may go beyond those eventually agreed under the Paris Agreement Article 6 mechanism (Hoch et al. 2019). It is noted, however, that ICAO applies a set of 'Emissions Unit Eligibility Criteria' agreed in March 2019, which specify required design elements for eligible programs. In June 2020, the ICAO Council decided to define 2019 emissions levels, rather than an average of 2019 and 2020 emissions, as the baseline year for at least the first three years of CORSIA, although there were significant reductions (45-60%) in aviation CO_2 emissions in 2020 compared with 2019 as a result of reductions in air travel associated with the COVID-19 pandemic (Climate Action Tracker 2020b).

Other measures adopted by ICAO include an aircraft CO_2 emissions standard that applies to new aircraft type designs from 2020, and to aircraft type designs already in production as of 2023 (Smith and Ahmad 2018). Overall, CORSIA and regional measures, such as the EU ETS, are estimated to reduce aviation carbon emissions by only 0.8% per year from 2017-2030 (noting, however, that 'if non-CO_2 emissions are included in the analysis, then emissions will increase') (Larsson et al. 2019). Accordingly, pathways consistent with the temperature goal of the Paris Agreement are likely to require more stringent international measures for the aviation sector (Larsson et al. 2019).

Similar to ICAO, the IMO has a stated vision of remaining committed to reducing greenhouse gas emissions from international shipping and, as a matter of urgency, aims to phase them out as soon as possible in this century. IMO has considered a range of measures to monitor and reduce shipping emissions. In 2016, the IMO's Marine Environment Protection Committee (MEPC) approved an amendment to the MARPOL Convention Annex VI for the introduction of a Mandatory Global Data Collection scheme for fuel oil consumption of ships (Dobson 2020). Other IMO measures have focused on energy efficiency (Martinez Romera 2016). The IMO's Energy Efficiency Design Index (EEDI), which is mandatory 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). In May 2019, the MEPC approved draft amendments to the MARPOL Convention Annex VI, which if adopted, will bring forward the entry into force of the third phase of the EEDI requirements to 2022 instead of 2025 (IMO 2019; Joung et al. 2020).

However, it is unlikely that the EEDI and other IMO technical and operational measures will be sufficient to produce 'the 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 (IMO 2018). This includes a goal for declining carbon intensity of the sector by reducing CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, and pursuing efforts towards 70% by 2050, compared to 2008 levels (IMO 2018, para. 3.1). The strategy also aims for peaking of total annual GHG emissions from international shipping as soon as possible and a reduction by at least 50% by 2050 compared to 2008 levels, whilst pursuing efforts towards phasing them out 'as soon as possible in this century' as a point 'on a pathway of CO_2 emissions reduction consistent with the Paris Agreement temperature goals' (IMO 2018, para. 2, 3.1). The shipping industry is on track to overachieve the 2030 carbon intensity target but not its 2050 target (Climate Action Tracker 2020c). The initial IMO strategy is to be kept under review by the MEPC with a view to adoption of a revised strategy in 2023.

The IMO's initial strategy identifies a series of candidate short-term (2018-2023), medium-term (2023-2030) and long-term (beyond 2030) measures for achieving its emissions reduction goals, including possible market-based measures in the medium-to-long term (IMO 2018, paras. 4.7-4.9). Further progress on market-based measures faces difficulty in light of conflicts between the CBDRRC principle of the climate regime and the traditional non-discrimination approach and principle of no more favourable treatment enshrined in MARPOL and other IMO conventions (Zhang 2016). Both the CBDRRC and non-discrimination principles are designated as 'principles guiding the initial strategy' (IMO 2018, para. 3.2). The challenges encountered in introducing global market-based measures for shipping emissions under the IMO have prompted regional initiatives such as the proposed extension of the EU ETS to emissions from maritime activities (Christodoulou et al. 2021), which was announced on 14 July 2021 by the EU Commission as part of its 'Fit for 55' legislative package (European Commission 2021).

While the IMO strategy is viewed as a reasonable first step that is ambitious for the shipping industry, achieving the 'vision' of alignment with the temperature goals of the Paris Agreement requires concrete implementation measures and strengthened targets in the next iteration in 2023 (Doelle and Chircop 2019; Climate Action Tracker 2020c). As a step towards this, in 2020, the IMO's MEPC put forward draft amendments to the MARPOL convention that would require ships to combine a technical and an operational approach to reduce their carbon intensity. These amendments were formally adopted by the Committee at its session in June 2021.

14.5.3 Civil society and social movements

Transnationally organised civil society actors have had long-standing involvement in international climate policy, with a particular focus on consulting or knowledge-sharing where they are present in transnational climate governance initiatives (Michaelowa and Michaelowa 2017). The term 'civil society' generally denotes 'the voluntary association of individuals in the public sphere beyond the realms of the state, the market and the family' (de Bakker et al. 2013, p. 575). Whereas civil society organisations are usually involved in lobbying or advocacy activities in a public arena, social movements focus on mobilisation and action for social change (Daniel and Neubert 2019). Examples of civil society groups involved in international climate policy include non-governmental organisations (NGOs) such as Greenpeace International, the World Wide Fund for Nature, the Environmental Defence Fund, the World Resources Institute, Friends of the Earth and Earthjustice among many others, as well as NGO networks such as the Climate Action Network (CAN), which has over 1300 NGO members in more than 130 countries, working to promote government and individual action to limit human-induced climate change to ecologically sustainable levels (Climate Action Network International 2020). The influence of civil society engagement in global climate governance is well-acknowledged, with these organisations' globally dispersed constituencies and non-state status offering perspectives that differ in significant ways from those of many negotiating states (Derman 2014).

Historically, the issue of climate change did not give rise to intense, organised transnational protest characteristic of social movements (McAdam 2017). 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). The mid-2000s onwards, however, saw the beginnings of use of more non-institutionalised 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). Groups representing Indigenous, youth, women, and labour rights brought to the fore new tools of contention and new issues in the UNFCCC, such as questions of a just transition and gender equity (Allan 2020).

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). Contemporary climate justice groups mobilise multiple strands of environmental justice movements from the Global North and South, as well as from distinct indigenous rights and peasant rights movements, and are organised as a decentralised network of semiautonomous, coordinated units (Claeys and Delgado Pugley 2017; Tormos-Aponte and García-López 2018). The climate justice movement held global days of protest in most of the world's countries in 2014 and 2015, and mobilised another large campaign in 2018 (Almeida 2019). The polycentric arrangement of the global climate movement allows simultaneous influence on multiple sites of climate governance, from the local to the global levels (Tormos-Aponte and García-López 2018).

Prominent examples of new climate social movements that operate transnationally are Extinction Rebellion and Fridays for Future, which collectively held hundreds of coordinated protests across the globe in 2019-2021, 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 encompass more than 200 countries and millions of 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 climate change (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 (Booth 2019; Extinction Rebellion 2019). The movement first arose in the United Kingdom (UK) – where it 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).

The Paris Agreement's preamble explicitly recognises the importance of engaging "various actors" in addressing climate change, and the decision adopting the Agreement created the Non-State Actor Zone for Climate Action platform to aid in scaling up these efforts. Specific initiatives have also been taken to facilitate participation of particular groups, such as the UNFCCC's Local Communities and Indigenous Peoples Platform, which commenced work in Katowice in 2019. Climate movements based in the Global South, as well as in Indigenous territories, are playing an increasingly important role in transnational negotiations through networks such as the Indigenous Peoples Platform. These groups highlight the voices and perspectives of communities and peoples particularly affected by climate change. For instance, the Pacific Climate Warriors is a grassroots network of young people from various countries in the Pacific Islands region whose activities focus on resisting narratives of future inevitability of their Pacific homelands disappearing, and re-envisioning islanders as warriors defending rights to homeland and culture (McNamara and Farbotko 2017). Youth global climate activism, particularly involving young Indigenous climate activists, is another notable recent development. Although there remains little published literature on Indigenous youth climate activism (MacKay et al. 2020), analysis of online sources indicates the emergence of several such groups, including the Pacific Climate Warriors and Te Ara Whatu from Aotearoa New Zealand (Ritchie 2021), as well as Seed Mob in Australia.

Transnational civil society organisations advocating for climate justice in global governance have articulated policy positions around rights protections, responsibility-based approaches to climate finance, and the need for transparency and accountability (Derman 2014). Another recent area of activity, which overlaps with that of emerging investor alliances (discussed further in Section 14.5.4), is the sustainability of capital investment in fossil fuel assets. Efforts to shift away from fossil fuels led by civil society include the Beyond Coal Campaign (in the US and Europe) and the organisation for a Fossil Fuel Non-proliferation Treaty. 350.org has supported mobilisation of youth and university students around a campaign of divestment that has grown into a global movement (Gunningham 2019). As Mormann (2020) notes, as of November 2020 'more than 1,200 institutional investors managing over USD14 trillion of assets around the world have committed to divest some or all of their fossil fuel holdings' (Mormann 2020). Studies suggest that the direct impacts of the divestment movement have so far been small, given a failure to differentiate between different types of fossil fuel companies, a lack of engagement with retail investors, and a lack of guidance for investors on clean energy re-investment (Osofsky et al. 2019; Mormann 2020). The movement has had a more significant impact on public discourse by raising the profile of climate change as a financial risk for investors (Bergman 2018). Blondeel et al. (2019) also find that broader appeal of the divestment norm was achieved when moral arguments were linked to financial ones, through the advocacy of economic actors, such as Bank of England's governor.

Climate justice campaigns by transnational civil society organisations increasingly embrace action through the courts. Chapter 13 discusses the growth and policy impact of such 'climate litigation' brought by civil society actors in domestic courts, which is attracting increasing attention in the literature (Setzer and Vanhala 2019; Peel and Osofsky 2020). Transnational and international court actions focused on climate change, by contrast, have been relatively few in number (Peel and Lin 2019). This reflects—at least in part—the procedural hurdles to bringing such claims, as in many international courts and tribunals (outside of the area of human rights or investor-state arbitration) litigation can only be brought by states (Bruce 2017). However, there have been active discussions about seeking an advisory opinion from the International Court of Justice (ICJ) on states' international obligations regarding the reduction of greenhouse gas emissions (Sands 2016; Wewerinke-Singh and Salili 2020), or bringing a case to the International Tribunal for the Law of the Sea on marine pollution harms caused by climate change (Boyle 2019). In September 2021 the Government of Vanuatu announced a campaign to seek an advisory opinion from the ICJ. The aim of climate litigation more generally is to supplement other regulatory efforts by filling gaps and ensuring that interpretations of laws and policies are aligned with climate mitigation goals (Osofsky 2010).

The overall impact of transnationally-organised civil society action and social movements for international cooperation on climate change mitigation has not been comprehensively evaluated in the literature. This may reflect the polycentric organisation of the movement, which 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). There is some literature emerging on environmental defenders and their need for protection against violence and repression, particularly in the case of Indigenous environmental defenders who face significantly higher rates of violence (Scheidel et al. 2020). Scheidel et al. (2020) also find that combining strategies of preventive mobilisation, protest diversification and litigation can enhance rates of success for environmental defenders in halting environmentally destructive projects. In the area of climate litigation, commentators have noted the potential for activists and even researchers to suffer retaliation through the courts as a result of "strategic lawsuits against public participation" (SLAPP) and lawsuits against researchers brought by fossil fuel interests (Setzer and Byrnes 2019; Setzer and Benjamin 2020). Influence of social movements 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 general societal change suggest that once 3.5% of the population are mobilised on an issue, far-reaching change becomes possible (Gladwell 2002; Chenoweth and Belgioioso 2019) – a tipping point that may be approaching in the case of climate change (Gunningham 2019). As noted in Chapter 5, in the particular case of low-carbon technologies, 'if 10-30% of the population were to demonstrate commitment to low-carbon technologies, behaviours, and lifestyles, new social norms would be established.'

14.5.4 Transnational business and public-private partnerships and initiatives

Combined national climate commitments fall far short of the Paris Agreement's long term temperature goals. Similar political ambition gaps persist across various areas of sustainable development. Many therefore argue that actions by nonstate actors, such as businesses and investors, cities and regions, and nongovernmental organizations (NGOs), are crucial. However, nonstate climate and sustainability actions may not be self-reinforcing but may heavily depend on supporting mechanisms. Governance risk-reduction strategies can be combined to maximize nonstate potential in sustainable and climate-resilient transformations (Chan et al. 2019).

An important feature of the evolving international climate policy landscape of the recent years is the entrepreneurship of UN agencies such as UNEP and UNDP, as well as international organizations such as the World Bank in initiating public-private partnerships (PPPs). 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). 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.

An example of a prominent PPP in the area of climate mitigation is the Renewable Energy Network (REN21 2019), which is a global multi-stakeholder network focused on promoting renewable energy policies in support of the transition to renewable energy through knowledge, established 2004. It includes members from industry, NGOs, intergovernmental organizations, and science and academia. Another example is the Green Economy Coalition founded in 2009 to bring to bear the perspectives of workers, business, poor people, the environment community, and academics in the transition to greener and more sustainable economy. Another example is that in 2015 Peru in collaboration with France and the UNFCCC Secretariat launched the 'Non-State Actor Zone for Climate Action' (NAZCA), an online platform to showcase commitments to climate action by companies, cities, regions and investors (Chan et al. 2016; Bertoldi et al. 2018). More recently, the UNFCCC 'Race to Zero' initiative led by High-level Climate Champions Nigel Topping and Gonzalo Muñoz seeks to mobilize actors beyond national governments to join the Climate Ambition Alliance and pursue net zero CO_2 targets. Its membership includes 454 cities, 23 regions, 1,391 businesses, 74 of the biggest investors, and 569 universities.

PPPs may also be developed to assist with implementation and support of states' climate mitigation commitments. For instance, UNEP has initiated a number of PPPs for climate change finance. These are designed to increase financing for the purposes of disseminating low-carbon technologies to tackle climate change and promote clean energy in many parts of developing countries (UNEP 2018b; Charlery and Traerup 2019).

In the same vein, 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, UNFCCC and UN-REDD program focus on REDD+ and UNEP focus on TEEB (a global initiative focusing on the economics of ecosystems and biodiversity) 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 the 'win-win-win' discourse (Zia and Kauffman 2018; Goulder et al. 2019). 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).

The World Bank has also 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; now entering a phase II) and the Carbon Pricing Leadership Coalition, established in 2015 and spanning a wide range of governmental and non-governmental actors, not least within business (World Bank 2018, 2019; Wettestad et al. 2021). 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.

PPPs for cooperation on climate mitigation goals have emerged at multiple levels of governance beyond the realm of international organizations. For example, 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).

Local governments are also creating cross-sector social partnerships (CSSPs) at the sub-national level; entities created for addressing social, economic, and/or environmental issues with partner organizations from the public, private and civil society sectors (Crane and Seitanidi 2014). In particular, with support from international networks such as ICLEI Local Governments for Sustainability, C40, Global Covenant of Mayors, and Global 100% Renewable Energy, local governments around the world are committing to aggressive carbon reduction targets for their cities (Ivanova et al. 2015; Clarke and Ordonez-Ponce 2017; Kona et al. 2018). Research on CSSPs implementing community sustainability plans shows that climate change is one of the four most common issues, after waste, energy and water (which are also highly relevant to climate mitigation) (MacDonald et al. 2017).

Community climate action plans consider all GHGs emitted within the local geographic boundaries, including from industry, home heating, burning fuel in vehicles, etc. It is these community plans that require large multi-stakeholder partnerships to be successful. Partners in these partnerships generally include the local government departments, other government departments, utilities, large businesses, Chamber of Commerce, some small and medium sized enterprises, universities, schools, and local civil society groups (Clarke and MacDonald 2016). Research shows that the partnership's structural features enable the achievement of plan outcomes, such as reducing GHG emissions, while also generating value for the partners (Austin and Seitanidi 2012; Clarke and MacDonald 2016; Clarke and Ordonez-Ponce 2017). Stua (2017b) explores the Mitigation Alliances (MAs) on the national level. The internal governance model of MAs consists of overarching authorities mandated to harmonize the overall organizational structure These authorities guarantee an effective, equitable and transparent functioning of the MA's pillars (the demand, supply, and exchange of mitigation outcomes), in line with the principles and criteria of the Paris Agreement. This hybrid governance model relies upon its unique links with international climate institutions (Stua 2017a).

Transnational business partnerships are a growing feature of the landscape of multi-level, multi-actor governance of climate change. Many business leaders embraced the ethos of ''business cannot succeed in societies that fail''. Examples of this line of reasoning are: poverty limits consumer spending, political instability disrupts business activity, and climate change threatens the production and distribution of goods and services. Such situations endanger MNE investments, global asset management funds, and the core business of international insurance companies and pension funds (van Tulder et al. 2021).

A leading example is the World Business Council on Sustainable Development (WBCSD), 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 USD8.5 trillion and with 19 million employees. The WBCSD aims to enhance '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 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. An 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 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.

The Global Methane Initiative is a multilateral partnership launched in 2010 by the United States Environmental Protection Agency along with thirty-six other countries to generate a voluntary, non-binding agenda for global collaboration to decrease anthropogenic methane releases. The GMI builds on the Methane to Market (M2M) Partnership, an international partnership launched in 2004. In addition to the GMI's own financial assistance, the initiative receives financial backing from the Global Methane Fund (GMF) for methane reduction projects. The GMF is a fund created by governments and private donors (Leonard 2014).

Another potentially influential type of transnational 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. 2020).

Transnational cooperative action by investors on climate mitigation has been facilitated by international standard-setting on issues of climate risk and disclosure. For example, 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 USD33 trillion in assets under management), the Global Investor Coalition on Climate Change (a coalition of regional investor groups across Asia, Australia, Europe and North America) and the Institutional Investors Group on Climate Change (IIGCC). 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 pursuit of limiting the temperature increase to 1.5 °C above pre-industrial levels, 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 their effectiveness is premature. Instead, 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 (Ivanova et al. 2020). 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, for example, contributing to the evolution of relevant public policies, is the most prominent part of these partnerships, with the majority including such activities.

There is a relatively large volume of literature that assesses PPPs in general. 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 (Liu et al. 2017b), their economic and social value added (Quélin et al. 2017), their efficiency (Estache and 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. Michaelowa and Michaelowa assess 109 trans-national partnerships and alliances based on four design criteria: existence of mitigation targets; incentives for mitigation; definition of a baseline; and existence of a monitoring, reporting, and verification procedure (Michaelowa and Michaelowa 2017). About half of the initiatives do not meet any of these criteria, and not even 15% satisfy three or more. A recent study using a systematic review of business and public administration literature on PPPs concludes that research in the past 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 (Pinz et al. 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. PPT 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). The issue of double counting should be revised. GHGs are accounted both at the national and sub-national level or company level (Schneider et al. 2014). 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 (Berrone et al. 2019). These systems will most likely continue to evolve.

14.5.5 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 recognised by the Paris Agreement, and also assessed in Chapter 13 of this report, sections 13.3.2 and 13.3.4. 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 policymaking has occurred at the level of city governments in particular. Cities have been 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). International cooperation plays a role in such action. Several international networks , such as C40, ICLEI, Mayors for Climate Protection, and the Covenant of Mayors 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 through information sharing platforms linked to specific goals that member cities make (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, even when controlling for national-level policies that may be in place (Rashidi and Patt 2018). Kona et al. (2018) find that cities belonging to the Covenant of Mayors are engaging in emissions reductions at a rate consistent with achieving a 2°C global temperature target. Kona et al. (2021) document this trend continuing.

With respect to their role in formal international cooperation, however, it is unclear what authority, as a non-state actor, they actually have. Cities, for example, are members of transnational initiatives aimed at non-state actors, such as Global Climate Action, originally the Non-state Actor Zone for Climate Action, under the UNFCCC. While there is reason to believe that such membership can add value to mitigation efforts, one study suggests that the environmental effects have yet to be reliably quantified (Hsu et al. 2019a). By contrast, Kuramochi et al. (2020) provide evidence that non-state actors are leading to significant emission reductions beyond what countries would otherwise be achieving. In terms institutional strength, Michaelowa and Michaelowa (2017) suggest that few such networks fulfil governance criteria, and hence challenge their effectiveness. Several researchers suggest that their role is important in informal ways, given issues about the legitimacy of non-state actors (Nasiritousi et al. 2016; Chan et al. 2016). Bäckstrand et al. (2017) advance the concept of 'hybrid multilateralism' 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 (Busby 2016; Hale et al. 2016; Chan et al. 2015). 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). Stua (2017b) suggests that networks involving non-state actors can play an important role in enhancing transparency. 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).

14.6 Synthesis

14.6.1 Changing nature of international cooperation

The main development since AR5 in terms of international climate cooperation has been the shift from the Kyoto Protocol to the Paris Agreement as the primary multilateral driver of climate mitigation policy worldwide (Section 14.3). Most *ex-post* assessments of the Kyoto Protocol suggest that it did lead to emissions reductions in countries with binding targets, in addition to changing investment patterns in low-carbon technologies. As noted earlier, 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 in the scientific literature supporting different views. To some extent these views align with the different analytic frameworks (Section 14.2.1): the Paris Agreement does not address the free-riding issue seen as important within the global commons framing, but may provide the necessary incentives and support mechanisms viewed as important under the political and transitions framings, respectively. The strongest critique of the Paris Agreement is that current 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 (see Section 14.3.3 and Figure 14.2), and that there is no legally binding obligation to achieve the NDCs. 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, including in developing countries. The growing number of countries with mid-century net zero GHG or CO_2 targets, consistent with Article 4 of Paris, lends support to this proposition, although there is as yet no empirical literature drawing an unambiguous connection. The collective quantified goal from a floor of USD100 billion a year in transfers to developing countries, the Green Climate Fund and other provisions on finance in the Paris Agreement have also been recognised as key to cooperation (Sections 14.3.2.8 and 14.4.1).

But then these arguments are met with counter arguments, 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 (Section 14.3.3). The degree to which countries are willing to increase the ambition and secure the achievement of their NDCs over time will be an important indicator of the success of the Paris Agreement; evidence of this was expected by the end of 2020, but the COVID-19 pandemic has delayed the process of updating NDCs.

An increasing role is also played by other cooperative agreements, in particular (potentially) under Article 6 (Sections 14.3.2.10 and 14.4.4), 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, also referred to as building blocks or incremental approach (Sections 14.2 and 14.5.1.4). There has been little analysis of whether these other agreements are of sufficient scale and scope to ensure that transformations happen quickly enough. This chapter, appraising them together, concludes that they are not. First, many agreements, such as those related to trade, may stand in the way of bottom-up mitigation efforts (Section 14.5.1.3). Second, many sectoral agreements aimed at decarbonisation – such as within the air travel sector – have not yet adopted targets comparable in scale, scope or legal character to those adopted under the Paris Agreement (Section 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 decarbonisation, while learning from each other how to implement successful policies to realise climate goals (Section 14.5.5). An increasing number of large corporations have committed to decarbonising their industrial processes and supply chains (Section 14.5.4). And, an ever-increasing number of non-state actors are adopting goals and initiating mitigation actions (Section 14.5.3). These goals and actions, some argue, could bridge the mitigation gap created by inadequate NDCs, although the empirical literature to date challenges this, suggesting that there is less transparency and limited accountability for such actions, and mitigation targets and incentives are also not clear (Sections 14.3.3 and 14.5).

14.6.2 Overall assessment of international cooperation

This section provides an overall assessment of international cooperation, taking into account the combined effects of cooperation within the UNFCCC process, other global agreements, as well as regional, sectoral, and transnational processes. Recent literature consistent with the transitions framing highlights that cooperation can be particularly effective when it addresses issues on a sector-by-sector basis (Geels et al. 2019). Table 14.4 below summarises the effects of international cooperation on mitigation efforts in each of the sectoral areas covered in Chapter 5 – 12 of this Assessment Report. As it indicates, there are some strong areas of sectoral-specific cooperation, but also some important weaknesses. Formal agreements and programs, both multilateral and bilateral, are advancing mitigation efforts in energy, AFOLU, and transportation, while transnational networks and partnerships are addressing issues in urban systems, industry, and buildings. Although many of the concerns relevant for buildings may be embedded in the energy sector with respect to their operation, and the industrial sector with respect to their materials, reinforcing the networks with more formal agreements could be vital to putting these sectors on a pathway to net zero GHG or CO_2 emissions. Several of the sectors have very little formal cooperation at the international level, and a common theme across many of them is a need for increased financial flows to achieve particular objectives.

Table 14.4 Effects of international cooperation on sectoral mitigation efforts

Sector	Key strengths	Key gaps and weaknesses
Demand, services, social aspects	Adoption of SDGs addressing social inequities and sustainable development in the context of mitigation.	Little international attention to demand-side mitigation issues.
Energy	Greater incorporation of climate goals into sectoral agreements and institutions; formation of new specialised agencies (e.g. IRENA, SE4All) devoted to climate-compatible energy.	Need for enhanced financial support to place low-carbon energy sources on an equal footing with carbon emitting energy in developing countries; investor-state dispute settlement mechanisms designed to protect the interests of companies engaged in high-carbon energy supply from national policies; ensuring just transition; and, addressing stranded assets.
AFOLU	Bilateral support for REDD+ activities; transnational partnerships disincentivising use of products from degraded lands.	Need for increased global finance for forest restoration projects and REDD+ activities; failure of national governments to meet internationally agreed upon targets with respect to deforestation and restoration; no cooperative mechanisms in place to address agricultural emissions
Urban systems	Transnational partnerships enhancing the capacity of municipal governments to design and implement effective policies.	Need for increased financial support for climate compatible urban infrastructure development.
Buildings	Transnational initiative aimed at developing regional roadmaps.	Need for formal international cooperation to enhance mitigation activities in buildings.
Transport	Sectoral agreements in aviation and shipping begin to address climate concerns.	Need to raise the level of ambition in sectoral agreements consistent with the Paris Agreement and complete decarbonisation, especially as emissions from international aviation and shipping continue to grow, unaccounted for in NDCs.
Industry	Transnational partnerships and networks encouraging the adoption of zero emission supply chain targets.	No formal multilateral or bilateral cooperation to address issues of decarbonisation in industry.
Cross-sectoral, including CDR and SRM	International agreements addressing risks of ocean-based CDR	Lack of cooperative mechanisms addressing risks and benefits of SRM; lack of cooperative mechanisms addressing financial and governance aspects of land- and technology-based CDR.

Table 14.5 provides examples of mechanisms addressing each of the assessment criteria identified in Section 14.2.3. The effects of different forms of international cooperation are separated out, including not only UNFCCC and other multilateral processes, but also sub-global and sectoral agreements. Several points stand out. First, the Paris Agreement has the potential to significantly advance the UN

climate regime's transformative potential. Second, the international market mechanisms under Article 6 – should an agreement on implementation deals be reached – allow a shift from projects and programs to policy-based and sectoral generation of emissions credits. Moreover, the sectoral agreement CORSIA also makes use of such credits. Third, there is a lack of attention to both distributive outcomes and institutional support within sectoral agreements, representing a serious gap in efforts to harmonise mitigation with equity and sustainable development. Fourth, there are transnational partnerships and initiatives, representing the actions of non-state actors, addressing each of the assessment criteria, with the exception of economic effectiveness.

Table 14.5 Illustrative examples of multi-level governance addressing criteria of effectiveness

	Environmental effectiveness	Transformative potential	Distributive Outcomes	Economic effectiveness	Institutional strength
UNFCCC	Stabilisation goal, and quasi-targets for industrialised countries	Financial mechanism; technology mechanism, provisions for capacity building	Financial mechanism, transfers from developed to developing; leadership role for industrialised countries listed in Annex 1		Reporting requirements; capacity building for national climate change offices.
Kyoto Protocol	Binding national targets for industrialised countries		Adaptation Fund; targets restricted to industrialised countries	Market-based mechanisms	Emissions accounting and reporting requirements, institutional capacity building
Paris Agreement	NDCs and the global stocktake	Mechanisms for capacity building and technology development and transfer	Furthering financial commitments under the UNFCCC, including enhanced transparency on finance	Voluntary cooperation	Mechanism for enhanced transparency
Other multilateral agreements (Montreal protocol, and SDG 7, etc)	Phase out of Ozone depleting substances (ODS) with high global warming potential - significant effects on GHG mitigation	Ozone Fund, technology transfer; development and sharing of knowledge and expertise	SDGs embedding mitigation in sustainable development		Processes for adjustment and amendment, reporting requirements

Multilateral and regional economic agreements and institutions	Harmonised lending practices of MDBs; mainstreaming climate change into IMF practices; liberalisation of trade in climate-friendly goods and services; negative effect from regulatory chill		Concessional financing agreements		Potentially negative results from dispute settlement processes
Sectoral agreements and institutions	Climate mitigation targets and actions in AFOLU, energy, and transport	Institutions devoted to developing and deploying zero-carbon energy technologies (e.g. IRENA).		Use of carbon offsets to reduce growth in emissions from aviation	
Transnational networks and partnerships	Youth climate movement raising mitigation and fossil fuel divestment on political agendas and in financial sector	Non-state actor commitments to renewable energy-based supply chains	Climate justice legal initiatives		City networks providing information exchange and technical support

14.7 Knowledge Gaps

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 assessed here are global in their geographical coverage. One exception is with respect to the effects of the Kyoto Protocol, which we have reported. Time series analysis is also challenging, given that other determinants of climate mitigation, including technology costs and the effects of national and sub-national level policies, are rapidly evolving. Thus, this chapter primarily reviews scholarship that compares observations with theory-based counter-factual scenarios.

Many of the international agreements and institutions discussed in this chapter, in particular the Paris Agreement, are new. The logic and architecture of the Paris Agreement, in particular, breaks new ground, and there is limited evaluation of prior experience in the form of analogous treaties to draw on. Such instruments have 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 operationalising 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.

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 are accumulated.

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. This chapter has noted in particular the partial dichotomy between a global-commons framing of climate change and a transitions framing, which include different indicators to be used to evaluate the effectiveness of policies. 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 a more complete picture of the nature and effectiveness of international cooperation.

Frequently Asked Questions

FAQ 14.1: **Is international cooperation working?**

Yes, to an extent. Countries' emissions were in line with their internationally agreed targets: the collective Greenhouse Gas (GHG) mitigation target for Annex I countries in the UNFCCC to return to their 1990 emissions by 2000, and their individual targets in the Kyoto Protocol for 2008-12. Numerous studies suggest that participation in the Kyoto Protocol led to substantial reductions in national GHG emissions, as well increased levels of innovation and investment in low-carbon technologies. In this latter respect, the Kyoto Protocol set in motion some of the transformational changes that will be required to meet the temperature goal of the Paris Agreement. It is too soon to tell whether the processes and commitments embodied in the Paris Agreement will be effective in achieving its stated goals with respect to limiting temperature rise, adaptation, and financial flows. There is, however, evidence that its entry into force has been a contributing factor to many countries' adopting mid-century targets of net-zero GHG or CO_2 emissions.

FAQ 14.2: **What is the future role of international cooperation in the context of the Paris Agreement?**

Continued international cooperation remains critically important both to stimulate countries' enhanced levels of mitigation ambition, and through various means of support to increase the likelihood that they achieve these objectives. The latter is particularly the case in developing countries, where mitigation efforts often rely on bilateral and multilateral cooperation on low-carbon finance, technology support, capacity building, and enhanced South-South cooperation. The Paris Agreement is structured around nationally determined contributions (NDCs) 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 instil confidence and trust, and foster solidarity among nations, with theory-based arguments that this will lead to greater levels of ambition. Together with other cooperative agreements at the sub-global and sectoral levels, as well as a growing number of transnational networks and initiatives, the implementation of all of these mechanisms are likely to play an important role in making political, economic, and social conditions more favourable to ambitious mitigation efforts in the context of sustainable development and efforts to eradicate poverty.

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' and pursuing efforts towards '1.5°C' above pre-industrial levels?**

While international cooperation is contributing to global mitigation efforts, its effects are far from uniform. Cooperation has contributed to setting a global direction of travel, and to falling greenhouse gas emissions in many countries and avoided emissions in others. It remains to be seen whether it can achieve the kind of transformational changes needed to achieve the Paris Agreement's long-term global goals. There appears to be a large potential role for international cooperation to better address sector-specific technical and infrastructure challenges that are associated with such transformational changes. Finalising the rules to pursue voluntary cooperation, such as through international carbon market mechanisms and public climate finance in the implementation of NDCs, without compromising environmental integrity, may play an important role in accelerating mitigation efforts in developing countries. Finally, there is room for international cooperation to more explicitly address transboundary issues associated with Carbon Dioxide Removal (CDR) and Solar Radiation Management (SRM).

References

Aakre, S., S. Kallbekken, R. Van Dingenen, and D. G. Victor, 2018: Incentives for small clubs of Arctic countries to limit black carbon and methane emissions. *Nat. Clim. Chang.*, **8**(1), 85–90, doi:10.1038/s41558-017-0030-8.

Abas, N. et al., 2018: Natural and synthetic refrigerants, global warming: A review. *Renew. Sustain. Energy Rev.*, **90**, 557–569, doi:10.1016/j.rser.2018.03.099.

Abatayo, A. Lou, V. Bosetti, M. Casari, R. Ghidoni, and M. Tavoni, 2020: Solar geoengineering may lead to excessive cooling and high strategic uncertainty. *Proc. Natl. Acad. Sci.*, **117**(24), 13393–13398, doi:10.1073/pnas.1916637117.

Acemoglu, D., P. Aghion, L. Bursztyn, and D. Hemous, 2012: The Environment and Directed Technical Change. *Am. Econ. Rev.*, **102**(1), 131–166, doi:10.1257/aer.102.1.131.

Adelman, S., 2018: Human Rights in the Paris Agreement: Too Little, Too Late? *Transnatl. Environ. Law*, **7**(1), 17–36, doi: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**(3), 179–195, doi:10.1191/1464993403ps060oa.

Aghion, P., P. Antràs, and E. Helpman, 2007: Negotiating free trade. *J. Int. Econ.*, **73**(1), 1–30, doi:10.1016/j.jinteco.2006.12.003.

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*. 1–17 pp. https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2014/11/Aghion_et_al_policy_paper_Nov20141.pdf.

Agueda Corneloup, I. de, and A. P. J. Mol, 2014: Small island developing states and international climate change negotiations: the power of moral "leadership." *Int. Environ. Agreements Polit. Law Econ.*, **14**(3), 281–297, doi:10.1007/s10784-013-9227-0.

Ahlm, L. et al., 2017: Marine cloud brightening - As effective without clouds. *Atmos. Chem. Phys.*, **17**(21), 13071–13087, doi:10.5194/acp-17-13071-2017.

Aichele, R., and G. Felbermayr, 2013: The Effect of the Kyoto Protocol on Carbon Emissions. *J. Policy Anal. Manag.*, **32**(4), 731–757, doi:10.1002/pam.21720.

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**(2), 239–249, doi:10.1111/j.1467-9388.2010.00680.x.

Aklin, M., and M. Mildenberger, 2020: Prisoners of the Wrong Dilemma: Why Distributive Conflict, Not Collective Action, Characterizes the Politics of Climate Change. *Glob. Environ. Polit.*, **20**(4), 4–27, doi:10.1162/glep_a_00578.

Al Khourdajie, A., and M. Finus, 2020: Measures to enhance the effectiveness of international climate agreements: The case of border carbon adjustments. *Eur. Econ. Rev.*, **124**(103405), 1–18, doi:10.1016/j.euroecorev.2020.103405.

Alcaraz, O. et al., 2019: The global carbon budget and the Paris agreement. *Int. J. Clim. Chang. Strateg. Manag.*, **11**(3), 310–325, doi: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**(4), 501–515, doi:10.1080/14693062.2015.1119098.

Allan, J. I., 2019: Dangerous Incrementalism of the Paris Agreement. *Glob. Environ. Polit.*, **19**(1), 4–11, doi:10.1162/glep_a_00488.

Allan, J. I., 2020: *The New Climate Activism: NGO Authority and Participation in Climate Change Governance*. University of Toronto Press, Toronto, 226 pp.

Allgaier, J., 2019: Science and Environmental Communication on YouTube: Strategically Distorted Communications in Online Videos on Climate Change and Climate Engineering. *Front. Commun.*, **4**(36), 1–15, doi:10.3389/fcomm.2019.00036.

Almeida, M., 2020: *Global Green Bond State of the Market 2019. Climate Bonds Initiative, July 2020*. 1–16 pp. https://www.climatebonds.net/system/tdf/reports/cbi_sotm_2019_vol1_04d.pdf (Accessed December 9, 2020).

Almeida, P., 2019: Climate justice and sustained transnational mobilization. *Globalizations*, **16**(7), 973–979, doi:10.1080/14747731.2019.1651518.

Almer, C., and R. Winkler, 2017: Analyzing the effectiveness of international environmental policies: The case of the Kyoto Protocol. *J. Environ. Econ. Manage.*, **82**(C), 125–151, doi:10.1016/j.jeem.2016.11.003.

Ameli, N., P. Drummond, A. Bisaro, M. Grubb, and H. Chenet, 2020: Climate finance and disclosure for institutional investors: why transparency is not enough. *Clim. Change*, **160**(4), 565–589, doi:10.1007/s10584-019-02542-2.

Anderson, W., and N. Peimbert, 2019: About Initiative 20X20. *Initiat. 20X20*,. https://initiative20x20.org/es/node/386 (Accessed October 29, 2021).

Anderson, Z. R., K. Kusters, J. McCarthy, and K. Obidzinski, 2016: Green growth rhetoric versus reality: Insights from Indonesia. *Glob. Environ. Chang.*, , doi:10.1016/j.gloenvcha.2016.02.008.

Andler, L., and S. Behrle, 2009: *Managers of Global Change: The Influence of International Environmental Bureaucracies*. [Biermann, F. and B. Siebenhüner, (eds.)]. MIT Press 2009, Cambridge, MA,.

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

Andresen, S., 2014: Exclusive Approaches to Climate Governance: More Effective than the UNFCCC? In: *Toward A New Climate Agreement: Conflict, Resolution and Governance* [Cherry, T., J. Hovi, and D.M. McEvoy, (eds.)], Routledge, London and New York, pp. 167–181.

Andresen, S., T. Skodvin, A. Underdal, and J. Wettestad, 2000: *Science and Politics in International Environmental Regimes*. [Andresen, S., T. Skodvin, A. Underdal, and J. Wettestad, (eds.)]. Manchester University Press, Manchester, 221 pp.

Angelsen, A., 2017: REDD+ as Result-based Aid: General Lessons and Bilateral Agreements of Norway. *Rev. Dev. Econ.*, **21**(2), 237–264.

Anouliès, L., 2015: The Strategic and Effective Dimensions of the Border Tax Adjustment. *J. Public Econ. Theory*, **17**(6), 824–847, doi:10.1111/jpet.12131.

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, doi:10.1016/j.envsci.2017.07.015.

Antwi-Agyei, P., A. J. Dougill, T. P. Agyekum, and L. C. Stringer, 2018: Alignment between nationally determined contributions and the sustainable development goals for West Africa. *Clim. Policy*, **18**(10), 1296–1312, doi:10.1080/14693062.2018.1431199.

Arino, Y. et al., 2016: Estimating option values of solar radiation management assuming that climate sensitivity is uncertain. *Proc. Natl. Acad. Sci.*, **113**(21), 5886–5891, doi:10.1073/pnas.1520795113.

Ascensão, F. et al., 2018: Environmental challenges for the Belt and Road Initiative. *Nat. Sustain.*, **1**(5), 206–209, doi:10.1038/s41893-018-0059-3.

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**(1), 93–109, doi:10.1016/j.jeem.2005.04.004.

Asheim, G. B. et al., 2019: The case for a supply-side climate treaty. *Science (80-.).*, **365**(6451), 325–327, doi:10.1126/science.aax5011.

Asian Development Bank, 2019: *High Level MDB Statement - For Publication at the UNSG Climate Action Summit, 22 September 2019*.

Asmelash, H. B., 2015: Energy Subsidies and WTO Dispute Settlement: Why Only Renewable Energy Subsidies Are Challenged. *J. Int. Econ. Law*, **18**(2), 261–285, doi:10.1093/jiel/jgv024.

AUDA-NEPAD, 2019: African Forest Landscape Restoration Initiative. *African Union Dev. Agency*,.

Austin, J. E., and M. M. Seitanidi, 2012: Collaborative Value Creation. *Nonprofit Volunt. Sect. Q.*, **41**(5), 726–758, doi:10.1177/0899764012450777.

Axel, M., 2019: Public-Private Partnerships for Sustainable Development: Exploring their design and Impact on Effectiveness. *Sustainability*, **11**(1087), doi:10.3390/su11041087.

Baatz, C., 2016: Can we have it both ways? On potential trade-offs between mitigation and solar radiation management. *Environ. Values*, **25**(1), 29–49, doi:10.3197/096327115x14497392134847.

Bacchus, J., 2016: *Global Rules for Mutually Supportive and Reinforcing Trade and Climate Regimes*. , Geneva,.

Bäckstrand, K., and J. W. Kuyper, 2017: The democratic legitimacy of orchestration: the UNFCCC, non-state actors, and transnational climate governance. *Env. Polit.*, **26**(4), doi:10.1080/09644016.2017.1323579.

Bäckstrand, K., J. W. Kuyper, B.-O. Linnér, and E. Lövbrand, 2017: Non-state actors in global climate governance: from Copenhagen to Paris and beyond. *Env. Polit.*, **26**(4), 561–579, doi:10.1080/09644016.2017.1327485.

Baghdadi, L., I. Martinez-Zarzoso, and H. Zitouna, 2013: Are RTA agreements with environmental provisions reducing emissions? *J. Int. Econ.*, **90**(2), 378–390, doi:https://doi.org/10.1016/j.jinteco.2013.04.001.

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

Bailey, I., and T. H. J. Inderberg, 2018: Australia: domestic politics, diffusion and emissions trading design as a technical and political project. In: *The Evolution of Carbon Markets: Design and Diffusion* [Wettestad, J.; Gulbrandsen, L.H., (ed.)], Routledge, pp. 124–144.

Bakhtiari, F., 2018: International cooperative initiatives and the United Nations Framework Convention on Climate Change. *Clim. Policy*, **18**(5), 655–663, doi:10.1080/14693062.2017.1321522.

Baldwin, E., Y. Cai, and K. Kuralbayeva, 2020: To build or not to build? Capital stocks and climate policy. *J. Environ. Econ. Manage.*, **100**, 102235, doi: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.*, , doi:10.17645/pag.v4i3.640.

Banks, G. D., and T. Fitzgerald, 2020: A sectoral approach allows an artful merger of climate and trade policy. *Clim. Change*, **162**(2), 165–173, doi:10.1007/s10584-020-02822-2.

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

Barrett, S., 2008: Climate treaties and the imperative of enforcement. *Oxford Rev. Econ. Policy*, , doi:10.1093/oxrep/grn015.

Barrett, S., 2013: Climate treaties and approaching catastrophes. *J. Environ. Econ. Manage.*, **66**(2), 235–250, doi:10.1016/j.jeem.2012.12.004.

Barrett, S., 2018: Choices in the climate commons. *Science (80-.).*, **362**(6420), 1217 LP – 1217, doi:10.1126/science.aaw2116.

Barrett, S., and A. Dannenberg, 2016: An experimental investigation into 'pledge and review' in climate negotiations. *Clim. Change*, **138**(1–2), 339–351, doi:10.1007/s10584-016-1711-4.

Battaglini, M., and B. Harstad, 2016: Participation and Duration of Environmental Agreements. *J. Polit. Econ.*, **124**(1), 160–204, doi:10.1086/684478.

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

Bayramoglu, B., M. Finus, and J.-F. Jacques, 2018: Climate agreements in a mitigation-adaptation game. *J. Public Econ.*, **165**, 101–113, doi:10.1016/j.jpubeco.2018.07.005.

Beauregard, C., D. Carlson, S. Robinson, C. Cobb, and M. Patton, 2021: Climate justice and rights-based litigation in a post-Paris world. *Clim. Policy*, **21**(5), 652–665, doi:10.1080/14693062.2020.1867047.

Beer, C. et al., 2010: Terrestrial Gross Carbon Dioxide Uptake: Global Distribution and Covariation with Climate. *Science (80-.).*, **329**(5993), 834–838, doi:10.1126/science.1184984.

Beiser-McGrath, L. F., and T. Bernauer, 2021: Domestic Provision of Global Public Goods: How Other Countries' Behavior Affects Public Support for Climate Policy. *Glob. Environ. Polit.*, , 1–22, doi:10.1162/glep_a_00612.

Bellamy, R., and J. Lezaun, 2017: Crafting a public for geoengineering. *Public Underst. Sci.*, , doi:10.1177/0963662515600965.

Bellamy, R., and O. Geden, 2019: Govern CO2 removal from the ground up. *Nat. Geosci.*, , doi:10.1038/s41561-019-0475-7.

Benjamin, L., 2021: *Companies and Climate Change: Theory and Law in the United Kingdom*. Cambridge University Press, Cambridge, UK,.

Benoit, C., 2011: Picking Tariff Winners: Non-Product Related PPMs and DSB Interpretations of Unconditionally within Article I:1. *Georg. J. Int. Law*, **42**(2), 583–604.

Benveniste, H., O. Boucher, C. Guivarch, H. Le Treut, and P. Criqui, 2018: Impacts of nationally determined contributions on 2030 global greenhouse gas emissions: Uncertainty analysis and distribution of emissions. *Environ. Res. Lett.*, **13**(1), doi:10.1088/1748-9326/aaa0b9.

Bergman, N., 2018: Impacts of the Fossil Fuel Divestment Movement: Effects on Finance, Policy and Public Discourse. *Sustainability*, **10**(7), 2529, doi:10.3390/su10072529.

Bernasconi-Osterwalder, N., and A. Cosbey, 2021: Carbon and Controversy: Why we need global cooperation on border carbon adjustment. *Int. Inst. Sustain. Dev. Blog*,. https://www.iisd.org/articles/carbon-border-adjustment-global-cooperation.

Berrone, P. et al., 2019: EASIER: An evaluation Model for public private partnerships contributing to sustainable development. *Sustainability*, **11**(8), 2339, doi:10.3390/su11082339.

Bertoldi, P., A. Kona, S. Rivas, and J. F. Dallemand, 2018: Towards a global comprehensive and transparent framework for cities and local governments enabling an effective contribution to the Paris climate agreement. *Curr. Opin. Environ. Sustain.*, **30**(C), 67–74, doi:10.1016/j.cosust.2018.03.009.

Besharati, N. A., C. Rawhani, and O. G. Rios, 2017: *A Monitoring And Evaluation Framework For South-South Cooperation*. NeST Africa, Johannesburg, 1–28 pp. https://saiia.org.za/research/a-monitoring-and-evaluation-framework-for-south-south-cooperation/.

Best, R., and P. J. Burke, 2018: Adoption of solar and wind energy: The roles of carbon pricing and aggregate policy support. *Energy Policy*, **118**, 404–417, doi:10.1016/J.ENPOL.2018.03.050.

Betsill, M. M., and H. Bulkeley, 2004: Transnational Networks and Global Environmental Governance:

The Cities for Climate Protection Program. *Int. Stud. Q.*, **48**(2), 471–493, doi:10.1111/j.0020-8833.2004.00310.x.

Biermann, F., and I. Möller, 2019: Rich man's solution? Climate engineering discourses and the marginalization of the Global South. *Int. Environ. Agreements Polit. Law Econ.*, **19**(2), 151–167, doi:10.1007/s10784-019-09431-0.

Biermann, F., P. Pattberg, H. van Asselt, and F. Zelli, 2009: The fragmentation of global governance architectures: A framework for analysis. *Glob. Environ. Polit.*, **9**(4), doi:10.1162/glep.2009.9.4.14.

Blondeel, M., J. Colgan, and T. Van de Graaf, 2019: What drives norm success? Evidence from anti–fossil fuel campaigns. *Glob. Environ. Polit.*, **19**(4), 63–84, doi:10.1162/glep_a_00528.

Blondeel, M., T. Van de Graaf, and T. Haesebrouck, 2020: Moving beyond coal: Exploring and explaining the Powering Past Coal Alliance. *Energy Res. Soc. Sci.*, **59**, 101304, doi:10.1016/j.erss.2019.101304.

Bodansky, D., 2013: The who, what, and wherefore of geoengineering governance. *Clim. Change*, **121**(3), 539–551, doi:10.1007/s10584-013-0759-7.

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

Bodansky, D., 2016: The legal character of the Paris agreement. *Rev. Eur. Comp. Int. Environ. Law*, **25**(2), 142–150, doi:10.1111/reel.12154.

Bodansky, D., and L. Rajamani, 2016: The Evolution and Governance Architecture of the United Nations Climate Change Regime. In: *Global Climate Policy: Actors, Concepts, and Enduring Challenges* [Sprinz, D. and U. Luterbacher, (eds.)], Cambridge University Press, pp. 13–66.

Bodansky, D., J. Brunnée, and L. Rajamani, 2017a: Introduction to International Climate Change Law. In: *International Climate Change Law*, Oxford University Press, pp. 1–34.

Bodansky, D., J. Brunnée, and L. Rajamani, 2017b: *International Climate Change Law*. First. Oxford University Press, Oxford, 374 pp.

Bodansky, D. M., S. A. Hoedl, G. E. Metcalf, and R. N. Stavins, 2016: Facilitating linkage of climate policies through the Paris outcome. *Clim. Policy*, , doi:10.1080/14693062.2015.1069175.

Bodle, R. et al., 2014: *Options and Proposals for the International Governance of Geoengineering*. Umweltbundesamt,.

Boekholt, P., J. Edler, P. Cunningham, and K. Flanagan, 2009: *Drivers of International Collaboration in Research. Final Report*. 47 pp.

Böhringer, C., A. Müller, and J. Schneider, 2015: Carbon tariffs revisited. *J. Assoc. Environ. Resour. Econ.*, **2**(4), 629–672, doi:10.1086/683607.

Booth, E., 2019: Extinction Rebellion: social work, climate change and solidarity. *Crit. Radic. Soc. Work*, **7**(2), 257–261, doi:10.1332/204986019x15623302985296.

Bos, A. B. et al., 2017: Comparing methods for assessing the effectiveness of subnational REDD+ initiatives. *Environ. Res. Lett.*, **12**(7), 74007, doi:10.1088/1748-9326/aa7032.

Bos, K., and J. Gupta, 2019: Stranded assets and stranded resources: Implications for climate change mitigation and global sustainable development. *Energy Res. Soc. Sci.*, **56**, 101215, doi:10.1016/j.erss.2019.05.025.

Bouwer, L. M., and J. C. J. H. Aerts, 2006: Financing climate change adaptation. *Disasters*, **30**(1), 49–63, doi:10.1111/j.1467-9523.2006.00306.x.

Bows-Larkin, A., 2015: All adrift: aviation, shipping, and climate change policy. *Clim. Policy*, **15**(6), 681–702, doi: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**(3), 285–288, doi:10.1016/j.oneear.2019.10.026.

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

Boyle, A., 2019: Litigating climate change under Part XII of the LOSC. *Int. J. Mar. Coast. Law*, **34**(3), 458–481, doi:10.1163/15718085-13431097.

Brandi, C., 2017: *Trade Elements in Countries' Climate Contributions under the Paris Agreement*. , Geneva,.

Brandi, C., D. Blümer, and J.-F. Morin, 2019: When Do International Treaties Matter for Domestic Environmental Legislation? *Glob. Environ. Polit.*, **19**(4), 14–44, doi:10.1162/glep_a_00524.

Brauch, M. D. et al., 2019: Treaty on Sustainable Investment for Climate Change Mitigation and Adaptation: Aligning International Investment Law with the Urgent Need for Climate Change Action. *J. Int. Arbitr.*, **36**(1), 7–35.

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**(3–4), 311–320, doi:10.1007/s10584-017-1938-8.

Brenton, A., 2013: "Great Powers" in climate politics. *Clim. policy*, **13**(5), 541–546, doi:10.1080/14693062.2013.774632.

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

Brewer, T. L., H. Derwent, A. Błachowicz, and M. Grubb, 2016: *Carbon Market Clubs and the New Paris Regime*. World Bank, Washington, DC,.

Brockhaus, M. et al., 2017: REDD+, transformational change and the promise of performance-based payments: a qualitative comparative analysis". *Clim. Policy*, **17**(6), 708–730.

Bruce, S., 2017: The Project for an International Environmental Court. In: *Concilitation in International Law* [Tomuschat, C., R.P. Mazzeschi, and D. Thürer, (eds.)], Brill Nijhoff, pp. 133–170.

Bruce, S., 2018: Global Energy Governance and International Institutions. *SSRN Electron. J.*, , doi:10.2139/ssrn.3402057.

Buck, H. J. et al., 2020: Evaluating the efficacy and equity of environmental stopgap measures. *Nat. Sustain.*, **3**, 499–504, doi:10.1038/s41893-020-0497-6.

Budolfson, M. B. et al., 2021: Utilitarian benchmarks for emissions and pledges promote equity, climate and development. *Nat. Clim. Chang.*, **11**(10), 827–833, doi:10.1038/s41558-021-01130-6.

Buis, H., 2009: The role of local government associations in increasing the effectiveness of city-to-city cooperation. *Habitat Int.*, **33**(2), 190–194, doi:10.1016/j.habitatint.2008.10.017.

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

Burniaux, J.-M., J. Château, and J. Sauvage, 2011: *The Trade Effects of Phasing Out Fossil-Fuel Consumption Subsidies*. OECD Publishing, 1–18 pp.

Burns, E. T. et al., 2016: What do people think when they think about solar geoengineering? A review of empirical social science literature, and prospects for future research. *Earth's Futur.*, **4**(11), 536–542, doi:10.1002/2016ef000461.

Burns, W., and C. R. Corbett, 2020: Antacids for the Sea? Artificial Ocean Alkalinization and Climate Change. *One Earth*, **3**(2), 154–156, doi:10.1016/j.oneear.2020.07.016.

Burton, C., R. A. Betts, C. D. Jones, and K. Williams, 2018: Will Fire Danger Be Reduced by Using

Solar Radiation Management to Limit Global Warming to 1.5 °C Compared to 2.0 °C? *Geophys. Res. Lett.*, **45**(8), 3644–3652, doi:10.1002/2018gl077848.

Busby, J., 2016: After Paris: good enough climate governance. *Curr. Hist.*, **115**(777), 3–9, doi:10.1525/curh.2016.115.777.3.

Busby, J., and J. Urpelainen, 2020: Following the Leaders? How to Restore Progress in Global Climate Governance. *Glob. Environ. Polit.*, **20**(4), 99–121, doi:10.1162/glep_a_00562.

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**(2), 101–116, doi:10.1111/j.1755-263x.2010.00150.x.

Caetano, T., H. Winker, and J. Depledge, 2020: Towards zero carbon and zero poverty: integrating national climate change mitigation and sustainable development goals. *Clim. Policy*, **20**(7), 773–778, doi:10.1080/14693062.2020.1791404.

Caldeira, K., and G. Bala, 2017: Reflecting on 50 years of geoengineering research. *Earth's Futur.*, **5**(1), 10–17, doi:10.1002/2016ef000454.

Callies, D. E., 2019: The Slippery Slope Argument against Geoengineering Research. *J. Appl. Philos.*, **36**(4), 675–687, doi:10.1111/japp.12345.

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), 1–39, doi:10.17159/1727-3781/2018/v21i0a3189.

Cames, M. et al., 2016: *How additional is the Clean Development Mechanism? Analysis of the application of current tools and proposed alternatives*. Öko-Institut/INFRAS/SEI, Berlin, 173 pp.

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, doi:10.1016/j.worlddev.2019.05.015.

Campbell-Duruflé, C., 2018a: Clouds or Sunshine in Katowice? Transparency in the Paris Agreement Rulebook. *Carbon Clim. Law Rev.*, **12**(3), 209–217.

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

Caney, S., 2011: Climate change, energy rights, and equality. In: *The Ethics of Global Climate Change* [Arnold, D.G., (ed.)], Cambridge University Press (CUP), pp. 77–103.

Caparrós, A., 2016: The Paris Agreement as a step backward to gain momentum: Lessons from and for theory. *Rev. Econ. Polit.*, **126**(3), 347, doi:10.3917/redp.263.0347.

Caparrós, A., and J. C. Péreau, 2017: Multilateral versus sequential negotiations over climate change. *Oxf. Econ. Pap.*, **69**(2), 365–387, doi:10.1093/oep/gpw075.

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

Carazo, M. P., 2017: Contextual Provisions (Preamble and Article 1). In: *The Paris Agreement on Climate Change: Analysis and Commentary* [Daniel Klein, M.P. Carazo, M. Doelle, J. Bulmer, and A. Higham, (eds.)], Oxford University Press, pp. 107–121.

Carlson, C. J. et al., 2020: Solar geoengineering could redistribute malaria risk in developing countries. *medRxiv*, , 1–17, doi:10.1101/2020.10.21.20217257.

Carr, W. A., and L. Yung, 2018: Perceptions of climate engineering in the South Pacific, Sub-Saharan Africa, and North American Arctic. *Clim. Change*, **147**(1), 119–132, doi:10.1007/s10584-018-2138-x.

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**(5), 175, doi:10.5539/jsd.v9n5p175.

Carty, T., J. Kowalzig, and B. Zagema, 2020: *Climate Finance Shadow Report 2020: Assessing progress towards the $100 billion commitment*. Oxfam International, 32 pp.

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**(3), 437–473, doi:10.1017/s0143814x13000287.

CBD, 2020: *Global Biodiversity Outlook 5*. , Montreal, 1–208 pp. https://www.cbd.int/gbo/gbo5/publication/gbo-5-en.pdf.

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.

CESCR, 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.

CESCR, 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**(3), 196–208, doi:10.1080/10042857.2017.1365450.

Chain Reaction Research, 2020: The Chain: Detected Deforestation Within Oil Palm Concessions Has Decreased So Far in 2020. *Sustain. Risk Anal.*,. https://chainreactionresearch.com/the-chain-detected-deforestation-within-oil-palm-concessions-has-decreased-so-far-in-2020/ (Accessed August 26, 2021).

Chan, G., R. Stavins, and Z. Ji, 2018: International Climate Change Policy. *Annu. Rev. Resour. Econ.*, **10**(1), 335–360, doi:10.1146/annurev-resource-100517-023321.

Chan, N., 2016a: Climate Contributions and the Paris Agreement: Fairness and Equity in a Bottom-Up Architecture. *Ethics Int. Aff.*, **30**(3), 291–301, doi:10.1017/s0892679416000228.

Chan, N., 2016b: The 'New' Impacts of the Implementation of Climate Change Response Measures. *Rev. Eur. Comp. Int. Environ. Law*, **25**(2), 228–237, doi:https://doi.org/10.1111/reel.12161.

Chan, S. et al., 2015: Reinvigorating International Climate Policy: A Comprehensive Framework for Effective Nonstate Action. *Glob. Policy*, **6**(4), 466–473, doi:10.1111/1758-5899.12294.

Chan, S., 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**(2), 238–247, doi:10.1111/reel.12168.

Chan, S. et al., 2019: Promises and risks of nonstate action in climate and sustainability governance. *Wiley Interdiscip. Rev. Clim. Chang.*, **10**(3), e572, doi:10.1002/wcc.572.

Chander, P., 2017: Subgame-perfect cooperative agreements in a dynamic game of climate change. *J. Environ. Econ. Manage.*, **84**, 173–188, doi:10.1016/j.jeem.2017.03.001.

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, doi:10.1080/14693062.2018.1479957.

Charnovitz, S., and C. Fischer, 2015: Canada–Renewable Energy: Implications for WTO Law on Green and Not-So-Green Subsidies. *World Trade Rev.*, **14**(2), 177–210, doi:10.1017/s1474745615000063.

Chasek, P. et al., 2019: Land degradation neutrality: The science-policy interface from the UNCCD to national implementation. *Environ. Sci. Policy*, , doi:10.1016/j.envsci.2018.11.017.

Chazdon, R. L. et al., 2017: A Policy-Driven Knowledge Agenda for Global Forest and Landscape Restoration: A policy-driven agenda for restoration. *Conserv. Lett.*, **10**(1), 125–132, doi:10.1111/conl.12220.

Chen, K., Y. Zhang, and X. Fu, 2019: International research collaboration: An emerging domain of innovation studies? *Res. Policy*, **48**(1), 149–168, doi:10.1016/j.respol.2018.08.005.

Chenoweth, E., and M. Belgioioso, 2019: The physics of dissent and the effects of movement momentum. *Nat. Hum. Behav.*, **3**, 1088–1095, doi:10.1038/s41562-019-0665-8.

Chepeliev, M., and D. van der Mensbrugghe, 2020: Global fossil-fuel subsidy reform and Paris Agreement. *Energy Econ.*, **85**, 104598, doi:https://doi.org/10.1016/j.eneco.2019.104598.

Christensen, J., and A. Olhoff, 2019: *Lessons from a decade of emissions gap assessments*. , Nairobi, 1–14 pp. https://wedocs.unep.org/bitstream/handle/20.500.11822/30022/EGR10.pdf.

Christodoulou, A., D. Dalaklis, A. I. Ölçer, and P. G. Masodzadeh, 2021: Inclusion of Shipping in the EU-ETS: Assessing the Direct Costs for the Maritime Sector Using the MRV Data. *Energies*, **14**(13), 3915, doi:10.3390/en14133915.

Christoff, P., 2016: The promissory note: COP 21 and the Paris Climate Agreement. *Env. Polit.*, **25**(5), 765–787, doi:10.1080/09644016.2016.1191818.

Cima, E., 2021: Retooling the Energy Charter Treaty for climate change mitigation: lessons from investment law and arbitration. *J. World Energy Law Bus.*, **14**(2), 75–87, doi:10.1093/jwelb/jwab007.

Ciplet, D., and J. Roberts, 2017: Splintering South: Ecologically Unequal Exchange Theory in a Fragmented Global Climate. *J. World - Syst. Res.*, **23**(2), 372–398, doi:10.5195/jwsr.2017.669.

Ciplet, D., J. T. Roberts, and M. R. Khan, 2015: *Power in a warming world: The new global politics of climate change and the remaking of environmental inequality.* MIT Press, 342 pp.

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**(3), 130–150, doi: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**(3), 325–340, doi: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**(2), 298–332, doi:10.1177/0007650316660534.

Clarke, A., and E. Ordonez-Ponce, 2017: City scale: Cross-sector partnerships for implementing local climate mitigation plans. *Climate Change and Public Administration: A Blog Commentary Symposium*, [Dolšak, N. and A. Prakash, (eds.)], Vol. 2 of, Public Administration Review, 25–28 http://faculty.washington.edu/aseem/Public_Administration_Review_cliamte_change_symposium.pdf.

Clémençon, R., 2016: The Two Sides of the Paris Climate Agreement: Dismal Failure or Historic Breakthrough? *J. Environ. Dev.*, **25**(1), 3–24, doi:10.1177/1070496516631362.

Climate Action Network International, 2020: About CAN: Overview. *CAN Int.*,. https://climatenetwork.org/overview/ (Accessed October 27, 2021).

Climate Action Tracker, 2020a: Global update: Paris Agreement Turning Point. https://climateactiontracker.org/publications/global-update-paris-agreement-turning-point/ (Accessed August 25, 2021).

Climate Action Tracker, 2020b: International Aviation.

https://climateactiontracker.org/sectors/aviation/ (Accessed October 27, 2021).

Climate Action Tracker, 2020c: International Shipping. https://climateactiontracker.org/sectors/shipping/ (Accessed October 27, 2021).

Climate Focus, 2016: *Progress on the New York Declaration on Forests: Eliminating Deforestation from the Production of Agricultural Commodities – Goal 2 Assessment Report*. 1–8 pp. https://www.climatefocus.com/sites/default/files/2016-NYDF-Goal-2-Assessment-Report-Executive-Summary.pdf.

Climate Focus, 2017: *Progress on the New York Declaration on Forests: Finance for Forests - Goals 8 and 9 Assessment Report*. 1–53 pp. www.climatefocus.com/sites/default/files/NYDF report 2017 FINAL.pdf.

Cochran, I., and A. Pauthier, 2019: *A framework for Aligning with Paris Agreement. The Why, What and how for financial institutions. Discussion Paper.* Institute for Climate Economics, 51 pp. https://www.i4ce.org/wp-core/wp-content/uploads/2019/09/I4CE•Framework_Alignment_Financial_Paris_Agreement_52p.pdf.

Coen, D., J. Kreienkamp, and T. Pegram, 2020: *Global Climate Governance*. Cambridge University Press,.

Collier, P., and A. J. Venables, 2014: Closing coal: economic and moral incentives. *Oxford Rev. Econ. Policy*, **30**(3), 492–512, doi:10.1093/oxrep/gru024.

Colmer, J., R. Martin, M. Muûls, and U. J. Wagner, 2020: Does Pricing Carbon Mitigate Climate Change? Firm-Level Evidence from the European Union Emissions Trading Scheme. SSRN Electron. J., , doi:10.2139/SSRN.3725482.

Committee on the Elimination of Discrimination against Women, 2018: *General Recommendation No. 37 on Gender-related dimensions of disaster risk reduction in the context of climate change. (7 February 2018) UN Doc. CEDAW/C/GC/37*. 1–22 pp. https://tbinternet.ohchr.org/Treaties/CEDAW/Shared Documents/1_Global/CEDAW_C_GC_37_8642_E.pdf.

Coninck, H. de, and D. Puig, 2015: Assessing climate change mitigation technology interventions by international institutions. *Clim. Change*, **131**(3), 417–433, doi:10.1007/s10584-015-1344-z.

Corry, O., 2017: The international politics of geoengineering: The feasibility of Plan B for tackling climate change. *Secur. Dialogue*, **48**(4), 297–315, doi:10.1177/0967010617704142.

Cosbey, A., and P. C. Mavroidis, 2014: A Turquoise Mess: Green Subsidies, Blue Industrial Policy and Renewable Energy: The Case for Redrafting the Subsidies Agreement of the WTO. *J. Int. Econ. Law*, **17**(1), 11–47, doi:10.1093/jiel/jgu003.

Cosbey, A., S. Droege, C. Fischer, and C. Munnings, 2019: Developing Guidance for Implementing Border Carbon Adjustments: Lessons, Cautions, and Research Needs from the Literature. *Rev. Environ. Econ. Policy*, **13**(1), 3–22, doi:10.1093/reep/rey020.

CPI, 2021: *Preview: Global Landscape of Climate Finance 2021*. 1–56 pp. https://www.climatepolicyinitiative.org/wp-content/uploads/2021/10/Global-Landscape-of-Climate-Finance-2021.pdf.

Crane, A., and M. M. Seitanidi, 2014: *Social partnerships and responsible business: What, why and how?* Routledge, 1–40 pp.

Creutzig, F. et al., 2017: The underestimated potential of solar energy to mitigate climate change. *Nat. Energy*, **2**(9), 17140, doi:10.1038/nenergy.2017.140.

Crook, J. A., L. S. Jackson, S. M. Osprey, and P. M. Forster, 2015: A comparison of temperature and precipitation responses to different Earth radiation management geoengineering schemes. *J. Geophys. Res. Atmos.*, **120**(18), 9352–9373, doi:10.1002/2015jd023269.

Crutzen, P. J., 2006: Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to

Resolve a Policy Dilemma? *Clim. Change*, **77**(3–4), 211–220, doi:10.1007/s10584-006-9101-y.

CTCN, 2020a: About the Climate Technology Centre and Network (CTCN). *Connect. Ctries. to Clim. Technol. Solut.*,. https://www.ctc-n.org/about-ctcn (Accessed June 4, 2020).

CTCN, 2020b: Network. *Connect. Ctries. to Clim. Technol. Solut.*,. https://www.ctc-n.org/network (Accessed June 4, 2020).

Cullenward, D., and D. G. Victor, 2020: *Making climate policy work*. John Wiley & Sons, 1–242 pp.

Cummings, C. L., S. H. Lin, and B. D. Trump, 2017: Public perceptions of climate geoengineering: a systematic review of the literature. *Clim. Res.*, **73**(3), 247–264, doi:10.3354/cr01475.

Curry, C. L. et al., 2014: A multimodel examination of climate extremes in an idealized geoengineering experiment. *J. Geophys. Res. Atmos.*, **119**(7), 3900–3923, doi:10.1002/2013jd020648.

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**(6407), 1108–1111, doi:10.1126/science.aau3445.

Dagnet, Y. et al., 2016: *Staying on track from Paris: advancing the key elements of the Paris Agreement*. , Washington DC, US, 1–60 pp. https://www.wri.org/publication/staying-track-paris.

Dagon, K., and D. P. Schrag, 2019: Quantifying the effects of solar geoengineering on vegetation. *Clim. Change*, **153**(1), 235–251, doi:10.1007/s10584-019-02387-9.

Dai, Z., D. K. Weisenstein, F. N. Keutsch, and D. W. Keith, 2020: Experimental reaction rates constrain estimates of ozone response to calcium carbonate geoengineering. *Commun. Earth Environ.*, **1**(63), 1–9, doi:10.1038/s43247-020-00058-7.

Daniel, A., and D. Neubert, 2019: Civil society and social movements: conceptual insights and challenges in African contexts. *Crit. African Stud.*, **11**(2), 176–192, doi:10.1080/21681392.2019.1613902.

Darrin, Grimsey and Mervyn, L., 2002: Evaluating the risks of public private partnerships for infrastructure project. *Internatioanal J. Public Manag.*, **20**(2), 107–118, doi:10.1016/s0263/d0263-7863(00)00040-5.

Das, K., H. van Asselt, S. Droege, and M. Mehling, 2019: Making the International Trade System Work for the Paris Agreement: Assessing the Options. *Environ. Law Report.*, **49**(6), 10553–10580.

Dave, R. et al., 2019: *Second Bonn Challenge progress report: application of the Barometer in 2018*. IUCN, International Union for Conservation of Nature, 80 pp.

Davidson Ladly, S., 2012: Border carbon adjustments, WTO-law and the principle of common but differentiated responsibilities. *Int. Environ. Agreements Polit. Law Econ.*, **12**(1), 63–84, doi:10.1007/s10784-011-9153-y.

Davin, E. L., S. I. Seneviratne, P. Ciais, A. Olioso, and T. Wang, 2014: Preferential cooling of hot extremes from cropland albedo management. *Proc. Natl. Acad. Sci.*, **111**(27), 9757–9761, doi:10.1073/pnas.1317323111.

Day, T. et al., 2020: *Navigating the nuances of net-zero targets*. 1–74 pp. newclimate.org/wp-content/uploads/2020/10/NewClimate_NetZeroReport_October2020.pdf (Accessed August 25, 2021).

de Bakker, F. G. A., F. den Hond, B. King, and K. Weber, 2013: Social Movements, Civil Society and Corporations: Taking Stock and Looking Ahead. *Organ. Stud.*, **34**(5–6), 573–593, doi:10.1177/0170840613479222.

De Bièvre, D., I. Espa, and A. Poletti, 2017: No iceberg in sight: on the absence of WTO disputes challenging fossil fuel subsidies. *Int. Environ. Agreements Polit. Law Econ.*, **17**(3), 411–425, doi:10.1007/s10784-017-9362-0.

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

de Coninck, H., and A. Sagar, 2015b: *Technology in the 2015 Paris Climate Agreement and beyond*. , Geneva, Switzerland, 1–31 pp. https://www.ru.nl/publish/pages/749373/2015_-_technology_in_the_2015_paris_climate_agreement_and_beyond_-_ictsd_issue_paper_no_42.pdf.

de Coninck, H. et al., 2018: Strengthening and implementing the global response. In: *Global Warming of 1.5C: an IPCC special report on the impacts of global warming of 1.5C 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* [MassonDelmotte, V. et al., (eds.)], pp. 313–443.

de Melo, J., and J.-M. Solleder, 2020: Barriers to trade in environmental goods: How important they are and what should developing countries expect from their removal. *World Dev.*, **130**, 104910, doi:https://doi.org/10.1016/j.worlddev.2020.104910.

Dehm, J., 2020: Climate change, 'slow violence' and the indefinite deferral of responsibility for 'loss and damage.' *Griffith Law Rev.*, , 1–33, doi:10.1080/10383441.2020.1790101.

Delimatsis, P., 2016: Sustainable Standard-setting, Climate Change and the TBT Agreement. In: *Research Handbook on Climate Change and Trade Law* [Delimatsis, P., (ed.)], Edward Elgar Publishing, Cheltenham, UK, pp. 148–180.

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**(1), 73–88, doi:10.1007/s10784-016-9344-7.

Delina, L. L., and B. K. Sovacool, 2018: Of temporality and plurality: an epistemic and governance agenda for accelerating just transitions for energy access and sustainable development. *Curr. Opin. Environ. Sustain.*, **34**, 1–6, doi:10.1016/j.cosust.2018.05.016.

Dellaux, J., 2017: Le mécanisme visant la conservation des forêts tropicales de la convention-cadre sur les changements climatiques (REDD+) : illustration de l'adaptativité du droit international. Université Aix-Marseille, 1–737 pp.

den Elzen, M. et al., 2016: Contribution of the G20 economies to the global impact of the Paris agreement climate proposals. *Clim. Change*, **137**(3), 655–665, doi:10.1007/s10584-016-1700-7.

Depledge, J., 2017: The legal and policy framework of the United Nations Climate Change Regime. In: *The Paris Agreement on climate change: Analysis and commentary* [Carazo,P., Doelle, M., Bulmer, J., and Higham, A., (ed.)], Oxford University Press.

Derman, B. B., 2014: Climate governance, justice, and transnational civil society. *Clim. Policy*, **14**(1), 23–41, doi:10.1080/14693062.2014.849492.

Di Ciommo, M., 2017: *Approaches to measuring and monitoring South-South cooperation.* Development Initiatives, 2–3 pp. http://devinit.org/wp-content/uploads/2017/02/Approaches-to-measuring-and-monitoring-South–South-cooperation.pdf.

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.*, **10**(4), e583, doi: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**(4), 906, doi:10.3390/su10040906.

Dobson, N. L., 2018: The EU's conditioning of the 'extraterritorial' carbon footprint: A call for an integrated approach in trade law discourse. *Rev. Eur. Comp. Int. Environ. Law*, **27**(1), 75–89, doi:https://doi.org/10.1111/reel.12226.

Dobson, N. L., 2020: Competing Climate Change Responses: Reflections on EU Unilateral Regulation of International Transport Emissions in Light of Multilateral Developments. *Netherlands Int. Law Rev.*, **67**(2), 183–210, doi:10.1007/s40802-020-00167-2.

Doda, B., and L. Taschini, 2017: Carbon Dating: When Is It Beneficial to Link ETSs? *J. Assoc. Environ. Resour. Econ.*, **4**(3), 701–730, doi:10.2139/ssrn.2610076.

Doda, B., S. Quemin, and L. Taschini, 2019: Linking Permit Markets Multilaterally. *J. Environ. Econ. Manage.*, **98**(1), 102259, doi:10.1016/j.jeem.2019.102259.

Doelle, M., 2016: The Paris Agreement: Historic Breakthrough or High Stakes Experiment? *Clim. Law*, **6**(1–2), 1–20, doi:10.1163/18786561-00601001.

Doelle, M., 2019: The Heart of the Paris Rulebook: Communicating NDCs and Accounting for Their Implementation. *Clim. Law*, **9**(1–2), 3–20, doi:10.1163/18786561-00901002.

Doelle, M., and A. Chircop, 2019: Decarbonizing international shipping: An appraisal of the IMO's Initial Strategy. *Rev. Eur. Comp. Int. Environ. Law*, **28**(3), 268–277, doi:10.1111/reel.12302.

Dong, Y., and K. Holm Olsen, 2017: Stakeholder participation in CDM and new climate mitigation mechanisms: China CDM case study. *Clim. Policy*, **17**(2), 171–188, doi:10.1080/14693062.2015.1070257.

Donofrio, S., P. Rothrock, and J. Leonard, 2017: *Supply-change: Tracking Corporate Commitments to Deforestation-free Supply Chain*. Forest Trends, Washington DC, 1–32 pp. https://www.forest-trends.org/wp-content/uploads/2017/03/2017SupplyChange_FINAL.pdf.

Dow, K. et al., 2013: Limits to adaptation. *Nat. Clim. Chang.*, **3**(4), 305–307, doi:10.1038/nclimate1847.

Downs, G. W., D. M. Rocke, and P. N. Barsoom, 1996: Is the Good News About Compliance Good News About Cooperation? *Int. Organ.*, **50**(3), 379–406, doi:10.1017/s0020818300033427.

Draguljić, G., 2019: The Climate Change Regime Complex: Path Dependence amidst Institutional Change. *Glob. Gov. A Rev. Multilater. Int. Organ.*, **25**(3), 476–498, doi:10.1163/19426720-02503006.

Droege, S., H. van Asselt, K. Das, and M. Mehling, 2017: The Trade System and Climate Action: Ways Forward under the Paris Agreement. *South Carolina J. Int. Law Bus.*, **13**(2), 195–276.

Duan, L., L. Cao, G. Bala, and K. Caldeira, 2020: A Model-Based Investigation of Terrestrial Plant Carbon Uptake Response to Four Radiation Modification Approaches. *J. Geophys. Res. Atmos.*, **125**(9), e2019jd031883, doi:10.1029/2019jd031883.

Dubash, N. K., 2020: Climate laws help reduce emissions. *Nat. Clim. Change* **10**(8), 709–710, doi:10.1038/s41558-020-0853-6.

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**(3), 420–432, doi: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, doi:10.1093/yiel/yvx011.

Duyck, S., 2019: Delivering on the Paris Promises? Review of the Paris Agreement's Implementing Guidelines from a Human Rights Perspective. *Clim. Law*, **9**(3), 202–223, doi:10.1163/18786561-00903004.

Duyck, S., 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.*, **12**(3), 191–202, doi:10.21552/cclr/2018/3/5.

Dzebo, A., H. Janetschek, C. Brandi, and G. Iacobuta, 2019: *Connections between the Paris Agreement and the 2030 Agenda The case for policy coherence*. Stockholm Environment Institute, Stockholm, 1–38 pp. https://www.sei.org/wp-content/uploads/2019/08/connections-between-the-paris-agreement-and-the-2030-agenda.pdf.

Eastham, S. D., D. K. Weisenstein, D. W. Keith, and S. R. H. Barrett, 2018: Quantifying the impact of sulfate geoengineering on mortality from air quality and UV-B exposure. *Atmos. Environ.*, **187**, 424–434, doi:10.1016/j.atmosenv.2018.05.047.

Edwards, G., I. Cavelier Adarve, M. C. Bustos, and J. T. Roberts, 2017: Small group, big impact: how AILAC helped shape the Paris Agreement. *Clim. Policy*, **17**(1), 71–85, doi:10.1080/14693062.2016.1240655.

Effiong, U., and R. L. Neitzel, 2016: Assessing the direct occupational and public health impacts of solar radiation management with stratospheric aerosols. *Environ. Heal.*, **15**(1), 1–9, doi:10.1186/s12940-016-0089-0.

Ehara, M., K. Hyakumura, and Y. Yokota, 2014: REDD+ initiatives for safeguarding biodiversity and ecosystem services: harmonizing sets of standards for national application. *J. For. Res.*, **19**, 427–436, doi:10.1007/s10310-013-0429-7.

Ehara, M. et al., 2019: REDD+ engagement types preferred by Japanese private firms: The challenges and opportunities in relation to private sector participation. *For. Policy Econ.*, **106**, 101945, doi:10.1016/j.forpol.2019.06.002.

Eisenack, K., and L. Kähler, 2016: Adaptation to climate change can support unilateral emission reductions. *Oxf. Econ. Pap.*, **68**(1), 258–278, doi:10.1093/oep/gpv057.

Ekawati, S., Subarudi, K. Budiningsih, G. K. Sari, and M. Z. Muttaqin, 2019: Policies affecting the implementation of REDD+ in Indonesia (cases in Papua, Riau and Central Kalimantan). *For. Policy Econ.*, **108**(C), 101939, doi:10.1016/j.forpol.2019.05.025.

El-Sayed, A., and S. J. Rubio, 2014: Sharing R and D investments in cleaner technologies to mitigate climate change. *Resour. Energy Econ.*, **38**, 168–180, doi:10.1016/j.reseneeco.2014.07.003.

Emmerling, J., and M. Tavoni, 2018: Exploration of the interactions between mitigation and solar radiation management in cooperative and non-cooperative international governance settings. *Glob. Environ. Chang.*, **53**, 244–251, doi:10.1016/j.gloenvcha.2018.10.006.

Emmerling, J., U. Kornek, V. Bosetti, and K. Lessmann, 2020: Climate thresholds and heterogeneous regions: Implications for coalition formation. *Rev. Int. Organ.*, **16**(2), 293–316, doi:10.1007/s11558-019-09370-0.

Engen, L., and A. Prizzon, 2018: *A guide to multilateral development banks*. Overseas Development Institute 2018, London, 1–92 pp.

Epps, T., and A. Green, 2010: *Reconciling Trade and ClimateHow the WTO Can Help Address Climate Change*. Edward Elgar Publishing, Cheltenham, UK, 280 pp.

Erickson, L. E., 2017: Reducing greenhouse gas emissions and improving air quality: Two global challenges. *Environ. Prog. Sustain. Energy*, **36**(4), 982–988, doi:10.1002/ep.12665.

Erickson, P., M. Lazarus, and R. Spalding-Fecher, 2014: Net climate change mitigation of the Clean Development Mechanism. *Energy Policy*, **72**(September), 146–154, doi:10.1016/j.enpol.2014.04.038.

Erickson, P. et al., 2020: Why fossil fuel producer subsidies matter. *Nature*, **578**(7793), doi:10.1038/s41586-019-1920-x.

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**(2), 195–210, doi:10.1111/reel.12079.

Erling, U. M., 2018: How to Reconcile the European Union Emissions Trading System (EU ETS) for Aviation with the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)? *Air Sp. Law*, **43**(4), 371–386.

Ernst & Young, 2017: *Report on the independent review of the effective implementation of the Climate Technology Centre and Network presented to the Twenty-Third Conference of the Parties of the UNFCCC*. 72 pp. http://unfccc.int/resource/docs/2017/cop23/eng/03.pdf.

Eskander, S. M. S. U., and S. Fankhauser, 2020: Reduction in greenhouse gas emissions from national climate legislation. *Nat. Clim. Change*, **10**(8), 750–756, doi:10.1038/s41558-020-0831-z.

Espa, I., and G. Marín Durán, 2018: Renewable Energy Subsidies and WTO Law: Time to Rethink the Case for Reform Beyond Canada – Renewable Energy/Fit Program. *J. Int. Econ. Law*, **21**(3), 621–653, doi:10.1093/jiel/jgy031.

Estache, A., and S. Saussier, 2014: Public-Private Partnerships and Efficiency: A short assessment. *CESifo DICE Rep.*, **12**(3), 8–13.

European Commission, 2019: *Communication From The Commission To The European Parliament, The European Council, The Council, The European Economic And Social Committee And The Committee Of The Regions: The European Green Deal*. , Brussels, 1–24 pp.

European Commission, 2021: *Proposal for a directive of the European Parliament and of the Council amending Directive 2003/87/EC. No. COM/2021/551*. 65 pp. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0551.

European Court of Human Rights, 2020: *Duarte Agostinho and Others v. Portugal and Others, Application Number 39371/20*.

Evans, J. R. G., E. P. J. Stride, M. J. Edirisinghe, D. J. Andrews, and R. R. Simons, 2010: Can oceanic foams limit global warming? *Clim. Res.*, **42**(2), 155–160, doi:10.3354/cr00885.

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*. 4 pp. https://core.ac.uk/download/pdf/19918344.pdf.

Eyland, T., and G. Zaccour, 2012: Strategic effects of a border tax adjustment. *Int. Game Theory Rev.*, **14**(3), 1250016, doi:10.1142/s0219198912500168.

Falkner, R., 2016a: A Minilateral Solution for Global Climate Change? On Bargaining Efficiency, Club Benefits, and International Legitimacy. *Perspect. Polit.*, **14**(1), 87–101, doi:10.1017/s1537592715003242.

Falkner, R., 2016b: The Paris agreement and the new logic of international climate politics. *Int. Aff.*, **92**(5), 1107–1125, doi:10.1111/1468-2346.12708.

Falkner, R., 2019: The unavoidability of justice - and order - in international climate politics: From Kyoto to Paris and beyond. *Br. J. Polit. Sci. Int. Relations*, **21**, 270–278, doi:10.1177/1369148118819069.

Falkner, R., N. Nasiritousi, and G. Reischl, 2021: Climate clubs: politically feasible and desirable? *Clim. Policy*, , 1–8, doi:10.1080/14693062.2021.1967717.

FAO, 2010: *Managing forests for climate change*. FAO, Rome, 19 pp. http://www.fao.org/3/i1960e/i1960e00.pdf.

FAO, 2018: *FAO's south-south and triangular cooperation to achieve the sustainable development goals. Fostering partnership among the global South*. FAO, Rome, Italy, 16 pp. http://www.fao.org/3/ca1379en/CA1379EN.pdf.

FAO, 2019: *South-South and Triangular Cooperation in FAO – Strengthening partnerships to achieve the Sustainable Development Goals*. FAO, Rome, 84 pp. http://www.fao.org/3/ca3695en/CA3695EN.pdf.

Fattouh, B., and L. Mahadeva, 2013: OPEC: What Difference Has It Made? *Annu. Rev. Resour. Econ.*, **5**(1), 427–443, doi:10.1146/annurev-resource-091912-151901.

Fay, M. et al., 2015: Getting the Finance Flowing. In: *Decarbonizing Development: Three Steps to a Zero-Carbon Future. Climate Change and Development.*, The World Bank, Washington DC, pp. 119–136.

FDI Intelligence, 2020: *The fDi report 2020. Global Greenfield Investment Trends*. [McMillan, C. and G. Ewing, (eds.)]. The Financial Times Limited 2020, London, 1–24 pp.

Field, L. et al., 2018: Increasing Arctic Sea Ice Albedo Using Localized Reversible Geoengineering. *Earth's Futur.*, **6**(6), 882–901, doi:10.1029/2018ef000820.

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

Finus, M., and M. McGinty, 2019: The anti-paradox of cooperation: Diversity may pay! *J. Econ. Behav. Organ.*, **157**, 541–559, doi:10.1016/j.jebo.2018.10.015.

Flegal, J. A., and A. Gupta, 2018: Evoking equity as a rationale for solar geoengineering research? Scrutinizing emerging expert visions of equity. *Int. Environ. Agreements Polit. Law Econ.*, **18**(1), 45–61, doi:10.1007/s10784-017-9377-6.

Flegal, J. A., A. M. Hubert, D. R. Morrow, and J. B. Moreno-Cruz, 2019: Solar Geoengineering: Social Science, Legal, Ethical, and Economic Frameworks. *Annu. Rev. Environ. Resour.*, **44**(1), 399–423, doi:10.1146/annurev-environ-102017-030032.

Forest Declaration, 2019: *Protecting and Restoring Forests: A Story of Large Commitments yet Limited Progres: Five Year Assessment Report. September 2019.* [Climate Focus, (ed.)]. 1–96 pp.

Forsell, N. et al., 2016: Assessing the INDCs' land use, land use change, and forest emission projections. *Carbon Balance Manag.*, **11**(1), 26, doi:10.1186/s13021-016-0068-3.

Foster, V., and A. Rana, 2020: *Rethinking Power Sector Reform in the Developing World*. World Bank, Washington, D.C., 359 pp.

Freestone, D., 2010: From Copenhagen to Cancun: Train Wreck or Paradigm Shift? *Environ. Law Rev.*, **12**(2), 87–93, doi:10.1350/enlr.2010.12.2.081.

Fridahl, M., 2017: Socio-political prioritization of bioenergy with carbon capture and storage. *Energy Policy*, , doi:10.1016/j.enpol.2017.01.050.

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

Friedrich, J., 2017: Global Stocktake (Article 14). In: *The Paris Agreement on Climate Change - Analysis and Commentary* [Klein, D., M.P. Carazo, M. Doelle, J. Bulmer, and A. Higham, (eds.)], Oxford University Press, Croydon, pp. 319–337.

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, doi: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**(2), 317–319, doi:10.1016/j.econlet.2007.07.013.

Frumhoff, P. C., and J. C. Stephens, 2018: Towards legitimacy of the solar geoengineering research enterprise. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, **376**(2119), 1–12, doi:10.1098/rsta.2016.0459.

Fuglestvedt, J. et al., 2018: Implications of possible interpretations of 'greenhouse gas balance' in the Paris Agreement. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, **376**(2119), 20160445, doi:10.1098/rsta.2016.0445.

Fujimori, S. et al., 2016: Will international emissions trading help achieve the objectives of the Paris Agreement? *Environ. Res. Lett.*, **11**(10), 104001, doi:10.1088/1748-9326/11/10/104001.

Fünfgeld, H., 2015: Facilitating local climate change adaptation through transnational municipal networks. *Curr. Opin. Environ. Sustain.*, **12**, 67–73, doi:10.1016/j.cosust.2014.10.011.

Fuss, S. et al., 2014: Betting on negative emissions. *Nat. Clim. Chang.*, **4**(10), 850–853, doi:10.1038/nclimate2392.

Fuss, S. et al., 2018: Negative emissions—Part 2: Costs, potentials and side effects. *Environ. Res. Lett.*, **13**(6), 63002, doi:10.1088/1748-9326/aabf9f.

Fyson, C. L., and M. L. Jeffery, 2019: Ambiguity in the Land Use Component of Mitigation Contributions Toward the Paris Agreement Goals. *Earth's Futur.*, **7**(8), 873–891, doi:10.1029/2019ef001190.

Fyson, C. L., S. Baur, M. Gidden, and C.-F. Schleussner, 2020: Fair-share carbon dioxide removal increases major emitter responsibility. *Nat. Clim. Chang.*, **10**(9), 836–841, doi:10.1038/s41558-020-0857-2.

Gajevic Sayegh, A., 2017: Climate justice after Paris: a normative framework. *J. Glob. Ethics*, **13**(3), 344–365, doi: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, doi:10.1016/j.enpol.2018.06.009.

Gampfer, R., 2016: Minilateralism or the UNFCCC? The Political Feasibility of Climate Clubs. *Glob. Environ. Polit.*, **16**(3), 62–88, doi:10.1162/glep_a_00366.

Gandenberger, C., M. Bodenheimer, J. Schleich, R. Orzanna, and L. Macht, 2015: Factors driving international technology transfer: Empirical insights from a CDM project survey. *Clim. Policy*, **16**(8), 1065–1084, doi:10.1080/14693062.2015.1069176.

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**(4), 841–868, doi: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, doi:10.1016/j.enpol.2016.08.036.

Gardiner, A., M. Bardout, F. Grossi, and S. Dixson-Declève, 2016: *Public-Private Partnerships for Climate Finance*. TemaNord, Nordic Council of Ministers, Copenhagen, 78 pp.

Garrett, R. D. et al., 2019: Criteria for effective zero-deforestation commitments. *Glob. Environ. Chang.*, **54**, 135–147, doi:10.1016/j.gloenvcha.2018.11.003.

Gasparini, B., Z. McGraw, T. Storelvmo, and U. Lohmann, 2020: To what extent can cirrus cloud seeding counteract global warming? *Environ. Res. Lett.*, **15**(5), 54002, doi:10.1088/1748-9326/ab71a3.

GCF, 2011: *Governing Instrument for the Green Climate Fund*. 17 pp. https://www.greenclimate.fund/sites/default/files/document/governing-instrument.pdf (Accessed December 11, 2020).

GCF, 2021: *Status of the GCF pipeline – Addendum IV Update on the REDD-plus Results-Based Payments*. , Washington DC, 1–5 pp. https://www.greenclimate.fund/sites/default/files/document/gcf-b28-inf08-add04.pdf.

GEA, 2012: *Global Energy Assessment Toward a Sustainable Future*. Cambridge University Press, Cambridge and New York,.

Geden, O., 2016a: An actionable climate target. *Nat. Geosci.*, **9**(5), 340–342, doi:10.1038/ngeo2699.

Geden, O., 2016b: The Paris Agreement and the inherent inconsistency of climate policymaking. *WIREs Clim. Chang.*, **7**(6), 790–797, doi:https://doi.org/10.1002/wcc.427.

Geels, F., B. K. Sovacool, T. Schwanen, and S. Sorrell, 2017: Sociotechnical transitions for deep decarbonization. *Science (80-.).*, **357**(6357), 1242, doi:10.1126/science.aao3760.

Geels, F., S. Sharpe, and D. Victor, 2019: *Accelerating the low carbon transition: the case for stronger, more targeted and coordinated international action.* , London, UK, 138 pp.

Gehring, M. W., and E. Morison, 2020: *Climate and Energy Provisions in Trade Agreements with Relevance to the Commonwealth*. Commonwealth Secretariat, London, 21 pp.

Gehring, M. W. et al., 2013: *Climate Change and Sustainable Energy Measures in Regional Trade Agreements (RTAs): An Overview. ICTSD Programme on Global Economic Policy and Institutions. Issue Paper No. 3.* International Centre for Trade and Sustainable Development, Geneva, 44 pp.

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*. [Davis, M. and S. Chatwin, (eds.)]. , London and Washington, DC, 24 pp.

Gerlagh, R., and T. O. Michielsen, 2015: Moving targets—cost-effective climate policy under scientific uncertainty. *Clim. Change*, **132**(4), 519–529, doi:10.1007/s10584-015-1447-6.

Germain, M., P. Toint, H. Tulkens, and A. de Zeeuw, 2003: Transfers to sustain dynamic core-theoretic cooperation in international stock pollutant control. *J. Econ. Dyn. Control*, **28**, 79–99, doi:10.1016/S0165-1889(02)00107-0.

German Constitutional Court, 2021: *Neubauer et al. v. Germany. Order of the First Senate of 24 March 2021. paras. 1-270.* 1–78 pp. http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2021/20210429_11817_judgment-1.pdf.

Gerres, T., M. Haussner, K. Neuhoff, and A. Pirlot, 2021: To ban or not to ban carbon-intensive materials: A legal and administrative assessment of product carbon requirements. *Rev. Eur. Comp. Int. Environ. Law*, **30**(2), 249–262, doi:10.1111/reel.12395.

GESAMP, 2019: *High level review of a wide range of proposed marine geoengineering techniques*. [Boyd, P.W. and C.M.G. Vivian, (eds.)]. International Maritime Organization (IMO), London, 144 pp.

Gewirtzman, J. et al., 2018: Financing loss and damage: reviewing options under the Warsaw International Mechanism. *Clim. Policy*, **18**(8), 1076–1086, doi: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**(9), 5326–5335, doi:10.1021/acs.est.5b00074.

Gilbert, P., and A. Bows, 2012: Exploring the scope for complementary sub-global policy to mitigate CO 2 from shipping. *Energy Policy*, **50**, 613–622, doi:10.1016/j.enpol.2012.08.002.

Gilroy, J. J. et al., 2014: Cheap carbon and biodiversity co-benefits from forest regeneration in a hotspot of endemism. *Nat. Clim. Chang.*, **4**, 503–507, doi:10.1038/nclimate2200.

GIZ, 2017: *Enabling subnational climate action through multi-level governance*. GIZ, Bonn, Germany, 13 pp. http://e-lib.iclei.org/wp-content/uploads/2017/11/GIZ-ICLEI-UNHabitat_2017_EN_Enabling-subnational-climate-action.pdf.

Gladwell, M., 2002: *The Tipping Point: How little things can make a big difference.* Back Bay Books, 301 pp.

Glienke, S., P. J. Irvine, and M. G. Lawrence, 2015: The impact of geoengineering on vegetation in experiment G1 of the GeoMIP. *J. Geophys. Res. Atmos.*, **120**(19), 10,110-196,213, doi:10.1002/2015jd024202.

Goldthau, A., and J. Witte, eds., 2010: *Global energy governance: The new rules of the game*. Brookings Institution Press, Washington, D.C., 372 pp.

Gollier, C., and J. Tirole, 2015: Negotiating effective institutions against climate change. *Econ. Energy Environ. Policy*, **4**(2), 5–28, doi: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**(2119), 20160444, doi:10.1098/rsta.2016.0444.

Goulder, L., M. A. Hafstead, G. Kim, and X. Long, 2019: Impacts of a Carbon Tax across US

Household Income Groups: What Are the Equity-Efficiency Trade-Offs? *J. Public Econ.*, **175**, 44–64, doi:10.1016/j.jpubeco.2019.04.002.

Government of Indonesia, 2016: *First Nationally Determined Contribution. Republic Of Indonesia*. 1–18 pp. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Indonesia First/First NDC Indonesia_submitted to UNFCCC Set_November 2016.pdf (Accessed January 9, 2021).

Grassi, G. et al., 2017: The key role of forests in meeting climate targets requires science for credible mitigation. *Nat. Clim. Chang.*, **7**, 220–226, doi:10.1038/nclimate3227.

Gray, K., and B. K. Gills, 2016: South–South cooperation and the rise of the Global South. *Third World Q.*, **37**(4), 557–574, doi:10.1080/01436597.2015.1128817.

Green, A., 2005: Climate Change, Regulatory Policy and the WTO: How Constraining Are Trade Rules? *J. Int. Econ. Law*, **8**(1), 143–189, doi:10.1093/jielaw/jgi008.

Green, J. F., 2017: The strength of weakness: pseudo-clubs in the climate regime. *Clim. Change*, **144**(1), 41–52, doi:10.1007/s10584-015-1481-4.

Green, J. F., 2021: Does carbon pricing reduce emissions? A review of ex-post analyses. *Environ. Res. Lett.*, **16**(4), 043004, doi:10.1088/1748-9326/abdae9.

Green, J. F., T. Sterner, and G. Wagner, 2014: A balance of "bottom–up" and "top–down" in linking climate policies. *Nat. Clim. Chang.*, **4**(12), 1064–1067, doi:10.1038/nclimate2429.

Greiner, S. et al., 2020: *Article 6 Piloting: State of play and stakeholder experiences*. 1–135 pp. https://www.climatefinanceinnovators.com/wp-content/uploads/2020/12/Climate-Finance-Innovators_Article-6-piloting_State-of-play-and-stakeholder-experiences_December-2020.pdf.

Griscom, B. W. et al., 2017: Natural climate solutions. *Proc. Natl. Acad. Sci. U. S. A.*, **114**(44), 11645–11650, doi:10.1073/pnas.1710465114.

Grubb, M., 2011: International climate finance from border carbon cost levelling. *Clim. Policy*, **11**(3), 1050–1057, doi:10.1080/14693062.2011.582285.

Grubb, M., J.-C. Hourcade, and K. Neuhoff, 2014: *Planetary economics: energy, climate change and the three domains of sustainable development*. Routledge, London,.

Grubb, M. et al., 2021: Induced innovation in energy technologies and systems: a review of evidence and potential implications for CO_2 mitigation. *Environ. Res. Lett.*, **16**(4), 043007, doi:10.1088/1748-9326/abde07.

Grunewald, N., and I. Martínez-Zarzoso, 2012: How Well Did the Kyoto Protocol Work? A Dynamic-GMM Approach with External Instruments. *SSRN Electron. J.*, (February), 37, doi:10.2139/ssrn.2013086.

Grunewald, N., and I. Martínez-Zarzoso, 2016: Did the Kyoto Protocol fail? An evaluation of the effect of the Kyoto Protocol on CO2 emissions. *Environ. Dev. Econ.*, **21**(1), 1–22, doi:10.1017/s1355770x15000091.

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**(5), 600–611, doi:10.1080/14693062.2017.1317628.

Gulbrandsen, L. H., J. Wettestad, D. G. Victor, and A. Underdal, 2019: The Political Roots of Diverging Carbon Market Design: implications for linking. *Clim. Policy*, **19**(4), 427–438, doi:10.1080/14693062.2018.1551188.

Gunningham, N., 2019: Averting Climate Catastrophe: Environmental Activism, Extinction Rebellion and coalitions of Influence. *King's Law J.*, **30**(2), 194–202, doi:10.1080/09615768.2019.1645424.

Gupta, A., and H. van Asselt, 2019: Transparency in multilateral climate politics: Furthering (or distracting from) accountability? *Regul. Gov.*, **13**(1), 18–34, doi:10.1111/rego.12159.

Gupta, A. et al., 2020: Anticipatory governance of solar geoengineering: conflicting visions of the future and their links to governance proposals. *Curr. Opin. Environ. Sustain.*, **45**, 10–19, doi:10.1016/j.cosust.2020.06.004.

Gupta, H., and L. C. Dube, 2018: Addressing biodiversity in climate change discourse: Paris mechanisms hold more promise. *Int. For. Rev.*, **20**(1), 104–114, doi:10.1505/146554818822824282.

Gupta, J. et al., 2010: Mainstreaming climate change in development cooperation policy: conditions for success. In: *Making climate change work for us* [Hulme, M. and H. Neufeldt, (eds.)], Cambridge University Press, Cambridge, UK, pp. 319–339.

Hadden, J., 2014: Explaining Variation in Transnational Climate Change Activism: The Role of Inter-Movement Spillover. *Glob. Environ. Polit.*, **14**(2), 7–25, doi:10.1162/glep_a_00225.

Haites, E., 2016: Experience with linking greenhouse gas emissions trading systems. *Wiley Interdiscip. Rev. Energy Environ.*, **5**(3), 246–260, doi:10.1002/wene.191.

Haites, E., 2018: Carbon taxes and greenhouse gas emissions trading systems: what have we learned? *Climate Policy* **18**(8), 955–966, doi:10.1080/14693062.2018.1492897.

Hale, T., 2016: "All Hands on Deck": The Paris Agreement and Nonstate Climate Action. *Glob. Environ. Polit.*, **16**(3), 12–22, doi:10.1162/glep_a_00362.

Hale, T., 2020: Catalytic Cooperation. *Glob. Environ. Polit.*, **20**(4), 73–98, doi:10.1162/glep_a_00561.

Hale, T. et al., 2016: Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs). *Clim. Policy*, **6**(4), 1–15, doi:10.1080/14693062.2019.1624252.

Hales, R., and B. Mackey, 2018: Carbon budgeting post-COP21: The need for an equitable strategy for meeting CO2e targets. In: *Pathways to a Sustainable Economy: Bridging the Gap between Paris Climate Change Commitments and Net Zero Emissions* [Hossain, M., R. Hales, and T. Sarker, (eds.)], Springer, Cham, pp. 209–220.

Hanger, S. et al., 2016: Community acceptance of large-scale solar energy installations in developing countries: Evidence from Morocco. *Energy Res. Soc. Sci.*, **14**, doi:10.1016/j.erss.2016.01.010.

Hanna, R., and D. G. Victor, 2021: Marking the decarbonization revolutions. *Nat. Energy*, **6**(6), 568–571, doi:10.1038/s41560-021-00854-1.

Harding, A. R., K. Ricke, D. Heyen, D. G. MacMartin, and J. Moreno-Cruz, 2020: Climate econometric models indicate solar geoengineering would reduce inter-country income inequality. *Nat. Commun.*, **11**(1), 1–9, doi:10.1038/s41467-019-13957-x.

Hartl, A., 2019: The effects of the Kyoto Protocol on the carbon trade balance. *Rev. World Econ.*, **155**, 539–574, doi:10.1007/s10290-019-00350-5.

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, doi: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**(6), 1865–1878, doi: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**(4), 527–537, doi:10.1111/1758-5899.12617.

Helland, L., J. Hovi, and H. Sælen, 2017: Climate leadership by conditional commitments. *Oxf. Econ. Pap.*, **70**(2), 417–442, doi:10.1093/oep/gpx045.

Helm, C., and D. F. Sprinz, 2000: Measuring the Effectiveness of International Environmental Regimes. *J. Conflict Resolut.*, **45**(5), 630–652.

Helwegen, K. G., C. E. Wieners, J. E. Frank, and H. A. Dijkstra, 2019: Complementing CO2 emission reduction by solar radiation management might strongly enhance future welfare. *Earth Syst. Dyn.*, **10**(3), 453–472, doi:10.5194/esd-10-453-2019.

Henderson, I., J. Coello, R. Fischer, I. Mulder, and T. Christophersen, 2013: *The Role of the Private Sector in REDD+: the Case for Engagement and Options for Intervention*. 12 pp. https://www.unredd.net/documents/redd-papers-and-publications-90/un-redd-publications-1191/policy-brief-series-3154/10509-private-sector-engagement-policy-brief-en-final-version-low-res-10509.html.

Hensengerth, O., 2017: Regionalism, Identity, and Hydropower Dams: The Chinese-Built Lower Sesan 2 Dam in Cambodia. *J. Curr. Chinese Aff.*, **46**(3), 85–118, doi:10.1177/186810261704600304.

Hermwille, L., A. Siemons, H. Förster, and L. Jeffery, 2019: Catalyzing mitigation ambition under the Paris Agreement: elements for an effective Global Stocktake. *Clim. Policy*, **19**(8), 988–1001, doi:10.1080/14693062.2019.1624494.

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

Hertel, M., 2011: Climate-Change-Related Trade Measures and Article XX: Defining Discrimination in Light of the Principle of Common but Differentiated Responsibilities. *J. World Trade*, **45**(3), 653–678.

Heutel, G., J. Moreno-Cruz, and S. Shayegh, 2018: Solar geoengineering, uncertainty, and the price of carbon. *J. Environ. Econ. Manage.*, **87**, 24–41, doi:10.1016/j.jeem.2017.11.002.

Hillman, J., 2013: *Changing Climate for Carbon Taxes: Who's Afraid of the WTO?. Climate & Energy Policy Paper Series, July 2013*. The German Marshall Fund of the United States, Washington, DC, 15 pp. https://scholarship.law.georgetown.edu/facpub/2030.

Hoch, S., A. Michaelowa, A. Espelage, and A. K. Weber, 2019: Governing complexity: How can the interplay of multilateral environmental agreements be harnessed for effective international market-based climate policy instruments? *Int. Environ. Agreements Polit. Law Econ.*, **19**, 595–613, doi:10.1007/s10784-019-09455-6.

Hochstetler, K., and M. Milkoreit, 2013: Emerging Powers in the Climate Negotiations: Shifting Identity Conceptions. *Polit. Res. Q.*, **67**(1), 224–235, doi:10.1177/1065912913510609.

Hof, A., C. Brink, A. M. Beltran, and M. den Elzen, 2012: *Greenhouse gas emission reduction targets for 2030 - Conditions for an EU target of 40%*. PBL Publishers, The Hague, 52 pp.

Hofman, E., and W. van der Gaast, 2019: Enhancing ambition levels in nationally determined contributions-Learning from Technology Needs Assessments. *Wiley Interdiscip. Rev. - Energy Environ.*, **8**(e311), doi:10.1002/wene.311.

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**(3), 399–414, doi:10.1177/0263774x16644815.

Höglund-Isaksson, L. et al., 2017: Cost estimates of the Kigali Amendment to phase-down hydrofluorocarbons. *Environ. Sci. Policy*, **75**, 138–147, doi:10.1016/j.envsci.2017.05.006.

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

Höhne, N., 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**(4), 425–441, doi:10.1080/14693062.2017.1294046.

Höhne, N. et al., 2021: Wave of net zero emission targets opens window to meeting the Paris Agreement. *Nat. Clim. Chang.*, **11**(10), 820–822, doi:10.1038/s41558-021-01142-2.

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, doi:10.1177/0907568219879970.

Holzer, K., 2014: *Carbon-related Border Adjustment and WTO Law*. Edward Elgar Publishing, Cheltenham, UK, 352 pp.

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, doi:10.1016/j.gloenvcha.2015.06.006.

Holzer, K., and A. H. Lim, 2020: Trade and Carbon Standards: Why Greater Regulatory Cooperation is Needed. In: *Cool Heads in a Warming World: How Trade Policy Can Help Fight Climate Change* [Esty, D.C. and S. Biniaz, (eds.)], Yale Center for Environmental Law & Policy, New Haven, CT, p. pp. 27.

Honegger, M., and D. Reiner, 2018: The political economy of negative emissions technologies: consequences for international policy design. *Clim. Policy*, **18**(3), 306–321, doi:10.1080/14693062.2017.1413322.

Honegger, M., A. Michaelowa, and J. Pan, 2021a: Potential implications of solar radiation modification for achievement of the Sustainable Development Goals. *Mitig. Adapt. Strateg. Glob. Chang.*, **26**(5), 1–20, doi:10.1007/s11027-021-09958-1.

Honegger, M., M. Poralla, A. Michaelowa, and H.-M. Ahonen, 2021b: Who Is Paying for Carbon Dioxide Removal? Designing Policy Instruments for Mobilizing Negative Emissions Technologies. *Front. Clim.*, **3**(June), 1–15, doi:10.3389/fclim.2021.672996.

Horlick, G., and P. A. Clarke, 2017: Rethinking Subsidy Disciplines for the Future: Policy Options for Reform. *J. Int. Econ. Law*, **20**(3), 673–703, doi:10.1093/jiel/jgx022.

Horton, J., and D. Keith, 2016: Solar geoengineering and obligations to the global poor. In: *Climate justice and geoengineering: Ethics and policy in the atmospheric anthropocene* [Preston, C., (ed.)], Rowman Littlefield, Lanham, pp. 79–92.

Horton, J. B., and B. Koremenos, 2020: Steering and influence in transnational climate governance: nonstate engagement in solar geoengineering research. *Glob. Environ. Polit.*, **20**(3), 93–111, doi:10.1162/glep_a_00572.

Hourdequin, M., 2018: Climate Change, Climate Engineering, and the 'Global Poor': What Does Justice Require? *Ethics, Policy Environ.*, **21**(3), 270–288, doi:10.1080/21550085.2018.1562525.

Hourdequin, M., 2019: Geoengineering Justice: The Role of Recognition: *Sci. Technol. Hum. Values*, **44**(3), 448–477, doi:10.1177/0162243918802893.

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

Hovi, J., D. F. Sprinz, H. Sælen, and A. Underdal, 2017: The Club Approach: A Gateway to Effective Climate Co-operation? *Br. J. Polit. Sci.*, **49**(3), 1071–1096, doi:10.1017/s0007123416000788.

Howard, A., 2017: Voluntary Cooperation (Article 6). In: *The Paris Agreement on climate change: Analysis and commentary* [Klein, D., M. Pía Carazo, M. Doelle, J. Bulmer, and A. Higham, (eds.)], Oxford University Press, Oxford, p. pp. 178.

Hsu, A. et al., 2019a: A research roadmap for quantifying non-state and subnational climate mitigation action. *Nat. Clim. Chang.*, **9**(1), doi:10.1038/s41558-018-0338-z.

Hsu, A., 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*, **6**(4), 1–15, doi:10.1080/14693062.2019.1624252.

Hu, X. et al., 2020: The impacts of the trade liberalization of environmental goods on power system and CO2 emissions. *Energy Policy*, **140**, 111173, doi:10.1016/j.enpol.2019.111173.

Huang, J., 2018: What Can the Paris Agreement's Global Stocktake Learn from the Sustainable Development Goals? *Carbon Clim. Law Rev.*, **12**(3), 218–228, doi:10.21552/cclr/2018/3/8.

Hubert, A. M., 2020: A Code of Conduct for Responsible Geoengineering Research. *Glob. Policy*, **12**(S1), 82–96, doi:10.1111/1758-5899.12845.

Hufbauer, G. C., J. Kim, and S. Charnovitz, 2009: *Global Warming and the World Trading System*. Peterson Institute for International Economics, Washington DC, 166 pp.

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**(2), 427–448, doi:10.1017/s2047102516000170.

Hulme, M., 2014: *Can science fix climate change? : a case against climate engineering*. Polity Press, Cambridge, UK, 144 pp.

Human Rights Committee, 2018: *General comment No. 36 (2018) on article 6 of the International Covenant on Civil and Political Rights, on the right to life (30 October 2018). UN Doc. CCPR/C/GC/36*. 1–21 pp. https://tbinternet.ohchr.org/Treaties/CCPR/Shared Documents/1_Global/CCPR_C_GC_36_8785_E.pdf.

Hurrell, A., and S. Sengupta, 2012: Emerging powers, North–South relations and global climate politics. *Int. Aff.*, **88**(3), 463–484, doi:10.1111/j.1468-2346.2012.01084.x.

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**(11), 114019, doi: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*. International Civil Aviation Organisation, 25–32 pp. https://www.icao.int/Meetings/a39/Documents/Resolutions/a39_res_prov_en.pdf.

ICAO, 2019: *SARPs - Annex 16 — Environmental Protection, Volume IV — Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)*. ICAO, 120 pp. https://www.icao.int/environmental-protection/CORSIA/Pages/SARPs-Annex-16-Volume-IV.aspx.

ICAP, 2019: *Emissions Trading Worldwide. International Carbon Action Partnership (ICAP) – Status Report 2019*. International Carbon Action Partnership, Berlin, 130 pp. https://icapcarbonaction.com/en/icap-status-report-2019.

ICSU ISSC, 2015: *Review of Targets for the Sustainable Development Goals: the science perspective*. International Council for Science, Paris, 88 pp. https://council.science/wp-content/uploads/2017/05/SDG-Report.pdf.

IIGCC, 2020: *Paris Aligned Investment Initiative: Net Zero Investment Framework for Consultation*. The Institutional Investors Group on Climate Change, 40 pp. https://www.iigcc.org/download/net-zero-investment-framework-consultation/?wpdmdl=3602&masterkey=5f270ef146677 (Accessed December 9, 2020).

IMO, 2018: *Resolution MEPC.304(72): Initial IMO Strategy on Reduction of GHG Emissions from Ships. MEPC 72/17/Add.1 Annex 11*. International Maritime Organization (IMO), 1–11 pp. https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Resolution MEPC.304(72)_E.pdf.

IMO, 2019: UN agency pushes forward on shipping emissions reduction. *Press Briefings*,. https://www.imo.org/en/MediaCentre/PressBriefings/Pages/11-MEPC-74-GHG.aspx (Accessed October 27, 2021).

InfoFLR, 2018: The Bonn Challenge Barometer. Info Forest Landscape Restoration. *Int. Union Conserv. Nat.*,. https://infoflr.org/bonn-challenge-barometer (Accessed October 27, 2021).

Ingham, A., J. Ma, and A. M. Ulph, 2013: Can adaptation and mitigation be complements? *Clim. Change*, **120**, 39–53, doi:10.1007/s10584-013-0815-3.

INPE, 2019: Monitoramento dos Focos Ativos por País - Programa Queimadas - INPE. http://queimadas.dgi.inpe.br/queimadas/portal-static/estatisticas_paises/ (Accessed December 22, 2020).

Institute for Climate Economics, 2017: THE INITIATIVE – Climate Action in Financial Institutions. https://www.mainstreamingclimate.org/initiative/ (Accessed December 8, 2020).

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

IPCC, 2018a: *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,*. [Masson-Delmotte, V. et al., (eds.)]. Intergovernmental Panel on Climate Change, 616 pp.

IPCC, 2018b: IPCC Special Report 1.5 - Summary for Policymakers. In: *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,* World Meteorological Organization, Geneva, Switzerland, p. pp. 32.

IPCC, 2019: Summary for Policy Makers. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [Pörtner, H.-O. et al., (eds.)], p. pp. 35.

IPCC, 2020: *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*. [Shukla, P.R. et al., (eds.)]. Intergovernmental Panel on Climate Change, 896 pp.

Irawan, S., T. Widiastomo, L. Tacconi, J. D. Watts, and B. Steni, 2019: Exploring the design of jurisdictional REDD+: The case of Central Kalimantan, Indonesia. *For. Policy Econ.*, **108**, 101853, doi:10.1016/j.forpol.2018.12.009.

IRENA, 2021: International Renewable Energy Agency Avoided Emissions Calculator. *https://www.irena.org/climatechange/Avoided-Emissions*-Calculator (Accessed 3 November 2021.

Irvine, P. J., and D. W. Keith, 2020: Halving warming with stratospheric aerosol geoengineering moderates policy-relevant climate hazards. *Environ. Res. Lett.*, **15**(4), 44011, doi:10.1088/1748-9326/ab76de.

Irvine, P. J. et al., 2017: Towards a comprehensive climate impacts assessment of solar geoengineering. *Earth's Futur.*, **5**(1), 93–106, doi:10.1002/2016ef000389.

ISA, 2015: Framework Agreement on the establishment of the International Solar Alliance. https://isolaralliance.org/about/framework-agreement#book5/undefined (Accessed October 28, 2021).

Ismer, R., and K. Neuhoff, 2007: Border tax adjustment: a feasible way to support stringent emission trading. *Eur. J. Law Econ.*, **24**(2), 137–164, doi:10.1007/s10657-007-9032-8.

Ismer, R., and M. Haussner, 2016: Inclusion of Consumption into the EU ETS: The Legal Basis under European Union Law. *Rev. Eur. Comp. Int. Environ. Law*, **25**(1), 69–80, doi:https://doi.org/10.1111/reel.12131.

Ismer, R., K. Neuhoff, and A. Pirlot, 2020: *Border Carbon Adjustments and Alternative Measures for the EU ETS: An Evaluation*. DIW Berlin, 2020, Berlin, 21 pp. https://www.diw.de/documents/publikationen/73/diw_01.c.743698.de/dp1855.pdf.

Ismer, R. et al., 2021: *Climate Neutral Production, Free Allocation of Allowances under Emissions Trading Systems, and the WTO: How to Secure Compatibility with the ASCM*. DIW Berlin, 2021, Berlin, 18 pp. https://www.diw.de/documents/publikationen/73/diw_01.c.818655.de/dp1948.pdf.

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

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

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. In: *The Sustainable City X* [Brebbia, C.A. and W.F. Florez-Escobar, (eds.)], Vol. 194 of *WIT Transactions on Ecology and the Environment*, WIT Press, pp. 439–449.

Ivanova, A., A. Zia, P. Ahmad, and M. Bastos-Lima, 2020: Climate mitigation policies and actions: access and allocation issues. *Int. Environ. Agreements Polit. Law Econ.*, **20**(2), 287–301, doi:10.1007/s10784-020-09483-7.

Iwata, H., and K. Okada, 2014: Greenhouse gas emissions and the role of the Kyoto Protocol. *Environ. Econ. Policy Stud.*, **16**(4), 325–342, doi:10.1007/s10018-012-0047-1.

Iyer, G. et al., 2017: Measuring progress from nationally determined contributions to mid-century strategies. *Nat. Clim. Chang.*, **7**(12), 871–874, doi:10.1038/s41558-017-0005-9.

Jachnik, R., M. Mirabile, and A. Dobrinevski, 2019: *Tracking finance flows towards assessing their consistency with climate objectives*. OECD Publishing, Paris, 41 pp.

Jackson, L. S., J. A. Crook, and P. M. Forster, 2016: An intensified hydrological cycle in the simulation of geoengineering by cirrus cloud thinning using ice crystal fall speed changes. *J. Geophys. Res. Atmos.*, **121**(12), 6822–6840, doi:10.1002/2015jd024304.

Jacquet, J., and D. Jamieson, 2016: Soft but significant power in the Paris Agreement. *Nat. Clim. Chang.*, **6**(7), 643–646, doi:10.1038/nclimate3006.

Jaffe, A. B., R. G. Newell, and R. N. Stavins, 2005: A tale of two market failures: Technology and environmental policy. *Ecol. Econ.*, **54**(2–3), 164–174, doi:10.1016/j.ecolecon.2004.12.027.

James, R. et al., 2014: Characterizing loss and damage from climate change. *Nat. Clim. Chang.*, **4**(11), 938–939, doi:10.1038/nclimate2411.

Janetschek, H., C. Brandi, A. Dzebo, and B. Hackmann, 2020: The 2030 Agenda and the Paris Agreement: voluntary contributions towards thematic policy coherence. *Clim. Policy*, **20**(4), 430–442, doi:10.1080/14693062.2019.1677549.

Janus, H., S. Klingebiel, and T. C. Mahn, 2014: *How to Shape Development Cooperation? The Global Partnership and the Development Cooperation Forum (March 10, 2014). Briefing Paper, 3/2014*. German Development Institute, 4 pp.

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**(9), 1260–1274, doi:10.1029/2018ef000865.

Jewell, J. et al., 2018: Limited emission reductions from fuel subsidy removal except in energy-exporting regions. *Nature*, **554**(7691), 229–233, doi:10.1038/nature25467.

Jewell, J., V. Vinichenko, L. Nacke, and A. Cherp, 2019: Prospects for powering past coal. *Nat. Clim. Chang.*, **9**(8), 592–597, doi:10.1038/s41558-019-0509-6.

Jinnah, S., and S. Nicholson, 2019: The hidden politics of climate engineering. *Nat. Geosci.*, **12**(11), 876–879, doi:10.1038/s41561-019-0483-7.

Jinnah, S., S. Nicholson, and J. Flegal, 2018: Toward Legitimate Governance of Solar Geoengineering Research: A Role for Sub-State Actors. *Ethics, Policy Environ.*, **21**(3), 362–381, doi:10.1080/21550085.2018.1562526.

Johnson, B. A., R. Dasgupta, A. D. Mader, and H. Scheyvens, 2019: Understanding national biodiversity targets in a REDD+ context. *Environ. Sci. Policy*, **92**, 27–33, doi:10.1016/j.envsci.2018.11.007.

Jones, A. et al., 2021: North Atlantic Oscillation response in GeoMIP experiments G6solar and G6sulfur: Why detailed modelling is needed for understanding regional implications of solar radiation management. *Atmos. Chem. Phys.*, **21**(2), 1287–1304, doi:10.5194/acp-21-1287-2021.

Jones, A. C. et al., 2018: Regional Climate Impacts of Stabilizing Global Warming at 1.5 K Using Solar Geoengineering. *Earth's Futur.*, **6**(2), 230–251, doi:10.1002/2017ef000720.

Jordan, A. J. et al., 2015: Emergence of polycentric climate governance and its future prospects. *Nat. Clim. Chang.*, **5**(11), 977–982, doi:10.1038/nclimate2725.

Joung, T.-H., S.-G. Kang, J.-K. Lee, and J. Ahn, 2020: The IMO initial strategy for reducing Greenhouse Gas(GHG) emissions, and its follow-up actions towards 2050. *J. Int. Marit. Safety, Environ. Aff. Shipp.*, **4**(1), 1–7, doi:10.1080/25725084.2019.1707938.

Jun, M., and S. Zadek, 2019: *Decarbonizing the Road and Belt. A Green Finance Roadmap.* 54 pp. https://www.vivideconomics.com/wp-content/uploads/2019/09/Decarbonizing-the-Belt-and-Road-–Final-Report-English.pdf.

Karlas, J., 2017: States, coalitions, and the legalization of the global climate regime: negotiations on the post-2020 architecture. *Env. Polit.*, **26**(5), 1–22, doi:10.1080/09644016.2017.1324754.

Karlsson-Vinkhuyzen, S. I. et al., 2018: Entry into force and then? The Paris agreement and state accountability. *Clim. Policy*, **18**(5), 593–599, doi:10.1080/14693062.2017.1331904.

Karlsson, C., M. Hjerpe, C. Parker, and B.-O. Linnér, 2012: The Legitimacy of Leadership in International Climate Change Negotiations. *Ambio*, **41**(1), 46–55, doi:10.1007/s13280-011-0240-7.

Kartha, S. et al., 2018: Cascading biases against poorer countries. *Nat. Clim. Chang.*, **8**(5), 348–349, doi:10.1038/s41558-018-0152-7.

Kasperson, R., and J. X. Kasperson, 2001: *Climate change, vulnerability, and social justice*. Stockholm Environment Institute, Stockholm, 18 pp. http://stc.umsl.edu/essj/unit4/climate change risk.pdf.

Kavlak, G., J. McNerney, and J. E. Trancik, 2018: Evaluating the causes of cost reduction in photovoltaic modules. *Energy Policy* **123**(August), 700–710, doi:10.1016/j.enpol.2018.08.015.

Keith, D. W., and D. G. MacMartin, 2015: A temporary, moderate and responsive scenario for solar geoengineering. *Nat. Clim. Chang.*, **5**, 201–206, doi:10.1038/nclimate2493.

Keller, D. P., 2018: Marine Climate Engineering. In: *Handbook on Marine Environment Protection* [Salomon, M. and T. Markus, (eds.)], Springer, Cham, Switzerland, pp. 261–276.

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

Keohane, N., A. Petsonk, and A. Hanafi, 2017: Toward a club of carbon markets. *Clim. Change*, **144**(1), 81–95, doi:10.1007/s10584-015-1506-z.

Keohane, R. O., and M. Oppenheimer, 2016: Paris: Beyond the Climate Dead End through Pledge and Review? *Polit. Gov.*, **4**(3), 142, doi:10.17645/pag.v4i3.634.

Kérébel, C., and J. Keppler, 2009: *La Gouvernance Mondiale De L'énergie. Gouvernance Européenne Et Géopolitique De L'énergie*. IFRI, Paris, 258 pp.

Kern, F., and K. S. Rogge, 2016: The pace of governed energy transitions: Agency, international dynamics and the global Paris agreement accelerating decarbonisation processes? *Energy Res.*

Soc. Sci., **22**, 13–17, doi:10.1016/j.erss.2016.08.016.

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**(2), 309–332, doi:10.1111/j.1468-5965.2009.00806.x.

Khan, M., D. Mfitumukiza, and S. Huq, 2020: Capacity building for implementation of nationally determined contributions under the Paris Agreement. *Clim. Policy*, **20**(4), 499–510, doi:10.1080/14693062.2019.1675577.

Khan, M. R., and J. T. Roberts, 2013: Adaptation and international climate policy. *Wiley Interdiscip. Rev. Clim. Chang.*, **4**(3), 171–189, doi:10.1002/wcc.212.

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**(1), 5–14, doi:10.1111/reel.12245.

Kim, Y., K. Tanaka, and S. Matsuoka, 2020: Environmental and economic effectiveness of the Kyoto Protocol. *PLoS One*, **15**(7), e0236299, doi:10.1371/journal.pone.0236299.

Kinley, R., M. Z. Cutajar, Y. de Boer, and C. Figueres, 2020: Beyond good intentions, to urgent action: Former UNFCCC leaders take stock of thirty years of international climate change negotiations. *Clim. Policy*, **21**(5), 593–603, doi:10.1080/14693062.2020.1860567.

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, doi: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, doi:10.1016/j.landusepol.2019.02.007.

Klein, D., M. Pia Carazo, M. Doelle, J. Bulmer, and A. Higham, eds., 2017: *The Paris agreement on climate change: analysis and commentary*. Oxford University Press, Oxford, 328 pp.

Klinsky, S. et al., 2017: Why equity is fundamental in climate change policy research. *Glob. Environ. Chang.*, **44**, 170–173, doi:10.1016/j.gloenvcha.2016.08.002.

Kloeckner, J., 2012: The power of eco-labels: Communicating climate change using carbon footprint labels consistent with international trade regimes under the WTO. *Clim. Law*, **3**(3–4), 209–230, doi:10.1163/cl-120064.

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, 22 pp. https://digitallibrary.un.org/record/861173?ln=en.

Knox, J. H., 2019: The Paris Agreement as a Human Rights Treaty. In: *Human Rights and the 21st Century Challenges: Poverty, Conflict and the Environment*, Oxford University Press, pp. 323–347.

Kollmuss, A., L. Schneider, and V. Zhezherin, 2015: *Has Joint Implementation reduced GHG emissions? Lessons learned for the design of carbon market mechanisms*. Stockholm Environment Institute, 124 pp. https://www.sei.org/publications/has-joint-implementation-reduced-ghg-emissions-lessons-learned-for-the-design-of-carbon-market-mechanisms/.

Kona, A., P. Bertoldi, F. Monforti-Ferrario, S. Rivas, and J. F. Dallemand, 2018: Covenant of mayors signatories leading the way towards 1.5 degree global warming pathway. *Sustain. Cities Soc.*, **41**, 568–575, doi:10.1016/j.scs.2018.05.017.

Kona, A. et al., 2021: Global Covenant of Mayors, a dataset of greenhouse gas emissions for 6200 cities in Europe and the Southern Mediterranean countries. *Earth Syst. Sci. Data*, **13**(7), 3551–3564, doi:10.5194/essd-13-3551-2021.

Kosugi, T., 2013: Fail-safe solar radiation management geoengineering. *Mitig. Adapt. Strateg. Glob.*

Chang., **18**(8), 1141–1166, doi:10.1007/s11027-012-9414-2.

Kowarsch, M. et al., 2016: Scientific assessments to facilitate deliberative policy learning. *Palgrave Commun.*, **2**(1), 16092, doi:10.1057/palcomms.2016.92.

Kramarz, T., and S. Park, 2016: Accountability in Global Environmental Governance: A Meaningful Tool for Action? *Glob. Environ. Polit.*, **16**(2), 1–21, doi:10.1162/glep_a_00349.

Kravitz, B., and D. G. MacMartin, 2020: Uncertainty and the basis for confidence in solar geoengineering research. *Nat. Rev. Earth Environ.*, **1**(1), 64–75, doi:10.1038/s43017-019-0004-7.

Kravitz, B. et al., 2015: The Geoengineering Model Intercomparison Project Phase 6 (GeoMIP6): simulation design and preliminary results. *Geosci. Model Dev.*, **8**(10), 3379–3392, doi:10.5194/gmd-8-3379-2015.

Kreibich, N., 2018: *Raising Ambition through Cooperation. Using Article 6 to bolster climate change mitigation. JIKO Policy Paper. No. 02/2018.* , Wuppertal, 1–29 pp. https://epub.wupperinst.org/frontdoor/deliver/index/docId/7122/file/7122_Raising_Ambition.pdf .

Krishnamohan, K. P. S. P., G. Bala, L. Cao, L. Duan, and K. Caldeira, 2019: Climate system response to stratospheric sulfate aerosols: Sensitivity to altitude of aerosol layer. *Earth Syst. Dyn.*, **10**(4), 885–900, doi:10.5194/esd-10-885-2019.

Krueger, P., Z. Sautner, and L. T. Starks, 2020: The Importance of Climate Risks for Institutional Investors. *Rev. Financ. Stud.*, **33**(3), 1067–1111, doi:10.1093/rfs/hhz137.

Krugman, P., 1991: History Versus Expectations. *Q. J. Econ.*, **106**(2), 651–667, doi:10.2307/2937950.

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**(1), 14–36, doi:10.1080/20430795.2016.1188537.

Kulovesi, K., 2014: International Trade Disputes on Renewable Energy: Testing Ground for the Mutual Supportiveness of WTO Law and Climate Change Law. *Rev. Eur. Comp. Int. Environ. Law*, **23**(3), 342–353, doi:10.1111/reel.12092.

Kumazawa, R., and M. S. Callaghan, 2012: The effect of the Kyoto Protocol on carbon dioxide emissions. *J. Econ. Financ.*, **36**(1), 201–210, doi:10.1007/s12197-010-9164-5.

Kuramochi, T. et al., 2020: Beyond national climate action: the impact of region, city, and business commitments on global greenhouse gas emissions. *Clim. Policy*, **20**(3), 275–291, doi:10.1080/14693062.2020.1740150.

Kuriyama, A., and N. Abe, 2018: Ex-post assessment of the Kyoto Protocol – quantification of CO2 mitigation impact in both Annex B and non-Annex B countries. *Appl. Energy*, **220**, 286–295, doi:10.1016/j.apenergy.2018.03.025.

Kuyper, J., H. Schroeder, and B.-O. Linnér, 2018a: The Evolution of the UNFCCC. *Annu. Rev. Environ. Resour.*, **43**(1), 343–368, doi: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), 1–18, doi:10.1002/wcc.497.

Kverndokk, S., 2018: Climate Policies, Distributional Effects and Transfers Between Rich and Poor Countries. *Int. Rev. Environ. Resour. Econ.*, **12**(2–3), 129–176, doi:10.1561/101.00000100.

Kwiatkowski, L., P. Cox, P. R. Halloran, P. J. Mumby, and A. J. Wiltshire, 2015: Coral bleaching under unconventional scenarios of climate warming and ocean acidification. *Nat. Clim. Chang.*, **5**(8), 777–781, doi:10.1038/nclimate2655.

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**(4), 401–413, doi:10.1080/14693062.2018.1540341.

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

Lamb, W. F. et al., 2021: A review of trends and drivers of greenhouse gas emissions by sector from 1990 to 2018. *Environ. Res. Lett.*, **16**(7), 073005, doi:10.1088/1748-9326/ABEE4E.

Lambin, E. F. et al., 2018: The role of supply-chain initiatives in reducing deforestation. *Nat. Clim. Chang.*, **8**, 109–116, doi:10.1038/s41558-017-0061-1.

Larsen, G. et al., 2018: *Towards Paris Alignment. How the Multilateral Development Banks Can Better Support the Paris Agreement*. World Resources Institute, 118 pp.

Larsson, J., A. Elofsson, T. Sterner, and J. Åkerman, 2019: International and national climate policies for aviation: a review. *Clim. Policy*, **19**(6), 787–799, doi:10.1080/14693062.2018.1562871.

Latham, J. et al., 2012: Marine cloud brightening. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, **370**(1974), 4217–4262, doi:10.1098/rsta.2012.0086.

Latham, J., J. Kleypas, R. Hauser, B. Parkes, and A. Gadian, 2013: Can marine cloud brightening reduce coral bleaching? *Atmos. Sci. Lett.*, **14**(4), 214–219, doi:10.1002/asl2.442.

Laurens, N., Z. Dove, J.-F. Morin, and S. Jinnah, 2019: NAFTA 2.0: The Greenest Trade Agreement Ever? *World Trade Rev.*, **18**(4), 659–677, doi:10.1017/s1474745619000351.

Lawrence, P., and D. Wong, 2017: Soft law in the paris climate agreement: Strength or weakness? *Rev. Eur. Comp. Int. Environ. Law*, **26**(3), 276–286, doi:10.1111/reel.12210.

Lawrence, P., and M. Reder, 2019: Equity and the Paris agreement: Legal and philosophical perspectives. *J. Environ. Law*, **31**(3), 511–531, doi:10.1093/jel/eqz017.

Le Blanc, D., 2015: Towards Integration at Last? The Sustainable Development Goals as a Network of Targets. *Sustain. Dev.*, **23**(3), 176–187, doi:10.1002/sd.1582.

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**(4), 472–490, doi:10.1177/1350508418759186.

Lee, D. S. et al., 2021a: The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. *Atmos. Environ.*, **244**, 117834, doi:10.1016/j.atmosenv.2020.117834.

Lee, K., C. Fyson, and C.-F. Schleussner, 2021b: Fair distributions of carbon dioxide removal obligations and implications for effective national net-zero targets. *Environ. Res. Lett.*, **16**(9), 94001, doi:10.1088/1748-9326/ac1970.

Lees, E., 2017: Responsibility and liability for climate loss and damage after Paris. *Clim. Policy*, **17**(1), 59–70, doi:10.1080/14693062.2016.1197095.

Leffel, B., 2018: *Subnational Diplomacy, Climate Governance & Californian Global Leadership*. USC Center on Public Diplomacy, 10 pp. https://www.uscpublicdiplomacy.org/sites/uscpublicdiplomacy.org/files/useruploads/u39301/Subnational Diplomacy%2C Climate Governance %26 Californian Global Leadership - Benjamin Leffel_0.pdf.

Leonard, L., 2014: Tackling Climate Change in the Global South: An Analysis of the Global Methane Initiative Multilateral Partnership. *J. Soc. Dev. Sci.*, **5**(4), 168–175, doi:10.22610/jsds.v5I4.817.

Le Quéré C, Korsbakken J I, Wilson C, Tosun J, Andrew R, Andres R J, Canadell J G, Jordan A, Peters G P and van Vuuren D P, 2019: Drivers of declining CO_2 emissions in 18 developed economies *Nat. Clim. Change* **9** 213–7.

Lesage, D., T. Van de Graaf, and K. Westphal, 2010: *Global Energy Governance in a Multipolar World*.

[Kirton, J.J. and M. Schreurs, (eds.)]. Ashgate Publishing Limited, Aldershot, UK, 221 pp.

Lessmann, K. et al., 2015: The Stability and Effectiveness of Climate Coalitions: A Comparative Analysis of Multiple Integrated Assessment Models. *Environ. Resour. Econ.*, **62**(4), 811–836, doi:10.1007/s10640-015-9886-0.

Lewis, J. I., 2014: The Rise of Renewable Energy Protectionism: Emerging Trade Conflicts and Implications for Low Carbon Development. *Glob. Environ. Polit.*, **14**(4), 10–35, doi:10.1162/glep_a_00255.

Liagre, L., P. L. Almuedo, C. Besacier, and M. Conigliaro, 2015: *Sustainable financing for forest and landscape restoration: Opportunities, challenges and the way forward*. FAO/UNCCD, Rome, 131 pp.

Lindberg, M. B., J. Markard, and A. D. Andersen, 2018: Policies, actors and sustainability transition pathways: A study of the EU's energy policy mix. *Res. Policy*, **48**(10), 103668, doi:10.1016/j.respol.2018.09.003.

Liu, J.-Y., S. Fujimori, and T. Masui, 2016: Temporal and spatial distribution of global mitigation cost: INDCs and equity. *Environ. Res. Lett.*, **11**(11), 114004, doi:10.1088/1748-9326/11/11/114004.

Liu, J., 2011a: The Cancun Agreements. *Environ. Law Rev.*, **13**(1), 43–49, doi:10.1350/enlr.2011.13.1.112.

Liu, J., 2011b: The Role of ICAO in Regulating the Greenhouse Gas Emissions of Aircraft. *Carbon Clim. Law Rev.*, **5**(4), 417–431.

Liu, J. et al., 2017a: South-south cooperation for large-scale ecological restoration. *Restor. Ecol.*, **25**(1), 27–32, doi:10.1111/rec.12462.

Liu, J., P. E. Love, J. Smith, and M. Regan, 2017b: A new framework for evaluating public-private partnerships. *Second International Conference on Public-Private Partnerships. May 26–29, 2015*, [Zhang, Z., C. Queiroz, and C.M. Walton, (eds.)], Austin, Texas, American Society of Civil Engineers, 290–301.

Liu, L., and M. Waibel, 2010: Managing Subnational Credit and Default Risks. In: *Sovereign Debt and the Financial Crisis* [Primo Braga, C.A. and G.A. Vincelette, (eds.)], The World Bank, Washington DC, Washington DC, pp. 273–293.

Liu, W., X. Zhang, and S. Feng, 2019: Does renewable energy policy work? Evidence from a panel data analysis. *Renew. Energy*, **135**(May), 635–642, doi:10.1016/j.renene.2018.12.037.

Livingston, D., 2016: *The G7 Climate Mandate and the Tragedy of the Horizons*. Carnegie Endowment for International Peace, 1–26 pp. http://www.jstor.org/stable/resrep12840.

Lloyd, I. D., and M. Oppenheimer, 2014: On the Design of an International Governance Framework for Geoengineering. *Glob. Environ. Polit.*, **14**(2), 45–63, doi: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**(1), 431–450, doi:10.3390/f2010431.

London Convention/Protocol, 2010: *Resolution LC-LP.2 on the assessment framework for scientific research involving ocean fertilization (14 October 2010). Document LC 32/15. Annex 5.* 2 pp. https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/LCLPDocuments/LC-LP.2(2010).pdf.

Low, S., and M. Honegger, 2020: A Precautionary Assessment of Systemic Projections and Promises From Sunlight Reflection and Carbon Removal Modeling. *Risk Anal.*, (Online), 1–15, doi:10.1111/risa.13565.

LSE, 2020: Climate Change Laws of the World database, Grantham Research Institute on Climate Change and the Environment and Sabin Center for Climate Change Law. https://climate-laws.org/ (Accessed December 14, 2020).

Lui, S. et al., 2021: Correcting course: the emission reduction potential of international cooperative initiatives. *Clim. Policy*, **21**(2), 232–250, doi:10.1080/14693062.2020.1806021.

Lyle, C., 2018: Beyond the ICAO's CORSIA: Towards a More Climatically Effective Strategy for Mitigation of Civil-Aviation Emissions. *Clim. Law*, **8**(1–2), 104–127, doi:10.1163/18786561-00801004.

Maamoun, N., 2019: The Kyoto protocol: Empirical evidence of a hidden success. *J. Environ. Econ. Manage.*, **95**(May), 227–256, doi:10.1016/j.jeem.2019.04.001.

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**(4), 193–200, doi:10.2307/24233201.

Macchi, C., and J. van Zeben, 2021: Business and human rights implications of climate change litigation: Milieudefensie et al. v Royal Dutch Shell. *Rev. Eur. Comp. Int. Environ. Law*, (Online), 1–7, doi:10.1111/reel.12416.

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. In: *World Sustainability Series* [Leal Filho, W., (ed.)], Springer, pp. 193–209.

MacDougall, A. H. et al., 2020: Is there warming in the pipeline? A multi-model analysis of the Zero Emissions Commitment from CO2. *Biogeosciences*, **17**(11), 2987–3016, doi:10.5194/bg-17-2987-2020.

Mace, M. J., 2016: Mitigation Commitments under the Paris Agreement and the Way Forward. *Clim. Law*, **6**(1–2), 21–39, doi:10.1163/18786561-00601002.

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**(2), 197–214, doi:10.1111/reel.12172.

Mace, M. J., C. Fyson, M. Schaeffer, and B. Hare, 2018: *Governing large-scale carbon dioxide removal: are we ready?* Carnegie Climate Geoengineering Governance Initiative (C2G2), New York, US, 46 pp. https://www.c2g2.net/wp-content/uploads/C2G2-2018-CDR-Governance-1.pdf.

Mace, M. J., C. L. Fyson, M. Schaeffer, and W. L. Hare, 2021: Large-Scale Carbon Dioxide Removal to Meet the 1.5°C Limit: Key Governance Gaps, Challenges and Priority Responses. *Glob. Policy*, **12**(S1), 67–81, doi:10.1111/1758-5899.12921.

MacKay, M., B. Parlee, and C. Karsgaard, 2020: Youth Engagement in Climate Change Action: Case Study on Indigenous Youth at COP24. *Sustainability*, **12**(16), 6299, doi:10.3390/su12166299.

MacLeod, M., and J. Park, 2011: Financial Activism and Global Climate Change: The Rise of Investor-Driven Governance Networks. *Glob. Environ. Polit.*, **11**(2), 54–74, doi:10.1162/glep_a_00055.

MacMartin, D. G., and B. Kravitz, 2019: Mission-driven research for stratospheric aerosol geoengineering. *Proc. Natl. Acad. Sci.*, **116**(4), 1089–1094, doi:10.1073/pnas.1811022116.

MacMartin, D. G., K. Caldeira, and D. W. Keith, 2014: Solar geoengineering to limit the rate of temperature change. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, **372**(2031), doi:10.1098/rsta.2014.0134.

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**(2119), 20160454, doi:10.1098/rsta.2016.0454.

Madani, K., 2020: How International Economic Sanctions Harm the Environment. *Earth's Futur.*, **8**(12), e2020ef001829, doi:10.1029/2020ef001829.

Maguire, P. et al., 2021: *Forest Trends' Ecosystem Marketplace - A Green Growth Spurt: State of Forest Carbon Finance 2021*. Forests Trend Association, Washington DC, 1–67 pp. www.ecosystemmarketplace.com/publications/state-of-forest-carbon-finance-2021/.

Malhotra, A., A. Mathur, S. Diddi, and A. D. Sagar, 2021: Building institutional capacity for addressing climate and sustainable development goals: achieving energy efficiency in India. *Climate Policy*, 1-19, doi:10.1080/14693062.2021.1984195.

Maljean-Dubois, S., 2016: The Paris Agreement: A New Step in the Gradual Evolution of Differential Treatment in the Climate Regime? *Rev. Eur. Community Int. Environ. Law*, **25**(2), 151–160, doi:10.1111/reel.12162.

Maljean-Dubois, S., 2019: Climate change litigation. In: *Max Planck Encyclopedia of Procedural Law*, Oxford University Press, pp. 1–26.

Maljean-Dubois, S., and M. Wemaëre, 2016: The Paris Agreement: A Starting Point towards Achieving Climate Neutrality? *Carbon Clim. Law Rev.*, **10**(1), 1–4.

Maltais, A., and B. Nykvist, 2020: Understanding the role of green bonds in advancing sustainability. *J. Sustain. Financ. Invest.*, (Online), 1–20, doi:10.1080/20430795.2020.1724864.

Mansourian, S., N. Dudley, and D. Vallauri, 2017: Forest Landscape Restoration: Progress in the Last Decade and Remaining Challenges. *Ecol. Restor.*, **35**(4), 281–288, doi:10.3368/er.35.4.281.

Marcu, A., 2016: *Carbon Market Provisions in the Paris Agreement (Article 6)*. Centre for European Policy Studies, Brussels, 26 pp. http://aei.pitt.edu/71012/1/SR_No_128_ACM_Post_COP21_Analysis_of_Article_6.pdf.

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**(3), 265–298, doi:10.1080/02646811.2018.1451020.

Markard, J., 2018: The next phase of the energy transition and its implications for research and policy. *Nat. Energy*, **3**(8), 628–633, doi:10.1038/s41560-018-0171-7.

Marques, A. et al., 2014: A framework to identify enabling and urgent actions for the 2020 Aichi Targets. *Basic Appl. Ecol.*, **15**(8), 633–638, doi: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**(2), 215–227, doi:10.1111/reel.12170.

Mayer, B., 2016a: The relevance of the no-harm principle to climate change law and politics. *Asia Pacific J. Environ. Law*, **19**(1), 79–104, doi:10.4337/apjel.2016.01.04.

Mayer, B., 2016b: Human Rights in the Paris Agreement. *Clim. Law*, **6**(1–2), doi:10.1163/18786561-00601007.

Mayer, B., 2018a: Obligations of conduct in the international law on climate change: A defence. *Rev. Eur. Comp. Int. Environ. Law*, **27**(2), 130–140, doi:10.1111/reel.12237.

Mayer, B., 2018b: International Law Obligations Arising in relation to Nationally Determined Contributions. *Transnatl. Environ. Law*, **7**(2), 251–275, doi:10.1017/s2047102518000110.

Mayer, B., 2019: Transparency Under the Paris Rulebook: Is the Transparency Framework Truly Enhanced? *Clim. Law*, **9**(1–2), 40–64, doi:10.1163/18786561-00901004.

Mayer, B., 2021: Climate Change Mitigation as an Obligation Under Human Rights Treaties? *Am. J. Int. Law*, **115**(3), 409–451, doi:10.1017/ajil.2021.9.

Mayer, B., and F. Crépeau, 2016: Introduction. In: *Research Handbook on Climate Change, Migration and the Law* [Mayer, B. and F. Crépeau, (eds.)], Elgar, Cheltenham, UK, pp. 1–26.

Mayr, S., B. Hollaus, and V. Madner, 2020: Palm Oil, the RED II and WTO Law: EU Sustainable Biofuel Policy Tangled up in Green? *Rev. Eur. Comp. Int. Environ. Law*, **30**(2), 233–248, doi:10.1111/reel.12386.

McAdam, D., 2017: Social Movement Theory and the Prospects for Climate Change Activism in the United States. *Annu. Rev. Polit. Sci.*, **20**, 189–208, doi:10.1146/annurev-polisci-052615-025801.

McAdam, J., 2016: Climate Change-related Displacement of Persons. In: *The Oxford Handbook of International Climate Change Law* [Gray, K.R., R. Tarasofsky, and C. Carlarne, (eds.)], Oxford University Press, Oxford, p. pp. 519.

McAusland, C., and N. Najjar, 2015: The WTO Consistency of Carbon Footprint Taxes. *Georg. J. Int. Law*, **46**(3), 765–801.

McCusker, K. E., K. C. Armour, C. M. Bitz, and D. S. Battisti, 2014: Rapid and extensive warming following cessation of solar radiation management. *Environ. Res. Lett.*, **9**(2), 24005, doi:10.1088/1748-9326/9/2/024005.

McDonald, J., J. McGee, K. Brent, and W. Burns, 2019: Governing geoengineering research for the Great Barrier Reef. *Clim. Policy*, **19**(7), 801–811, doi:10.1080/14693062.2019.1592742.

McGee, J., and R. Taplin, 2006: The Asia–Pacific partnership on clean development and climate: A complement or competitor to the Kyoto protocol? *Glob. Chang. Peace Secur.*, **18**(3), 173–192, doi:10.1080/14781150600960230.

McKinnon, C., 2019: Sleepwalking into lock-in? Avoiding wrongs to future people in the governance of solar radiation management research. *Env. Polit.*, **28**(3), 441–459, doi:10.1080/09644016.2018.1450344.

McLaren, D., 2016: Mitigation deterrence and the “moral hazard” of solar radiation management. *Earth’s Futur.*, **4**(12), 596–602, doi:10.1002/2016ef000445.

McLaren, D., and O. Corry, 2021: The politics and governance of research into solar geoengineering. *Wiley Interdiscip. Rev. Clim. Chang.*, **12**(3), e707, doi:10.1002/wcc.707.

McLaren, D. P., D. P. Tyfield, R. Willis, B. Szerszynski, and N. O. Markusson, 2019: Beyond “Net-Zero”: A Case for Separate Targets for Emissions Reduction and Negative Emissions. *Front. Clim.*, **1**, 1–5, doi:10.3389/fclim.2019.00004.

McNamara, K. E., and C. Farbotko, 2017: Resisting a ‘Doomed’ Fate: an analysis of the Pacific Climate Warriors. *Aust. Geogr.*, **48**(1), 17–26, doi:10.1080/00049182.2016.1266631.

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**(2), e564, doi:10.1002/wcc.564.

MDB, 2012: MDB Joint Statement for Rio +20. 2012. *Announcements*,. https://www.iadb.org/en/news/announcements/2012-06-19/mdb-joint-statement-for-rio20%2C10032.html (Accessed October 28, 2021).

Meehan, F., L. Tacconi, and K. Budiningsih, 2019: Are national commitments to reducing emissions from forests effective? Lessons from Indonesia. *For. Policy Econ.*, **108**(November), 101968, doi:10.1016/j.forpol.2019.101968.

Mehling, M. A., 2019: Governing Cooperative Approaches under the Paris Agreement. *Ecol. Law Q.*, **46**(3), 765–827, doi:10.15779/z389g5gd97.

Mehling, M. A., G. E. Metcalf, and R. N. Stavins, 2018: Linking climate policies to advance global mitigation. *Science (80-.).*, **359**(6379), 997–998, doi:10.1126/science.aar5988.

Mehling, M. A., H. Van Asselt, K. Das, S. Droege, and C. Verkuijl, 2019: Designing Border Carbon Adjustments for Enhanced Climate Action. *Am. J. Int. Law*, **113**(3), doi:10.1017/ajil.2019.22.

Meinshausen, M. et al., 2015: National post-2020 greenhouse gas targets and diversity-aware leadership. *Nat. Clim. Chang.*, **5**(12), 1098–1106, doi:10.1038/nclimate2826.

Meltzer, J. P., 2013: The Trans-Pacific Partnership Agreement, the environment and climate change. In: *Trade Liberalisation and International Co-operation. A Legal Analysis of the Trans-Pacific Partnership Agreement* [Voon, T., (ed.)], Edward Elgar Publishing, Cheltenham, UK, pp. 207–230.

Merk, C., G. Pönitzsch, C. Kniebes, K. Rehdanz, and U. Schmidt, 2015: Exploring public perceptions of stratospheric sulfate injection. *Clim. Change*, **130**(2), 299–312, doi:10.1007/s10584-014-1317-7.

Merk, C., G. Pönitzsch, and K. Rehdanz, 2016: Knowledge about aerosol injection does not reduce individual mitigation efforts. *Environ. Res. Lett.*, **11**(5), 54009, doi:10.1088/1748-9326/11/5/054009.

Merk, C., G. Pönitzsch, and K. Rehdanz, 2019: Do climate engineering experts display moral-hazard behaviour? *Clim. Policy*, **19**(2), 231–243, doi:10.1080/14693062.2018.1494534.

Meyer, T., 2017: Explaining energy disputes at the World Trade Organization. *Int. Environ. Agreements Polit. Law Econ.*, **17**(3), 391–410, doi:10.1007/s10784-017-9356-y.

Michaelowa, A., and K. Michaelowa, 2011a: Climate business for poverty reduction? The role of the World Bank. *Rev. Int. Organ.*, **6**, 259–286, doi:10.1007/s11558-011-9103-z.

Michaelowa, A., and K. Michaelowa, 2011b: Coding Error or Statistical Embellishment? The Political Economy of Reporting Climate Aid. *World Dev.*, **39**(11), 2010–2020, doi:10.1016/j.worlddev.2011.07.020.

Michaelowa, A., L. Hermwille, W. Obergassel, and S. Butzengeiger, 2019a: Additionality revisited: guarding the integrity of market mechanisms under the Paris Agreement. *Clim. Policy*, **19**(10), 1211–1224, doi:10.1080/14693062.2019.1628695.

Michaelowa, A., I. Shishlov, and D. Brescia, 2019b: Evolution of international carbon markets: lessons for the Paris Agreement. *Wiley Interdiscip. Rev. Clim. Chang.*, **10**(6), doi:10.1002/wcc.613.

Michaelowa, A., A. Espelage, and B. Müller, 2020a: *2020 Update: Negotiating cooperation under Article 6 of the Paris Agreement*. [Sharma, A., (ed.)]. European Capacity Building Initiative, 1–30 pp. https://ecbi.org/sites/default/files/Article 6 2020_0.pdf (Accessed August 24, 2021).

Michaelowa, A., S. Hoch, A. K. Weber, R. Kassaye, and T. Hailu, 2020b: Mobilising private climate finance for sustainable energy access and climate change mitigation in Sub-Saharan Africa. *Clim. Policy*, **21**(1), 47–62, doi:10.1080/14693062.2020.1796568.

Michaelowa, K., and A. Michaelowa, 2017: Transnational Climate Governance Initiatives: Designed for Effective Climate Change Mitigation? *Int. Interact.*, **43**, 129–155, doi:10.1080/03050629.2017.1256110.

Miles, K., 2019: *Research Handbook on Environment and Investment Law*. [Miles, K., (ed.)]. Edward Elgar Publishing, Cheltenham, UK, 576 pp.

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**(1), 89–106, doi: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**(4), 755–770, doi:10.1007/s10584-013-0917-y.

Mitchell, I., E. Ritchie, and A. Tahmasebi, 2021: *Is Climate Finance Towards $100 Billion 'New and Additional'?* , Washington, DC, 1–14 pp. https://www.cgdev.org/sites/default/files/PP205-Mitchell-Ritchie-Tahmasebi-Climate-Finance.pdf.

Miyamoto, M., and K. Takeuchi, 2019: Climate agreement and technology diffusion: Impact of the Kyoto Protocol on international patent applications for renewable energy technologies. *Energy Policy*, **129**(June), 1331–1338, doi:10.1016/j.enpol.2019.02.053.

Moerenhout, T. S. H., and T. Irschlinger, 2020: *Exploring the Trade Impacts of Fossil Fuel Subsidies*. International Institute for Sustainable Development, Geneva, 50 pp. https://www.iisd.org/system/files/publications/trade-impacts-fossil-fuel-subsidies.pdf.

Molina, M. et al., 2009: Reducing abrupt climate change risk using the Montreal Protocol and other regulatory actions to complement cuts in CO_2 emissions. *Proc. Natl. Acad. Sci.*, **106**(49), 20616–

20621, doi: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**(5), e471, doi:10.1002/wcc.471.

Morin, J.-F., and S. Jinnah, 2018: The untapped potential of preferential trade agreements for climate governance. *Env. Polit.*, **27**(3), 541–565, doi:10.1080/09644016.2017.1421399.

Moriyama, R. et al., 2017: The cost of stratospheric climate engineering revisited. *Mitig. Adapt. Strateg. Glob. Chang.*, **22**(8), 1207–1228, doi:10.1007/s11027-016-9723-y.

Mormann, F., 2020: Why the divestment movement is missing the mark. *Nat. Clim. Chang.*, **10**, 1067–1068, doi:10.1038/s41558-020-00950-2.

Morrow, D. R., 2014: Ethical aspects of the mitigation obstruction argument against climate engineering research. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, **372**(2031), 1–14, doi:10.1098/rsta.2014.0062.

Müller, B., and A. Michaelowa, 2019: How to operationalize accounting under Article 6 market mechanisms of the Paris Agreement. *Clim. Policy*, **19**(7), 812–819, doi:10.1080/14693062.2019.1599803.

Multilateral Investment Guarantee Agency, 2019: About MIGA. *About*,. https://www.miga.org/about-us (Accessed October 28, 2021).

Murata, A. et al., 2016: Environmental co-benefits of the promotion of renewable power generation in China and India through clean development mechanisms. *Renew. Energy*, **87**(Part 1), 120–129, doi:10.1016/j.renene.2015.09.046.

Muri, H., U. Niemeier, and J. E. Kristjánsson, 2015: Tropical rainforest response to marine sky brightening climate engineering. *Geophys. Res. Lett.*, **42**(8), 2951–2960, doi:10.1002/2015gl063363.

Nakhooda, S. et al., 2014: *Climate Finance - Is it making a difference? A review of the effectiveness of multilateral climate funds*. Overseas Development Institute, London, UK, 88 pp.

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**(1), 109–126, doi:10.1007/s10784-014-9243-8.

National Academies of Sciences Engineering and Medecine, 2021: *Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance*. National Academies Press, Washington DC, 1–328 pp.

NCE, 2016: *The Sustainable Infrastructure Imperative, Financing for better growth and development. The 2016 New Climate Economy Report.* [Davis, M., (ed.)]. New Climate Economy, 150 pp. http://newclimateeconomy.report/2016/wp-content/uploads/sites/4/2014/08/NCE_2016Report.pdf.

Nelson, J. P., L. Kaplan, and D. Tomblin, 2021: Assessing solar geoengineering research funders: Insights from two US public deliberations: *Anthr. Rev.*, **8**(1), 37–55, doi:10.1177/2053019620964845.

Nemati, M., W. Hu, and M. Reed, 2019: Are free trade agreements good for the environment? A panel data analysis. *Rev. Dev. Econ.*, **23**(1), 435–453, doi:10.1111/rode.12554.

Nemet, G. F., 2019: How solar energy became cheap a model for low-carbon innovation. Routledge., 260 pp.

Newell, P., and A. Simms, 2020: Towards a fossil fuel non-proliferation treaty. *Clim. Policy*, **20**(8), 1043–1054, doi:10.1080/14693062.2019.1636759.

Newton, P., J. A Oldekop, G. Brodnig, B. K. Karna, and A. Agrawal, 2016: Carbon, biodiversity, and livelihoods in forest commons: synergies, trade-offs, and implications for REDD+. *Environ. Res.*

Lett., **11**(4), 44017, doi:10.1088/1748-9326/11/4/044017.

Nicholson, S., S. Jinnah, and A. Gillespie, 2018: Solar radiation management: a proposal for immediate polycentric governance. *Clim. Policy*, **18**(3), 322–334, doi:10.1080/14693062.2017.1400944.

Niemeier, U., H. Schmidt, and C. Timmreck, 2011: The dependency of geoengineered sulfate aerosol on the emission strategy. *Atmos. Sci. Lett.*, **12**(2), 189–194, doi:10.1002/asl.304.

Nilsson, M., D. Griggs, and M. Visbeck, 2016: Policy: map the interactions between Sustainable Development Goals. *Nature*, **534**(7607), 320–322, doi:10.1038/534320a.

Nordhaus, W., 2015: Climate Clubs: Overcoming Free-riding in International Climate Policy. *Am. Econ. Rev.*, **105**(4), 1339–1370, doi:10.1257/aer.15000001.

NYDF Assessment Partners, 2020: *Progress on the New York Declaration on Forests (NYDF): Balancing forests and development - Addressing infrastructure and extractive industries, promoting sustainable livelihoods. Goals 3 & 4 Progress Report*. , Washington DC, 1–109 pp. www.forestdeclaration.org/images/uploads/resource/2020NYDFReport.pdf.

Obergassel, W., F. Mersmann, and H. Wang-Helmreich, 2017a: Two for One: Integrating the Sustainable Development Agenda with International Climate Policy. *Gaia - Ecol. Perspect. Sci. Soc.*, **26**, 249–253, doi:10.14512/gaia.26.3.8.

Obergassel, W. et al., 2017b: Human rights and the clean development mechanism: lessons learned from three case studies. *J. Hum. Rights Environ.*, , doi:10.4337/jhre.2017.01.03.

Oberthür, S., 2016: Reflections on Global Climate Politics Post Paris: Power, Interests and Polycentricity. *Int. Spect.*, **51**, 80–94, doi:10.1080/03932729.2016.1242256.

Oberthür, S., and R. Bodle, 2016: Legal Form and Nature of the Paris Outcome. *Clim. Law*, **6**(1–2), 40–57, doi:10.1163/18786561-00601003.

Oberthür, S., and E. Northrop, 2018: Towards an Effective Mechanism to Facilitate Implementation and Promote Compliance under the Paris Agreement. *Clim. Law*, **8**(1–2), 39–69, doi:10.1163/18786561-00801002.

Oberthür, S., and L. Groen, 2020: Hardening and softening of multilateral climate governance towards the Paris Agreement. *J. Environ. Policy Plan.*, **22**(6), 801–813, doi:10.1080/1523908x.2020.1832882.

Oberthür, S. et al., 2017: *COP21: Results and Implications for Pathways and Policies for Low Emissions European Societies. Ref. Ares(2017)5316295 - 31/10/2017*. European Commission, 129 pp. https://cordis.europa.eu/project/id/730427/results.

OECD, 2012: *Meeting global challenges through better governance: international co-operation in science, technology and innovation*. OECD Publishing, Paris, France, 242 pp.

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

OECD, 2019b: *Annual survey of large pension funds and public pension reserve funds*. Organisation for Economic Co-operation and Development, 45 pp. www.oecd.org/finance/survey-large-pension-funds.htm (Accessed December 9, 2020).

OECD, 2021: *Climate Finance Provided and Mobilised by Developed Countries: Aggregate Trends Updated with 2019 Data, Climate Finance and the USD 100 Billion Goal*. OECD Publishing, Paris, 1–21 pp.

Office of the High Commissioner for Human Rights, 2019: Five UN human rights treaty bodies issue a joint statement on human rights and climate change (16 September 2019). https://www.ohchr.org/EN/NewsEvents/Pages/DisplayNews.aspx?NewsID=24998 (Accessed October 25, 2021).

Oh, C., 2019: Political Economy of International Policy on the Transfer of Environmentally Sound Technologies in Global Climate Change Regime. *New Polit. Econ.*, **24**(1), 22–36, doi:10.1080/13563467.2017.1417361.

Oh, C., 2020a: Discursive Contestation on Technological Innovation and the Institutional Design of the UNFCCC in the New Climate Change Regime. *New Polit. Econ.*, **25**(4), 660–674, doi:10.1080/13563467.2019.1639147.

Oh, C., 2020b: Contestations over the financial linkages between the UNFCCC's Technology and Financial Mechanism: using the lens of institutional interaction. *Int. Environ. Agreements*, **20**, 559–575, doi:10.1007/s10784-020-09474-8.

Oh, C., and S. Matsuoka, 2017: The genesis and end of institutional fragmentation in global governance on climate change from a constructivist perspective. *Int. Environ. Agreements Polit. Law Econ.*, **17**(2), 143–159, doi:10.1007/s10784-015-9309-2.

Olmstead, S. M., and R. N. Stavins, 2012: Three Key Elements of a Post-2012 International Climate Policy Architecture. *Rev. Environ. Econ. Policy*, **6**(1), 65–85, doi: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**(4), 383–395, doi:10.1080/14693062.2016.1277686.

Orr, B. J. et al., 2017: *Scientific Conceptual Framework for Land Degradation Neutrality. A report of the science-policy interface*. United Nations Convention to Combat Desertification (UNCCD), Bonn, Germany, 136 pp.

Osofsky, H., J. Peel, B. McDonnell, and A. Foerster, 2019: Energy re-investment. *Indiana Law J.*, **94**(2), 595–652.

Osofsky, H. M., 2010: The continuing importance of climate change litigation. *Clim. Law*, **1**(1), 3–29, doi:10.1163/cl-2010-002.

Ostrom, E., 2010: Polycentric systems for coping with collective action and global environmental change. *Glob. Environ. Chang.*, **20**(4), 550–557, doi:10.1016/j.gloenvcha.2010.07.004.

Otto, F. E. L., R. B. Skeie, J. S. Fuglestvedt, T. Berntsen, and M. R. Allen, 2017: Assigning historic responsibility for extreme weather events. *Nat. Clim. Chang.*, **7**(11), 757–759, doi:10.1038/nclimate3419.

Ourbak, T., and A. K. Magnan, 2018: The Paris Agreement and climate change negotiations: Small Islands, big players. *Reg. Environ. Chang.*, **18**(8), 2201–2207, doi:10.1007/s10113-017-1247-9.

PAGE, 2018: *International Investment Agreements and Sustainable Development: Safeguarding Policy Space and Mobilising Investment for a Green Economy*. United Nations Environment Programme, 1–35 pp. https://www.un-page.org/files/public/international_investment_agreements_sustainable_development_1.pdf.

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**(2), 143–150, doi:10.1111/conl.12188.

Parker, A., 2014: Governing solar geoengineering research as it leaves the laboratory. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, **372**(2031), 1–17, doi:10.1098/rsta.2014.0173.

Parker, A., and P. J. Irvine, 2018: The Risk of Termination Shock From Solar Geoengineering. *Earth's Futur.*, **6**(3), 456–467, doi:10.1002/2017ef000735.

Parker, A., J. B. Horton, and D. W. Keith, 2018: Stopping Solar Geoengineering Through Technical Means: A Preliminary Assessment of Counter-Geoengineering. *Earth's Futur.*, **6**(8), 1058–1065, doi:10.1029/2018ef000864.

Parker, C. F., C. Karlsson, and M. Hjerpe, 2014: Climate change leaders and followers: Leadership recognition and selection in the UNFCCC negotiations. *Int. Relations*, **29**(4), 434–454, doi:10.1177/0047117814552143.

Parker, C. F., C. Karlsson, and M. Hjerpe, 2015: Climate change leaders and followers: Leadership recognition and selection in the UNFCCC negotiations. *Int. Relations*, **29**(4), 434–454, doi:10.1177/0047117814552143.

Parkes, B., A. Challinor, and K. Nicklin, 2015: Crop failure rates in a geoengineered climate: impact of climate change and marine cloud brightening. *Environ. Res. Lett.*, **10**(8), 84003, doi:10.1088/1748-9326/10/8/084003.

Paroussos, L. et al., 2019: Climate clubs and the macro-economic benefits of international cooperation on climate policy. *Nat. Clim. Chang.*, **9**(7), 542–546, doi:10.1038/s41558-019-0501-1.

Parson, E. A., 2014: Climate Engineering in Global Climate Governance: Implications for Participation and Linkage. *Transnatl. Environ. Law*, **3**(1), 89–110, doi:10.1017/s2047102513000496.

Parson, E. A., and L. N. Ernst, 2013: International Governance of Climate Engineering. *Theor. Inq. Law*, **14**(1), 307–338, doi:10.1515/til-2013-015.

Partanen, A.-I., D. P. Keller, H. Korhonen, and H. D. Matthews, 2016: Impacts of sea spray geoengineering on ocean biogeochemistry. *Geophys. Res. Lett.*, **43**(14), 7600–7608, doi:10.1002/2016gl070111.

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

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

Patton, L. E., 2021: Litigation needs the latest science. *Nat. Clim. Chang.*, **11**(8), 644–645, doi:10.1038/s41558-021-01113-7.

Pauw, W. P. et al., 2018: Beyond headline mitigation numbers: we need more transparent and comparable NDCs to achieve the Paris Agreement on climate change. *Clim. Change*, **147**(1–2), 23–29, doi:10.1007/s10584-017-2122-x.

Pauw, W. P., P. Castro, J. Pickering, and S. Bhasin, 2020: Conditional nationally determined contributions in the Paris Agreement: foothold for equity or Achilles heel? *Clim. Policy*, **20**(4), 468–484, doi:10.1080/14693062.2019.1635874.

Pauwelyn, J., 2013: Carbon leakage measures and border tax adjustments under WTO law. In: *Research handbook on Environment, Health and the WTO* [Van Calster, G. and D. Prévost, (eds.)], Edward Elgar Publishing, Cheltenham, UK, pp. 448–506.

Pavlova, Y., and A. De Zeeuw, 2013: Asymmetries in international environmental agreements. *Environ. Dev. Econ.*, **18**(1), 51–68, doi:10.1017/s1355770x12000289.

Peake, S., and P. Ekins, 2017: Exploring the financial and investment implications of the Paris Agreement. *Clim. Policy*, **17**(7), 832–852, doi:10.1080/14693062.2016.1258633.

Pearse, R., 2017: Gender and climate change. *Wiley Interdiscip. Rev. Clim. Chang.*, **8**(2), e451, doi:10.1002/wcc.451.

Peel, J., and H. M. Osofsky, 2018: A Rights Turn in Climate Change Litigation? *Transnatl. Environ. Law*, **7**(1), 37–67, doi:10.1017/S2047102517000292.

Peel, J., and J. Lin, 2019: Transnational Climate Litigation: The Contribution of the Global South. *Am. J. Int. Law*, **113**(04), 679–726, doi:10.1017/ajil.2019.48.

Peel, J., and H. M. Osofsky, 2020: Climate Change Litigation. *Annu. Rev. Law Soc. Sci.*, **16**(1), 21–38, doi:10.1146/annurev-lawsocsci-022420-122936.

Pekkarinen, V., 2020: Going beyond CO2: Strengthening action on global methane emissions under the UN climate regime. *Rev. Eur. Comp. Int. Environ. Law*, **29**(3), 464–478, doi:10.1111/reel.12329.

Pereira, L. et al., 2021: From Fairplay to Climate Wars: Making climate change scenarios more dynamic, creative and integrative. *Ecol. Soc.*, (accepted).

Peters, G. P. et al., 2017: Key indicators to track current progress and future ambition of the Paris Agreement. *Nat. Clim. Chang.*, **7**(2), 118–122, doi:10.1038/nclimate3202.

Peterson, L., and J. Skovgaard, 2019: Bureaucratic politics and the allocation of climate finance. *World Dev.*, **117**, 72–97, doi: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, doi:10.1038/nclimate1462.

Phillips, J., and P. Newell, 2013: The governance of clean energy in India: The clean development mechanism (CDM) and domestic politics. *Energy Policy*, **59**, 654–662, doi:10.1016/j.enpol.2013.04.019.

Pickering, J., F. Jotzo, and P. J. Wood, 2015: Sharing the Global Climate Finance Effort Fairly with Limited Coordination. *Glob. Environ. Polit.*, **15**(4), 39–62, doi:10.1162/GLEP_a_00325.

Pickering, J., C. Betzold, and J. Skovgaard, 2017: Special issue: managing fragmentation and complexity in the emerging system of international climate finance. *Int. Environ. Agreements Polit. Law Econ.*, **17**, 1–16, doi:10.1007/s10784-016-9349-2.

Pickering, J., 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*, **31**(1), 1–28, doi:10.1093/jel/eqy018.

Pidgeon, N. et al., 2012: Exploring early public responses to geoengineering. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, **370**(1974), 4176–4196, doi:10.1098/rsta.2012.0099.

Piggot, G., P. Erickson, H. van Asselt, and M. Lazarus, 2018: Swimming upstream: addressing fossil fuel supply under the UNFCCC. *Clim. Policy*, **18**(9), 1189–1202, doi:10.1080/14693062.2018.1494535.

Pinke, Z., S. Pow, and Z. Kern, 2019: Volcanic mega-eruptions may trigger major cholera outbreaks. *Clim. Res.*, **79**(2), 151–162, doi:10.3354/cr01587.

Pinz, A., N. Roudyani, and J. Thaler, 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), 1–22, doi:10.1080/14719037.2017.1293143.

Pirard, R. et al., 2019: *Effectiveness of forest conservation interventions: An evidence gap map*. Green Climate Fund, Songdo, 57 pp. https://www.cbd.int/doc/presentations/tc-imrr/Learning-Paper-2.pdf.

Pistorius, T., and L. Kiff, 2015: The Politics of German Finance for REDD+. In: *CGD Working Paper 390, CGD Climate and Forest Paper Series #16*, Center for Global Development, Washington DC, pp. 1–49.

Pitari, G. et al., 2014: Stratospheric ozone response to sulfate geoengineering: Results from the Geoengineering Model Intercomparison Project (GeoMIP). *J. Geophys. Res. Atmos.*, **119**(5), 2629–2653, doi:10.1002/2013jd020566.

Pitt, D., 2010: The impact of internal and external characteristics on the adoption of climate mitigation policies by US municipalities. *Environ. Plan. C Polit. Sp.*, **28**(5), 851–871, doi:10.1068/c09175.

Pollitt, H., K. Neuhoff, and X. Lin, 2020: The impact of implementing a consumption charge on carbon-intensive materials in Europe. *Clim. Policy*, **20**(sup1), s74–s89, doi:10.1080/14693062.2019.1605969.

Pongratz, J., D. B. Lobell, L. Cao, and K. Caldeira, 2012: Crop yields in a geoengineered climate. *Nat. Clim. Chang.*, **2**(2), 101–105, doi:10.1038/nclimate1373.

Popp, D., 2019: Environmental Policy and Innovation: A Decade of Research. *Int. Rev. Environ. Resour. Econ.*, **13**(3–4), 265–337, doi:10.1561/101.00000111.

Porterfield, M., 2019: Border Adjustments for Carbon Taxes, PPMs, and the WTO. *Univ. Pennsylvania*

J. Int. Law, **41**(1), 1–42.

Porterfield, M., K. P. Gallagher, and J. C. Schachter, 2017: Assessing the Climate Impacts of U.S. Trade Agreements. *Michigan J. Environ. Adm. Law*, **7**(1), 51–81.

Potoski, M., 2017: Green clubs in building block climate change regimes. *Clim. Change*, **144**(1), 53–63, doi:10.1007/s10584-015-1517-9.

Potoski, M., and A. Prakash, 2013: Green Clubs: Collective Action and Voluntary Environmental Programs. *Annu. Rev. Polit. Sci.*, **16**(1), 399–419, doi:10.1146/annurev-polisci-032211-211224.

Pozo, C., Á. Galán-Martín, D. M. Reiner, N. Mac Dowell, and G. Guillén-Gosálbez, 2020: Equity in allocating carbon dioxide removal quotas. *Nat. Clim. Chang.*, **10**, 640–646, doi:10.1038/s41558-020-0802-4.

Preston, B. J., 2020: The Influence of the Paris Agreement on Climate Litigation: Legal Obligations and Norms (Part I). *J. Environ. Law*, **33**(1), 1–32, doi:10.1093/jel/eqaa020.

Preston, C., and W. Carr, 2018: Recognitional Justice, Climate Engineering, and the Care Approach. *Ethics, Policy Environ.*, **21**(3), 308–323, doi:10.1080/21550085.2018.1562527.

Proctor, J., S. Hsiang, J. Burney, M. Burke, and W. Schlenker, 2018: Estimating global agricultural effects of geoengineering using volcanic eruptions. *Nature*, **560**(7719), 480–483, doi:10.1038/s41586-018-0417-3.

Quélin, B. V., I. Kivleniece, and S. Lazzarini, 2017: Public-private collaboration, hybridity and social value: Towards new theoretical perspectives. *J. Manag. Stud.*, **54**(6), 763–792, doi:10.1111/joms.12274.

Rabitz, F., 2019: Governing the termination problem in solar radiation management. *Env. Polit.*, **28**(3), 502–522, doi:10.1080/09644016.2018.1519879.

Rahman, A. A., P. Artaxo, A. Asrat, and A. Parker, 2018: Developing countries must lead on solar geoengineering research. *Nature*, **556**(7699), 22–24, doi:10.1038/d41586-018-03917-8.

Raiser, K., U. Kornek, C. Flachsland, and W. F. Lamb, 2020: Is the Paris Agreement effective? A systematic map of the evidence. *Environ. Res. Lett.*, **15**(8), 83006, doi:10.1088/1748-9326/ab865c.

Rajamani, L., 2010: The making and unmaking of the Copenhagen accord. *Int. Comp. Law Q.*, **59**(3), 824–843, doi:10.1017/s0020589310000400.

Rajamani, L., 2015: The Devilish Details: Key Legal Issues in the 2015 Climate Negotiations. *Mod. Law Rev.*, **78**(5), 826–853, doi:10.1111/1468-2230.12145.

Rajamani, L., 2016a: Ambition and Differentiation in the Paris Agreement: Interpretative Possibilities and Underlying Politics. *Int. Comp. Law Q.*, **65**(2), 493–514, doi:10.1017/s0020589316000130.

Rajamani, L., 2016b: The 2015 Paris Agreement: Interplay between hard, soft and non-obligations. *J. Environ. Law*, **28**(2), 337–358, doi:10.1093/jel/eqw015.

Rajamani, L., 2017: India's approach to international law in the climate change regime. *Indian J. Int. Law*, **57**(1), 1–23, doi:10.1007/s40901-018-0072-0.

Rajamani, L., 2018: Human Rights in the Climate Change Regime: From Rio to Paris and Beyond. In: *The Human Right to a Healthy Environment* [Knox, J.H. and R. Pejan, (eds.)], Cambridge University Press, 2018, pp. 236–251.

Rajamani, L., 2019: Integrating Human Rights in the Paris Climate Architecture: Contest, Context, and Consequence. *Clim. Law*, **9**(3), 180–201, doi:10.1163/18786561-00903003.

Rajamani, L., 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**(2119), 20160458, doi:10.1098/rsta.2016.0458.

Rajamani, L., and D. Bodansky, 2019: The Paris Rulebook: Balancing Prescriptiveness with National Discretion. *Int. Comp. Law Q.*, **68**(4), 1023–1040, doi:10.1017/s0020589319000320.

Rajamani, L. et al., 2021: National 'fair shares' in reducing greenhouse gas emissions within the principled framework of international environmental law. *Clim. Policy*, **21**(8), 983–1004, doi:10.1080/14693062.2021.1970504.

Rampa, F., S. Bilal, and E. Sidiropoulos, 2012: Leveraging South–South cooperation for Africa's development. *South African J. Int. Aff.*, **19**(2), 247–269, doi: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**(4), 507–523, doi:10.1007/s11027-017-9747-y.

Rashidi, K., 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, doi:10.1016/j.scs.2017.06.003.

Rashidi, K., M. Stadelmann, and A. Patt, 2019: Creditworthiness and climate: Identifying a hidden financial co-benefit of municipal climate adaptation and mitigation policies. *Energy Res. Soc. Sci.*, **48**, 131–138, doi:10.1016/j.erss.2018.09.021.

Ravikumar, A., 2020: Opinion: Carbon border taxes are unjust. *MIT Technol. Rev.*,. https://www.technologyreview.com/2020/07/27/1005641/carbon-border-taxes-eu-climate-change-opinion/ (Accessed October 29, 2021).

Rayner, S. et al., 2013: The Oxford Principles. *Clim. Change*, **121**(3), 499–512, doi:10.1007/s10584-012-0675-2.

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

REN21, 2019: REN21: Renewables Now! *ren21.net*,. https://www.ren21.net/about-us/who-we-are/ (Accessed December 18, 2019).

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

Reynolds, J. L., 2019b: Solar geoengineering to reduce climate change: a review of governance proposals. *Proc. R. Soc. A*, **475**(2229), 1–33, doi:10.1098/rspa.2019.0255.

RGI, 2011: *European Grid Declaration On Electricity Network Development and Nature Conservation in Europe (10 November 2011)*. Renewables Grid Initiative, 11 pp.

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**(10), 1271–1285, doi:10.1080/14693062.2018.1430018.

Ricke, K. L., J. B. Moreno-Cruz, and K. Caldeira, 2013: Strategic incentives for climate geoengineering coalitions to exclude broad participation. *Environ. Res. Lett.*, **8**, 014021, doi:10.1088/1748-9326/8/1/014021.

Rickels, W. et al., 2020: Who turns the global thermostat and by how much? *Energy Econ.*, **91**, 104852, doi:10.1016/j.eneco.2020.104852.

Ripley, K., and C. Verkuijl, 2016: "Ozone Family" Delivers Landmark Deal for the Climate. *Environ. Policy Law*, **46**(6), 371–375.

Ritchie, H., and D. S. Reay, 2017: Delivering the two degree global climate change target using a flexible ratchet framework. *Clim. Policy*, **17**(8), 1031–1045, doi:10.1080/14693062.2016.1222260.

Ritchie, J., 2021: Movement from the margins to global recognition: climate change activism by young people and in particular indigenous youth. *Int. Stud. Sociol. Educ.*, **30**(1–2), 53–72, doi:10.1080/09620214.2020.1854830.

Roberts, C. et al., 2018: The politics of accelerating low-carbon transitions: Towards a new research agenda. *Energy Res. Soc. Sci.*, **44**, 304–311, doi:10.1016/j.erss.2018.06.001.

Roberts, E., K. van der Geest, K. Warner, and S. Andrei, 2014: Loss and Damage: When adaptation is not enough. *Environ. Dev.*, **11**, 219–227, doi:10.1016/j.envdev.2014.05.001.

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**(1), 129–137, doi:10.1007/s10784-016-9347-4.

Roberts, J. T. et al., 2017: How Will We Pay for Loss and Damage? *Ethics Policy Environ.*, **20**(2), 208–226, doi:10.1080/21550085.2017.1342963.

Roberts, J. T. et al., 2021: Rebooting a failed promise of climate finance. *Nat. Clim. Chang.*, **11**(3), 180–182, doi:10.1038/s41558-021-00990-2.

Roberts, M. W., 2017: Finishing the job: The Montreal Protocol moves to phase down hydrofluorocarbons. *Rev. Eur. Comp. Int. Environ. Law*, **26**(3), 220–230, doi:10.1111/reel.12225.

Robinson, S.-A., 2018: Capacity building and transparency under Paris. In: *The Paris Framework for Climate Change Capacity Building* [Khan, M.R., J.T. Roberts, S. Huq, and V. Hoffmeister, (eds.)], Routledge, London, pp. 203–222.

Robiou du Pont, Y., and M. Meinshausen, 2018: Warming assessment of the bottom-up Paris Agreement emissions pledges. *Nat. Commun.*, **9**(1), 4810, doi:10.1038/s41467-018-07223-9.

Robiou du Pont, Y. et al., 2017: Equitable mitigation to achieve the Paris Agreement goals. *Nat. Clim. Chang.*, **7**(1), 38–43, doi:10.1038/nclimate3186.

Roelfsema, M. et al., 2020: Taking stock of national climate policies to evaluate implementation of the Paris Agreement. *Nat. Commun.*, **11**(1), 2096, doi:10.1038/s41467-020-15414-6.

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

Rogelj, J. et al., 2015: Energy system transformations for limiting end-of-century warming to below 1.5 °C. *Nat. Clim. Chang.*, **5**(6), 519–527, doi:10.1038/nclimate2572.

Rogelj, J. et al., 2016: Paris Agreement climate proposals need a boost to keep warming well below 2 °c. *Nature*, **534**(7609), 631–639, doi:10.1038/nature18307.

Rogelj, J. et al., 2017: Understanding the origin of Paris Agreement emission uncertainties. *Nat. Commun.*, **8**(15748), doi:10.1038/ncomms15748.

Rogelj, J. et al., 2018: Mitigation pathways compatible with 1.5°C in the context of sustainable development. In: *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* [Masson-Delmotte, V. et al., (eds.)], In Press, pp. 93–174.

Rogelj, J., O. Geden, A. Cowie, and A. Reisinger, 2021: Net-zero emissions targets are vague: three ways to fix. *Nature*, **591**(7850), 365–368, doi:10.1038/d41586-021-00662-3.

Rosen, A. M., 2015: The Wrong Solution at the Right Time: The Failure of the Kyoto Protocol on Climate Change. *Polit. Policy*, **43**(1), 30–58, doi:10.1111/polp.12105.

Rosenow, J., F. Kern, and K. Rogge, 2017: The need for comprehensive and well targeted instrument mixes to stimulate energy transitions: The case of energy efficiency policy. *Energy Res. Soc. Sci.*, **33**, 95–104, doi:10.1016/J.ERSS.2017.09.013.

Rubini, L., and I. Jegou, 2012: Who'll Stop the Rain? Allocating Emissions Allowances for Free: Environmental Policy, Economics, and WTO Subsidy Law. *Transnatl. Environ. Law*, **1**(2), 325–354, doi:10.1017/s2047102512000143.

Rubio, S. J., 2017: Sharing R & D investments in breakthrough technologies to control climate change. *Oxf. Econ. Pap.*, **69**(2), 496–521, doi:10.1093/oep/gpw067.

Rumpel, C. et al., 2020: The 4p1000 initiative: Opportunities, limitations and challenges for implementing soil organic carbon sequestration as a sustainable development strategy. *Ambio*, , doi:10.1007/s13280-019-01165-2.

Sabel, C. F., and D. G. Victor, 2017: Governing global problems under uncertainty: making bottom-up climate policy work. *Clim. Change*, **144**(1), 15–27, doi:10.1007/s10584-015-1507-y.

Sælen, H., 2020: Under What Conditions Will the Paris Process Produce a Cycle of Increasing Ambition Sufficient to Reach the 2°C Goal? *Glob. Environ. Polit.*, **20**(2), 83–104, doi:10.1162/glep_a_00548.

Sælen, H., J. Hovi, D. F. Sprinz, and A. Underdal, 2020: How US Withdrawal Might Influence Cooperation Under the Paris Climate Agreement. *Environ. Sci. Policy*, **108**, 121–132, doi:10.1016/j.envsci.2020.03.011.

Sands, P. Q. C., 2016: Climate change and the rule of law: Adjudicating the future in international law. *J. Environ. Law*, **28**(1), 19–35, doi:10.1093/jel/eqw005.

Sands, P. Q. C., and J. Peel, 2018: *Principles of International Environmental Law*. 4th ed. Cambridge University Press, Cambridge, 1032 pp.

Savaresi, A., 2016: The Paris agreement: A new beginning? *J. Energy Nat. Resour. Law*, **34**(1), 16–26, doi:10.1080/02646811.2016.1133983.

Savaresi, A., 2018: Climate change and human rights: Fragmentation, interplay, and institutional linkages. In: *Routledge Handbook of Human Rights and Climate Governance* [Duyck, S., S. Jodoin, and A. Johl, (eds.)], Routledge, London, pp. 31–42.

Savaresi, A., and J. Auz, 2019: Climate change litigation and human rights: Pushing the boundaries. *Clim. Law*, **9**(3), 244–262, doi:10.1163/18786561-00903006.

Schade, J., and W. Obergassel, 2014: Human rights and the Clean Development Mechanism. *Cambridge Rev. Int. Aff.*, **27**(4), 717–735, doi:10.1080/09557571.2014.961407.

Schäfer, S., 2019: Decoupling the EU ETS from subsidized renewables and other demand side effects: lessons from the impact of the EU ETS on CO_2 emissions in the German electricity sector. *Energy Policy*, **133**, 110858, doi:10.1016/J.ENPOL.2019.06.066.

Scheidel, A. et al., 2020: Environmental conflicts and defenders: A global overview. *Glob. Environ. Chang.*, **63**, 102104, doi:10.1016/j.gloenvcha.2020.102104.

Scheinman, L., 1987: *The International Atomic Energy Agency and World Nuclear Order*. Resources for the Future, Washington DC, 320 pp.

Schleussner, C. F. et al., 2016: Science and policy characteristics of the Paris Agreement temperature goal. *Nat. Clim. Chang.*, **6**(9), 827–835, doi: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**(3), 359–374, doi: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, doi:10.1038/515335a.

Schmieg, G. et al., 2017: Modeling normativity in sustainability: a comparison of the sustainable development goals, the Paris agreement, and the papal encyclical. *Sustain. Sci.*, **13**, 785–796, doi: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**(3), 386–400, doi:10.1080/14693062.2018.1521332.

Schneider, L., A. Kollmuss, and M. Lazarus, 2014: *Addressing the risk of double counting emission reductions under the UNFCCC*. Stockholm Environment Institute, Stockholm, 1–56 pp. https://mediamanager.sei.org/documents/Publications/Climate/SEI-WP-2014-02-Double-counting-risks-UNFCCC.pdf.

Schneider, L., M. Lazarus, C. Lee, and H. Van Asselt, 2017: Restricted linking of emissions trading systems: options, benefits and challenges. *Int. Environ. Agreements Polit. Law Econ.*, **17**(6), 883–898, doi:10.1007/s10784-017-9370-0.

Schneider, L. et al., 2019: Double counting and the Paris Agreement rulebook. *Science (80-.).*, **366**(6462), 180–183, doi:10.1126/science.aay8750.

Schroeder, H., and C. McDermott, 2014: Beyond carbon: Enabling justice and equity in REDD+ across levels of governance. *Ecol. Soc.*, **19**(1), 2–4, doi:10.5751/es-06537-190131.

Schroeder, H., M. Di Gregorio, M. Brockhaus, and T. T. Pham, 2020: Policy Learning in REDD+ Donor Countries: Norway, Germany, and the UK. *Glob. Environ. Chang.*, **63**, 102106, doi:10.1016/j.gloenvcha.2020.102106.

Schulte, I. et al., 2020: *Supporting Smallholder Farmers for a Sustainable Cocoa Sector: Exploring the Motivations and Role of Farmers in the Effective Implementation of Supply Chain Sustainability in Ghana and Cote d'Ivoire*. Meridian Institute, Washington DC, 1–59 pp. https://www.climatefocus.com/sites/default/files/Supporting Smallholder Farmers for a Sustainable Cocoa Sector June 2020.pdf.

Selin, H., 2014: Global Environmental Law and Treaty-Making on Hazardous Substances: The Minamata Convention and Mercury Abatement. *Glob. Environ. Polit.*, **14**(1), 1–19, doi:10.1162/glep_a_00208.

Seneviratne, S. I. et al., 2018: Land radiative management as contributor to regional-scale climate adaptation and mitigation. *Nat. Geosci.*, **11**(2), 88–96, doi:10.1038/s41561-017-0057-5.

Serdeczny, O., 2019: Non-economic Loss and Damage and the Warsaw International Mechanism. In: *Loss and Damage from Climate Change. Concepts, Methods and Policy Options. Climate Risk Management, Policy and Governance.* [Mechler, R., L. Bouwer, T. Schinko, S. Surminski, and J. Linnerooth-Bayer, (eds.)], Springer, Cham, pp. 205–220.

Sethi, M., W. Lamb, J. Minx, and F. Creutzig, 2020: Climate change mitigation in cities: a systematic scoping of case studies. *Environ. Res. Lett.*, **15(**9), 093008, doi:10.1088/1748-9326/AB99FF.

Setzer, J., and R. Byrnes, 2019: *Global trends in climate change litigation: 2019 snapshot*. London School of Economics and Political Science, London, UK, 14 pp. https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2019/07/GRI_Global-trends-in-climate-change-litigation-2019-snapshot-2.pdf.

Setzer, J., and L. C. Vanhala, 2019: Climate change litigation: A review of research on courts and litigants in climate governance. *Wiley Interdiscip. Rev. Clim. Chang.*, **10**(3), e580, doi:10.1002/wcc.580.

Setzer, J., and L. Benjamin, 2020: Climate litigation in the Global South: constraints and innovations. *Transnatl. Environ. Law*, **9**(1), 77–101, doi:10.1017/s2047102519000268.

Seymour, F., and J. Busch, 2016: *Why forests? Why now?: The science, economics, and politics of tropical forests and climate change*. Brookings Institution Press, Washington, D.C., 429 pp.

Shadikhodjaev, S., 2015: Renewable Energy and Government Support: Time to 'Green' the SCM Agreement? *World Trade Rev.*, **14**(3), 479–506, doi:10.1017/s1474745614000317.

Shepherd, J. G., 2009: *Geoengineering the climate: science, governance and uncertainty (RS Policy Document 10/09)*. The Royal Society 2009, London, 84 pp.

Sheriff, G., 2019: Burden Sharing under the Paris Climate Agreement. *J. Assoc. Environ. Resour. Econ.*, **6**(2), 275–318, doi:10.1086/701469.

Shi, X., Y. Chen, and H. Liu, 2017: The Negative Impact of Climate Change Mitigation Measures on Human Rights and the Countermeasures. *J. Hunan Police Acad.*, **1**, 7.

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**(2), 134–156, doi: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. In: *Scaling Up South-South and Triangular Cooperation* [Kato, H., (ed.)], Japan International Cooperation Agency Research Institute, Tokyo, pp. 149–172.

Shishlov, I., R. Morel, and V. Bellassen, 2016: Compliance of the Parties to the Kyoto Protocol in the first commitment period. *Clim. Policy*, **16**(6), 768–782, doi:10.1080/14693062.2016.1164658.

Simpson, I. R. et al., 2019: The Regional Hydroclimate Response to Stratospheric Sulfate Geoengineering and the Role of Stratospheric Heating. *J. Geophys. Res. Atmos.*, **124**(23), 12587–12616, doi:10.1029/2019jd031093.

Sindico, F., 2016: Paris, Climate Change, and Sustainable Development. *Clim. Law*, **6**(1–2), 130–141, doi:10.1163/18786561-00601009.

Skeie, R. B. et al., 2017: Perspective has a strong effect on the calculation of historical contributions to global warming. *Environ. Res. Lett.*, **12**(2), 024022, doi:10.1088/1748-9326/aa5b0a.

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**(3), 104–120, doi:10.1162/glep.2006.6.3.104.

Smit, B., and J. Wandel, 2006: Adaptation, adaptive capacity and vulnerability. *Glob. Environ. Chang.*, **16**(3), 282–292, doi:10.1016/j.gloenvcha.2006.03.008.

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**(1–2), 70–103, doi:10.1163/18786561-00801003.

Smith, W., and G. Wagner, 2018: Stratospheric aerosol injection tactics and costs in the first 15 years of deployment. *Environ. Res. Lett.*, **13**(124001), doi:10.1088/1748-9326/aae98d.

Solomon, S., G.-K. Plattner, R. Knutti, and P. Friedlingstein, 2009: Irreversible climate change due to carbon dioxide emissions. *Proc. Natl. Acad. Sci.*, **106**(6), 1704–1709, doi:10.1073/pnas.0812721106.

Sorgho, Z., and J. Tharakan, 2020: *Do PTAs with Environmental Provisions Reduce Emissions? Assessing the Effectiveness of Climate-related Provisions?* Fondation pour les études et recherches sur le développement internationa, Clermont-Ferrand, 47 pp. https://ferdi.fr/dl/df-nJ7WgYnTDp6qA2SGjnT25Y9F/ferdi-p274-do-ptas-with-environmental-provisions-reduce-emissions-assessing.pdf.

Sovacool, B. K., and A. Florini, 2012: Examining the Complications of Global Energy Governance. *J. Energy Nat. Resour. Law*, **30**(3), 235–263, doi:10.1080/02646811.2012.11435295.

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

Spalding-Fecher, R. et al., 2012: *Assessing The Impact Of The Clean Development Mechanism. Final Report. Report Commissioned By The High-Level Panel On The CDM Policy Dialogue*. UNFCCC, Bonn, 172 pp.

Spash, C. L., 2016: This Changes Nothing: The Paris Agreement to Ignore Reality. *Globalizations*, **13**(6), 928–933, doi:10.1080/14747731.2016.1161119.

Springmann, M., 2013: Carbon tariffs for financing clean development. *Clim. Policy*, **13**(1), 20–42, doi:10.1080/14693062.2012.691223.

Sprinz, D. F., H. Sælen, A. Underdal, and J. Hovi, 2018: The Effectiveness of Climate Clubs under Donald Trump. *Clim. Policy*, **18**(7), 828–838, doi:10.1080/14693062.2017.1410090.

Staver, A. C., S. Archibald, and S. A. Levin, 2011: The Global Extent and Determinants of Savanna and Forest as Alternative Biome States. *Science (80-.).*, **334**(6053), 230–232, doi:10.1126/science.1210465.

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

Steele, P., 2015: *Development finance and climate finance: Achieving zero poverty and zero emissions*. IIED, London, 1–31 pp.

Steenblik, R., and S. Droege, 2019: Time to ACCTS? Five countries announce new initiative on trade and climate change. *Int. Inst. Sustain. Dev. Blog*,. https://www.iisd.org/articles/time-accts-five-countries-announce-new-initiative-trade-and-climate-change (Accessed October 29, 2021).

Steenblik, R., J. Sauvage, and C. Timiliotis, 2018: Fossil Fuel Subsidies and the Global Trade Regime. In: *The Politics of Fossil Fuel Subsidies and their Reform* [Van Asselt, H. and J. Skovgaard, (eds.)], Cambridge University Press, Cambridge, pp. 121–139.

Stephens, J. C., and K. Surprise, 2020: The hidden injustices of advancing solar geoengineering research. *Glob. Sustain.*, **3**(e2), 1–6, doi:10.1017/sus.2019.28.

Stephenson, S. R. et al., 2018: Climatic Responses to Future Trans-Arctic Shipping. *Geophys. Res. Lett.*, **45**(18), 9898–9908, doi:10.1029/2018gl078969.

Stephenson, S. R., N. Oculi, A. Bauer, and S. Carhuayano, 2019: Convergence and Divergence of UNFCCC Nationally Determined Contributions. *Ann. Am. Assoc. Geogr.*, **109**(4), 1240–1261, doi:10.1080/24694452.2018.1536533.

Stewart, R. B., M. Oppenheimer, and B. Rudyk, 2013a: A new strategy for global climate protection. *Clim. Change*, **120**(1), 1–12, doi:10.1007/s10584-013-0790-8.

Stewart, R. B., M. Oppenheimer, and B. Rudyk, 2013b: Building Blocks for Global Climate Protection. *Stanford Environ. Law J.*, **32**(2), 341–392, doi:10.2139/ssrn.2186541.

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), 1–13, doi:10.1007/s10584-017-1932-1.

Stilgoe, J., 2015: *Experiment earth : responsible innovation in geoengineering*. Taylor and Francis Ltd., London, UK, 222 pp.

Stjern, C. W. et al., 2018: Response to marine cloud brightening in a multi-model ensemble. *Atmos. Chem. Phys.*, **18**(2), 621–634, doi:10.5194/acp-18-621-2018.

Storelvmo, T., and N. Herger, 2014: Cirrus cloud susceptibility to the injection of ice nuclei in the upper troposphere. *J. Geophys. Res. Atmos.*, **119**(5), 2375–2389, doi:10.1002/2013jd020816.

Streck, C., and C. Parker, 2012: Financing REDD+. In: *Analysing REDD+: Challenges and choices* [Angelsen, A., M. Brockhaus, W.D. Sunderlin, and L.. Verchot, (eds.)], CIFOR, Bogor, Indonesia, pp. 111–127.

Streck, C., and M. Terhalle, 2013: The changing geopolitics of climate change. *Clim. Policy*, **13**(5), 533–537, doi:10.1080/14693062.2013.823809.

Stua, M., 2017a: A single mechanism for the certification of mitigation outcomes. In: *From the Paris Agreement to a Low-Carbon Bretton Woods: Rationale for the Establishment of a Mitigation Alliance*, Springer International Publishing, Cham, Switzerland, pp. 85–107.

Stua, M., 2017b: *From the Paris agreement to a low-carbon bretton woods: Rationale for the establishment of a mitigation alliance*. Springer International Publishing, 239 pp.

Stuart-Smith, R. F. et al., 2021: Filling the evidentiary gap in climate litigation. *Nat. Clim. Chang.*, **11**(8), 651–655, doi:10.1038/s41558-021-01086-7.

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**(1), 34–41, doi:10.1007/s13280-014-0520-0.

Sugiyama, M., Y. Arino, T. Kosugi, A. Kurosawa, and S. Watanabe, 2018a: Next steps in geoengineering scenario research: limited deployment scenarios and beyond. *Clim. Policy*, **18**(6), 681–689, doi:10.1080/14693062.2017.1323721.

Sugiyama, M., A. Ishii, S. Asayama, and T. Kosugi, 2018b: Solar Geoengineering Governance. *Oxford Res. Encycl. Clim. Sci.*, , 26, doi:10.1093/acrefore/9780190228620.013.647.

Sugiyama, M., S. Asayama, and T. Kosugi, 2020: The North–South Divide on Public Perceptions of Stratospheric Aerosol Geoengineering?: A Survey in Six Asia-Pacific Countries. *Environ. Commun.*, **14**(5), 641–656, doi:10.1080/17524032.2019.1699137.

Svoboda, T., 2017: *The ethics of climate engineering : solar radiation management and non-ideal justice*. 1st ed. Routledge, New York, 1–186 pp.

Svoboda, T., and P. Irvine, 2014: Ethical and Technical Challenges in Compensating for Harm Due to Solar Radiation Management Geoengineering. *Ethics, Policy Environ.*, **17**(2), 157–174, doi:10.1080/21550085.2014.927962.

Tacconi, L., 2017: Strengthening policy research and development through foreign aid_ the case of reducing deforestation and forest degradation in Indonesia. *Aust. For.*, **80**(3), 188–194, doi:10.1080/00049158.2017.1335579.

Tacconi, L., R. J. Rodrigues, and A. Maryudi, 2019: Law enforcement and deforestation: Lessons for Indonesia from Brazil. *For. Policy Econ.*, **108**, 101943, doi:10.1016/j.forpol.2019.05.029.

Táíwò, O. O., and S. Talati, 2021: Who Are the Engineers? Solar Geoengineering Research and Justice. *Glob. Environ. Polit.*, , 1–7, doi:10.1162/glep_a_00620.

Talberg, A., S. Thomas, P. Christoff, and D. Karoly, 2018: How geoengineering scenarios frame assumptions and create expectations. *Sustain. Sci.*, **13**(4), 1093–1104, doi:10.1007/s11625-018-0527-8.

Tamiotti, L., 2011: The legal interface between carbon border measures and trade rules. *Clim. Policy*, **11**(5), 1202–1211, doi:10.1080/14693062.2011.592672.

Tamiotti, L. et al., 2009: *Trade and Climate Change, A report by the United Nations Environment Programme and the World Trade Organization*. 166 pp. 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*. 66 pp. https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf.

TDA, 2019: *Join us in raising ambition, action and advocacy towards the decarbonisation of the transport sector before 2050*. Transportation Decarbonisation Alliance, 4 pp. http://tda-mobility.org/wp-content/uploads/2018/08/TDA-Flyer.pdf.

TEC, and CTCN, 2019: *Joint annual report of the Technology Executive Committee and the Climate Technology Centre and Network for 2019*. 1–26 pp. https://unfccc.int/sites/default/files/resource/sb2019_04E.pdf.

Tedsen, E., and G. Homann, 2013: Implementing the Precautionary Principle for Climate Engineering. *Carbon Clim. Law Rev.*, **7**(2), 90–100, doi:10.21552/cclr/2013/2/250.

Terhalle, M., and J. Depledge, 2013: Great-power politics, order transition, and climate governance: insights from international relations theory. *Clim. policy*, **13**(5), 572–588, doi:10.1080/14693062.2013.818849.

Terrenoire, E., D. A. Hauglustaine, T. Gasser, and O. Penanhoat, 2019: The contribution of carbon dioxide emissions from the aviation sector to future climate change. *Environ. Res. Lett.*, **14**, 084019, doi:10.1088/1748-9326/ab3086.

The Supreme Court of Nepal, 2018: *Advocate Padam Bahadur Shrestha Vs The office of the Prime Minister and Council of Ministers, Singhadurbar, Kathmandu and others. Decision No. 10210, NKP, Part 61, Vol. 3 (25 December 2018)*. 1–15 pp. http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2018/20181225_074-WO-0283_judgment-1.pdf.

The Supreme Court of the Netherlands, 2019: *The State of the Netherlands v. Stichting Urgenda Foundation. Case 19/00135 (English translation)*.

Thompson, R., 2017: Whither climate change post-Paris? *Anthr. Rev.*, **4**(1), 62–69, doi:10.1177/2053019616676607.

Thorgeirsson, H., 2017: Objective (Article 2.1). In: *The Paris Agreement on Climate Change: Analysis and commentary* [Klein, D., M. Pía Carazo, M. Doelle, J. Bulmer, and A. Higham, (eds.)], Oxford University Press, pp. 123–130.

Thwaites, J., 2020: *The Good, the bad and the urgent in MDB Climate Finance 2019*. https://www.wri.org/insights/good-bad-and-urgent-mdb-climate-finance-2019 (Accessed October 25, 2021).

Tienhaara, K., 2018: Regulatory Chill in a Warming World: The Threat to Climate Policy Posed by Investor-State Dispute Settlement. *Transnatl. Environ. Law*, **7**(2), 229–250, doi:10.1017/s2047102517000309.

Tienhaara, K., and L. Cotula, 2020: *Raising the Cost of Climate Action? Investor-State Dispute Settlement and Compensation for Stranded Fossil Fuel Assets. IIED Land, Investment and Rights series*. International Institute for Environment and Development, London, 49 pp. https://pubs.iied.org/pdfs/17660IIED.pdf.

Tilmes, S., B. M. Sanderson, and B. C. O'Neill, 2016: Climate impacts of geoengineering in a delayed mitigation scenario. *Geophys. Res. Lett.*, **43**(15), 8222–8229, doi:10.1002/2016gl070122.

Tilmes, S. et al., 2018: CESM1(WACCM) Stratospheric Aerosol Geoengineering Large Ensemble Project. *Bull. Am. Meteorol. Soc.*, **99**(11), 2361–2371, doi:10.1175/bams-d-17-0267.1.

Tilmes, S. et al., 2020: Reaching 1.5 and 2.0 °C global surface temperature targets using stratospheric aerosol geoengineering. *Earth Syst. Dyn.*, **11**(3), 579–601, doi:10.5194/esd-11-579-2020.

Tingley, D., and G. Wagner, 2017: Solar geoengineering and the chemtrails conspiracy on social media. *Palgrave Commun.*, **3**(1), 1–7, doi:10.1057/s41599-017-0014-3.

Tormos-Aponte, F., and G. A. García-López, 2018: Polycentric struggles: The experience of the global climate justice movement. *Environ. Policy Gov.*, **28**(4), 284–294, doi:10.1002/eet.1815.

Tørstad, V. H., 2020: Participation, ambition and compliance: can the Paris Agreement solve the effectiveness trilemma? *Env. Polit.*, **29**(5), 761–780, doi:10.1080/09644016.2019.1710322.

Trachtman, J. P., 2017: WTO Law Constraints on Border Tax Adjustment and Tax Credit Mechanisms to Reduce the Competitive Effects of Carbon Taxes. *Natl. Tax J.*, **70**(2), 469–493, doi:10.17310/ntj.2017.2.09.

Tramel, S., 2016: The Road Through Paris: Climate Change, Carbon, and the Political Dynamics of Convergence. *Globalizations*, **13**(6), 960–969, doi:10.1080/14747731.2016.1173376.

Traut, M. et al., 2018: CO2 abatement goals for international shipping. *Clim. Policy*, **18**(8), 1066–1075, doi:10.1080/14693062.2018.1461059.

Trisos, C. H. et al., 2018: Potentially dangerous consequences for biodiversity of solar geoengineering implementation and termination. *Nat. Ecol. Evol.*, **2**(3), 475–482, doi: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**(3), 258–300, doi:10.3390/d4030258.

Tulkens, H., 2016: COP 21 and Economic Theory: Taking Stock. *Rev. Econ. Polit.*, **126**(4), 471–486, doi:10.3917/redp.264.0471.

Tulkens, H., 2019: *Economics, Game Theory and International Environmental Agreements. The Ca' Foscari Lectures.* World Scientific Publishing Co. Pte. Ltd., Singapore, 1–460 pp.

Turnhout, E. et al., 2017: Envisioning REDD+ in a post-Paris era: between evolving expectations and current practice. *Wiley Interdiscip. Rev. Clim. Chang.*, **8**(1), e425, doi:10.1002/wcc.425.

TWI2050, 2018: *Transformations to achieve the Sustainable Development Goals. Report prepared by the World in 2050 initiative.* International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, Austria, 154 pp.

Umemiya, C., M. Ikeda, and M. K. White, 2020: Lessons learned for future transparency capacity building under the Paris Agreement: A review of greenhouse gas inventory capacity building projects in Viet Nam and Cambodia. *J. Clean. Prod.*, **245**, 118881, doi:10.1016/j.jclepro.2019.118881.

UN, 2016: *Montreal Protocol, Kigali Amendment*. , Kigali, 15 October 2016, 63 pp. https://treaties.un.org/doc/Treaties/2016/10/20161015 03-23 PM/Ch_XXVII-2.f.pdf.

UN, 2017a: *UN System Strategic Approach on Climate Change Action. Report of the High Level Committee on Programmes, Chief Executives Board for Coordination. CEB/2017/4/Add.1.* 15 pp. https://unsceb.org/sites/default/files/2021-01/CEB_2017_4_Add1.pdf.

UN, 2017b: *Catalyzing the Implementation of Nationally Determined Contributions in the Context of the 2030 Agenda through South-South Cooperation*. 68 pp. https://unfccc.int/files/resource_materials/application/pdf/ssc_ndc_report.pdf.

UN, 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, 2019: *Buenos Aires outcome document of the second High-level United Nations Conference on South-South Cooperation (A/RES/73/291)*. 1–11 pp. digitallibrary.un.org/record/3801900/files/A_RES_73_291-EN.pdf.

UN Human Rights Council, 2021: *Promotion and protection of all human rights, civil, political, economic, social and cultural rights, including the right to development (5 October 2021). UN Doc. A/HRC/48/L.23/Rev.1.* 1–3 pp. https://undocs.org/a/hrc/48/l.23/rev.1.

UNCBD, 2010: *Decision X/2.The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets. UNEP/CBD/COP/DEC/X/2 (29 October 2010).* , Nagoya, 1–13 pp. https://www.cbd.int/doc/decisions/cop-10/cop-10-dec-02-en.pdf.

UNCCD, 2015: Land Degradation Neutrality: The Target Setting Programme. *Glob. Mech. UNCCD*,. https://www.unccd.int/actions/ldn-target-setting-programme (Accessed December 19, 2020).

UNCTAD, 2012: *State of South-South and Triangular Cooperation in the Production, Use and Trade of Sustainable Biofuels*. United Nations, New York and Geneva, 26 pp. https://unctad.org/en/PublicationsLibrary/ditcted2011d10_en.pdf.

UNCTAD, 2019: *Taking Stock of IIA Reform: Recent Developments. IIA Issue Note. Issue 3. June 2019.* UNCTAD, Geneva, 12 pp. https://unctad.org/system/files/official-document/diaepcbinf2019d5_en.pdf.

UNEP, 2013: *Global Mercury Assessment*. UNEP Chemicals Branch, Geneva, Switzerland, 32 pp. https://wedocs.unep.org/handle/20.500.11822/7984.

UNEP, 2018a: *Emissions Gap Report 2018*. United Nations Environment Programme, Nairobi, 1–85 pp. https://www.unenvironment.org/resources/emissions-gap-report-2018.

UNEP, 2018b: *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.* 14 pp.

UNEP, 2019: *Emissions Gap Report 2019*. United Nations Environment Programme, Nairobi, 1–81 pp. https://www.unep.org/resources/emissions-gap-report-2019.

UNEP, 2020: *Emissions Gap Report 2020*. United Nations Environment Programme, Nairobi, 101 pp. https://www.unenvironment.org/emissions-gap-report-2020.

UNFCCC, 1992: *United Nations Framework Convention on Climate Change*. 1–24 pp. https://unfccc.int/resource/docs/convkp/conveng.pdf (Accessed December 10, 2020).

UNFCCC, 1997: *Kyoto Protocol to the United Nations Framework Convention on Climate Change*. 20 pp. https://unfccc.int/resource/docs/convkp/kpeng.pdf.

UNFCCC, 2010a: *Decision 2/ CP. 15. Copenhagen Accord*. 1–9 pp. https://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf#page=4.

UNFCCC, 2010b: Decision 1/CP.16 The Cancun Agreements: Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention. *Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010*, 31.

UNFCCC, 2012: *Report of the Conference of the Parties on its seventeenth session, held in Durban from 28 November to 11 December 2011. Addendum. Part Two: Action taken by the Conference of the Parties at its seventeenth session*. UNFCCC, Durban, 86 pp. https://unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf.

UNFCCC, 2015a: *Paris Agreement*. 25 pp. https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

UNFCCC, 2015b: *Technology Mechanism: Enhancing climate technology development and transfer*. United Nations Framework Convention on Climate Change, 8 pp.

UNFCCC, 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.* 36 pp. https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf#page=2.

UNFCCC, 2016b: *Aggregate effect of the intended nationally determined contributions: an update. Synthesis report by the secretariat. FCCC/CP/2016/2.* 75 pp. https://unfccc.int/resource/docs/2016/cop22/eng/02.pdf.

UNFCCC, 2018: *UNFCCC Standing Committee on Finance: 2018 Biennial Assessment and Overview of Climate Finance Flows. Technical Report*. 170 pp. https://unfccc.int/sites/default/files/resource/2018 BA Technical Report Final.pdf.

UNFCCC, 2019a: *Decision 1/CP.25. Report of the Conference of the Parties on its twenty-fifth sesssion, Addendum, Part two.* 1–59 pp. https://unfccc.int/sites/default/files/resource/cp2019_13a01E.pdf.

UNFCCC, 2019b: 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*, 4–13 https://unfccc.int/sites/default/files/resource/cma2018_03a01E.pdf.

UNFCCC, 2019c: Decision 4/CP.24 Report of the Standing Committee on Finance.

FCCC/CP/2018/10/Add.1. *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 twenty-fourth session*, UNFCCC 2019, 14–28 https://unfccc.int/sites/default/files/resource/10a1.pdf.

UNFCCC, 2019d: Decision 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*, 18–52 https://unfccc.int/sites/default/files/resource/cma2018_3_add2_new_advance.pdf.

UNFCCC, 2019e: 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*, 53–58 https://unfccc.int/sites/default/files/resource/cma2018_3_add2_new_advance.pdf.

UNFCCC, 2019f: Decision 15/CMA.1 Technology framework under Article 10, paragraph 4, of the Paris Agreement. FCCC/PA/CMA/2018/3 Add.2. *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 Part two: Action taken by the Conference of the Parties servi*, 4–10 https://unfccc.int/sites/default/files/resource/cma2018_3_add2_new_advance.pdf.

UNFCCC, 2019g: 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 https://unfccc.int/sites/default/files/resource/cma2018_3_add2_new_advance.pdf.

UNFCCC, 2019h: *Implementation of the framework for capacity-building in developing countries. Synthesis report by the secretariat*. 22 pp. https://unfccc.int/sites/default/files/resource/03.pdf.

UNFCCC, 2019i: Decision 17/CMA.1 Ways of enhancing the implementation of education, training, public awareness, public participation and public access to information so as to enhance actions under 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*, 15–17 https://unfccc.int/sites/default/files/resource/cma2018_3_add2_new_advance.pdf.

UNFCCC, 2019j: Decision 20/CMA.1. Modalities and procedures for the effective operation of the committee to facilitate implementation and promote compliance referred to in Article 15, paragraph 2, 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 Addendum Part two: Action taken by the Conference of the Parties servi*, 59–64 https://unfccc.int/sites/default/files/resource/cma2018_3_add2_new_advance.pdf.

UNFCCC, 2019k: *Common tabular formats for the electronic reporting of the information on financial, technology development and transfer and capacity-building support provided and mobilized, as well as support needed and received, under Articles 9–11 of the Paris Agreeme*. 19 pp. https://unfccc.int/sites/default/files/resource/SBSTA51.IN_.i11c.pdf.

UNFCCC, 2019l: Decision 14/CP.24 Linkages between the Technology Mechanism and the Financial Mechanism of the Convention. FCCC/CP/2018/10/Add.2. *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 twenty-fourth session*, pg 5 https://unfccc.int/sites/default/files/resource/cp2018_10_add2_advance.pdf.

UNFCCC, 2020a: Bilateral and Multilateral Funding. *UNFCCC Top. Clim. Financ. Resour.*,. https://unfccc.int/topics/climate-finance/resources/multilateral-and-bilateral-funding-sources

(Accessed December 8, 2020).

UNFCCC, 2020b: Technology Executive Committee: Strengthening climate technology policies. *TT Clear*,. https://unfccc.int/ttclear/tec (Accessed June 4, 2020).

UNFCCC, 2020c: Developing the Santiago Network for Loss and Damage. *Event*,. https://unfccc.int/event/developing-the-santiago-network-for-loss-and-damage (Accessed October 30, 2021).

UNFCCC, 2020d: Subsidiary Body for Implementation, Compilation and synthesis of fourth biennial reports of Parties included in Annex I to the Convention. *https://unfccc.int/sites/default/files/resource/sbi2020_inf10.pdf* (Accessed 2 November 2021).

UNFCCC, 2021a: *Nationally determined contributions under the Paris Agreement - Synthesis report by the secretariat (FCCC/PA/CMA/2021/8)*. 1–42 pp. https://unfccc.int/sites/default/files/resource/cma2021_08_adv_1.pdf.

UNFCCC, 2021b: Building capacity in the UNFCCC process. *Big Pict.*,. https://unfccc.int/topics/capacity-building/the-big-picture/capacity-in-the-unfccc-process (Accessed October 30, 2021).

UNFCCC, 2021c: CDM Insights. *https://cdm.unfccc.int/Statistics/Public/CDMinsights/index.html* (Accessed 2 November 2021).

UNFCCC, and UNOSSC, 2018: *Potential of South South Cooperation and Triangular Cooperation on climate technologies for advancing the implementation of nationally determined contributions and national adaptation plans.* 34 pp.

UNFCCC Subsidiary Body for Implementation, 2020: *Annual technical progress report of the Paris Committee on Capacity-building. FCCC/SBI/2020/13.* 34 pp.

UNGA, 1948: *The Universal Declaration of Human Rights. A/RES/217.*

UNGA, 1966a: *International Covenant on Civil and Political Rights. General Assembly Resolution 2200A (XXI) of 16 December 1966*.

UNGA, 1966b: *International Covenant on Economic, Social and Cultural Rights. General Assembly Resolution 2200A (XXI) of 16 December 1966*.

UNGA, 2019: *Report of the Special Rapporteur on the issue of human rights obligations relating to the enjoyment of a safe, clean, healthy and sustainable environment (15 July 2019). UN Doc. A/76/161*. 1–25 pp.

UNOSC, 2017: United Nations Action Plan on South-South Climate Cooperation (2017-2021). https://www.unsouthsouth.org/south-south-cooperation-action-plan-for-climate-change-engagement-strategy-2017-2021/ (Accessed October 30, 2021).

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, doi:10.1016/j.enpol.2017.11.007.

Urpelainen, J., 2011: Can Unilateral Leadership Promote International Environmental Cooperation? *Int. Interact.*, **37**(3), 320–339, doi:10.1080/03050629.2011.596018.

Urpelainen, J., and T. Van de Graaf, 2015: The International Renewable Energy Agency: a success story in institutional innovation? *Int. Environ. Agreements Polit. Law Econ.*, **15**(2), 159–177, doi:10.1007/s10784-013-9226-1.

Urpelainen, J., and T. Van de Graaf, 2018: United States non-cooperation and the Paris agreement. *Clim. Policy*, **18**(7), 839–851, doi:10.1080/14693062.2017.1406843.

van Asselt, H., 2007: From UN-ity to Diversity? The UNFCCC, the Asia-Pacific Partnership and the Future of International Law on Climate Change. *Carbon Clim. Law Rev.*, **1**(1), 12, doi:10.21552/cclr/2007/1/9.

van Asselt, H., 2016: The Role of Non-State Actors in Reviewing Ambition, Implementation, and Compliance under the Paris Agreement. *Clim. Law*, **6**(1–2), 91–108, doi:10.1163/18786561-00601006.

van Asselt, H., 2017: *Climate Change and Trade Policy Interaction: Implications of Regionalism. OECD Trade and Environment Working Papers. 2017/03*. OECD Publishing, 54 pp.

van Asselt, H., and F. Zelli, 2014: Connect the dots: managing the fragmentation of global climate governance. *Environ. Econ. Policy Stud.*, **16**(2), 137–155, doi:10.1007/s10018-013-0060-z.

van de Graaf, T., 2013: Fragmentation in Global Energy Governance: Explaining the Creation of IRENA. *Glob. Environ. Polit.*, **13**(3), 14–33, doi:10.1162/glep_a_00181.

van de Graaf, T., and D. Lesage, 2009: The International Energy Agency after 35 years: Reform needs and institutional adaptability. *Rev. Int. Organ.*, **4**(3), 293–317, doi:10.1007/s11558-009-9063-8.

van de Graaf, T., and J. Colgan, 2016: Global energy governance: a review and research agenda. *Palgrave Commun.*, **2**, 15047, doi:10.1057/palcomms.2015.47.

van der Voorn, T., C. Pahl-Wostl, and J. Quist, 2012: Combining backcasting and adaptive management for climate adaptation in coastal regions: A methodology and a South African case study. *Futures*, **44**(4), 346–364, doi:10.1016/j.futures.2011.11.003.

van der Voorn, T., J. Quist, C. Pahl-Wostl, and M. Haasnoot, 2017: Envisioning robust climate change adaptation futures for coastal regions: a comparative evaluation of cases in three continents. *Mitig. Adapt. Strateg. Glob. Chang.*, **22**(3), 519–546, doi:10.1007/s11027-015-9686-4.

van der Voorn, T., Å. Svenfelt, K. E. Björnberg, E. Fauré, and R. Milestad, 2020: Envisioning carbon-free land use futures for Sweden: a scenario study on conflicts and synergies between environmental policy goals. *Reg. Environ. Chang.*, **20**(2), 35, doi:10.1007/s10113-020-01618-5.

van Soest, H. L., M. G. J. den Elzen, and D. P. van Vuuren, 2021: Net-zero emission targets for major emitting countries consistent with the Paris Agreement. *Nat. Commun.*, **12**(1), 2140, doi:10.1038/s41467-021-22294-x.

van Tulder, R., S. B. Rodrigues, H. Mirza, and K. Sexsmith, 2021: The UN's Sustainable Development Goals: Can multinational enterprises lead the Decade of Action? *J. Int. Bus. Policy*, **4**(1), 1–21, doi:10.1057/s42214-020-00095-1.

Vandyck, T. et al., 2018: Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris Agreement pledges. *Nat. Commun.*, **9**(1), 4939, doi:10.1038/s41467-018-06885-9.

Vanhala, L., and C. Hestbaek, 2016: Framing Climate Change Loss and Damage in UNFCCC Negotiations. *Glob. Environ. Polit.*, **16**(4), 111, doi:10.1162/glep_a_00379.

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**(12), 4814–4819, doi:10.1073/pnas.0610328104.

Velders, G. J. M., 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, doi:10.1016/j.atmosenv.2015.10.071.

Verkuijl, C., H. van Asselt, T. Moerenhout, L. Casier, and P. Wooders, 2019: Tackling Fossil Fuel Subsidies Through International Trade Agreements: Taking Stock, Looking Forward. *VA. J. Int. Law*, **58**(2), 309–368.

Victor, D. G., 2011: *Global Warming Gridlock: Creating More Effective Strategies for Protecting the Planet*. Cambridge University Press, Cambridge, UK, 392 pp.

Victor, D. G., 2016: What the Framework Convention on Climate Change Teaches Us About Cooperation on Climate Change. *Polit. Gov.*, **4**(3), 133, doi:10.17645/pag.v4i3.657.

Victor, D. G., K. Raustiala, and E. B. Skolnikoff, 1998: *The Implementation and Effectiveness of International Environmental Commitments: Theory and Practice*. [Victor, D.G., K. Raustiala, and E.B. Skolnikoff, (eds.)]. MIT Press, Cambridge, MA, 1–737 pp.

Vihma, A., Y. Mulugetta, and S. Karlsson-Vinkhuyzen, 2011: Negotiating solidarity? The G77 through the prism of climate change negotiations. *Glob. Chang. Peace Secur.*, **23**(3), 315–334, doi:10.1080/14781158.2011.601853.

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**(6), 3879–3889, doi:10.5194/acp-17-3879-2017.

Visioni, D. et al., 2020: What goes up must come down: impacts of deposition in a sulfate geoengineering scenario. *Environ. Res. Lett.*, **15**(9), 94063, doi:10.1088/1748-9326/ab94eb.

Visschers, V. H. M., J. Shi, M. Siegrist, and J. Arvai, 2017: Beliefs and values explain international differences in perception of solar radiation management: insights from a cross-country survey. *Clim. Change*, **142**(3), 531–544, doi:10.1007/s10584-017-1970-8.

Voigt, C., 2016: The compliance and implementation mechanism of the Paris agreement. *Rev. Eur. Comp. Int. Environ. Law*, **25**(2), doi:10.1111/reel.12155.

Voigt, C., 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.

Voigt, C., and F. Ferreira, 2016a: 'Dynamic Differentiation': The Principles of CBDR-RC, Progression and Highest Possible Ambition in the Paris Agreement. *Transnatl. Environ. Law*, **5**(2), 285–303, doi:10.1017/s2047102516000212.

Voigt, C., and F. Ferreira, 2016b: Differentiation in the Paris Agreement. *Clim. Law*, **6**(1–2), 58–74, doi:10.1163/18786561-00601004.

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

Wagner, C. S., T. A. Whetsell, and L. Leydesdorff, 2017: Growth of international collaboration in science: revisiting six specialties. *Scientometrics*, **110**(3), 1633–1652, doi: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**(6), 541–557, doi:10.1002/wcc.368.

Watts, J., and J. Depledge, 2018: Latin America in the climate change negotiations: Exploring the AILAC and ALBA coalitions. *Wiley Interdiscip. Rev. Clim. Chang.*, **9**(6), e533, doi:10.1002/wcc.533.

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

Weart, S. R., 2012: The evolution of international cooperation in climate science. *J. Int. Organ. Stud.*, **3**(1), 41–59.

Weikmans, R., and J. T. Roberts, 2019: The international climate finance accounting muddle: is there hope on the horizon? *Clim. Dev.*, **11**(2), 97–111, doi:10.1080/17565529.2017.1410087.

Weikmans, R., H. van Asselt, and J. T. Roberts, 2020: Transparency requirements under the Paris Agreement and their (un)likely impact on strengthening the ambition of nationally determined contributions (NDCs). *Clim. Policy*, **20**(4), 511–526, doi:10.1080/14693062.2019.1695571.

Weischer, L., J. Morgan, and M. Patel, 2012: Climate Clubs: Can Small Groups of Countries make a Big Difference in Addressing Climate Change? *Rev. Eur. Community Int. Environ. Law*, **21**(3), 177–192, doi:10.1111/reel.12007.

Weiss, E. B., and H. K. Jacobson, 1998: *Engaging Countries: Strengthening Compliance with International Environmental Accords*. [Weiss, E.B. and H.K. Jacobson, (eds.)]. MIT Press, Cambridge, MA, 640 pp.

Weitz, N., H. Carlsen, M. Nilsson, and K. Skånberg, 2018: Towards systemic and contextual priority setting for implementing the 2030 Agenda. *Sustain. Sci.*, **13**(2), 531–548, doi:10.1007/s11625-017-0470-0.

Weitzman, M. L., 2015: A Voting Architecture for the Governance of Free-Driver Externalities, with Application to Geoengineering. *Scand. J. Econ.*, **117**(4), 1049–1068, doi:10.1111/sjoe.12120.

Werksman, J., 2010: Legal symmetry and legal differentiation under a future deal on climate. *Clim. Policy*, **10**(6), 672–677, doi:10.3763/cpol.2010.0150.

Wettestad, J., and L. H. Gulbrandsen, 2018: *The Evolution of Carbon Markets: Design and Diffusion*. Routledge, London and New York, 1–264 pp.

Wettestad, J., L. H. Gulbrandsen, and S. Andresen, 2021: Calling in the heavyweights: Why the World Bank established the Carbon Pricing Leadership Coalition, and what it might achieve. *Int. Stud. Perspect.*, **22**(2), 201–217, doi:10.1093/isp/ekaa013.

Wewerinke-Singh, M., 2018: *State Responsibility, Climate Change and Human Rights Under International Law*. Hart Publishing, Oxford, 216 pp.

Wewerinke-Singh, M., and D. H. Salili, 2020: Between negotiations and litigation: Vanuatu's perspective on loss and damage from climate change. *Clim. Policy*, **20**(6), 681–692, doi:10.1080/14693062.2019.1623166.

Whitehouse, 2014: US-China Joint Announcements on Climate Change. *Whitehouse Press Briefings*,. https://obamawhitehouse.archives.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change (Accessed January 11, 2021).

Whyte, K. P., 2018: Indigeneity in Geoengineering Discourses: Some Considerations. *Ethics, Policy Environ.*, **21**(3), 289–307, doi:10.1080/21550085.2018.1562529.

Wieding, J., J. Stubenrauch, and F. Ekardt, 2020: Human Rights and Precautionary Principle: Limits to Geoengineering, SRM, and IPCC Scenarios. *Sustainability*, **12**(21), 8858, doi:10.3390/su12218858.

Wijaya, A., T. N. Samadhi, and R. Juliane, 2019: Indonesia Is Reducing Deforestation, but Problem Areas Remain. *World Resour. Inst. - Insights*,. https://www.wri.org/insights/indonesia-reducing-deforestation-problem-areas-remain (Accessed August 26, 2021).

Wilder, M. et al., 2010: Adapting Across Boundaries: Climate Change, Social Learning, and Resilience in the U.S.–Mexico Border Region. *Ann. Assoc. Am. Geogr.*, **100**(4), 917–928, doi:10.1080/00045608.2010.500235.

Winickoff, D. E., J. A. Flegal, and A. Asrat, 2015: Engaging the Global South on climate engineering research. *Nat. Clim. Chang.*, **5**(7), 627–634, doi:10.1038/nclimate2632.

Winkler, H., 2020: Putting equity into practice in the global stocktake under the Paris Agreement. *Clim. Policy*, **1**, 124–132, doi:10.1080/14693062.2019.1680337.

Winkler, H., and N. K. Dubash, 2016: Who determines transformational change in development and climate finance? *Clim. Policy*, **16**(6), 783–791, doi:10.1080/14693062.2015.1033674.

Winkler, H., B. Mantlana, and T. Letete, 2017: Transparency of action and support in the Paris Agreement. *Clim. Policy*, **17**(7), 853–872, doi:10.1080/14693062.2017.1302918.

Winkler, H. et al., 2018: Countries start to explain how their climate contributions are fair: More rigour needed. *Int. Environ. Agreements Polit. Law Econ.*, **18**, 99–115, doi:10.1007/s10784-017-9381-x.

Winterbottom, R., 1990: *Taking Stock - The Tropical Forestry Action Plan After Five Years*. World Resources Institute, New York and Washington DC, 1–59 pp.

WMO, 2018: *Scientific Assessment of Ozone Depletion: 2018*. , Geneva, Switzerland, 588 pp. http://www.wmo.int/pages/prog/arep/gaw/ozone/.

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.*, , 1–16, doi:10.2139/ssrn.3324509.

Wollenberg, E. et al., 2016: Reducing emissions from agriculture to meet the 2 °C target. *Glob. Chang. Biol.*, **22**(12), 3859–3864, doi:10.1111/gcb.13340.

World Bank, 2010: *Cities and Climate Change: An Urgent Agenda. Urban development series. Knowledge Papers no. 10.* World Bank, Washington DC, 81 pp. https://openknowledge.worldbank.org/handle/10986/17381 (Accessed October 31, 2021).

World Bank, 2015a: *Joint Statement by the Multilateral Development Banks at Paris, COP21 Delivering Climate Change Action at Scale: Our Commitment to Implementation*. 1–3 pp. https://www.worldbank.org/content/dam/Worldbank/document/Climate/Joint MDB Statement Climate_NOV 28_final.pdf (Accessed December 8, 2020).

World Bank, 2015b: *From Billions to Trillions: Transforming Development Finance Post-2015 Financing for Development: Multilateral Development Finance. Development Committee Discussion Note*. 23 pp. http://pubdocs.worldbank.org/en/622841485963735448/DC2015-0002-E-FinancingforDevelopment.pdf (Accessed December 9, 2020).

World Bank, 2018: *Carbon Markets for Greenhouse Gas Emission Reduction in a Warming World.* World Bank, Washington DC, 191 pp.

World Bank, 2019: *State and Trends of Carbon Pricing*. World Bank Group, Washington DC, 94 pp. http://documents.worldbank.org/curated/en/191801559846379845/State-and-Trends-of-Carbon-Pricing-2019.

World Bank, 2021: World Bank Country and Lending Groups. *Data Blog*,. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (Accessed October 31, 2021).

Wu, M., and J. Salzman, 2014: The Next Generation of Trade and Environment Conflicts: The Rise of Green Industrial Policy. *Northwest. Univ. Law Rev.*, **108**(2), 401–474.

Wurzel, R. K. W., D. Liefferink, and D. Torney, 2019: Pioneers, leaders and followers in multilevel and polycentric climate governance. *Env. Polit.*, **28**(1), 1–21, doi:10.1080/09644016.2019.1522033.

Xia, L. et al., 2014: Solar radiation management impacts on agriculture in China: A case study in the Geoengineering Model Intercomparison Project (GeoMIP). *J. Geophys. Res. Atmos.*, **119**(14), 8695–8711, doi:10.1002/2013jd020630.

Xia, L., J. P. Nowack, S. Tilmes, and A. Robock, 2017: Impacts of stratospheric sulfate geoengineering on tropospheric ozone. *Atmos. Chem. Phys.*, **17**(19), 11913–11928, doi:10.5194/acp-17-11913-2017.

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**(4), 235–244, doi:10.1080/10042857.2016.1258802.

Xuemei, B., 2007: Integrating Global Environmental Concerns into Urban Management: The Scale and Readiness Arguments. *J. Ind. Ecol.*, **11**(2), 15–29, doi:10.1162/jie.2007.1202.

Yamaguchi, S., 2020: *Greening Regional Trade Agreements: Subsidies Related to Energy and Environmental Goods*. OECD Publishing, Paris, 1–81 pp.

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**(2), 174–185, doi:10.1111/reel.12160.

Yamineva, Y., 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**(2), 201–227, doi:10.1017/s2047102517000401.

Yang, H. et al., 2016: Potential negative consequences of geoengineering on crop production: A study of Indian groundnut. *Geophys. Res. Lett.*, **43**(22), 11786–11795, doi:10.1002/2016gl071209.

Young, O. R., 2016: The Paris Agreement: Destined to Succeed or Doomed to Fail? *Polit. Gov.*, **4**(3), 124–132, doi:10.17645/pag.v4i3.635.

Young, P. J. et al., 2021: The Montreal Protocol protects the terrestrial carbon sink. *Nature*, **596**(7872), 384–388, doi:10.1038/s41586-021-03737-3.

Zahar, A., 2019: Collective Progress in the Light of Equity Under the Global Stocktake. *Clim. Law*, **9**(1–2), 101–121, doi:10.1163/18786561-00901006.

Zarin, D. J. et al., 2016: Can carbon emissions from tropical deforestation drop by 50% in 5 years? *Glob. Chang. Biol.*, **22**(4), 1336–1347, doi:10.1111/gcb.13153.

Zarnetske, P. L. et al., 2021: Potential ecological impacts of climate intervention by reflecting sunlight to cool Earth. *Proc. Natl. Acad. Sci.*, **118**(15), 1921854118, doi:10.1073/pnas.1921854118.

Zhan, P., W. Zhu, T. Zhang, X. Cui, and N. Li, 2019: Impacts of Sulfate Geoengineering on Rice Yield in China: Results From a Multimodel Ensemble. *Earth's Futur.*, **7**(4), 395–410, doi:10.1029/2018ef001094.

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**(4), 561–577, doi:10.1007/s10784-014-9270-5.

Zhang, H., 2019: Implementing Provisions on Climate Finance Under the Paris Agreement. *Clim. Law*, **9**(1–2), 21–39, doi:10.1163/18786561-00901003.

Zhang, J., K. Zhang, J. Liu, and G. Ban-Weiss, 2016: Revisiting the climate impacts of cool roofs around the globe using an Earth system model. *Environ. Res. Lett.*, **11**(8), 84014, doi:10.1088/1748-9326/11/8/084014.

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**(1–2), 99–104, doi: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**(2), doi: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**(1–2), 65–100, doi:10.1163/18786561-00901005.

Zimm, C., and N. Nakicenovic, 2020: What are the implications of the Paris Agreement for inequality? *Clim. Policy*, **20**(4), 458–467, doi:10.1080/14693062.2019.1581048.

Zürn, M., and S. Schäfer, 2013: The Paradox of Climate Engineering. *Glob. Policy*, **4**(3), 266–277, doi:10.1111/gpol.12004.

IRENA, 2021: International Renewable Energy Agency Avoided Emissions Calculator. https://www.irena.org/climatechange/Avoided-Emissions-Calculator (Accessed 3 November 2021

UNFCCC, 2020d: Subsidiary Body for Implementation, Compilation and synthesis of fourth biennial reports of Parties included in Annex I to the Convention. https://unfccc.int/sites/default/files/resource/sbi2020_inf10.pdf (Accessed 2 November 2021).