



Contents lists available at ScienceDirect

Earth System Governance

journal homepage: www.journals.elsevier.com/earth-system-governance

A sectoral perspective on global climate governance: Analytical foundation



Sebastian Oberthür ^{a, b, *}, Lukas Hermwille ^{c, d}, Tim Rayner ^e

^a Institute for European Studies, Vrije Universiteit Brussel, Pleinlaan 2, B-1050, Brussels, Belgium

^b Centre for Climate Change, Energy and Environmental Law, University of Eastern Finland, Yliopistokatu 2, FI-80100, Joensuu, Finland

^c Wuppertal Institute for Climate, Environment and Energy, Döppersberg 19, 42103, Wuppertal, Germany

^d Institute for Environmental Studies (IVM), Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam, De Boelelaan 1085, 1081, HV Amsterdam, the Netherlands

^e Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK, United Kingdom

ARTICLE INFO

Article history:

Received 16 July 2019

Received in revised form

22 March 2021

Accepted 22 March 2021

Available online 23 April 2021

Keywords:

Climate policy

Institutional complexes

International institutions

Polycentric governance

Sectoral systems

Transformation

ABSTRACT

This article develops a sectoral approach to the analysis of global climate governance. This approach advances the assessment of global climate governance by focusing on complexes of intergovernmental and transnational institutions co-governing key socio-technical sectoral systems. The actual and potential contribution of these sectoral institutional complexes to advancing decarbonization can be assessed according to five key governance functions: (1) providing guidance and signal to actors, (2) setting rules to facilitate collective action, (3) enhancing transparency and accountability, (4) offering support (finance, technology, capacity-building), and (5) promoting knowledge and learning. On this basis, we can assess the *potential* of international cooperation to address the challenges specific sectoral systems face in the climate transition as well as the extent to which existing sectoral institutional complexes deliver on this potential. This provides a solid starting point for developing options for filling identified gaps and enhancing the effectiveness of global climate governance.

© 2021 Published by Elsevier B.V. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Global governance (used here to encompass transboundary cooperation of various actors spanning from the regional to the global) has an important role to play in the fight against climate change and in advancing worldwide decarbonization. Action on climate change has been taken at different levels of governance and by various actors, including cities, firms, civil society, national governments, as well as supra- and international organisations (UNFCCC, 2019; Hsu et al., 2018). Such action does not always and necessarily require international cooperation. However, global governance can frequently and to varying degrees facilitate and accelerate action. It is hence widely seen as an essential part of adequately addressing climate change (IPCC, 2014).

The record of global climate governance, however, is mixed, if not dismal. As their number has grown, both intergovernmental

(including the UN Framework Convention on Climate Change – UNFCCC, and others) and transnational (involving private, non-governmental actors) institutions and initiatives, in which a wide variety of actors cooperate to address climate change, have come into focus (e.g., Keohane and Victor, 2011; Abbott, 2012; Bulkeley et al., 2014; Graichen et al., 2016; Sanderink et al., 2017; van der Ven et al., 2017; Hsu et al., 2018). Although this literature has focused especially on the effectiveness of these institutions, either individually or jointly, in addressing greenhouse gas (GHG) emissions, the ability of this evolving ‘polycentric climate governance’ to deliver on the Paris Agreement’s long-term temperature target remains in doubt (Jordan et al., 2015, 2018). Lack of progress in reducing GHG emissions – due to insufficient ambition of ‘Nationally Determined Contributions’ (NDCs) under the Paris Agreement and grave implementation deficits (UNEP, 2020) – nourishes these doubts. This special issue contributes to systematically assessing the adequacy and effectiveness of global climate governance in advancing climate mitigation so as to limit the increase of global average temperature to well below 2 °C or even 1.5 °C, compared to preindustrial levels, in accordance with the 2015 Paris Agreement.

* Corresponding author. Institute for European Studies, Vrije Universiteit Brussel, Pleinlaan 2, B-1050, Brussels, Belgium.

E-mail address: sebastian.oberthuer@vub.be (S. Oberthür).

There is much room for advancing the assessment of the effectiveness and adequacy of the global climate governance landscape. Inadequate global governance is not the only culprit for the insufficient progress of the zero-carbon transformation of our economies and societies (henceforth, ‘the climate transition’). However, global governance has its specific potential that policy-makers should be concerned to maximize. That being so, several questions may be asked: What precisely is this potential and to what extent does it need to be exploited for advancing the climate transition? To what extent does global governance allow key barriers to this transition to be addressed? Has it realised its potential? While much of the existing literature has taken problem solving as its benchmark (e.g., Young, 2011), it has not systematically assessed the potential of global governance to address climate change and the extent to which this potential has been exploited – the areas on which we aim to shed light in this special issue.

To this end, this article and special issue develop and apply a sectoral approach to the analysis of global climate governance. We hold that barriers to the climate transition as well as the potential of and need for global governance to address them vary across different sectoral systems. They are hence best analyzed at a more focused, sectoral level (rather than in general) (see also Victor et al., 2019). We therefore argue for the added value of focusing the analysis on sectoral institutional complexes structuring what is otherwise a rather amorphous global climate governance landscape. Doing so provides a structured and focused way to identify underexploited governance potentials and possibilities to enhance the contribution of global governance to an effective climate transition. While a sectoral approach is not necessarily superior, we argue that it advances our understanding of the adequacy of global climate governance and facilitates identifying related potentials for improvement (as further developed in section 2). It thereby also offers a way towards exploring the differentiated structure of global climate politics beyond its modeling as a global collective action problem, as has been demanded in recent literature (Aklin and Mildemberger, 2020; Hale, 2020).

Our approach goes beyond previous discussion of sectoral approaches in global climate governance. Sectoral approaches to mitigating GHG emissions were debated in the literature and in policymaking especially in the 2000s (e.g., Baron et al., 2007; Meckling and Chung, 2009; Sawa, 2011). Closely linked to the multilateral climate regime, these discussions were very much driven by political demands to expand international mitigation obligations/actions particularly to more advanced developing countries under a burden-sharing paradigm. Accordingly, the focus was on possible agreements on binding mitigation commitments at least for some sectors such as electricity generation and heavy industry with a view to creating a more level playing field. While using similar terminology, our proposed sectoral approach goes beyond the earlier discussions by taking as a different starting point that our entire economic systems require fundamental transformation which requires addressing sector-specific challenges.

Our analysis focuses on the international level. While it thereby makes a contribution to the understanding of ‘polycentric’ climate governance (Ostrom, 2010; Jordan et al., 2015, 2018), it does not fully incorporate the multi-level perspective that the concept of polycentricity entails. Our analysis hence focuses on a significant part of polycentric climate governance as we address international, transboundary cooperation and governance, while we leave exploration of, and interaction with, other levels of polycentric governance to future research (see also Rayner et al., this special issue).

We develop our argument in the following steps. Section 2 first introduces sectoral institutional complexes composed of international (i.e., intergovernmental and transnational) institutions as our

key units of analysis. Section 3 then establishes five key governance functions which international institutions may in principle perform (guidance and signal, rule-setting, transparency and accountability, means of implementation, and knowledge and learning). These enable a systematic analysis of the potential and actual contribution of international institutions to advancing the climate transition of sectoral systems. We subsequently discuss our approach’s limitations (section 4), before introducing its operationalisation in the sectoral case studies and providing an overview of the other contributions to the special issue.

2. Sectoral institutional complexes as units of analysis

We suggest focusing on sectoral institutional complexes as units of analysis that are composed of various international institutions and form part of broader governance landscapes comprising several sectoral complexes. Building on relevant literature, this section introduces this focus by first introducing intergovernmental and transnational institutions as the main fora of global governance that form broader institutional complexes and governance landscapes. On this basis, we introduce sectoral institutional (sub-)complexes as the core of our sectoral approach.

2.1. International institutions and institutional complexes

International institutions form the principal fora of global governance. Global governance can be understood as the steering of actors’ behaviour through the setting of rules, standards and guidelines, or through targeted support, towards a common or shared goal (see Roger et al., 2017: 5–6). International institutions that actors have purposively created through negotiations provide such governance since they establish systems of rules and practices that prescribe behavioural roles, constrain activity and shape actor expectations (Young, 1982, 1989; Keohane, 1989; North, 1991; Simmons and Martin, 2002). In contrast, regularities and practices that emerge from the uncoordinated behaviour of actors in the international system (‘spontaneous institutions’: Young, 1982) do not constitute governance instruments. The international governance institutions of interest here generally have two principal components: (1) substantive rules and norms that can prescribe, proscribe, permit or direct relevant behaviour of states and other actors with respect to the issue at stake (climate change, world trade, etc.); and (2) procedural rules for making and implementing decisions (including on substantive rules), thereby providing fora for exchange, deliberation and decision-making (Young, 1980; Gehring, 1994). Accordingly, we include in our analysis of global climate governance more or less formal intergovernmental and transnational institutional arrangements that fulfil the resulting minimum requirements of possessing a normative core and joint decision-making procedures towards a common purpose, while being relatively lasting. In the following we refer to such arrangements as ‘international institutions.’

International institutions traditionally comprise two types of intergovernmental governance arrangements. First, formal international organisations, such as the World Trade Organization (WTO), the Food and Agriculture Organization (FAO), or the International Monetary Fund (IMF) usually arise from intergovernmental agreements establishing the statutes of the organization. They possess the qualities of actors, including a physical location (‘a seat’), a staff of employees (secretariat) and usually legal personality (Young, 1986). Second, international regimes serve to govern specific issue areas usually on the basis of intergovernmental treaties, as further developed through subsequent decision-making by the parties. Hence, the climate change regime rests on the UNFCCC, the Kyoto Protocol and the Paris Agreement – which have been fleshed

out by decisions of the respective Conferences of the Parties (COPs). While lacking some formal qualities of international organisations (seat, statutes, legal personality), they are regularly served by secretariats (that can be self-standing, as in the case of the UNFCCC Secretariat, or hosted by international organisations) (Levy et al., 1995). The ongoing debate over the conceptual and empirical dividing line between international organisations and regimes can be left aside for our purposes, since we in any event include both types of intergovernmental institutions.

We expand the traditional focus on formal intergovernmental institutions in two respects. First, the enhanced role of non-state actors such as firms, civil society organisations and local authorities (cities, municipalities, regions) in international politics more generally has given rise to *transnational institutions* involving such actors. Transnational institutions include a fully private form run exclusively by non-state actors, as well as a hybrid variety operated by both non-state and state actors/governments. Transnational institutions have reached particular prominence in global climate governance with the growth of 'international cooperative initiatives' and various transnational networks (such as city networks, private certification initiatives, etc.; see Andonova et al., 2009; Abbott, 2012; Bulkeley et al., 2014; Abbott et al., 2016; Sanderink et al., 2017).

Second, we include intergovernmental and transnational arrangements below the threshold of formal organisations or regimes (such as the G20, various partnerships and international cooperative initiatives). In the wake of debates on polycentric (climate) governance, it has become increasingly acknowledged that such less formal arrangements constitute significant instruments of global governance (Ostrom, 2010; Bulkeley et al., 2014; Jordan et al., 2015). However, such relatively informal arrangements need to fulfil certain minimum requirements in order to qualify as international *governance* institutions. In line with the aforementioned understanding of governance institutions, they need to aim at realising a common purpose, possess a consequential normative core (through jointly setting and developing rules, standards and guidelines, or providing targeted support), be lasting, and have procedures for joint decision-making (for a further elaboration of relevant governance functions, see section 3). This understanding should help avoid confusing international governance institutions with various international coalitions and lobby groups as well as ad hoc fora, platforms, projects, programmes and networks. For example, neither the International Chamber of Commerce as a lobby group nor the 'high-ambition coalition' that was instrumental for bringing about the Paris Agreement fulfil the criteria of an international governance institution.

For any policy field, sub-field or sector, several institutions will usually operate and interact to form institutional complexes. Hence, Keohane and Victor (2011) have identified a regime complex on climate change including a host of primarily intergovernmental fora (such as the Montreal Protocol addressing fluorinated GHGs, various multilateral fora and others). As a key ingredient of 'polycentric' (climate) governance (Ostrom, 2010; Jordan et al., 2015, 2018), institutional complexes constitute networks of three or more international institutions that relate to a common subject matter; exhibit overlapping membership; and generate interactions in rulemaking or implementation (Orsini et al., 2013; see also Raustiala and Victor, 2004; Oberthür and Stokke, 2011). Such interactions can create interinstitutional conflict and tension that inhibit and harm effective governance, but they can also create synergy and result in complementary 'divisions of labour' (Biermann et al., 2009; Gehring and Faude, 2014; Oberthür, 2016). They can themselves be shaped by purposive policy intervention, referred to as 'interplay management' (Oberthür, 2009; Stokke, 2020) or 'orchestration' (Abbott et al., 2015).

One of the key issues in the literature has been how to delimit institutional complexes and the issue areas they capture. Scholars have identified a variety of regime complexes of varying size and scope in several fields (see discussion in Orsini et al., 2013; Gómez-Mera et al., 2020). We here suggest a focus on a sectoral delimitation of institutional complexes as a suitable approach for our purpose of assessing the effectiveness and adequacy of global climate governance.

2.2. Sectoral institutional complexes

To identify and delimit sectoral institutional complexes, we start from *sectoral systems* according to social transition theory (see also Victor et al., 2019). Each sectoral system provides identifiable societal functions such as transport, electricity, or raw materials for industrial production and is constituted of ensembles of actors (corporations, administrative bodies, political groups/parties, international organisations), technologies and infrastructures, economic structures, institutions and ideas that produce degrees of path dependency and resistance to change (Geels and Schot, 2010). Such systems are complex, which entails that (1) they can produce emergent phenomena/effects that are more than the systems' parts, and (2) they are open, i.e. closely related to and potentially overlapping and interdependent with other sectoral systems (Page, 2010). Our societies and economies are supported by a patchwork of such socio-technological systems. Their number tends to increase with the advancing functional differentiation of modern societies, which also entails that sectoral systems might be further subdivided into various overlapping sectoral subsystems. For example, relevant transport sub-sectors include land transport (by train, car, others), sea/water transport, air transport, passenger transport, freight transport, international transport (aviation and maritime), urban transport, etc. As this example indicates, sectoral systems can easily overlap (e.g., urban transport and passenger/freight transport) (Page, 2010; Schot and Laur, 2018; see also Unruh, 2000; Harich, 2010; Borrás and Edler, 2014).

On this basis, we can delimit sectoral institutional complexes of global climate governance by identifying their components: the intergovernmental and transnational institutions relevant for the decarbonization of a given sectoral system. This includes both overarching global institutions and more issue- or sector-specific and/or regional institutions that explicitly pursue climate mitigation or otherwise affect mitigation efforts, either positively or negatively. For example, the UNFCCC and its Paris Agreement are likely to form part of any sectoral institutional complex as the overarching global institution on climate change, whereas the International Renewable Energy Agency and the Renewable Energy and Energy Efficiency Partnership (REEEP) may affect one or more sectoral complexes as they promote carbon-free renewable energy. Similarly, the WTO may have particular relevance for a number of sectoral complexes, in part because its free-trade disciplines have been found to hinder efforts to address carbon leakage concerns (e.g., relating to energy-intensive industries). Mapping relevant intergovernmental and transnational institutions onto sectoral systems can hence serve to identify sectoral institutional complexes.

Placing such sectoral institutional complexes center-stage has the advantage of staying close to the actual challenges, barriers and opportunities actors face in advancing the climate transition. GHG emissions (and their mitigation) are ultimately the product of decisions relating to new and existing buildings, transport infrastructures, industrial facilities, the acquisition of energy-consuming appliances, urban planning, investments, etc. Actor constellations, available technological solutions, existing infrastructures and corresponding path dependencies vary widely

across these sectoral contexts, giving rise to diverging configurations of barriers and opportunities of decarbonization. For example, the decarbonization of energy-intensive industries requires the development and diffusion of costly new breakthrough technologies under conditions of global competition by a limited number of major companies and producer countries (see Oberthür et al., [this special issue](#)). In contrast, technologies for the decarbonization of the power sector are widely available and competitiveness concerns only loom indirectly, whereas grid development, storage and capital costs constitute major issues (Hermwille, [this special issue](#)). Hence, the climate change problem takes politically and socially different forms across the various socio-technical systems that need to be transformed for the decarbonization of our economies and societies. Our sectoral approach therefore aims to heed the insight that effective governance requires institutional arrangements that fit the structure of the problem (e.g., Young and Levy, 1999; Miles et al., 2002; Young, 2009).

Focusing on sectoral systems also brings the analysis closer to actual decision-making on policies and investments. Public policies are regularly developed in sectorally structured ministries. Private actors, including corporate and civil-society actors, also act in strongly sectoral socio-technical systems and organize themselves accordingly (e.g., in related industry associations). Consequently, climate policy – as a policy area cutting across many sectors – has at the domestic level very much taken a sectoral approach. Advanced domestic climate governance systems commonly include a portfolio of targeted sectoral policies, even if embedded in an overarching legal framework such as a principal climate change act (e.g., Dupont and Oberthür, 2015; Iacobuta et al., 2018). This is not to deny the existence of overarching or crosscutting action contexts or the need for more integrated decision-making, but to recognize that sectoral structures and contexts of decision-making have remained a prominent and even prevalent feature of modern public and private policy-making – as is apparent not least from the continuing debate about the need for environmental and climate policy integration (e.g., Jordan and Lenschow, 2010; Dupont, 2016).

Our delimitation of sectoral systems and related institutional complexes overlaps with, but is distinct from, other established distinctions of sectors that are not necessarily related to the actual decision contexts of public and private actors. Hence, emission sectors (as, for example, reflected in inventories under the UNFCCC) or economic sectors (as may be reflected in macroeconomic accounting) may, but do not necessarily, delimit meaningful decision contexts. For example, the distinction between direct energy-related emissions and process emissions of industry is hardly socio-politically relevant in this sense; nor is a crude distinction between manufacturing and services. Ministerial portfolios may be closer to (and shape) relevant decision contexts, but usually combine several relevant contexts and do so in ways that differ across countries. Furthermore, they are known to face difficulties in accounting for overlaps and cross-cutting issues that transcend ministerial portfolios (hence the already noted challenge of inter-ministerial coordination and policy integration).

The focus on sectoral institutional complexes is a novel way of establishing a suitable middle ground. Existing literature has largely either focused on individual institutions, on the overall institutional complex, or on small groups of institutions relevant for a particular sub-problem (e.g., Keohane and Victor, 2011; Abbott, 2012; Bulkeley et al., 2014; Graichen et al., 2016; Sanderink et al., 2017; van der Ven et al., 2017; Hsu et al., 2018). While analysing individual institutions only reveals a smaller part of the bigger picture, the overall institutional landscape appears too wide a field and does not allow to differentiate between varying barriers and challenges across different sub-fields. Focusing on small groups of institutions seems a suitable middle ground, but the definition of

such institutional complexes has so far occurred ad hoc rather than by applying a clear logic to systematically bring into view key barriers and challenges. Our sectoral approach aggregates individual institutions' contributions into meaningful sectoral complexes of global climate governance. It cuts the overall polycentric governance landscape into meaningful groups of institutions that co-govern particular sectoral systems. As a result, the key challenges and barriers to climate protection and what global climate governance may contribute to addressing them come into focus.

In line with the primary purpose of our effort (namely to systematically assess the effectiveness and adequacy of global climate governance), we focus on determining the overall contribution of each sectoral complex to addressing the pertinent barriers and challenges and advancing the decarbonization of the relevant sectoral system. As a result, our primary focus is not on clarifying the relationship and interaction of the complex' component institutions, otherwise a prime concern of research on institutional complexes (see Gómez-Mera et al., 2020). We rather concentrate on aggregating the components' governance effects to determine the complex' overall performance and identify gaps and insufficiencies. To be sure, interactions among the component institutions are not ignored but duly considered, since inter-institutional synergy and tensions/conflict can reinforce or weaken climate mitigation, respectively. However, the inter-institutional connections themselves are not the central, let alone single, focus. The overall picture emerging as a result also provides a sound basis for exploring how to enhance the effectiveness of sectoral complexes through action in the component institutions, improved coordination between them, creation of new institutions or action in overarching fora.

Aggregating the effects of individual institutions towards sectoral complexes does not yet deliver an overall assessment of global climate governance. Such an overall assessment would require an aggregation of sectoral assessments, including due attention to interdependencies and interlinkages across sectoral systems. It also implies asking how (lack of) progress toward the climate transition in one sectoral system affects other sectoral transformations (e.g., implications of electrification of transport and energy-intensive industries for the power sector) and to what extent these interdependencies are properly addressed. In so doing, we can derive a more complete picture of the performance of global climate governance more broadly. While the wider setting of global climate governance can also be understood as an institutional complex (e.g., Keohane and Victor, 2011; van Asselt and Zelli, 2018), we refer to it here as the broader "governance landscape", to distinguish it from our sectoral institutional complexes.

3. Assessing the effectiveness and adequacy of international governance institutions: five key functions

Assessing the effectiveness and adequacy of sectoral institutional complexes requires three steps. First, it is foundational to establish the main barriers and key challenges that efforts to advance the climate transition face in each sectoral system, thereby capturing the specific problem structure. On this basis, we can, second, explore the *need for* and the *potential of* international institutions to address the identified barriers and challenges and contribute to the climate transition of the sectoral system in focus (as such international institutions are not necessarily suitable for resolving any and all issues). Third, we can determine the actual supply of global governance and compare it to the identified hypothetical potential so as to derive how much of this potential has been realised and how much scope for enhancing the contribution of global governance remains, not least as a basis for thinking about how the potential could be more fully exploited (Young, 2011; see also section 5).

As a foundation for this analysis, in the following we distinguish five main governance functions that international institutions, both intergovernmental and transnational, *may* in principle perform. Building on the rich literature on international institutions, governance and cooperation (e.g., Young, 1999; Simmons and Martin, 2002; Andonova et al., 2009; Loorbach, 2010; Stokke, 2012; Bulkeley et al., 2014; De Búrca et al., 2014), these reflect the aforementioned double-nature of international institutions as both normative systems and decision-making/communication processes (Gehring, 1994). The five functions provide the basis for assessing the potential and actual contribution of governance institutions to the climate transition of the sectoral systems investigated. Going much beyond a narrow understanding of climate change as a global collective action problem (see also Aklin and Mildenberger, 2020; Hale, 2020), they allow comparing the potential of international institutions to the problem structure, and the actual performance of the sectoral complex to this potential.

3.1. Guidance and signal

International institutions can provide guidance and signal to members and other actors. This function derives mainly from an institution's principles and objectives. Frequently reflected in the underlying treaty, statutes or related secondary decision-making, international institutions are regularly established for a specific purpose and with a particular objective (such as advancing free trade, protecting human rights, limiting climate change, etc.). The guidance and signal emanating therefrom can generate effects far beyond the institution itself. By signalling the resolve of the institution's members to pursue a certain course of action, likely policy trajectories are indicated to business, investors and other actors. As such, the signal and direction provided has the potential to provide impetus to, and help synchronise and align developments across, different levels of governance (Kanie and Biermann, 2017; Young, 2017). For example, the objectives of the Paris Agreement have provided an important (though imperfect) signal to business and others to pursue low- or zero-carbon development (Morseletto et al., 2016; Falkner, 2016; Bodansky, 2017; Hermwille et al., 2017; see also the other special issue articles).

3.2. Setting rules to facilitate collective action

International institutions can facilitate collective action by setting rules. Members thus agree to certain reciprocal obligations and standards of behaviour that can take different forms. They may prohibit, prescribe or permit certain conduct and harmonise (technical) standards, through a range of (environmental) policy instruments including 'command and control' regulation, market-based instruments, informational instruments, etc. (Jordan et al., 2012; Sterner and Coria, 2013; Wurzel et al., 2013). The implementation of such obligations by individual parties is then expected to trigger pertinent behavioural effects. Various transnational institutions are considered to possess a strong regulatory component (e.g., Andonova et al., 2009; Abbott, 2012; Roger et al., 2017).

The need for international rules grows with the level of international interdependence. Some problems may not require international cooperation at all (e.g., reform of local public administrations). In other cases, actors' behaviour is contingent on each other to varying degrees. For example, restricting industrial GHG emissions may imply direct or indirect costs to industry that affect its international competitiveness (see also Oberthür et al., *this special issue*). Under such circumstances, international rules can facilitate collective action by levelling the playing field. Agreement on such rules regularly requires 'burden-sharing'

arrangements to address related distributional issues. Hence, actors not only need to understand the benefits of collective action, but also consider their respective contributions to be fair and equitable (e.g., Levy et al., 1995; Hasenclever et al., 1997).

3.3. Transparency and accountability

International institutions frequently enhance the transparency of their parties' actions and hold parties to account for any implementation deficits. We refer to this as their 'transparency and accountability' function.¹ Institutions' secretariats may either themselves collect relevant data or receive reports from individual parties. On this basis, the institution may engage in a review of the quality and comparability of submitted data and of parties' implementation (Gupta and van Asselt, 2019). The effort required may depend on the activities regulated. For example, emissions from large point sources like power stations may be easier to verify than the carbon uptake by forests. International institutions can furthermore entail specific mechanisms for addressing any implementation deficits identified (Keohane et al., 2000), such as the compliance procedures that commonly form part of modern multilateral environmental agreements (Bulmer, 2012).

High levels of transparency and accountability generally encourage effective implementation. Whereas the relationship with effectiveness is not necessarily straight-forward (Gupta and van Asselt, 2019), transparency and accountability are widely held to enhance trust, provide reassurance to parties, facilitate acknowledgement of efforts, and promote learning and common understanding (Mitchell, 1998; Bodansky, 2010; Park and Kramarz, 2019). They hence closely inter-relate with the functions of rule-setting and knowledge and learning (see below). If rule-setting addresses 'coordination problems' that entail an incentive for all parties to comply, less oversight and verification are required than for 'cooperation problems' involving mixed motives of actors and consequently an incentive to 'free-ride' (Snidal, 1985). Furthermore, efforts at enhancing transparency can generate crucial data and knowledge. Transparency and accountability also interrelate with actors' willingness to accept ambitious obligations (Bodansky, 2012) and are frequently themselves highly politicised – as evident from related discussions under the UN climate regime (Dagnet and Levin, 2017; Levin, 2018; Oberthür and Northrop, 2018).

3.4. Capacity building, technology and finance (means of implementation)

The provision of capacity building, technology, and financial resources is a further key function, particularly relevant in a North-South context. Developing countries, who generally bear less responsibility for global environmental problems than developed countries, frequently lack these means of implementation (Chayes and Chayes, 1993). Accordingly, various international financial institutions and mechanisms provide means of implementation, including the World Bank, several Multilateral Development Banks, the Global Environment Facility, the Green Climate Fund, as well as initiatives of private financial institutions (Keohane and Levy, 1996; Bodansky, 2010; UNFCCC, 2019).

The rationale for providing such means of implementation through international institutions is at least twofold. While bilateral channels and the private sector are important sources,

¹ Please note that the international transparency at stake here differs from transparency that may be pursued as a policy instrument, for example by informational policy instruments such as product labelling.

Table 1
Overview of main functions of international governance institutions.

Functions	Key features	Main added value
Guidance & Signal Setting Rules	<ul style="list-style-type: none"> • Results from overall agreement, including targets/objectives • Various forms of obligations and standards 	<ul style="list-style-type: none"> • Aligns actors across countries • Enables action by addressing interdependence & competitiveness concerns
Transparency & Accountability	<ul style="list-style-type: none"> • Reporting, review/verification, compliance 	<ul style="list-style-type: none"> • Contributes to effective reciprocity and implementation (addressing free riding) & mutual trust
Means of Implementation	<ul style="list-style-type: none"> • Capacity building, technology transfer and finance (North-South) 	<ul style="list-style-type: none"> • Facilitates pooling of donors/investors' resources and reducing transaction costs
Knowledge & Learning	<ul style="list-style-type: none"> • Generation and collective appraisal of information/knowledge • Science and policy learning 	<ul style="list-style-type: none"> • Improved and shared understanding (authoritative knowledge) • Improved policies (learning)

Source: Authors' own compilation (Oberthür et al., 2017).

international cooperation allows donors/investors to coordinate and thereby address the second-order collective-action problem of who is to contribute how much to the overall effort. Furthermore, international cooperation helps reduce 'transaction costs' in addressing various countries and contexts that face similar issues and require similar expertise. In short, international cooperation allows resources to be pooled and duplication of effort to be minimised (Keohane and Levy, 1996).

3.5. Knowledge and learning

Finally, international institutions can enhance knowledge and learning in various ways. They may collect, aggregate and disseminate relevant data/information and other knowledge about scientific, economic, technical and policy problems and solutions (e.g., the International Energy Agency's World Energy Outlook and the UN Environment Programme's Global Environment Outlook). Actors may also decide to engage in a collective appraisal of available knowledge, be it through separate international institutions (e.g., the Intergovernmental Panel on Climate Change) or in separate processes within a broader institution (e.g., the assessment panels of the Montreal Protocol; Parson, 2003). As mentioned, mechanisms to provide for transparency may also generate relevant knowledge. The knowledge generated may itself foster learning and awareness raising, but learning may also emanate from exchange and discussion within international institutions, for example on best practices (Haas, 1990; Hasenclever et al., 1997; Young and Levy, 1999).

Knowledge and learning may help advance both the implementation by individual actors and the international process. They may lead actors to re-interpret their interests and adapt their policies. The general authority of the institution in question (such as the International Energy Agency, IEA, on matters of energy) and the process of collective appraisal support the acceptance of knowledge and information (see also Mitchell et al., 2006). The resulting consensual knowledge can in turn help advance international political discussions since it provides common ground and frames policy options (Gehring, 2007).

3.6. The governance functions in overview

The five functions distinguished indicate the governance *potential* of international institutions: any specific international institution may fulfil one or several of these functions to varying degrees. In other words, to what extent any specific international institution or set of institutions performs each governance function is an empirical question. Table 1 provides an overview of the key features and main added value of the five governance functions.

The five key governance functions capture first-order effects of international institutions that are closely linked to the outputs they

produce, as discussed in the literature. These outputs may include various documents (treaties, decisions, scientific assessments, etc.) and processes (e.g., joint deliberations and discussions). Staying close to these outputs allows us to trace how institutions can concretely affect relevant behaviour: how specific rules, norms and processes of international institutions may concretely enable actors to advance emission mitigation. Broader second-order effects (such as the creation of general 'benefits' or 'wealth') that may follow from the five first-order functions are not considered, as they are beyond our focus on climate mitigation.

4. Limitations

Panaceas, or best approaches, for studying social phenomena such as global climate governance are elusive. Each approach typically has specific potentials and limitations. Having presented the potential of the sectoral approach above, we here discuss four limitations and trade-offs that in particular follow from the intermediate range of the approach (see for further relevant lessons from the application of the approach, Rayner et al., [this special issue](#)).

First, by dissecting the global climate governance landscape into several sectoral complexes, the proposed approach may be considered 'reductionist'. Although the sectoral approach goes beyond an analysis of individual institutions, it brings only parts of the overall institutional complex into focus, namely groups of governance institutions co-governing specific sectoral systems. Like other reductionist approaches, it hence runs the risk of losing sight of the bigger whole and of important interdependencies and interlinkages between the different complexes. For example, the climate transition of the transport and broader energy sector is set to have repercussions on international transport (by reducing the demand for shipping of coal and oil), thereby affecting this sectoral system's contribution to GHG emissions and the urgency and options for its decarbonization (Walsh et al., 2017, 32; Rayner, [this special issue](#)). Similarly, pursuing the decarbonization of energy-intensive industries, transport and buildings through electrification has important ramifications for the development of a decarbonized power sector (Rayner et al., 2018; Oberthür et al., [this special issue](#); Obergassel et al., [this special issue](#)). The reductionist fallacy can be significantly mitigated by (1) aggregating the results of the sectoral analyses and (2) systematically reflecting on the cross-sectoral interdependencies and interlinkages in the sectoral analyses (see also section 2.2).

Second, and related, the sectoral framing carries the risk of masking important social systems not typically viewed as 'sectors'. For example, finance and investment has traditionally not been considered a sector and indeed requires us to go beyond the 'financial industry' and include regulatory and other aspects in order to grasp their full significance as a key system for the climate

transition (see Rayner et al., 2018). Similarly, a sectoral lens may tend to leave important options for addressing climate change, such as negative emission technologies, concepts of de- or post-growth, circular economy, contraception and family planning, out of focus. However, to the extent that these options assemble identifiable ensembles of actors, technologies and infrastructures, economic structures, institutions and ideas (see section 2.2), it is possible to employ the sectoral approach in order to analyse them as (emerging) sectoral systems. Particular attention may be required, though, to ensure cross-cutting issues do not fall through the cracks when identifying relevant sectoral systems.

Third, and in contrast to the previous points, a sectoral system approach necessarily limits the amount of detailed analysis of individual institutions. As the approach explores medium-sized groups of institutions, the analysis cannot go into as much depth as case studies of particular institutions could. Unless we can build on other studies that address the institutions concerned in more detail, the analysis will inevitably lose out on detail and hence, possibly, nuance.

Finally, we wish to acknowledge two limitations of the scope of our analysis. First of all, as we focus on global, transboundary governance, we do not consider options for advancing the climate transition at other levels of multilevel governance. The sectoral approach developed here focuses on the specific potential of global governance to advance the decarbonization of particular sectoral systems – realising that this potential may rarely suffice. We leave to future research the exploration of what overall action at different levels of governance might be needed for the full climate transition of the selected sectoral systems (see Rayner et al., [this special issue](#)). In addition, our analysis only addresses a select number of sectoral systems and hence does not cover the full scope of sectoral systems relevant for the deep decarbonization of the complete economy.

Overall, the sectoral approach developed here necessarily strikes a balance. Focusing on institutional complexes governing sectoral systems allows us to mitigate some of the shortcomings of exploring either individual institutions (not seeing the forest for the trees) or global climate governance as a whole (neglecting the details). We hence suggest that the intermediate sectoral approach proposed here can make a significant contribution to a better understanding of the theoretical and actual potential of global governance to help mitigate climate change. This should provide a sound basis for identifying areas for improvement, which is much needed for retaining a chance of limiting global temperature increase to 2 °C, let alone 1.5 °C.

5. Operationalisation and overview of the special issue

From the potentially very large number of sectoral systems and related institutional complexes, choices of where to focus need to be made, based on clear criteria. In a first step, for our purposes it seems reasonable to focus on relatively broad sectoral systems that are known to contribute significantly to global GHG emissions or to be particularly relevant for efforts to address such emissions. A second useful criterion may be a significant potential for global governance to advance the sector's climate transition. Thirdly, we may aim to avoid excessive overlap between systems selected for in-depth analysis.

We have used these criteria to select five sectoral systems for further analysis in this special issue. We first selected 14 prominent sectoral systems for which we analyzed the barriers, the potential of international cooperation and mapped the relevant international institutions (Oberthür et al., 2017). Subsequently, we narrowed this selection down for the in-depth analysis of the supply of global governance, the resulting gaps and existing policy options in the five key sectoral systems covered here, namely fossil-fuel extractive

industries, power generation, energy-intensive industries, land transport, and international transport.² We do not claim that the selected sectoral systems are necessarily the most important ones, nor that they together provide a complete or representative picture. We do hold, however, that they figure prominently in the climate transition, are significant and can serve to illustrate how a sectoral approach to global climate governance can be applied and adds value. Taken together, their analysis allows us to gain a broader picture of the contribution of global governance to the climate transition.

To tease out to what extent existing international institutions exploit the potential of international cooperation to advance the climate transition in each sectoral system, each study in principle contains four elements. First is the identification of the main barriers and key challenges to the climate transition: economic (costs, competitiveness, access to capital), technological, political and institutional barriers, and barriers related to a lack of knowledge and awareness (of the problems themselves or of available technological and policy solutions). Second, the sectoral studies explore the potential of international institutions to address the identified barriers and challenges, given the five main functions international institutions can perform (see section 3). The analysis thereby identifies the specific *need for and potential of* international institutions to contribute to the climate transition of the sectoral system in focus.

Third, the actual supply of global governance is assessed and compared to the identified hypothetical potential. To lay the basis, the relevant international institutions are mapped, drawing on existing databases of international institutions, complemented by our own research taking into account available secondary literature and expert review (Rayner et al., 2018, esp. 15–18). For each of the identified institutions, we assess to what extent they contribute to, or hinder, the performance of the governance functions found to be most critical to decarbonization. In order to arrive at an overall assessment, the results for all institutions included are then aggregated (taking due account of any overlaps and conflicts) and compared to the previously derived hypothetical needs and potentials of international cooperation so as to identify any gaps, i.e. unmet governance needs or underexploited governance potentials. We distinguish three approximate levels of governance supply, namely high (governance needs/potential are largely met), medium (partially met), and low (largely unmet). Throughout this analysis, as mentioned above, we aim to pay systematic attention to interdependencies and interlinkages across sectoral systems.

Fourth, this analysis provides a solid starting point for thinking about options for filling the identified gaps and enhancing the contribution of global governance. We start exploring whether existing institutions could, given their mandate, be reformed to enhance their performance and contribution, and what the added value of any new institutions in the governance landscape could be, including what their membership and focus might usefully be. Where existing or new institutions overlap or even conflict with each other, options for better coordinating or orchestrating the 'concert' of institutions can be considered. While this constitutes only a first, explorative identification of available fora and general options, we hope that it can provide a solid basis for more detailed future assessment and weighing of options, in view of their political feasibility and costs, which is beyond the scope of our current efforts (see also Rayner et al., [this special issue](#)).

This special issue aims to develop and put to the test a sectoral approach to global climate governance. After this scene-setting

² A sixth field – finance and investment – was analyzed but could not be included in the special issue; see Rayner et al. (2018).

introductory article, we hence first turn to the analysis of global governance in the aforementioned five key sectoral systems. Subsequently, we synthesize the main lessons learned from our application of the sectoral approach. The special issue is rounded off with some broader reflections on this approach in assessing the adequacy of the global response to the Paris Agreement.

Tim Rayner analyses the current and potential contribution of global governance to addressing increasing concerns over fossil fuel (over) supply. With many economies heavily reliant on fossil-fuel extractive industries, steps to curtail supply raise significant questions of equity and justice. Despite increasing rhetorical commitments (for example on the need to reduce subsidies), existing inter- or transnational institutions meet critical governance needs only to a limited degree. Potentials are not exploited, while conflicting objectives continue to be pursued. Options for enhancing global governance, including in institutions such as the World Trade Organization, the G20, and the UNFCCC, as well as potential smaller 'coalitions of the willing', are identified. The importance of addressing supply issues through institutions covering development cooperation and governance of finance is also noted.

Lukas Hermwille investigates the global governance of power production/electricity generation. He identifies a wide range of inter- and transnational governance institutions that address various aspects of the sectoral transformation challenges related to the integration of increasing shares of fluctuating renewable energy, the development of grid infrastructure, the mobilization and de-risking of massive renewable energy investments, competitiveness concerns, and related distributive effects. Existing international institutions meet the governance needs to some extent, particularly with respect to the deployment of renewable energy. However, the phase-out of oil and gas in electricity generation remains an important blind spot. The IEA is highlighted as a particularly pertinent point of departure to optimize the supply of global governance and fill the identified gap.

The global governance of energy-intensive industries is the focus of the analysis by Sebastian Oberthür, Gauri Khandekar and Tomas Wyns. Global governance of the climate transition of these industries has a strong rationale, since international competition is fierce and costs are a major barrier to decarbonization. As a limited number of countries and usually multinational companies dominate most relevant industries (steel, aluminum, chemicals, cement), conditions for international cooperation are relatively favorable. Nevertheless, the supply of global governance for the climate transition has remained scarce so far. Fora for international cooperation are in short supply and structures for firm international regulation non-existent. Building up such structures – including both relevant countries and industrial players – has a high potential and is urgently required.

Wolfgang Obergassel, Oliver Lah and Frederic Rudolph bring global governance of land transport into focus. Passenger and freight transport are among the fastest growing GHG emission sources, which international cooperation could help address in various ways. The supply of global governance involves a multitude of intergovernmental and transnational institutions and initiatives. This institutional complex conspicuously lacks a center of gravity, and succeeds neither in meeting the need for, nor exploiting the potential of, international cooperation to advance the climate transition. Supply of global governance is stronger with respect to knowledge and learning than in providing clear guidance, establishing supporting regulatory frameworks, promoting transparency and mobilizing means of implementation. Hence, there remains enormous potential to strengthen global governance of transport's climate transition through mandating the establishment of emission targets, policies and measures as well as transparency provisions at sector level.

In focusing on international transport, Tim Rayner notes the urgent need for, but also the major barriers to, decarbonization of aviation and shipping. The need and potential for global climate governance to address these issues varies across both sectors, given different industry structures and characteristics. The International Maritime Organization (IMO) and International Civil Aviation Organization (ICAO) are the main focus, but non-state activity also has significant potential in the shipping sector, especially if better orchestrated. Overall, the shipping sector has shown considerably more seriousness in addressing GHG emissions, although effective implementation remains to be ensured. In the aviation sector, reliance on 'offsets' and future techno-fixes while demand growth remains unmanaged, is cause for concern. Better coordination between the UNFCCC and IMO and ICAO respectively is identified as a short-term priority, along with more effective mechanisms to finance R&D and incentivise investment.

A concluding, synthesizing paper by Tim Rayner, Sebastian Oberthür and Lukas Hermwille sets out key findings, takes stock and outlines possible resultant research priorities. Overall, the application of our sectoral approach reveals that the need and potential for global governance to contribute to effective climate protection varies significantly across sectoral systems. The role played by the UNFCCC/Paris Agreement in addressing sector-specific challenges and advancing sectoral governance is important but often relatively limited. Strong signals that certain high-carbon activities need to be actively phased out (as opposed to alternatives phased in) are found to be missing in particular in power, fossil-fuel extractive industry and transport-related sectoral systems. The setting of rules to facilitate collective action generally seems in shortest supply, whereas the supply of 'learning and knowledge building' and means of implementation varies across sectoral systems. Finally, in view of the gaps identified, the paper reflects on some implications for the UNFCCC, G20 and other leading institutions.

Finally, Marta Torres Gunfaus and Henri Waisman reflect in a shorter commentary on the contribution of the special issue to a fuller assessment of the adequacy of the global response to meeting the Paris Agreement's long-term goals. They argue that the sectoral approach developed here provides a useful steppingstone towards multidimensional adequacy assessments that eventually need to integrate multiple levels of governance and short- and long-term time horizons. This leads them to highlight priorities for the design of the Global Stocktake and the further elaboration of countries' long-term strategies under the Paris Agreement.

CRedit authorship contribution statement

Sebastian Oberthür: Conceptualization, Methodology, Writing – original draft. **Lukas Hermwille:** Conceptualization, Methodology, Writing – review & editing. **Tim Rayner:** Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This contribution is a result of the COP21 RIPPLES project funded under the European Union's Horizon 2020 research and innovation programme under grant agreement No 730427. For more information visit <https://www.cop21ripples.eu/>. We owe many thanks to the partners of this project and especially its work package on

global governance. We would also like to thank three anonymous reviewers for their thoughtful comments.

References

- Abbott, K.W., 2012. The transnational regime complex for climate change'. *Environ. Plann. C Govern. Pol.* 30 (4), 571–590.
- Abbott, K.W., Genschel, P., Snidal, D., Zangl, B. (Eds.), 2015. *International Organizations as Orchestrators*. Cambridge University Press, Cambridge.
- Abbott, K.W., Greene, J., Keohane, R.O., 2016. Organizational ecology and institutional change in global governance. *Int. Organ.* 70 (2), 247–277.
- Aklin, M., Mildenerberger, M., 2020. Prisoners of the wrong dilemma: why distributive conflict, not collective action, characterizes the politics of climate change. *Global Environ. Polit.* 20 (4), 4–27. https://doi.org/10.1162/glep_a_00578.
- Andonova, L.B., Betsill, M.M., Bulkeley, H., 2009. Transnational climate governance. *Global Environ. Polit.* 9 (2), 52–73.
- Baron, R., Reinaud, J., Genasci, M., Philibert, C., 2007. *Sectoral Approaches to Greenhouse Gas Mitigation: Exploring Issues for Heavy Industry*. IEA Information Paper. November 2007). OECD/IEA.
- Biermann, F., Pattberg, P., van Asselt, H., Zelli, F., 2009. The fragmentation of global governance architectures: a framework for analysis. *Global Environ. Polit.* 9 (4), 14–40.
- Bodansky, D., 2010. *The Art and Craft of International Environmental Law*. Harvard University Press, Cambridge, MA/London.
- Bodansky, D., 2012. The Durban Platform: Issues and Options for a 2015 Agreement. Center for Climate and Energy Solutions, Arlington, VA.
- Bodansky, D., 2017. The Paris climate change agreement: a new hope? *Am. J. Int. Law* 110 (2), 288–319. <https://doi.org/10.5305/amerjintlaw.110.2.0288>.
- Borrás, S., Edler, J. (Eds.), 2014. *The Governance of Socio-Technical Systems: Explaining Change*. Edward Elgar Publishing, Cheltenham/Northampton, MA.
- Bulkeley, H., Andonova, L.B., Betsill, M.M., Compagnon, D., Hale, T., Hoffmann, M.J., Newell, P., Paterson, M., Roger, C., Vandever, S.D., 2014. *Transnational Climate Change Governance*. Cambridge University Press, New York.
- Bulmer, J., 2012. Compliance regimes in multilateral environmental agreements. In: Brunnée, J., Doelle, M., Rajamani, L. (Eds.), *Promoting Compliance in an Evolving Climate Regime*. Cambridge University Press, Cambridge, pp. 55–73.
- Chayes, A., Chayes, A., 1993. On compliance. *Int. Organ.* 47 (2), 175–205. <https://doi.org/10.1017/S0020818300027910>.
- Dagnet, Y., Levin, K., 2017. Transparency (Article 13). In: Klein, D., Carazo, M.P., Doelle, M., Bulmer, J., Higham, A. (Eds.), *The Paris Agreement on Climate Change: Analysis and Commentary*. Oxford University Press, Oxford, pp. 301–318.
- De Búrca, G., Keohane, R.O., Sabel, C., 2014. Global experimentalist governance. *Br. J. Polit. Sci.* 44 (3), 477–486. <https://doi.org/10.1017/S0007123414000076>.
- Dupont, C., 2016. *Climate Policy Integration into EU Energy Policy: Progress and Prospects*. Routledge, London.
- Dupont, C., Oberthür, S. (Eds.), 2015. *Decarbonization in the European Union: Internal Policies and External Strategies*. Palgrave MacMillan, Houndmills.
- Falkner, R., 2016. The Paris Agreement and the new logic of international climate politics. *Int. Aff.* 92 (5), 1107–1125. <https://doi.org/10.1111/1468-2346.12708>.
- Geels, F.W., Schot, J., 2010. The dynamics of transitions: a socio-technical perspective. In: Grin, J., Rotmans, J., Schot, J. (Eds.), *Transitions to Sustainable Development – New Directions in the Study of Long Term Transformative Change*. Routledge, New York and London, pp. 11–104.
- Gehring, T., 1994. *Dynamic International Regimes: Institutions for International Environmental Governance*. Peter Lang, Frankfurt/M. et al.
- Gehring, T., 2007. Treaty-making and treaty evolution. In: Bodansky, D., Brunnée, J., Hey, E. (Eds.), *The Oxford Handbook of International Environmental Law*. Oxford University Press, New York, pp. 469–497.
- Gehring, T., Faude, B., 2014. A theory of emerging order within institutional complexes: how competition among regulatory international institutions leads to institutional adaptation and division of labor. *Rev. Int. Organ.* 9 (4), 471–498. <https://doi.org/10.1007/s11558-014-9197-1>.
- Gómez-Mera, L., Morin, J.F., Van de Graaf, T., 2020. Regime complexes. In: Biermann, F., Kim, R.E. (Eds.), *Architectures of Earth System Governance: Institutional Complexity and Structural Transformation*. Cambridge University Press, Cambridge, pp. 137–157.
- Graichen, P., Healy, S., Siemons, A., Höhne, N., Kuramochi, T., Gonzales-Zuniga, S., Sterl, S., Kersting, J., Wachsmuth, J., 2016. International Climate Initiatives – a way forward to close the emissions gap? Initiatives' potential and role under the Paris Agreement. Discussion Paper 31/2016. *Clim. Change. Umweltbundesamt, Dessau-Roßlau*. <http://www.umweltbundesamt.de/publikationen/international-climate-initiatives-a-way-forward-to>.
- Gupta, A., van Asselt, H., 2019. Transparency in multilateral climate politics: furthering (or distracting from) accountability? *Regul. Govern.* 13 (1), 18–34. <https://doi.org/10.1111/rego.12159>.
- Haas, E.B., 1990. *When Knowledge Is Power: Three Models of Change in International Organizations*. University of California Press, Berkeley.
- Hale, T., 2020. Catalytic cooperation. *Global Environ. Polit.* 20 (4), 73–98. https://doi.org/10.1162/glep_a_00561.
- Harich, J., 2010. Change resistance as the crux of the environmental sustainability problem. *Syst. Dynam. Rev.* 26 (1), 35–72. <https://doi.org/10.1002/sdr.431>.
- Hasenclever, A., Mayer, P., Rittberger, V., 1997. *Theories of International Regimes*. Cambridge University Press, Cambridge.
- Hermwille, L., Forthcoming, H., 2017. Hardwired towards transformation? Assessing global climate governance for power sector decarbonization. *Earth Syst. Govern.* <https://doi.org/10.1016/j.esg.2020.100054> (in press).
- Hermwille, L., Obergassel, W., Ott, H.E., Beuermann, C., 2017. UNFCCC before and after Paris – what's necessary for an effective climate regime? *Clim. Pol.* 17 (2), 150–170.
- Hsu, A., Weinfurter, A., Feerman, A., Xie, Y., Yeo, Z.Y., Lütkehermöller, K., Kuramochi, T., Lui, S., Höhne, N., Roelfsema, M., 2018. *Global Climate Action from Cities, Regions, and Businesses*. Data Driven Yale. NewClimate Institute, PBL Netherlands Environmental Assessment Agency. https://datadrivenlab.org/wp-content/uploads/2018/08/YALE-NCI-PBL_Global_Climate_Action.pdf.
- Iacobuta, G., Dubash, N.K., Upadhyaya, P., Deribe, M., Höhne, N., 2018. National climate change mitigation legislation, strategy and targets: a global update. *Clim. Pol.* 18 (9), 1114–1132. <https://doi.org/10.1080/14693062.2018.1489772>.
- IPCC, 2014. Chapter 13 - international cooperation: agreements and instruments. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, pp. 1001–1082.
- Jordan, A., Lenschow, A., 2010. Environmental policy integration: a state of the art review. *Environ. Pol. Govern.* 20 (3), 147–158.
- Jordan, A., Benson, D., Wurzel, R., Zito, A., 2012. Policy instruments in practice. In: Dryzek, J.S., Norgaard, R.B., Schlosberg, D. (Eds.), *The Oxford Handbook of Climate Change and Society*. Oxford University Press, New York. <https://doi.org/10.1093/oxfordhb/9780199566600.003.0036>.
- Jordan, A., Huitema, D., van Asselt, H., Forster, J. (Eds.), 2018. *Governing Climate Change – Polycentricity in Action?*. Cambridge University Press, Cambridge et al.
- Jordan, A.J., Huitema, D., Hildén, M., van Asselt, H., Rayner, T.J., Schoenefeld, J.J., Tosun, J., Forster, J., Boasson, E.L., 2015. Emergence of polycentric climate governance and its future prospects. *Nat. Clim. Change* 5 (11), 977–982. <https://doi.org/10.1038/nclimate2725>.
- Kanie, N., Biermann, F. (Eds.), 2017. *Governing through Goals: Sustainable Development Goals as Governance Innovation*. MIT Press, Cambridge, MA.
- Keohane, R.O., 1989. *International Institutions and State Power*. Westview Press, London.
- Keohane, R.O., Levy, M.A. (Eds.), 1996. *Institutions for Environmental Aid. Pitfalls and Promises*. MIT Press, Cambridge, MA.
- Keohane, R.O., Moravcsik, A., Slaughter, A.M., 2000. Legalized dispute resolution: interstate and transnational. *Int. Organ.* 54 (3), 457–488. <https://doi.org/10.1162/002081800551299>.
- Keohane, R.O., Victor, D.G., 2011. The regime complex for climate change. *Perspect. Polit.* 9 (1), 7–23. <https://doi.org/10.1017/S1537592710004068>.
- Levin, K., 2018. The interplay between accounting and reporting on mitigation contributions under the Paris Agreement. *Carbon Clim. Law Rev.* 12 (3), 203–208. <https://doi.org/10.21552/cclr/2018/3/6>.
- Levy, M.A., Young, O.R., Zürn, M., 1995. The study of international regimes. *Eur. J. Int. Relat.* 1 (1), 267–330.
- Loorbach, D.A., 2010. Transition management for sustainable development: a prescriptive, complexity-based governance framework. *Governance* 23 (1), 161–183.
- Meckling, J.O., Chung, G.Y., 2009. Sectoral approaches for a post-2012 climate regime: a taxonomy. *Clim. Pol.* 9 (6), 652–668.
- Miles, E.L., Underdal, A., Andresen, S., Wettestad, J., Skjærseth, J.B., Carlin, E.M., 2002. *Environmental Regime Effectiveness: Confronting Theory with Evidence*. MIT Press, Cambridge, MA.
- Mitchell, R.B., 1998. Sources of transparency: information systems in international regimes. *Int. Stud. Q.* 42 (1), 109–130. <https://doi.org/10.1111/0020-8833.00071>.
- Mitchell, R.B., Clark, W.C., Cash, D.W., Dickson, N.M. (Eds.), 2006. *Global Environmental Assessments: Information and Influence*. The MIT Press, Cambridge, MA and London.
- Morseletto, P., Biermann, F., Pattberg, P., 2016. Governing by targets: reductio ad unum and evolution of the two-degree climate target'. *Int. Environ. Agreements Polit. Law Econ.* 17 (5), 655–676. <https://doi.org/10.1007/s10784-016-9336-7>.
- North, D., 1991. *Institutions*. *J. Econ. Perspect.* 5 (1), 97–112.
- Obergassel, Wolfgang, Lah, Oliver, Rudolph, Frederic, Forthcoming. Driving towards transformation? To what extent does global climate governance promote decarbonization of land transport? *Earth Syst. Govern.* <https://doi.org/10.1016/j.esg.2021.100098> (in this issue)
- Oberthür, S., 2009. Interplay management: enhancing environmental policy integration among international institutions. *Int. Environ. Agreements Polit. Law Econ.* 9 (4), 371–391.
- Oberthür, S., 2016. Regime-interplay management. In: Blome, K., Fischer-Lescano, A., Franzki, H., Markard, N., Oeter, S. (Eds.), *Contested Regime Collisions: Norm Fragmentation in World Society*. Cambridge University Press, Cambridge, pp. 49–87.
- Oberthür, S., Hermwille, L., Khandekar, G., Obergassel, W., Rayner, T., Wyns, T., Mersmann, F., Jones, D., Kretschmer, B., Melkie, M., 2017. Key concepts, core challenges and governance functions of international climate governance. Deliverable 4.1. Paris: COP21 RIPPLES Project (Horizon2020). <https://www.cop21ripples.eu/wp-content/uploads/2017/02/Deliverable-4.1-Ripples-Final2.pdf> (in this issue).
- Oberthür, Sebastian, Khandekar, Gauri, Wyns, Tomas, Forthcoming. Global governance for the decarbonization of energy-intensive industries. great potential underexploited. *Earth Syst. Govern.* <https://doi.org/10.1016/j.esg.2020.100072> (in this issue).

- Oberthür, S., Northrop, E., 2018. Towards an effective mechanism to facilitate implementation and promote compliance under the Paris Agreement. *Clim. Law* 8 (1–2), 39–69. <https://doi.org/10.1163/18786561-00801002>.
- Oberthür, S., Stokke, O.S. (Eds.), 2011. *Managing Institutional Complexity: Regime Interplay and Global Environmental Change*. MIT Press, Cambridge, MA.
- Orsini, A., Morin, J.F., Young, O.R., 2013. Regime complexes: a buzz, a boom, or a boost for global governance? *Global Govern.* 19 (1), 27–39. <https://doi.org/10.5555/1075-2846-19.1.27>.
- Ostrom, E., 2010. Beyond markets and states: polycentric governance of complex economic systems. *Am. Econ. Rev.* 100 (3), 641–672. <https://doi.org/10.1257/aer.100.3.641>.
- Page, S.E., 2010. *Diversity and Complexity*. University Press Group, Princeton, NJ.
- Park, S., Kramarz, T. (Eds.), 2019. *Global Environmental Governance and the Accountability Trap*. The MIT Press, Cambridge, MA.
- Parson, E.A., 2003. *Protecting the Ozone Layer. Science and Strategy*. Oxford University Press, New York.
- Raustiala, K., Victor, D.G., 2004. The regime complex for plant genetic resources. *Int. Organ.* 32 (58), 147–154.
- Rayner, Tim, Forthcoming(a). Keeping it in the ground? Assessing global governance for fossil-fuel supply reduction. *Earth Syst. Govern.* (in this issue). <https://doi.org/10.1016/j.esg.2020.100061>.
- Rayner, Tim, Forthcoming(b). Taking the slow route to decarbonisation? Developing climate governance for international transport. *Earth Syst. Govern.* (in this issue). <https://doi.org/10.1016/j.esg.2021.100100>.
- Rayner, T., Shawoo, Z., Hermwille, L., Obergassel, W., Mersmann, F., Asche, F., Rudolph, F., Lah, O., Kodukala, S., Oberthür, S., Khandekar, G., Wyns, T., Kretschmer, B., Jones, D., Melkie, M., Zamarioli, L., 2018. Evaluating the adequacy of the outcome of COP21 in the context of the development of the broader international climate regime complex. Deliverable 4.2. Paris: COP21 RIPPLES Project (Horizon2020). https://www.cop21ripples.eu/wp-content/uploads/2018/07/RIPPLES_D4.2-Final.pdf.
- Rayner, T., Oberthür, S., Hermwille, L., Forthcoming. A sectoral perspective on global climate governance: key findings and research priorities. *Earth Syst. Govern.* (in this issue).
- Roger, C., Hale, T., Andonova, L., 2017. The comparative politics of transnational climate governance. *Int. Interact.* 43 (1), 1–25. <https://doi.org/10.1080/03050629.2017.1252248>.
- Sanderink, L., Widerberg, O., Kristensen, K., Pattberg, P., 2017. *Mapping the Institutional Architecture of the Climate-Energy Nexus*. IVM Institute for Environmental Studies, Amsterdam.
- Sawa, A., 2011. Sectoral approaches to a post-Kyoto international climate policy framework. In: Aldy, J.E., Stavins, R.N. (Eds.), *Post-Kyoto International Climate Policy. Implementing Architectures for Agreement*. Cambridge University Press, Cambridge, pp. 201–239.
- Schot, J., Laur, K., 2018. Deep transitions: emergence, acceleration, stabilization and directionality. *Res. Pol.* 47 (6), 1045–1059.
- Simmons, B.A., Martin, L.L., 2002. International organizations and institutions. In: Carlsnaes, Walter, Risse, Thomas, Simmons, Beth A. (Eds.), *The Handbook of International Relations*, second ed. Sage Publications, London, pp. 192–201.
- Snidal, D., 1985. Coordination versus prisoners' dilemma: implications for international cooperation and regimes. *Am. Polit. Sci. Rev.* 79 (4), 923–942. <https://doi.org/10.2307/1956241>.
- Sternier, T., Coria, J., 2013. *Policy Instruments for Environmental and Natural Resource Management*, second ed. RFF Press, New York. <https://doi.org/10.4324/9781315780894>.
- Stokke, O.S., 2012. *Disaggregating International Regimes. A New Approach to Evaluation and Comparison*. MIT Press, Cambridge, MA.
- Stokke, O.S., 2020. Interplay management. In: Biermann, F., Kim, R.E. (Eds.), *Architectures of Earth System Governance: Institutional Complexity and Structural Transformation*. Cambridge University Press, Cambridge, pp. 207–232.
- United Nations Environment Programme (UNEP), 2020. *Emissions Gap Report 2020*. United Nations Environment Programme, Nairobi.
- UNFCCC, 2019. *Yearbook of Global Climate Action 2019*. UN Climate Change Secretariat, Bonn.
- Unruh, G.C., 2000. Understanding carbon lock-in. *Energy Pol.* 28 (12), 817–830.
- van Asselt, H., Zelli, F., 2018. *International Governance: Polycentric Governing by and beyond the UNFCCC*. In: Jordan, A., Huitema, D., van Asselt, H., Forster, J. (Eds.), *Governing Climate Change - Polycentricity in Action?* Cambridge University Press, Cambridge, pp. 29–46.
- van der Ven, H., Bernstein, S., Hoffmann, M., 2017. Valuing the contributions of nonstate and subnational actors to climate governance. *Global Environ. Polit.* 17 (1), 1–20. https://doi.org/10.1162/GLEP_a_00387.
- Victor, D.G., Geels, F.W., Sharpe, S., 2019. *Accelerating the Low Carbon Transition – the Case for Stronger, More Targeted and Coordinated International Action*. London, Manchester, San Diego. Available at: www.energy-transitions.org/sites/default/files/Accelerating-The-Transitions_Report.pdf.
- Walsh, C., Mander, S., Larkin, A., 2017. Charting a low carbon future for shipping: a UK perspective. *Mar. Pol.* 82, 32–40. <https://doi.org/10.1016/j.marpol.2017.04.019>.
- Wurzel, R., Zito, A., Jordan, A.J., 2013. *Environmental Governance in Europe: A Comparative Analysis of the Use of New Environmental Policy Instruments*. Edward Elgar, Cheltenham. <https://doi.org/10.1108/meq.2013.08324eaa.009>.
- Young, O.R., 1980. International regimes: problems of concept formation. *World Polit.* 32, 331–356.
- Young, O.R., 1982. *Resource Regimes: Natural Resources and Social Institutions*. University of California Press, Berkeley.
- Young, O.R., 1986. International regimes: towards a new theory of institutions. *World Polit.* 39, 104–122.
- Young, O.R., 1989. The power of institutions: why international regimes matter. In: Young, O.R. (Ed.), *International Cooperation: Building Regimes for Natural Resources and the Environment*. Cornell University Press, Ithaca, NY, pp. 58–80.
- Young, O.R. (Ed.), 1999. *The Effectiveness of International Environmental Regimes: Causal Connections and Behavioral Mechanisms*. MIT Press, Cambridge, MA.
- Young, O.R., 2009. Building regimes for socioecological systems: institutional diagnostics. In: Young, O.R., King, L.A., Schroeder, H. (Eds.), *Institutions and Environmental Change. Principal Findings, Applications, and Research Frontiers*. MIT Press, Cambridge, MA, pp. 115–144.
- Young, O.R., 2011. Effectiveness of international environmental regimes: existing knowledge, cutting-edge themes, and research strategies. *Proc. Natl. Acad. Sci. Unit. States Am.* 108 (50), 19853–19860. <https://doi.org/10.1073/pnas.1111690108>.
- Young, O.R., 2017. *Governing Complex Systems: Social Capital for the Anthropocene*. MIT Press, Cambridge, MA.
- Young, O.R., Levy, M.A., 1999. The effectiveness of international environmental regimes. In: Young, O.R. (Ed.), *The Effectiveness of International Environmental Regimes: Causal Connections and Behavioural Mechanisms*. MIT Press, Cambridge, MA, pp. 1–32.