EARTH SYSTEM GOVERNANCE

Science and Implementation Plan
of the Earth System Governance Project

2018

Coordinating Lead Authors:
Sarah Burch, Aarti Gupta, Cristina Yumie Aoki Inoue, Agni Kalfagianni, Åsa Persson

Lead Authors:
Andrea K. Gerlak, Atsushi Ishii, James Patterson, Jonathan Pickering, Michelle Scobie, Jeroen van der Heijden, Joost Vervoort

Contributing Authors
Carolina Adler, Michael John Bloomfield, Riyanti Djalante, John S. Dryzek, Victor Galaz, Christopher Gordon, Renée Harmon, Sikina Jinnah, Rakhyun E. Kim, Lennart Olsson, Judith van Leeuwen, Vasna Ramasar, Paul Wapner, Ruben Zondervan

Citation
This report can be cited as: Earth System Governance Project. 2018. Earth System Governance. Science and Implementation Plan of the Earth System Governance Project. Utrecht, the Netherlands.

Contact
Earth System Governance International Project Office
www.earthsystemgovernance.org
Email: IPO@earthsystemgovernance.org

Contents

List of Figures

List of Tables

1 Introduction

This Science and Implementation Plan sets out the agenda for the next decade of earth system governance research. In this section, we present a new vision developed by the research community and describe the background and process of developing the plan. We explain the structure of the plan, and provide an overview of environmental, economic, social and political trends that define the context of the next generation of earth system governance research. To facilitate high-quality and novel earth system governance research, we need to regularly rethink the relevance and urgency of our research endeavour in light of a changing world and changing earth system.

This plan builds on successful elements of the previous plan but adds new research lenses and approaches that have come to the fore and will be important to earth system governance in the coming decade. While the timeframe of this plan is the next ten years, we expect that there will be active engagement and discussion when taking it forward, to ensure high relevance to governance challenges and new scientific findings.

The implementation of this plan will be aided by shorter-term action plans developed by the Scientific Steering Committee.

1.1 Background and Process

The Earth System Governance Project was launched in 2009 to explore governance mechanisms addressing multilevel environmental change, as presented in its ten-year Science and Implementation Plan (BIERMANN ET AL., 2009A). The Science and Implementation Plan proposed to coordinate research using a framework of five analytical problems: Accountability, Adaptiveness, Agency, Allocation and access, and Architecture ('the five As'), with crosscutting themes of knowledge, norms, power and scale.

Since 2009, the earth system governance research network has grown and is now well established in the scientific community. Project activities have expanded to include 14 research centres, more than 65 lead faculty members, 60 senior research fellows, 210 research fellows, and about 20 otherwise affiliated researchers, coordinators and staff, as well as a considerable communication and outreach capacity and a wide variety of conferences, initiatives and publication series delivered. A decade after its inception, it is now a timely moment to update the existing Earth System Governance Research Framework to reflect new innovations, opportunities and complexities emerging in earth system governance, and to continue to stimulate a pluralistic, vibrant and relevant research community in this field. While most of the five As are still seen as relevant, a need has been identified to more prominently incorporate concepts like democracy, power, anticipation and imagination in the analytical framework.

With this new Science and Implementation Plan for the next decade, the aim is to learn from past achievements and simultaneously take the next step in our ability and efforts to understand new, emerging and existing problems and solutions related to global environmental change. The new plan also aims to expand the global mobilization of researchers, stimulate and facilitate research collaboration, and effectively communicate and engage with society.

Our vision is to understand, imagine and help realize just and sustainable futures by stimulating a pluralistic, vibrant and relevant research community

The first steps towards this plan were taken through open discussions with the Earth System Governance Lead Faculty and research fellows as well as the wider community at the 2014 Norwich Conference on Earth System Governance, and the 2015 Canberra Conference on Earth System Governance, which identified issues for a next-generation research agenda and new potential modes of collaboration and engagement with society. In 2016, the New Directions Initiative was launched. A team of lead authors was established to co-develop a Science and Implementation Plan with the earth system governance research community. The 22 lead authors represented a variety of disciplines, areas of research expertise, gender and geographical balance. Five coordinating lead authors were selected by the group, with the responsibility to initiate the discussion and coordinate the writing process. At the 2016 Nairobi Conference on Earth System Governance, the lead authors met to develop the first draft of the table of contents. It was then presented to and discussed with the conference participants. Based on this feedback, the lead authors developed a full draft Science and Implementation Plan for discussion during and after the 2017 Lund Conference on Earth System Governance. Based on feedback received at the conference, the lead authors revised the plan and presented it at a round table at the 2018 Annual Convention of the International Studies Association in San Francisco, April 2018.

In May and June 2018, the full draft was made available online for review and feedback by the entire earth system governance community of researchers. Based on this feedback, the coordinating lead authors led the final revision. The final plan was launched at the 2018 Utrecht Conference on Earth System Governance, in November 2018.

2006	Appointment of a Scientific Planning Committee to design a new core project under the International Human Dimensions Programme on Global Environmental Change
2007	2007 Amsterdam Conference on Earth System Governance (first global conference on earth system governance, shaping the new research agenda)
2009	Launch of the Earth System Governance Project and the original Science and Implementation Plan in New Delhi
2014	Initial discussions on new directions at the 2014 Norwich Conference on Earth System Governance
2015	Continued discussions on new directions at the 2015 Canberra Conference on Earth System Governance
2016	Lead authors were invited and coordinating lead authors selected to start writing a new Science and Implementation Plan Lead authors met at the 2016 Nairobi Conference on Earth System Governance and presented an outline of the plan to all conference participants
2017	A full draft plan was discussed by lead authors at a meeting prior to the Lund conference and its key elements were discussed with conference participants in plenary
2018	Earth system governance community invited to review a revised plan in early summer Coordinating lead authors led the final revision of the plan Launch of the new Earth System Governance Science and Implementation Plan at the 2018 Utrecht Conference on Earth System Governance

Table 1
The New Earth System Governance Science and Implementation Plan: Process and Timeline

In parallel with the New Directions process, a Harvesting Initiative was launched by the Earth System Governance Project, whereby the Lead Faculty and other members of the community synthesized research findings from the past decade and sought to establish the key lessons and insights for future governance of the earth system.

We aimed for a transparent and inclusive writing process for this new Science and Implementation Plan. Therefore, drafts of the table of contents and of the plan itself have been discussed with the earth system governance community at various conferences and meetings, and information has been available on the Earth System Governance Project's website. Further, the lead author team has been conscious of the need to balance sustainability, durability and consistency – in terms of keeping

elements of the existing analytical framework (the five As), to maintain a joint terminology for the community, enable longer-term research and lesson-drawing, and offer opportunities to validate theories – with the need to refresh and build on the advances of the last decade. Novel approaches and innovative concepts are needed to study new and emerging – as well as existing – unsolved problems. For example, including research lenses like anticipation and imagination, and contextual conditions like transformation and the Anthropocene, reflect the need to systematically study how societies prepare for accelerated climate change and wider earth system change as well as policy responses. They are also needed to extend, diversify and globalize the research network, to benefit from a wider set of research disciplines and traditions and more geographically diverse membership. For example, we have included a stronger emphasis on democracy as a research lens in order to better add culturally informed perspectives on governance. Finally, we have strived to ensure simplicity in this new Science and Implementation Plan, to not predetermine research questions, to avoid excessive jargon and to recognize the new digital landscape, which has facilitated more direct, efficient and inclusive research communication and networking.

1.2 Relevance and Urgency

In setting out a new scientific agenda it is useful to begin by critically questioning why earth system governance research continues to be needed, and what form it should take. The world has changed tremendously over the last decade since the former Science and Implementation Plan was developed. While successes have been secured in promoting human development and reversing some environmentally unsustainable trends (PINKER, 2018), new problems have emerged, longstanding problems remain inadequately addressed and many diverse problems are becoming ever more tightly intertwined. Global shifts in interconnected social, political, economic, technological and environmental systems are reshaping the empirical context for earth system governance research in profound ways. These changes challenge earth system governance researchers to rethink the relevance and urgency of our work.

The scale and rate of change in both natural and human systems is accelerating. Some global indicators have improved in recent years – for example, the growth of fossil fuel carbon dioxide emissions seems to have slowed down in recent years (GLOBAL CARBON PROJECT, 2017), the number of oil spills has dropped (ITOPF, 2018) and the spatial extent of marine and terrestrial protected areas has increased globally (UNEP-WCMC AND IUCN, 2016). Many others demonstrate rapid change and cause for concern, like atmospheric carbon dioxide concentration (NOAA, 2017), biodiversity loss (IUCN, 2017) and global fish stock depletion (FAO, 2016). Furthermore, global trends mask local problems and uneven distribution of environmental pressures and impacts, including food insecurity, water stress and vulnerability to natural hazards. Air pollution is having dire human health and environmental effects, not least in growing urban areas

in the developing world (WATTS ET AL., 2015). Global plastics waste is projected to continue to increase rapidly, by more than four times by 2050 (GEYER, JAMBECK AND LAW, 2017). Compared with 1990, natural disasters are more frequent and have higher costs (GUHA-SAPIR ET AL., 2017), as well as non-economic losses. While there has been relative decoupling of carbon dioxide emissions with economic growth at the global level (WORLD BANK, 2018), the fact that the global economy has grown faster means that there has not yet been an absolute decoupling. Similar trends of concern – but also signs of progress – are visible in many of the issue areas that earth system governance research has engaged with, such as climate change, deforestation, marine ecosystems, resource extraction, growing cities and food security.

Some new issues have made their way from scientific study to broader public awareness, like ocean acidification, ocean plastics, Arctic melting and the broader phenomenon of climate tipping points. UNEP (2017) has recently identified antimicrobial resistance, engineered nanomaterials, sand and dust storms, and environmental displacement as emerging environmental issues with global implications. Specific manifestations of environmental change have over the past decade been increasingly connected through overarching diagnoses and concepts. For example, the implications of entering the Anthropocene epoch are the subject of hot debate in scientific circles (e.g. WATERS ET AL., 2016; LEWIS AND MASLIN, 2015) and some domains of public discourse (e.g. THE ECONOMIST, 2011; KOLBERT, 2011). Concepts like 'planetary boundaries' have been developed and invoked by various actors, responding to calls for concerted global action across environmental changes beyond climate change (ROCKSTRÖM ET AL., 2009). The most recent benchmarking against the planetary boundaries suggests that human societies have transgressed four of the boundaries (biosphere integrity, biogeochemical flows, land-system change, climate change; STEFFEN ET AL., 2015B).

Compared with ten years ago, problem awareness has undoubtedly increased generally (see e.g. STOKES, WIKE AND CARLE, 2015) and in some actor groups particularly (e.g. business and finance sectors; SEE CDP, 2017), fuelled by intensified communication outside the traditional environmental arena. In the lead-up to the milestone 2015 Paris climate negotiations, a more optimistic discourse emerged that emphasized solutions within reach, not least facilitated by the price on renewable energy technologies falling more quickly than expected (REN21, 2017). Electric vehicle penetration is increasing quickly (IEA, 2017A). The business and financial risks of unfettered global environmental change, as well as ambitious environmental policies, are increasingly being discussed and quantified (e.g. TCFD, 2017), leading to growing potential for anticipatory action like climate-proofing of supply chains, divesting from fossil fuel resources to avoid stranded assets, and revised business strategies.

Over the past decade, the governance response to growing problem awareness at the global level has frequently been to increase the level of ambition of targets, as seen for example with the 2010 Aichi targets on biodiversity, the 2015 Paris climate target to

limit global warming to 2°C and preferably 1.5°C degrees and the 2015 UN Sustainable Development Goals. Concrete mechanisms to achieve these kinds of targets, however, have generally become less specified and more uncertain, leading to studies of 'governance through goals' (KANIE AND BIERMANN, 2017). There appears to have been a general shift away from 'hard law' frameworks towards voluntary, 'pledge-and-review' approaches. While this shift could be seen as a symptom of a general decline in multilateralism, the new approaches can also be seen as 'all-hands-on-deck' and crowd-sourced models where both state and non-state actors contribute and can be held to account by their respective constituencies (CHAN ET AL., 2015).

In either case, in the coming decade the onus is on states and sub-national actors, as national plans and domestic action to achieve the targets need to be implemented. It remains to be seen to what extent such a large-scale and society-wide implementation effort will develop new governance approaches, and to what extent it will rely on traditional policy tools such as taxation, regulation, and public and private investment or a mix thereof. It also remains to be seen how domestic implementation will be characterized by multi-level governance, and how power and authority will be configured among national, sub-national and non-state actors.

The pace of change required in our societies, particularly to achieve the 1.5°C or 2°C degree targets, is stunning. A 2018 IPCC assessment shows that to limit warming to 1.5°C with no or low overshoot, carbon dioxide emissions must start declining in the early 2020s and be around 40% lower in 2030 compared with 2010 (IPCC, 2018:FIGURE SPM.3A). It has been suggested this level of effort would require the realization of a 'carbon law' that is a halving of emissions each decade (ROCKSTRÖM ET AL., 2017). This is unprecedented in international environmental cooperation, which has typically been based on longer timetables and more gradual change – as compared with deep decarbonization and deep adaptation of entire societies and economies (PATTERSON ET AL., 2018).

Compared with a decade ago, there are more calls for broad and deep societal transitions or transformation, including shifts in individual behaviour and social norms, than for discrete policy interventions (such as a carbon cap-and-trade scheme) or singular technological innovations. Embarking on societal transitions, which encompass whole innovation systems and a wide set of path-dependent policy incentives and social norms, means governance dilemmas abound. For example, how can 'just transitions' for people in economies dependent on fossil fuel revenues be ensured (NEWELL AND MULVANEY, 2013)? Distributional impacts from transitions are raised both by fossil fuel workers and industry in developed countries, and by developing countries who are exploring new untapped fossil reserves. Research questions around transitions are made more complex considering the changing social and political dynamics seen in many parts of the world.

These changing social and political dynamics include income inequality, which is falling globally but increasing in many parts of the world, both developed and developing (ISSC, IDS AND UNESCO, 2016; PIKETTY, 2014). Rising inequalities have been used to explain a series of conditions, such as decreasing social trust and growing political polarization (see e.g. PUTNAM, 2015; GOULD AND HIJZEN, 2016; DUCA AND SAVING, 2016). Populist tendencies are seen in different parts of the world (e.g. RODRIK, 2017), which question perceived elite establishments, the nature of the social contract and how national self-interest is defined – all with potential impacts for earth system governance.

Migration and mobility is also changing the social and political fabric of societies, as it has throughout history. At the global level, the number of migrants has been rising, with an estimated 244 million migrants in 2015 (IOM, 2017). In recent years, the level of forced displacement (refugees, asylum seekers and internally displaced people) has increased rapidly. In parallel with debates on social and political challenges and opportunities of refugee flows, the prospect of displacement induced by environmental change and 'climate refugees' has been increasingly raised, although large uncertainties characterize quantitative estimates (see e.g. WARNER, 2010; FARBOTKO AND LAZRUS, 2012). Considering international migration more broadly, there has been a slow upward trend in the number of international migrants relative to world population, from 2.2% in 1970 to 3.3% in 2015 (IOM, 2017). Most migration takes place between developing countries, and the economic significance of remittance flows globally has continued to increase.

Over the past ten years, the world map has been redrawn not just in terms of changing income levels and human mobility, but also changing geopolitics and trade patterns. Emerging economies such as China, India and Brazil have matured, and particularly China has been described as a new climate leader, whether motivated by domestic public opinion related to environmental quality or foreign policy opportunities. With the Trump administration entering office in 2017, a more uncertain era started regarding the role of the United States in earth system governance. Meanwhile, the capacity of the European Union to provide leadership has been questioned in light of the United Kingdom's decision to exit (Brexit) and other large member states struggling to meet their own targets. The last decade has seen some groups emerge, like the BASIC group that formed for the 2009 Copenhagen climate negotiations, and other traditional forums continuing to operate, like G77 and G20. Roles are being reshaped within blocs, such as new development banks being established by BRICS economies, particularly in Asia. More diffusely, there are several examples across the world of national-level retreats from liberal democracy in recent years, and even democratic decay in mature democracies (FUKUYAMA, 2014). This – as well as questioning of the liberal democracy model itself – is a cause for growing uncertainty about the stability and capacity of the global governance arena within which earth system governance occurs.

Technological change in the 21st century is rapid and sometimes disruptive. Except perhaps for debates on geoengineering technologies, it has been a largely neglected boundary condition in earth system governance research, but increasingly cannot be ignored. Increased automation will have implications for jobs and the labour market globally. Algorithmic systems, artificial intelligence and blockchain technology will have implications for decision-making, power and accountability at unprecedented scales. Rapid improvements of hardware such as sensors, the emergence of big data, the 'internet of things' and distributed renewable energy capacity will have implications for resource use, impacting all parts of the biosphere. With the information revolution over the past decade, there is an emerging concern that the internet and social media now facilitate a 'post-truth' era and spreading of inflammatory or factually incorrect news stories about, for example, climate change. All these shifts may have major implications for the limits and possibilities of earth system governance, which now needs to contend with hyper-connected global financial markets underpinned by advanced algorithms (GALAZ ET AL., 2015), tele-coupling phenomena arising from complex global resource supply chains (LIU ET AL., 2015) and growing political polarization.

Moreover, interconnections between social, political, technological and economic change across the globe shift the boundary conditions for earth system governance, posing major new challenges for scholars. This creates a context of 'globally networked risks' (GALAZ ET AL., 2017) within which earth system governance is embedded. These risks involve rapid change in human systems, technological as well as unfolding earth system changes.

As a number of new challenges and opportunities have emerged, significant achievements have also been made. The level of human development is higher globally than ever before, largely due to poverty reduction strategies in China, India and elsewhere (UNDP, 2016). This has been associated with rapid urbanization. Many of the world's cities and regions now stand on the brink of making major infrastructure investments (NCE, 2016) and, taking up this challenge, some of them increasingly assert themselves as key agents for change for low-carbon transitions. The next couple of decades is likely to see a tremendous wave of global infrastructure investment, both within and beyond cities, which will have profound impacts on the biosphere (ELMQVIST ET AL., 2013), with critical implications for addressing climate change and the UN Sustainable Development Goals.

The empirical context for earth system governance is thus rapidly changing and becoming more complex and dynamic than a decade ago. While the global environment and development agenda was updated in 2015-16 through several major global agreements, including the UN Sustainable Development Goals and Agenda 2030 as an integrative mechanism, the extreme urgency for climate action stands out as one of the most challenging issues facing the globe. This cannot be overstated.

Considering interconnections and global variation in impacts and progress, there is no simple list of empirical areas and problems that should guide the next generation of earth system governance research. Future research should focus on emerging problems, as well as longstanding, intractable ones. Multiple levels of earth system governance and interactions between environmental and societal problems will require examination and critical engagement.

While flexibility is important in terms of the empirical areas and trends that the next ten years of earth system governance research focuses on, this plan sets out an analytical framework that we hope acts as a source of mobilization, coordination and stability in the joint research effort. Future earth system governance research should also be open to regularly rethinking what issues it engages with and how, to ensure its continued relevance in the face of ever-more complex and urgent global challenges. To ensure responsiveness to a changing research environment, this plan will be complemented by short-term action plans developed by the Scientific Steering Committee.

KEY POINTS

- The scale and rate of earth system change has in many ways increased, making improved governance more urgent than ever. At the same time, some unsustainable trends have been reversed, meaning there are examples to be emulated.
- At the international level, there has been a shift towards emphasizing more inclusive and voluntary approaches in earth system governance, although these targets and pledges will need to be effectively implemented over the coming decade.
- In the context of sustainability transitions, a range of changing social, political, geopolitical and technological dynamics outside of the environmental governance sphere need to be understood and considered.
- While some earth system governance research topics remain relevant, the new Science and Implementation Plan must consider new issues, emerging world trends and imperatives for broad societal transformation. The analytical framework in Section 2 includes new contextual conditions and partially new research lenses that open up for better informed study of contemporary and future earth system governance challenges and opportunities.

1.3 Structure of the Plan

After this introduction, **Part I** presents the scientific part of the plan and the new Earth System Governance Research Framework. **Section 2** gives an overview of the framework and its two main elements and explains how the framework can be used to help generate research questions. **Section 3** elaborates on the first element, namely four contextual conditions. *Transformations*, *inequality*, *Anthropocene* and *diversity* have emerged as key issues in scientific and societal debates over the past decade and

will likely shape debates over the coming decade. **Section 4** elaborates on the second element: the five sets of research lenses. These five pairs of concepts represent dynamic clusters of social scientific research, each inviting the engagement of diverse disciplines and research traditions: *architecture and agency*; *democracy and power*; *justice and allocation*; *anticipation and imagination*; and *adaptiveness and reflexivity*.

Part II of the plan shifts the focus to implementation of earth system governance research, as well as activities of the Earth System Governance Research Alliance. In **Section 5**, different ontologies and epistemologies, methodologies and methods for conducting earth system governance research are discussed, together with a reflection on inter- and transdisciplinarity. **Section 6** looks outside of the research community and considers ways that earth system governance researchers can interact with society, as well as identifies new approaches to earth system governance education. Finally, **Section 7** addresses the modus operandi of the earth system governance network, including its people, places and projects, and proposes activities to create an enabling environment for a new decade of vibrant earth system governance research.

2

A New Earth System Governance Research Framework

With a changing world as backdrop, the New Directions process has led to a new Earth System Governance Research Framework. This draws substantially on the past framework, which consisted of five analytical problems – Accountability, Adaptiveness, Agency, Allocation and access, and Architecture (the five As) – and four cross-cutting themes: power, knowledge, norms and scale (BIERMANN ET AL., 2009A). Several of these themes and concepts remain valid and urgent. Yet, the New Directions process also led to identification of a number of new relevant themes and concepts, reflecting both a changing empirical context and a changing scientific enquiry.

In this section, we provide an overview of the new research framework (Figure 1) and how it is intended to support and stimulate future earth system governance research. Its constituent parts are further justified, elaborated and explained in Sections 3 and 4.

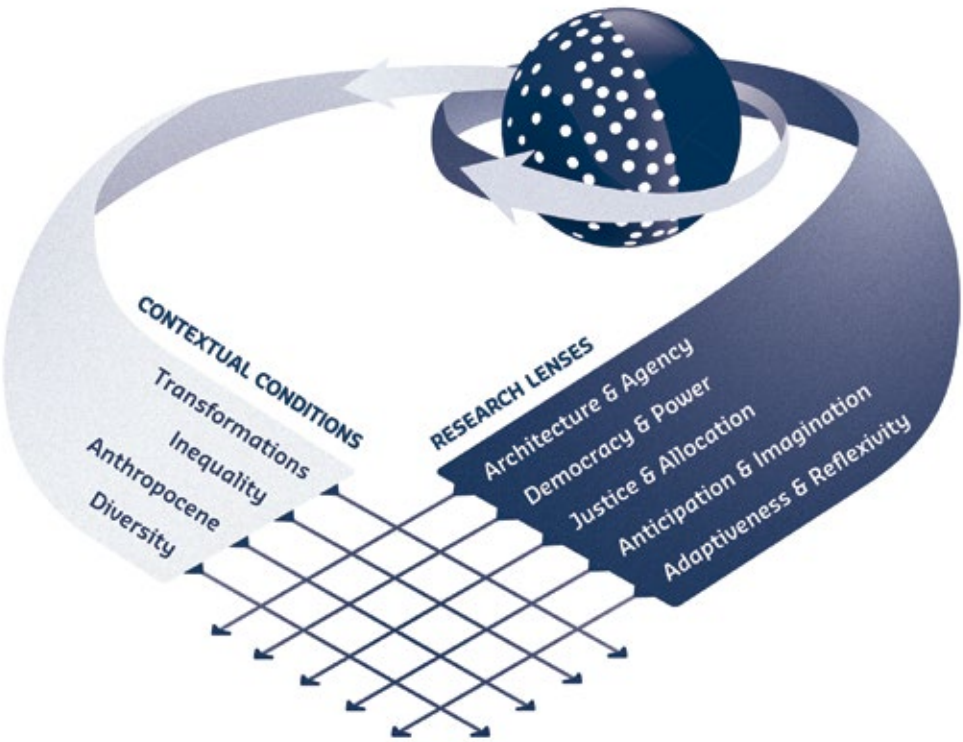

Figure 1
The Earth System Governance Research Framework

Earth system governance research starts with observations of our **complex and dynamic world** and the earth system it operates within. Some key trends and drivers of change likely to shape the coming decade were described in Section 1. Importantly, the Earth System Governance Framework recognizes that multiple world views coexist and that drivers and directions of change are often messy and dynamic. For this reason, we need multiple perspectives.

The first part of the framework identifies **four contextual conditions**: transformations, inequality, Anthropocene and diversity. Against the backdrop of our complex and dynamic trends across the world, these represent meta-level conditions that define the research context we observe at the outset of the second decade of earth system governance research. These four conditions, or concepts, encompass and distil broader patterns of change. A common denominator is that all four are subject to extensive empirical research and to scientific and societal debate. Note that not all future earth system governance research is expected to actively and explicitly relate to one or several of these four conditions, and they are not intended to be exclusive entry points. Instead, they are intended to help provide a common language for the research context in which the Earth System Governance Project operates and to stimulate interesting and relevant research questions, when brought together with the third part of the framework. Each contextual condition is described and justified in Section 3.

The second, and core, part of the framework are the **five sets of research lenses**: *architecture and agency, democracy and power, justice and allocation, anticipation and imagination,* and *adaptiveness and reflexivity*. These lenses together provide a multifaceted view of earth system governance. Individually, they relate to established or emerging research fields, with roots in various social scientific disciplines. The lenses were intentionally coupled to enrich analysis of earth system governance, by highlighting not only similarities but also productive tensions between the two paired concepts. Note that individual lenses can be paired in myriad ways and new pairings can lead to new research questions. These pairs of research lenses have been identified as the most pertinent and productive when starting this new phase of earth system governance research, as well as representing distinct clusters of earth system governance research activity. However, we encourage researchers to use the framework to consider alternative pairings, in an effort to generate novel and relevant research questions. Each set of research lenses is described and justified in Section 4.

The purpose of this matrix is to identify and list key concepts and terminology for earth system governance research, but primarily to help generate salient research questions where contextual conditions and research lenses intersect. These questions would be applicable to a wide range of empirical domains. To illustrate with examples, Figure 2 shows some generic research questions that appear at the intersections of the five research lenses and the four contextual conditions. In Section 4, similar research questions are systematically identified under each research lens, in relation to the four contextual conditions.

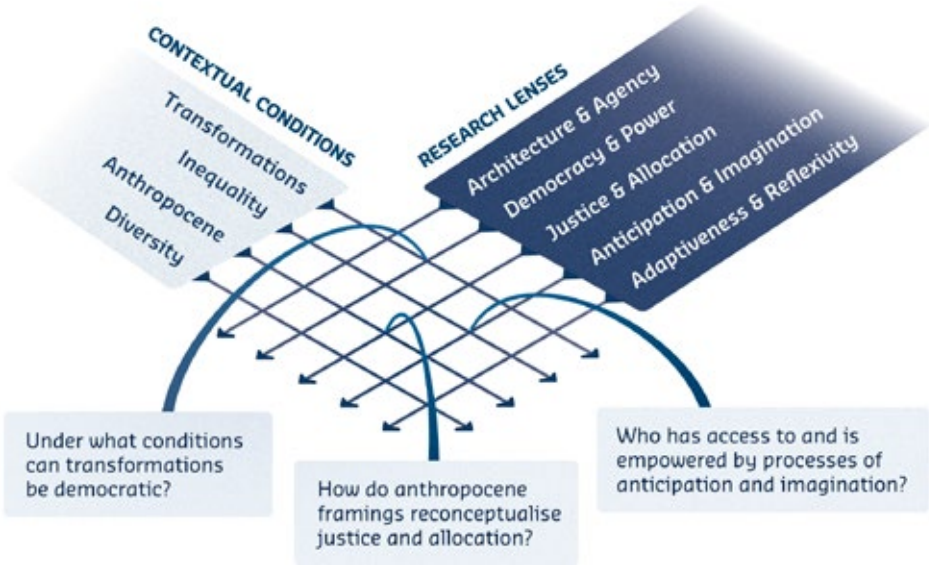

Figure 2
Illustration of how the ESG Research Framework generates research questions

3

Contextual Conditions

This section discusses the context within which earth system governance research takes place. We expect that our analytical concerns, our normative commitments, our critical interrogations of our specific research topics will necessarily engage with this context. We identify four key conditions that characterize this context, which we have distilled out of the numerous empirical trends presented in Section 1 of this document. These are: (a) the numerous political, technological and socio-economic *transformations* that are shaping and being shaped by governance processes; (b) the increasing and multifaceted *inequalities* across and within countries and socio-economic groups; (c) the tremendous as well as contested impact of human beings on the entire planet and the changing human-nature relationship captured by the notion of the *Anthropocene*; and (d) the opportunities and challenges offered by the *diversity* and pluralism of human societies in knowledge, culture and identities in addressing sustainability challenges in the contemporary world. Below we conceptualize these four conditions and draw the links between each one of them and earth system governance research.

3.1 Transformations

Social science enquiry has long been concerned with understanding many different forms of change in human society. Yet, the deepening urgency of major global sustainability and human development challenges is now catapulting a focus on transformative change to the forefront of earth system governance scholarship. This is driven by concerns about the dramatic scale and pace of change that both human and natural systems are undergoing, and a need to understand how transformations towards sustainability can be achieved within diverse human societies across the globe.

Transformations are both processes as well as conditions for earth system governance research: here we consider their role as conditions in order to highlight the deeply dynamic and uncertain contemporary contexts that governance research must grapple with, descriptively, analytically and normatively.

Transformations involve fundamental changes in structural, functional, relational and cognitive dimensions of linked socio-technical-ecological systems (de haan and rotmans, 2011; feola, 2014; hackmann and st. clair, 2012; o'brien, 2012). This includes both pervasive global changes in human societies (e.g. urbanization, climate change, economic globalization, digitization), but also efforts to (re)imagine and intentionally pursue desirable (sustainable) futures in a wide range of ways. The emerging focus on sustainability transformations among researchers and policymakers reflects a desire to move from description and diagnosis to action and solutions (patterson et al., 2017). The study of transformations can be approached in several ways: analytically (e.g. what actually happens, and how and why), normatively (e.g. as a good/desirable thing to do) or critically (e.g. who is deciding, shaping, and benefiting

from certain transformations and why). Crucially, transformations imply changes in power relations (e.g. challenging, disrupting or entrenching), and thus are deeply contested, political phenomena.

3.1.1 Conceptualizing Transformations

Scholars have studied transformations from different perspectives over recent years, developing various conceptual heuristics and empirical methods that bring to light various aspects of transformation dynamics. Key perspectives include: sustainability transitions, social-ecological systems, sustainability pathways and transformative adaptation (following PATTERSON ET AL., 2017). These bodies of literature offer complementary insights into critical aspects such as the boundaries of the systems being transformed, dynamics of change and resistance to change, and potential mechanisms of intentional change towards sustainability.

Sustainability transitions literature has explored how niche innovations in technology and social practices may lead to changes in broader social order, and how institutions may enmesh particular technology systems (FRANTZESKAKI, LOORBACH AND MEADOWCROFT, 2012; GEELS AND SCHOT, 2007; LOORBACH, 2010). Socio-ecological systems literature has explored 'transformability' (FOLKE ET AL., 2010; WALKER ET AL., 2004), how transformations may be actively navigated (CHAPIN ET AL., 2009; MOORE ET AL., 2014), and the role of social innovation within transformation processes (BIGGS, WESTLEY AND CARPENTER, 2010; WESTLEY ET AL., 2011, 2013). Sustainability pathways literature has explored the inherently contested nature of sustainability transformations (e.g. contestations over values, narratives of change, knowledge, marginalization; LEACH, SCOONES AND STIRLING, 2010; SCOONES, LEACH AND NEWELL, 2015), and proposed new framings centred on navigating pathways of human development between a 'foundation' of social boundaries and a 'ceiling' of planetary boundaries (LEACH, RAWORTH AND ROCKSTRÖM, 2013; LEACH ET AL., 2012). Transformative adaptation literature has explored the interplay between local vulnerability and global forces of change, arguing that incremental adjustment to earth system change will be ineffective unless the systemic causes of vulnerability and unsustainability are also addressed (O'BRIEN, 2012; PELLING, 2011; RIBOT, 2011).

These bodies of literature often consider transformation within particular sustainability problem domains, such as energy, water, waste, transportation or community vulnerability. Larger systems are also increasingly a focus of analysis, such as in regard to global climate change (e.g. CLARKE ET AL., 2014; WBGU, 2011), global urbanization trajectories (NCE, 2016; WBGU, 2016), economic transformations and technological shifts (GALAZ, 2014). In particular, realizing deep decarbonization at the scale and pace required to address the Paris climate goals is an immensely important topic for earth system governance researchers, cutting across political, economic, behavioural, cultural and technological dimensions (BERNSTEIN AND HOFFMAN, 2018; KERN AND ROGGE, 2016; NEWELL AND PATERSON, 2010).

As touched upon in the previous section, the pace of technological change, in particular, continues to accelerate, and the ramifications of a multitude of emerging technologies trigger increasing socio-political debate and anxiety. For example, climate geoengineering, algorithms in the financial system, social media, big data, artificial intelligence, blockchain and cryptocurrencies, manufacturing automation, nanotechnology and genetic engineering – all have increasing and potentially far-reaching consequences for human society. This creates major new challenges for earth system governance scholars at the intersection of emerging technologies, environmental governance and politics.

Tremendous knowledge voids open up regarding impacts and opportunities of new technologies. For example, novel challenges arise regarding earth system governance issues linked to algorithmic decision-making in the global financial system, which may drastically increase the complexity and dynamics of patterns of financial investment in resource consumption and production systems. Privatization and secrecy of new technologies increasingly have major implications for the balance between public and private interests. Altogether, this points to overarching questions about how societies can make wise decisions about the use and governance of new technologies, and ensure that they sufficiently take account of potential consequences and risks for human societies and the global earth system. In the same way that global scale environmental impacts and risks now increasingly characterize contemporary society, so too are the impacts and risks of technologies increasingly global in scale (GALAZ, 2014). The intersection of these domains is a fundamental new frontier for earth system governance scholars over the next decade.

Across these diverse patterns and global trends, scholars identify common insights about the dynamics of transformation processes, including: the complex systems nature of transformations (e.g. nonlinearity, unpredictability, co-evolutionary dynamics, unintended consequences), the importance of temporal dynamics (e.g. lock-ins, path-dependence, interplay between incremental and transformative change), and the need to better understand spatial dynamics of transformations (COENEN, BENNEWORTH AND TRUFFER, 2012).

3.1.2 Governance and Transformations

Transformation is closely linked to the very definition of governance that is proposed in the initial Science and Implementation Plan, which refers to "[t]he interrelated and increasingly integrated system of formal and informal rules, rule-making systems, and actor-networks at all levels of human society (from local to global) that are set up to steer societies towards preventing, mitigating and adapting to global and local environmental change and, in particular, earth system transformation, within the normative context of sustainable development" (BIERMANN ET AL., 2009A). Of course, in recent years this agenda has broadened (Section 2.1.1).

Yet overall the role of governance in sustainability transformations remains underdeveloped and often ambiguous. Different angles may include:

- Governance *for* transformations (i.e. governance that creates the conditions for transformation in socio-technical-ecological systems to emerge),
- Governance *of* transformations (i.e. governance to actively trigger and steer a transformation process), or
- Transformations *in* governance (i.e. transformative change in governance regimes).

All three angles are important, but have different implications for understanding governance in relation to sustainability transformations.

The last decade of earth system governance research exploring forms, effects and complexity of governance lays an outstanding foundation for novel efforts to understand transformations in governance systems and human societies looking forward over the next decade. Moreover, earth system governance scholars take as a departure point that sustainability problems are deeply political, and sustainability transformations must also be seen this way (MEADOWCROFT, 2011; SCOONES, LEACH AND NEWELL, 2015; SMITH AND STIRLING, 2010). Transformations will be increasingly salient in many areas of earth system governance, including global governance systems (e.g. BIERMANN ET AL., 2012), responding to the Anthropocene (DRYZEK, 2016; GALAZ, 2014), and shaping the unfolding wave of global urbanization in sustainable directions. Furthermore, earth system governance scholars are ideally placed to draw on insights from other bodies of social science theory such as policy, institutional, economic and societal change to effectively leverage and build on existing knowledge about transformations in the social sciences.

Sustainability transformations will typically be difficult to understand looking forward because there may be "no obvious turning or tipping points ... for clearly indicating the before and after of a transformation" (WBGU, 2011). This may require changing the criteria used to evaluate unfolding success; for example, Van den Bergh, Truffer and Kallis (2011) state that "in order to support long-term structural shifts, policies may have to interact with many transformative changes as they unfold rather than being defined and fixed at some initial date". This raises questions about what transformations may look like over both short and long timeframes (e.g. years, decades).

Interestingly, a dichotomy is increasingly drawn in the literature between 'incremental' and 'transformative' change (e.g. KATES, TRAVIS AND WILBANKS, 2012), which can be useful as a simple heuristic, but is likely to belie a more complex reality. For example, Duit et al. (2010) argue that "at the end of the day, governance solutions for many of those problems rooted in complex systems dynamics will, as always, consist in incrementally implemented, heterogenic, and piecemeal mixes of policy instruments,

institutions, networks and organizations". Earth system governance scholars need to understand how both incremental and more radical change interrelate.

The deeply political nature of transformations, furthermore, poses challenges for governance such as dealing with redistributional impacts, powerful vested interests, the short-termism of policy and political cycles that discourages longer-term agendas, institutional fragmentation and deficits in representation. It also links closely to the other key contextual conditions of inequality, the Anthropocene and diversity. It raises questions about sources of agency, the role of the state, emergence and embedding of new norms, and tensions between singular or plural transformation goals. Yet, earth system governance also needs to consider contexts that are under-studied to date, such as authoritarian regimes and politically unstable settings (including those experiencing civil conflict); current theories may be vastly underprepared to explain such settings.

Lastly, tensions are evident in the ways scholars talk about the potential for shaping transformations, versus the open-ended, emergent, and to a large degree unpredictable nature of actual transformations in practice. This is reflected through the UN Sustainable Development Goals, which may be useful as a high-level driver, but at the same time should not create a 'cockpit' view where it is assumed that "top-down steering by governments and intergovernmental organizations alone can address global problems" (HAJER ET AL., 2015). Ultimately, it is vital to understand the interplay between top-down and bottom-up efforts for sustainability transformations (e.g. WESTLEY ET AL., 2011).

3.1.3 Conclusions

Although the initial focus within the earth system governance community was on earth system transformations, multiple forms of transformation are now unfolding in human society, which intersect in highly complex and dynamic ways. At the same time, calls to realize intentional transformations to sustainability are growing. Altogether, this deeply challenges earth system governance research to recognize and respond to a milieu of unfolding transformation dynamics. Many new questions arise about processes of change at all scales. Importantly, this demands a significantly future-oriented outlook encompassing analytical, normative and critical orientations. Earth system governance scholars are uniquely placed to interrogate the governance implications of both unintentional and intentional transformations with particular attention to their inherently political and contested nature.

KEY POINTS

- The deepening urgency of global sustainability and human development challenges is catapulting a focus on transformative change to the forefront of earth system governance.
- Transformations are deeply political and contested, which poses major challenges for earth system governance research.

- A tension exists between the emergent, bottom-up nature of transformations and efforts to steer or guide them. New approaches to governance research must interrogate and navigate these tensions.
- Sustainability transformations have significant implications for equity and social justice along with ecological concerns, but this intersection is vastly under-researched.
- Transformations may be fluid, shifting and complex phenomena that have no clear beginning or end. This suggests the need for evaluative tools that are iteratively revised, and encompass longer time horizons.

3.2 Inequality

Inequality is becoming a central academic and political discourse after decades of neglect (KLINSKY ET AL., 2017; MILANOVIC, 2011; OXFAM, 2016; PIKETTY, 2014; UNDP, 2013; WSSR, 2016). Inequality pervades almost all spheres of social life, from income distribution to gender, education, to the burdens of environmental harm or unequal access to opportunity or resources across different countries and socio-economic groups (RAGIN AND FISS, 2017). Thus, inequality is multi-faceted as well as intersectional, i.e. one form of inequality may influence and reinforce another (RAGIN AND FISS, 2017). Against this context, scholars face the challenge to develop research that sharpens our understanding of inequality as a theoretical concept and its concrete implications for earth system governance, while also acknowledging that the research community itself may be hampered by inequality.

3.2.1 Conceptualizing Inequality

Inequality and its opposite, equality, are contested concepts. A clear conceptualization of inequality is crucial in order to establish a common frame of reference in earth system governance research but at the same time difficult due to its multiple dimensions, causes, manifestations and consequences. In a very general formulation, inequality signifies differences in qualities between groups of persons, objects or circumstances (GOSEPATH, 2011).

Research to date has focused on the importance of economic inequality (the income disparities between individuals, groups and countries); social inequality (the differences between the social statuses of different population groups such as classes, gender or age groups); cultural inequality (the differences in status among identity-based groups); political inequality (the differentiated capacity for individuals and groups to influence decision-making processes and to benefit from those decisions); spatial inequality (i.e. the disparities in economic activity and income across spaces); and knowledge inequality, (i.e. the factors influencing access to and generation of knowledge; WSSR, 2016; DETRAZ, 2017).

Global economic inequality has decreased particularly due to poverty reduction in China and India (WSSR, 2016). Still, 15.6 percent of the world's people shared a total of 81 percent of global income, while the remaining 19 percent of the income had to suffice for the other 84.4 percent of human beings (WETTSTEIN, 2009). Within OECD countries income inequality is at its highest level, with the average income of the richest 10 percent of the population about nine times that of the poorest 10 percent: seven times higher than it was twenty-five years ago (KEELY, 2015). Inequality across individuals is even more staggering. Importantly, research underlines that economic inequality is likely to continue driving unsustainable patterns of global resource consumption (WILKINSON AND PICKETT, 2009).

In sustainability research, a key aspect of inequality is environmental or ecological inequality. Environmental inequality highlights the intersection between environmental assets and social hierarchies. It addresses environmental questions that focus on the unequal distribution of power, resources and burdens in society (PELLOW, 2000). Environmental inequality results in environmental unsustainability, degradation, resource conflicts (FAN, 2016) and circular cycles of poverty (DEUTZ, 2014). The poor and marginalized are the principal victims of environmental deterioration, which disproportionately affect their livelihoods and chances for survival (BARKER, SCRIECIU AND TAYLOR, 2008; COMIM, 2008; CLAPP AND DAUVERGNE, 2005; OKEREKE, 2008; PAEHLKE, 2001). Environmental risks tend to be transferred onto the least powerful, leaving these individuals and communities disproportionately vulnerable (ASH ET AL., 2009; NEWELL, 2005). The poor and disenfranchised tend to live in the areas with higher environmental hazards, which are most exposed to unpredictable and extreme climatic events, are the most reliant on local ecosystems to sustain their livelihoods and have the fewest assets to hedge against such environmental change. These vulnerable groups also tend to be marginalized and disenfranchised in the political processes deciding environmental outcomes at all levels of governance, both within and across societies. Likewise, scholars note that inequality of access to resources, particularly land ownership, allows the few to utilize such resources in ecologically unsustainable ways to the detriment of the many (MUROMBEDZI, 2016).

3.2.2 Inequality and Governance

Inequality in earth system governance is often the outcome of unjust procedural and distributive justice systems (DEUTZ, 2014; IKEME, 2003). International, global and national justice systems have increased inequalities (KLINKE, 2014; SPAGNUOLO, 2011) and disempowerment (GUPTA, POUW AND ROS-TONEN, 2015). Inequality is the seed, driver and consequence of unjust social and ecological systems (WILKINSON AND PICKETT, 2009, 2011). Poor governance in resource allocation and distribution systems leads to unfair distribution of environmental rights, duties, risks, hazards and harms. Earth system governance research is challenged to discover how inequality is embedded in the complex interactions of governance (actors, sectors, interests, forums, scales, technologies, etc.); within unpredictable natural systems; and in the context of competing economic (EHRESMAN AND OKEREKE, 2015) and political

pressures to allocate limited resources. Environmental inequality is also embedded in the diffuse and often contradictory processes, forces, outcomes of global and national politics (HYLE, 2016), finance, taxation and subsidies, and broader development trajectories (GUPTA AND VEGELIN, 2016).

Earth system governance architectures (BIERMANN ET AL., 2009A; BIERMANN, 2014) have the potential to challenge inequalities if adequately inclusive in their construction (ANDERSSON AND AGRAWAL, 2011). If not, these architectures risk locking in existing inequalities. Democratic governance systems that seek to distribute power among different actor groups in ways that curtail the power of any single individual or interest group can potentially reduce inequalities among individuals and groups. But democratic institutions may also be permeated with and entrench power inequalities among the various interest groups.

Although the body of research on inequality and sustainability governance is growing, more studies are necessary to understand how structural inequalities, power imbalances and intersecting axes of privilege and marginalization shape vulnerabilities to global environmental change and are shaped by them. Likewise, attention to the relationship between the intersecting forms of discrimination on the basis of age, class, race, caste, ethnicity, indigeneity, religion, (dis)ability and earth system governance needs to be strengthened (OLSSON ET AL., 2014).

3.2.3 Conclusion

Although often associated with income and wealth, inequality has multiple intersecting dimensions that drive and shape the ability of human societies to address environmental change in fundamental and complex ways. Importantly, inequality provides a context against which new and challenging questions emerge for earth system governance research. A promising way forward is to explore the consequences of inequality for the analytical lenses of the new Science and Implementation Plan. More specifically, inequality forces us to think more deeply about the way institutional architectures and different forms of agency may foster or combat existing inequalities. It confronts us with questions of the democratic quality of our societies in the context of big power discrepancies among different socio-economic groups. It calls for a more profound engagement with questions of justice and allocation. It invites us to rethink the ways in which we organize processes of anticipation and imagination. And, it calls for a careful consideration of proposals for change and their consequences for the adaptive capacities of all human societies worldwide.

KEY POINTS

- Inequality as a contextual condition for earth system governance research has multiple manifestations and consequences.
- Environmental inequality worsens the position of already vulnerable groups worldwide.

- Economic inequality is deeply interlinked with environmental unsustainability and intertwined in multiple ways with poverty.
- Inequality provides a context from which new and challenging questions emerge for earth system governance research.

3.3 Anthropocene

The Anthropocene refers to the idea that the earth has entered a new geological epoch characterized by humanity's collective transformation of the earth system (STEFFEN, CRUTZEN AND MCNEILL, 2007). The Anthropocene idea was first popularized by the atmospheric chemist and Nobel Laureate Paul Crutzen (2002), and the idea has subsequently attracted considerable attention in research communities as well as in public debate (BRONDIZIO ET AL., 2016). Proponents of the Anthropocene concept point to rapid changes in the world's population, patterns of material production and consumption, and consequential environmental degradation, particularly since the 'Great Acceleration' that began around 1945 with the end of World War II (STEFFEN ET AL., 2015A). Key changes in the earth system include heightened concentration of greenhouse gases, rapidly accelerating biodiversity loss, ocean acidification and the alteration of global nitrogen and phosphorus cycles (STEFFEN ET AL., 2015B). These changes, proponents argue, have moved the earth system beyond the parameters of the Holocene epoch, which began around 11,700 years ago when the last ice age ended. Geologists have commenced investigating whether the Anthropocene should be included in the geologic time scale (GTS). While a formal decision is yet to be made, a working group on the Anthropocene formed by the body that governs the GTS (the International Commission on Stratigraphy) has recommended its inclusion (ZALASIEWICZ ET AL., 2017). Whether or not it achieves official geological recognition, the Anthropocene has already come to serve as a fruitful but contested contextual condition for understanding ongoing changes in the earth system.

3.3.1 Conceptualizing the Anthropocene

A key challenge for demonstrating the relevance of the Anthropocene concept for research on earth system governance is whether it adds value beyond existing concepts, rather than merely being a fashionable label for long-standing concerns about environmental change (as some critics argue: AUTIN AND HOLBROOK, 2012). For many proponents of the Anthropocene idea, a distinctive strength of the concept is that it highlights a step change in humanity's interaction with the earth system. Thus the Anthropocene connotes not just an extension or intensification of existing environmental pressures, but a more fundamental shift because humanity's impact on social-ecological systems is now so great that it is altering basic earth system processes (HAMILTON, 2017), such as the global climate, flows of nitrogen and phosphorus between land, oceans and atmosphere, and the chemical composition of the oceans. Others argue that the Anthropocene should be viewed from a longer-term historical

perspective, as a continuation of humanity's environmental influence going back many centuries (e.g. to the colonization of the Americas; LEWIS AND MASLIN, 2015) or even back millennia to early agricultural practices (RUDDIMAN ET AL., 2015).

Beyond questions of scholarly relevance and dating, a range of commentators have criticized or voiced caution about the political and ethical implications of the Anthropocene concept. Key criticisms are that it: portrays an oversimplified and globalized vision of humanity (MALM AND HORNBORG, 2014; BONNEUIL AND FRESSOZ, 2016); collapses the distinction between humanity and nature or conversely produces a new but still unsatisfactory distinction between the two, as in narratives of human control over planetary systems (HAMILTON, 2017); fails to take into account the political dimensions of global environmental change (BASKIN, 2015). Lövbrand et al. (2015), while not rejecting the concept as a whole, warn against tendencies towards overgeneralizing and singularizing human agency that are implicit in some conceptions of the Anthropocene. A particular concern is that focusing only on humanity as a single entity tends to obscure the fact that the Great Acceleration has been driven largely by a much smaller proportion of the world's population (previously the wealthy countries of the global North, although increasingly also populous middle-income countries such as China and India). As a consequence, the Anthropocene concept exhibits a vague and ambiguous moral basis that makes it difficult to specify responsibilities of and for certain actors (MEISCH, 2016; ZELLI AND PATTBERG, 2016).

Against this backdrop, Lövbrand et al. (2015), argue that social sciences are well equipped to address tensions over singularity and diversity and over the society-nature divide by outlining multiple ways of framing humanity and nature. Others argue that the Anthropocene concept can and should embody a global perspective while remaining attuned to diversity: "the Anthropocene can be a useful conceptual frame only when it is viewed from a cross-scalar perspective that takes into account developments at local, regional and global levels, variant connections among these levels and issue domains, as well as societal inequality and injustice" (BIERMANN ET AL., 2016:342).

3.3.2 Governance and the Anthropocene

The distinctive character of the Anthropocene gives rise to the possibility that previous modes of governing environmental change may no longer be fit for purpose (GALAZ, 2014). Importantly, the Anthropocene idea reinforces the need to think not only about environmental governance in general, but specifically about *earth system* governance (BIERMANN, 2014). Pattberg and Zelli (2016) argue that the Anthropocene involves three major challenges for earth system governance: urgency, responsibility and complexity. These three challenges are not new to environmental governance but become particularly pressing when combined under the conditions of the Anthropocene.

Since the Anthropocene epoch is marked by the collective and accelerated transformation of the earth system towards unsustainability, there is unprecedented urgency for collective action in the pursuit of more sustainable societies. This raises important dilemmas about how to safeguard other values such as justice and democracy when urgent action is required, and how to build and maintain political support for radical technological and economic change. This is linked to the question about ethical foundations and criteria to inform decisions about where urgent action is to be targeted (MEISCH, 2016). A related dilemma is to ascertain whether it is possible to overhaul institutions completely within the time available. One critique is that "[t]he fundamental challenges to societal organization posed by the Anthropocene are, paradoxically, to be countered by many of the same institutions that have allowed the recent human conquest of the natural world" (LÖVBRAND ET AL., 2015:214), such as unregulated capitalist markets or governments that prioritize economic growth over environmental imperatives (see also DRYZEK, 2016). The urgency of responding to the planetary instability associated with the Anthropocene also raises questions about what kinds of governance responses should be prioritized: should societies aim to restore the earth system to the more stable conditions that prevailed in the Holocene epoch (see ROCKSTRÖM ET AL., 2009)? Or, given that many changes are now irreversible, is the task for governance to find new benchmarks and focus on how societies can adapt to the inevitability of an altered earth system (DRYZEK AND PICKERING, FORTHCOMING)?

Assigning *responsibility* for reducing risks to the earth system, and for remedying environmental loss and damage, becomes ever more difficult because unsustainable patterns of consumption are driven by a wide range of actors across many countries, including producers, consumers, investors and governments. Thus it is necessary to rethink, possibly through constructing new theories of justice, how subjects and objects of ethical responsibilities are re-defined in the Anthropocene (MEISCH, 2016; SCHMIDT, BROWN AND ORR, 2016) and to develop new forms of legal and policy instruments for attributing responsibilities for action (KIM AND BOSSELMANN, 2015; YOUNG ET AL., 2017; STEPHENS, 2017). A key question for earth system governance is how responsibilities for action should be distributed across different scales (e.g. through more centralized or polycentric approaches) and across different actors (e.g. state and non-state actors; BIERMANN, 2014). A related set of questions concerns the implications of the Anthropocene for humanity's collective responsibilities towards the earth system. Now that humans are unintentionally altering the earth system to its detriment, does this give rise to a responsibility to use their unprecedented technological capabilities to actively manage it, for example through geo-engineering the earth's climate to counteract the warming effects of greenhouse gas emissions? Or should responsibility be understood as one of collective restraint from radical intervention in the earth system (PRESTON, 2015), focusing instead on strategies to reduce humanity's ecological footprint?

Complexity reaches beyond questions of responsibility to include the multifarious interactions between society and non-human nature, and the possibility of non-linear changes (or state shifts) in the earth system (UNDERDAL, 2010; YOUNG, 2017). Wissenburg (2016) stresses that the Anthropocene brings together several different types of complexity, including the natural complexity of the planet's ecology, the psycho-social complexity of humans and their institutions, and the political or moral complexity of bringing both together in a meaningful way. This multi-faceted view of the earth system as a complex, interconnected system places considerable importance on understanding and governing key processes that regulate the system, including the climate, biodiversity, land use and global chemical flows. Of particular concern are dangerous state shifts that could be triggered by climate change, such as multi-metre sea-level rise or the collapse of the Amazon rainforest (LENTON, 2011). Thus it becomes necessary to find new ways of governing key earth system processes: not only those that have prominent, established multilateral institutions (such as the UN climate change and biodiversity regimes) but also those that lack extensive transnational governance, such as the global nitrogen and phosphorus cycles or marine plastic pollution. An Anthropocene perspective also points to the need to be attentive to interactions across multiple earth system processes and the distinctive governance challenges these raise (GALAZ ET AL., 2012). This relates to the question of institutional fit: to what extent does the complexity of governance systems (sufficiently) reflect the different complexities of their subject matters? (YOUNG, 2002, 2017)

Finally, complexity highlights the importance of science-policy interactions in governing the Anthropocene. Scientific expertise is crucial for understanding earth system processes and anticipating potential state shifts. The idea of planetary boundaries (ROCKSTRÖM ET AL., 2009) has been widely discussed both as a way of understanding how these processes interact to characterize the Anthropocene, as well as a guide for policymakers on what is needed to avoid dangerous thresholds in the earth system. However, some critics raise the concern that the Anthropocene could imply delegating too much power to experts and other elites at the expense of democratic processes (LEACH, 2013; BASKIN, 2015). Thus Lövbrand et al. (2015:214), building on the work of Swyngedouw (2013), warn of the dangers of a post-political ontology – a "socio-political arrangement that replaces ideological contestation and struggles by techno-managerial planning" – which may obscure the possibility of political transformation of societies.

3.3.3 Conclusion

The Anthropocene informs many of the research lenses in this Science and Implementation Plan. The idea of the Anthropocene itself foregrounds human agency, but in a way that complicates questions of responsibility and attribution, and relations between humans and non-humans. The question remains to what extent meaningful governance interventions can be crafted in an ever more complex and diverse world. The concept of the Anthropocene thus casts a new light on one of the key meta-theoretical debates in social sciences: the relationship between agency and structure

(ZELLI AND PATTBERG, 2016:241). The global scale of Anthropocene problems foregrounds challenges of designing appropriate architectures for managing those problems, while recognizing the enduring diversity of human communities (BIERMANN ET AL., 2016). This diversity and its associated inequalities in power and resources in turn ground the need to pursue just and democratic responses to the Anthropocene. Uncertainties about possible state shifts in the earth system place considerable demands on anticipation and imagination (BAI ET AL., 2016B). Finally, adaptiveness and reflexivity become particularly important in the Anthropocene. Dryzek (2016) argues that many of the risks to the earth system that characterize the Anthropocene are the product of 'problematic path dependencies' in institutions that emerged in the Holocene which fail to take account of their environmental impacts. What is needed in response is to build capacity for ecological (or ecosystemic) reflexivity (DRYZEK, 2016:945; see also DRYZEK AND PICKERING, FORTHCOMING).

KEY POINTS

The Anthropocene concept encapsulates the idea that humanity now exerts a pervasive influence on the earth system.

- While the Anthropocene concept remains debated, there is growing recognition that its use in research and policy must not only reflect global interconnectedness but also acknowledge diversity across human societies.
- The Anthropocene poses major challenges for earth system governance due to the urgency of global environmental risks, uncertainty about how the earth system will respond to human influence and the complexities associated with addressing the multiple drivers of those risks.
- Key issues for governance in the Anthropocene include: evaluating the potential and limitations of coordinated and polycentric approaches for anticipating and responding to risks to the earth system; and identifying equitable and democratically legitimate ways of allocating responsibilities for limiting the adverse impacts resulting from earth system disruption.

3.4 Diversity

As a contextual condition, diversity influences governance research and practice. Governance refers to modern forms of steering (BIERMANN ET AL., 2009A), thus it is important to consider that the different directions to which societies can be steered are results not only from power struggles but also from diversity in world views, knowledge systems, values and norms, as well as in ecosystems. Moreover, as earth system governance researchers live and work in different contexts and come from different disciplinary backgrounds, such facts influence how we produce, validate and diffuse knowledge, as well as the way we teach and educate youths and are involved in governance capacity building. These latter dimensions will be further explored in

Section 5. Below, we explore diversity as an ontological standpoint and empirical condition for governance of earth systems, emphasizing that diversity is a norm that calls for participation of different actors in governance processes, but also and most importantly that diversity in norms, world views and knowledge systems affects governance.

3.4.1 Conceptualizing Diversity

The notions of the Anthropocene and planetary limits, even if controversial, bring to our attention the fact that we live on one planet. However, while the planet is one, the world is not: we live in many *worlds* (INOUE AND MOREIRA, 2016). Human existence is experienced in very diverse and sometimes mutually exclusive geographical, economic, cultural, societal, spiritual and political realities. Such "being in the world" conditions our reading of the world: we simultaneously live in and make worlds (TICKNER AND BLANEY, 2012, 2013).

Furthermore, ecological diversity conditions and is conditioned by social diversity, and as such it is an important consideration for governance. For many indigenous peoples, for example, there is no dichotomy between society and nature (INOUE AND MOREIRA, 2016). Concepts like socio-biodiversity are used by Brazilian socio-environmental organizations (among others) to point out that biodiversity richness is connected to social diversity. The idea of "biocultural diversity" was developed by ethnobiologists who introduced this concept to inextricably link the variation within ecological systems to cultural and linguistic differences (MARTIN, MINCYTE AND MÜNSTER, 2012). Simultaneously, the notion that there is no place on Earth that has not been impacted by humans has brought to the fore debates about the end of nature (WAPNER, 2010, 2014), hybridity (RUDY AND WHITE, 2014) and about the agency of non-humans and social nature (BURKE ET AL., 2016). Thus, diversity leads us to think not only about diversity in society, but also to think of "many natures" (INOUE AND MOREIRA, 2016). As the society-nature dichotomy loses centrality, the idea of non-human agency increases the complexity of governance.

Governance research and practice are deeply conditioned by this. Several broad trends are already highlighted here, including the deepening of inequalities, technological changes, migrations and geopolitical conflicts. These trends evidence the challenges of governance of earth systems and governance research on one planet with many *worlds*. Moreover, we live in times of power shifts. Nye (2011:xv) points to a power transition among states, characterized by the emergence of China as well as by a power diffusion away from states to non-state actors. These trends and power shifts influence the way research is carried out and how agents establish and act within different governance architectures.

Diversity within and among societies comes to the forefront in times of power shifts and large-scale technological and socio-environmental change. Diversity is fundamental to earth system governance research and practice: it is a core contextual

condition, an instance, a state or a fact of life that refers to differing elements of a whole. It signals the existence of different types of things or people as parts of something, or simply to a state of being varied. More recently, diversity has been given normative nuances: it refers to a norm or agenda to include people of different races, cultures, genders, regions, organizational and socio-economic conditions into a group, a policy or governance arrangements. As a result, diversity has been embraced as an emerging norm by many organizations. For Mignolo, there is a world composed of multiple worlds. In this view, the claim for diversity is a universal project, or *the right to be different because we are all equals* (MIGNOLO, 2002:263); herein, diversity is a norm that we as scholars acknowledge – and an ontological standpoint.

Some scholars' ontological standpoints are rooted in diversity (MIGNOLO, 2002; ESCOBAR, 2007, 2016). Escobar (2016) considers that speaking of multiple *knowledges* means speaking about *worlds*. He states that we should look at reality as a pluriverse, or multiple 'reals' contrasting with the assumption of the '*One-World World*', or a single reality encompassing multiple cultures, perspectives or subjective representations (ESCOBAR, 2016:22). Social norms and the generation of knowledge are interconnected, and deeply embedded with power. Diversity and power imbalances result in multiple ways of knowing that often do not count as knowledge (SANTOS, 2016). This Science and Implementation Plan acknowledges that there are many knowledge systems, ontologies, epistemologies and research methodologies and stimulates dialogue among them. In this sense, the realms of diversity for governance research are infinite (SANTOS, 2016). The earth system governance community of researchers and practitioners live in different regions of the planet, conceptualize different (understandings of) *worlds*, focus on varied elements of governance and come from different disciplinary and institutional contexts. This is an invaluable asset for governance research.

Diversity results, among other things, from differences in material endowments, political contexts, genders and global political-economy realities. Different ideas, perceptions, cognitions, understandings and opinions about something can also be considered diversity. Santos (2016) states that diversity relates to modes of being, thinking and feeling, to conceptions of time and to how people face the past and the future, and collectively organize life, produce goods and services, or have fun – as well as to how relationships among humans and between humans and non-humans are conceived. Consequently, different norms emerge and affect governance. Earth system governance is one of the areas where normative diversity is most evident.

3.4.2 Diversity and Governance

All forms of diversity affect the setting of global norms and priorities of environmental policy and thus affect the conceptualization of (environmental) justice across the globe. The previous Earth System Governance Science and Implementation Plan has recognized the value of normative diversity. However, this diversity is an important but

insufficiently developed and under-theorized area of earth system governance research (HANSEN, RAMASAR AND BUCHANAN, 2014).

Earth system governance research should give prominence to the drivers and nature of diverse and (often) conflicting norms. Norms are accepted standards, principles of behaviour or claims as to how things ought to be. Norms may be constitutive (creating standards or principles), regulatory (establishing laws and regulating behaviour), prescriptive (directing acceptable types of action) or visionary (prescribing a desired state of affairs). Norms are dynamic and have life cycles – from emergence to demise or rebirth (FINNEMORE AND SIKKINK, 2005). Norm life cycles are influenced by other norms, actor interests, contexts, etc. The underlying sources, dynamics, tensions and consequences of normative diversity and the contestation of norms contribute to the formation, longevity and demise of governance architectures and environmental policies.

Normative diversity relates to desired or contested governance outcomes. Diversity also connects to desired methodologies of governance that influence outcomes: the inclusion of actors, voices and knowledge systems that are traditionally excluded, consensus, deliberation (DRYZEK AND PICKERING, 2017), coproduction, top down and bottom up, scenario building, imagining futures, decentralization (DENNIS, ARMITAGE AND JAMES, 2016), inclusive conservation (MATULIS AND MOYER, 2017), community management (VAN PUTTEN ET AL., 2016), science in governance (NILSSON ET AL., 2017; MONTANA, 2017; MATULIS AND MOYER, 2017), etc. In this direction, we need to identify, understand and theorize normative diversity and how it interacts with governance practice and research in different ecological contexts. It is important to consider how societies and ecosystems are intertwined, and that diverse socio-ecological systems require specific responses.

As stated, diversity means that there are multiple knowledge systems. The earth system governance community provides a forum for exchange among different forms of knowledge from different (and not mutually exclusive nor homogenous) groups or sectors that can contribute to earth system knowledge. These include, but are not limited to, the scientific community, policymakers, civil society, think tanks, business, indigenous peoples and the global poor. Tengö et al. (2014) argue that it is necessary to promote dialogue among different knowledge systems for improved policy and to support mechanisms for learning and decision-making (TENGÖ ET AL., 2014:589). The challenge here is to balance the breadth and depth of the various forms of knowledge from various groups or sectors with a desire to present timely answers to pressing environmental problems. While including all viewpoints, all voices and all interests may provide for high levels of equality, it will unlikely result in an efficient process of decision-making or knowledge creation. Yet, excluding viewpoints, voices and interests from dialogues will result in power imbalances. Earth system governance research is challenged to seek forms of knowledge creation and governance solutions that are as inclusive as possible within the functional boundaries of their research projects.

While diversity in norms and knowledge systems can be an asset, it can also hamper just and ecologically sound governance. Rather than relying on the dominant or most abundant knowledge, policymakers, civil society and the business sector may select different understandings of phenomena to support their views and interests. Diversity in knowledge allows policymakers and the business sector to use the knowledge that best suits their interests in making decisions. Different understandings in the science community of, for instance, the risks of climate change have long fuelled climate scepticism as well as hampered policy action (HOFFMANN, 2015). But even a similar piece of knowledge may transfer differently and may be used differently merely because of diversity in the subject and medium of communication. A scholar's gender, nationality, institutional affiliation and so on, may give them more or less credibility in the eyes of receivers. Likewise, diversity in communication channels – a peer-reviewed journal article, a blog post, a video clip, a one-on-one discussion, etc. – may affect how knowledge is received and used (LAURING, 2009).

Diversity in knowledge systems means that governance as a set of rules and practices, or institutions, is a result of a process or processes that reflect diverse values and world views. Such processes can be more or less inclusive. The paradox here is that too much diversity runs the risk that for every argument in support of a claim, arguments can be made against it (and vice versa), but that too little diversity marginalizes and even excludes viewpoints and interests. Consequently, different courses of action are possible, depending on the actors and power relations among them. Typical forums for action that earth system governance scholars engage with are governmental organizations, community groups, academic institutions, non-governmental organizations and the business sector. Each of these forums may consider different types of action as more desirable or more suitable to achieve specific ends. The challenge is how to create and maintain decision-making processes that are at the same time inclusive and efficient. We need to better analyse, theorize and criticize how diversity affects earth system governance practice.

3.4.3 Conclusion

Diversity means that we live in many worlds, as such the realms of diversity are infinite, however, we also live on one planet. Researchers increasingly recognize that social and ecological systems are interweaved, thus social and ecological diversity are mutually constitutive and affect governance practice and research. Explaining and understanding how diverse knowledge systems, world views, socio-ecological systems and norms affect the conceptualization of governance as well as how they result in different possible courses of action for governance are important dimensions of earth system governance research.

We should consider the world-making effects of our theories and concepts and what is part or not part of our worlds, what counts or not, which ways of knowing are viewed as knowledge or not. This has implications for the inclusivity or exclusivity of both research and governance practices. At the same time that diversity can be stimulating

and enriching, there are risks. Diversity in normative hierarchies, knowledge systems, ideological and world views, as well as in terminology, and sometimes in the diverse meanings of similar terminology, as well as diversity in understandings of validity and generalizability of research findings within different paradigms, across scales, temporal and geographical contexts, sectors and forums may result in distinct research 'cultures' competing against each other, instead of looking for bridges in understanding. Hence, diversity is both a challenge and an opportunity for earth system governance to navigate this pluralism.

KEY POINTS

- Diversity refers to ways of being, valuing, knowing and doing, resulting in differences in world views, norms, knowledge systems. As such, diversity conditions governance research and practice.
- Normative diversity is an important but insufficiently developed and undertheorized area of earth system governance research.
- As the society-nature dichotomy increasingly fades, we should consider governance responses in the context of the diversity of socio-ecological systems.
- Diversity is both a challenge and an opportunity for earth system governance research.

4

Research Lenses

In this section, we elaborate upon the five sets of *interconnected research lenses* that constitute the central element of the Earth System Governance Research Framework, as introduced in Section 2. This section builds on the elaboration in the previous section of the contextual conditions that constitute part of the research framework. This section discusses each coupled research lens by first introducing each one then elaborates upon the current understanding and knowledge. We then explore long-standing and emerging interlinkages and productive tensions between each set of coupled concepts, and how each coupled research lens engages with and can be considered in light of our four contextual conditions. We conclude by identifying some timely research questions in each case.

4.1 Architecture and Agency

4.1.1 Introduction

This research lens focuses on understanding the institutional frameworks and actors implicated in earth system governance and how these institutions and actors resist or respond to change and evolve over time. It combines two previously separate As: *Architecture* and *Agency*. Over the last decade, researchers studying governance have increasingly highlighted the interaction between architecture and agency within governance systems. Combining these topics as a coupled research lens offers new opportunities for understanding dynamics and change in governance systems and the actors herein, as a key ambition of the new Earth System Governance Science and Implementation Plan.

4.1.2 Architecture

Governance architecture refers to "the interlocking web of widely shared principles, institutions and practices that shape decisions at all levels in a given area of earth system governance" (BIERMANN ET AL., 2009A: 31). This has been an important focus of earth system governance research over the last decade. Three themes that have been particularly prominent are: fragmentation, complexity and polycentricity.

Fragmentation research has studied patterns of integration and decentralization in global environmental governance (BIERMANN ET AL., 2009B; BIERMANN, 2014; KEOHANE AND VICTOR, 2011; ZELLI AND VAN ASSELT, 2013; ZÜRN AND FAUDE, 2013). It has considered the growing prominence of 'private' governance (e.g. CSR, self-regulation, certification; AULD, RENCKENS AND CASHOREET, 2015; VAN DER VEN, 2015), the role of partnerships between state and non-state actors (KRAMARZ, 2016; PATTBERG, 2010; PATTBERG AND WIDERBERG, 2016; SZULECKI, PATTBERG AND BIERMANN, 2011), and implications for the legitimacy of global governance systems (BÄCKSTRAND AND KYLSÄTER, 2014; KARLSSON-VINKHUYZEN AND MCGEE, 2013). More recently, scholars have turned to considering how to respond to fragmentation, including ways of managing fragmented governance systems (VAN ASSELT AND ZELLI, 2014), particularly

through attention to interactions between different regimes within and beyond the environmental domain (JINNAH, 2014; JINNAH AND LINDSAY, 2016; VAN ASSELT, 2014).

Complexity is also an important lens for analysing governance systems, from local to global scales (DUIT ET AL., 2010; DUIT AND GALAZ, 2008; OBERTHÜR AND STOKKE, 2011; UNDERDAL, 2010; ZELLI AND PATTBERG, 2016). Complexity has long been a defining feature of environmental governance, and it is now becoming an explicit topic of analytical study in earth system governance research, especially in light of increasing interest in regime complexes (ABBOTT, 2012; KEOHANE AND VICTOR, 2011; ORSINI, MORIN AND YOUNG, 2013) and network analysis (KIM, 2013). Complexity in governance architectures is likely to continue to be a key theoretical topic in earth system governance research, particularly with continued attention to institutional interplay between environmental and non-environmental domains (e.g. global trade, security, technology; JINNAH, 2014; VAN ASSELT, 2014) and increasing attention to systemic global risks resulting from these cross-sectoral, cross-scale interdependencies (GALAZ, 2014; GALAZ ET AL., 2017, 2016, 2014; VAN ASSELT, 2014; VAN ASSELT AND ZELLI, 2014).

Furthermore, there is strong emerging research and policy interest in understanding complex interactions under the Sustainable Development Goals (KANIE AND BIERMANN, 2017; BOWEN ET AL., 2017; GRIGGS ET AL., 2017; NILSSON, GRIGGS AND VISBECK, 2016), and regarding tipping points in planetary boundaries (GALAZ ET AL., 2016). Governance responses to complexity build on a rich heritage of earth system governance research on issues of fit, interplay and scale in the design of governance (YOUNG ET AL., 2008). Research has focused on responses to complex architectures and their effectiveness, including policy coherence and integration (JORDAN AND LENSCHOW, 2010; SCOBIE, 2016), interplay management (OBERTHÜR AND STOKKE, 2011; OBERTHÜR, 2009), orchestration (ABBOTT ET AL., 2012, 2015) and hierarchization (KIM AND BOSSELMANN, 2015; YOUNG ET AL., 2017; UNDERDAL AND KIM, 2017; BIERMANN, KANIE AND KIM, 2017; KOTZE, 2016). Governance across scales and interactions between scales is also an increasingly important focus of recent enquiries into architectural forms and arrangements (GORDON AND JOHNSON, 2017).

Polycentricity is a topic that is rapidly gaining prominence in scholarly debates about environmental governance. Originally proposed in the 1960s and 1970s (ALIGICA AND TARKO, 2012), research on polycentricity has recently been experiencing resurgent interest in several domains of earth system governance, including climate change (DORSCH AND FLACHSLAND, 2017; JORDAN ET AL., 2015; OSTROM, 2009, 2010A), water (HUITEMA ET AL., 2009; PAHL-WOSTL AND KNIEPER, 2014), biodiversity (MORRISON, 2017; NAGENDRA AND OSTROM, 2012) and regarding the interplay of multiple domains (GALAZ ET AL., 2012). Polycentricity refers to governance systems involving multiple coordinated but independent centres of decision-making across sectors and scales (ALIGICA AND TARKO, 2012; OSTROM, 2010A). These centres could consist of single actors or clusters of multiple actors that possess power and authority for making

certain types of decisions. Importantly, a key factor distinguishing polycentricity from fragmentation is the greater degree of interaction between decision-making centres (PAHL-WOSTL AND KNIEPER, 2014). Scholars are now seeking to deepen the conceptual foundations of polycentricity, moving beyond description to explore its analytical and normative utility (ALIGICA, 2014; ALIGICA AND TARKO, 2012; DORSCH AND FLACHSLAND, 2017; JORDAN ET AL., FORTHCOMING). Polycentricity is salient to earth system governance research for analysing whether and how fragmented and complex governance systems may come to successfully govern environmental issues (VAN LEEUWEN, 2016). It also resonates with the concepts of regime complexes (ABBOTT, 2012; KEOHANE AND VICTOR, 2011) and orchestration (ABBOTT AND SNIDAL, 2010), although identifying exactly how these ideas relate and interact requires further research. Thus, while polycentricity is an emerging concept with analytical promise, it remains under-theorized.

4.1.3 Agency

A key starting point for questions of agency is: who are agents in earth system governance and what roles do they play? Who acts and in whose name, and to further what aims? And importantly, how are agents constituted (through what means, methods and political processes)? Traditionally, questions of agency have centred on actors such as states (local, state/provincial, national; WBGU, 2011), international bodies (e.g. UN, World Bank, development banks), the private sector (e.g. industries, transnational corporations), environmental NGOs (both domestic and international), scientists, indigenous peoples and citizens. Over the last decade of earth system governance research, there has also been growing attention to intergovernmental institutions (e.g. European Union, trade regulators, standard-setting bodies; MITCHELL, 2013), international bureaucracies (JINNAH, 2014; BAUER ET AL., 2012; BIERMANN, 2009C), global financial investors and different types of 'non-state' actors (BÄCKSTRAND ET AL., 2017; KUYPER AND BÄCKSTRAND, 2016; SCOBIE, 2017A) including transnational networks (BULKELEY, 2014; CHAN ET AL., 2015; WIDERBERG AND PATTBERG, 2017) and the agency of global norms and their power to shape domestic policy especially in weaker societies and small-island developing states (SCOBIE 2017A, 2017B). There is growing attention to 'new agents' that have been traditionally under-studied, such as small-to-medium enterprises (SMEs) (BURCH ET AL., 2016), cities (KRAAS ET AL., 2016; NCE, 2016), voluntary governance initiatives (VAN DER VEN, 2015), and to groups at risk of being disproportionately affected by escalating environmental impacts and societal transformations (e.g. low socioeconomic groups, women, ethnic minorities, displaced people, indigenous groups, vulnerable sectors in developing countries; SCOBIE, 2013).

Finally, it is also necessary to better understand the role of media and social media, especially given allegations of 'post-truth' societies, as well as celebrity culture seeking to influence debates about environmental issues such as climate change. And more broadly, a focus on non-traditional and otherwise 'hidden' forms of agency and actorness is as crucial as those more readily seen.

The complex and changing array of actors in earth system governance leads to shifting patterns of authority and power, creating new domains, configurations and dynamics in environmental governance (JINNAH, 2017; NEWELL, PATTBERG AND SCHROEDER, 2012). This raises pressing questions about how authority and power are constituted, with what effects, and the interactions between diverse forms of agency (BULKELEY ET AL., 2014; GREEN, 2014; HICKMANN, 2016, 2017). Such interactions are multidimensional in their complexity, whereby actors may create, maintain, disrupt and modify the institutional structures, mandates and outcomes of which they are a part or of others within wider governance communities. Agency interactions include norm creation and diffusion, orchestration, regime creation, modification and demise. These interactions lead to questions relating to the relative power of the actors involved and the nature and implications of their actions in governance, including: the ethical (legal and fiduciary), normative (transparency, equity, accountability, inclusiveness), technical (effectiveness, sustainability), temporal (present and future consequences), spatial and scalar (state/non-state, global/international, geographical, economic, political, uni-/multi-/interdisciplinary). Orchestration, frequently used by international organizations when they engage intermediary actors to influence a target actor (ABBOTT ET AL., 2012; SCHLEIFER, 2013), raises new legitimacy questions (BÄCKSTRAND AND KUYPER, 2017) and has been a particular area of legitimacy studies in the earth system governance community (ABBOTT ET AL., 2015; ABBOTT AND BERNSTEIN, 2015; ABBOTT AND SNIDAL, 2010).

4.1.4 Interplay between Architecture and Agency

The interplay between architecture and agency opens up novel opportunities for studying institutional dynamics, relationships and change in governance systems. Earth system governance scholars increasingly point to the dynamic nature of institutional structures (YOUNG, 2010), and the importance of understanding relationships between actors and structures within evolving governance systems (BEUNEN, PATTERSON AND VAN ASSCHE, 2017; BEUNEN AND PATTERSON, 2016; SCOBIE, 2016). Institutional structures condition the behaviour of actors, but actors can also question, disrupt or modify institutional structures and thus cause them to change (BLOOMFIELD, 2017; LAWRENCE, SUDDABY AND LECA, 2009). It is also crucial to consider the interplay between structures, practices and agents that keep up unsustainable practices. Agency is important for learning about processes of creating governance architectures, their persistence or failure, and how they can be adapted to meet changing needs and expectations.

Understanding institutional change is a topic that earth system governance research needs to take on as a key focus. Scholars outside the earth system governance community have convincingly argued that current theories of institutional change are lacking, because they emphasize either stability (e.g. dynamics of self-replication) or radical change (e.g. in response to crisis), but fail to suitably explain more gradual and evolutionary modes of change that are arguably most common (MAHONEY AND THELEN, 2010; THELEN, 2009). In light of urgency of climate change and many other

sustainability and development challenges, there is increasing attention to innovation in governance (AULD ET AL., 2014; JORDAN AND HUITEMA, 2014A, 2014B), and overcoming path dependency and lock-in (e.g. SETO ET AL., 2016) in governance systems that are no longer fit for purpose to solve the problems at hand, at global to local scales (BIERMANN ET AL., 2016, 2012). Tackling this theoretical problem places earth system governance research at the forefront of institutional scholarship generally, because, as Hall (2010) surmises, the institutions literature has traditionally focused on exploring how institutions shape behaviour (a 'first-order problem') and is only now starting to shift towards exploring how institutions themselves change (a 'second-order problem').

Another key challenge for earth system governance research is understanding the implications of the Anthropocene for architectures and agency. The changing boundary conditions for environmental governance systems caused by the Anthropocene (e.g. potential planetary thresholds, nonlinear climatic changes) may cause governance systems to fail. Furthermore, in the global context of pressures on multilateral global problem solving, path-dependent domestic political systems, growing social inequality and threats to human development, addressing issues of institutional decay and renewal becomes a key imperative (FUKUYAMA, 2014). Here, questions about institutional adaptiveness and reflexivity (DRYZEK, 2016; GALAZ, 2014) and transformations in governance systems (BIERMANN ET AL., 2012; PATTERSON ET AL., 2017) become key topics. This is equally so for the other contextual conditions explored in the preceding section.

4.1.5. Linkages with Contextual Conditions

Table 2 overleaf illustrates how the two key elements of the new Earth System Governance Research Framework (contextual conditions and research lenses) can come together to generate timely and pressing research questions.

Architecture and Agency	
Contextual conditions	
Transformation	The pathways through which structures, regimes, institutions and actors authoritatively guide, shape or block societal transformations
Inequality	Analysing how architecture and agency entrench or disrupt global to local patterns of inequality, and/or inequality of interactions between agents in each governance regime, institution and domain
Anthropocene	The kinds of governance systems at scales from local to global needed in the Anthropocene, and how existing governance systems innovate or are being renewed to bring this about
Diversity	How existing and newly emerging complex interactions among earth system agents and architectures contribute towards better environmental outcomes, in light of diversity and pluralistic world views

Table 2
The ESG Research Framework: interplay between research lenses and contextual conditions – Architecture and Agency

4.1.6. Research Questions

Several key research questions emerge regarding architecture and agency (and the interlinkages between them) for earth system governance research in the next 5-10 years. These include, among others:

- What are the implications for earth system governance of polycentricity and long-standing and growing diversities and power disparities among agents? What are the analytical and normative implications of this? How can the performance of complex/fragmented/polycentric systems be evaluated?
- How are environmental issues influenced by complex global networks across sectors, scales and decision-making arenas, and what are the implications for earth system governance? How are shifting dynamics of agency impacting the ways in which institutions and architectures are evolving?
- How, why and with what implications are shifts in authority and power in earth system governance occurring (e.g. new actors emerging, state-business-society interactions, hidden actors)?
- What is the continuing and evolving role of the state in the complex, connected and rapidly changing milieu in which earth system governance occurs? In particular, what is the role of the state when it comes to societal transformations, such as in response to climate change and rapid global urbanization?

- What kinds of governance architectures at scales from local to global are suitable for governance in the Anthropocene, and how can existing governance systems innovate or be renewed to bring this about?
- What are the determinants and what is the value of measuring effectiveness and efficiency in environmental agency and architectures? How can the interdisciplinarity of the earth system governance community contribute to finding pathways for more effective action and architectures at different scales of governance?

4.2 Democracy and Power

4.2.1 Introduction

Democracy worldwide is under pressure from new configurations of power within states, notably the resurgence of populism and authoritarianism, often with a strident anti-environmental tenor (BOMBERG, 2017). Political currents at the national level may in turn have far-reaching implications for the international community's capacity to solve collective problems. In these conditions it is imperative for future research in earth system governance to examine whether new conceptions of democracy and power can help make sense of, and craft responses to, these trends. Earth system governance research must also contend with the fact that the exercise of power extending well beyond conventional political institutions may influence global environmental change, not least through the ways in which business interests and dominant discourses shape patterns of production and consumption. Any interrogation of democracy must also challenge the assumption that, prior to the emergence of new threats and pressures, meaningful democracy was already being widely practiced, even though many societies classed as 'democracies' fall well short of democratic ideals.

4.2.2 Democracy

While the previous Earth System Governance Science and Implementation Plan touched on democratic concerns through the themes of accountability and agency, it did not include democracy as a standalone theme. The extension of the accountability theme to include legitimacy enabled the project to encompass a broader range of concerns relevant to democracy, including the inclusion of affected interests in decision-making, the quality of deliberative processes, and the transmission of citizens' concerns to authoritative institutions (BIERMANN AND GUPTA, 2011). Nevertheless, for the reasons set out above, it is timely for the project to engage more directly and explicitly with democracy, even as it continues to address still pressing questions around sources and mechanisms of accountability, including calls for ever more transparency (GUPTA 2010; GUPTA AND MASON, 2014; GUPTA AND VAN ASSELT, 2017; KRAMARZ AND PARK, 2016).

Democracy bears on earth system governance at all levels: global, regional, national, sub-national and local. Earth system governance has a special concern with global governance, and so with global democracy. Despite a burgeoning literature on global democracy (HELD, 1995; ARCHIBUGI, KOENIG-ARCHIBUGI AND MARCHETTI, 2011), relatively little literature has addressed global democracy explicitly from an earth system governance perspective (for exceptions see DRYZEK AND STEVENSON, 2011; STEVENSON AND DRYZEK, 2014). This literature underscores, however, that claims for global democracy may be advanced even in the absence of some features that are often taken to be defining aspects of democracy at other levels (such as elections or a well-defined demos). At the same time, the Earth System Governance Project also welcomes contributions that are sceptical about the possibility or desirability of global democracy (e.g. KEOHANE, 2015). Furthermore, whatever the prospects for global democracy, strengthening democratic institutions at national and sub-national levels is crucial for securing what could be called *earth system democracy* worldwide. The intersections between global, national and local democracy are particularly important to study, not least because the legitimacy of national representatives in multilateral fora depends on the legitimacy of domestic processes for forming collective preferences. Similarly, democracy can be understood not only as a quality of state institutions, but also as extended to non-state actors and hybrid forms of governance.

The relationship between democracy and sustainability has been a longstanding theme of environmental political theory. From the 1980s onwards, theories of ecological (or green) democracy emerged to explore – and seek ways of resolving – potential tensions between democratic processes and environmental outcomes (see for example e.g. DRYZEK, 1987; GOODIN, 1992; ECKERSLEY, 1992). Public involvement in environmental decision-making is widely seen to improve the quality of those decisions, particularly by harnessing the knowledge of communities affected by environmental concerns or those with experience in managing environmental problems (ARIAS-MALDONADO, 2007). But, given that citizens often accord relatively low priority to environmental matters compared to other policy issues, it remains contested whether democratic institutions produce pro-environmental outcomes more reliably than autocratic or technocratic forms of decision-making. This makes the analysis of environmental governance in non-democratic settings likewise essential (e.g. BÖHMELT, 2014). The tension between democracy and sustainability has become particularly acute with the rise of populist leaders espousing climate science denial and broader anti-environmental views. This raises the further concern whether earth system governance can simultaneously attain input legitimacy (in relation to decision-making procedures) and output legitimacy (in relation to institutional outcomes; see generally BÄCKSTRAND, 2006). A particular focus of continuing research in this context is how to secure more accountable state, non-state and hybrid governance arrangements, and what the transformative potential of transparency herein is, with regard to both empowerment and improved sustainability outcomes (see generally, GUPTA AND MASON, 2014; KRAMARZ AND PARK, 2015).

Such research can also occur in the context of recent renewal of interest in the 'dilemma' of green democracy (WONG, 2016). However, the challenges are conceptual as well as practical. It is important to consider, for example, whether the conditions of the Anthropocene make it harder to secure democracy and sustainability simultaneously, or whether the very concept of democracy (and its relationship to sustainability) now needs to be rethought in the light of the Anthropocene (ECKERSLEY, 2017). Or whether and how the tensions between democracy and sustainability in earth system governance are more or less acute across different policy areas and governance levels, whether different varieties of democracy (e.g. corporatist or adversarial systems) are more adept at managing those tensions, or how articulations of ecology and democracy in different cultures yield new insights (KOTHARI, 2014). Thus, whether or not democracy is valued instrumentally (as a means to achieve better governance outcomes) or in its own right, much remains to be known about what is needed to secure democracy in earth system governance. Most eco-democratic innovations focus on the domestic level, although there have been some examples at the global level. These include efforts to promote the inclusion of civil society in multilateral environmental negotiations (BETSILL AND COREL, 2008; BERNAUER AND BETZOLD, 2012), institutionalization of procedural environmental rights (as in the Aarhus Convention: see MASON, 2010), transnational initiatives to strengthen transparency and accountability (GUPTA, 2010; BIERMANN AND GUPTA, 2011; KRAMARZ AND PARK, 2016) and deliberative initiatives to engage the views of citizens around the world on environmental issues, such as the World Wide Views initiatives on climate change and biodiversity (WORTHINGTON, RASK AND MINNA, 2013; RASK AND WORTHINGTON, 2015). Yet each of these has its limitations. So, for example, the process of creating the Sustainable Development Goals (SDGs) was accompanied by widespread consultation with civil society, yet questions remain about the depth of public engagement and its influence on the final set of goals (CHASEK AND WAGNER, 2016; GELLERS, 2016).

The inclusion of non-state actors and discourses has been a major theme of research in earth system governance that draws on theories of deliberative and stakeholder democracy (DRYZEK AND STEVENSON, 2011; BABER AND BARTLETT, 2015; BÄCKSTRAND ET AL., 2010). Although the involvement of non-state actors is often seen as essential for democratizing global environmental governance, questions remain about the extent to which the internal practices of non-state actors reflect norms of democratic legitimacy, including inclusive and high-quality deliberation (BÄCKSTRAND AND KUYPER, 2017). A major challenge for democratization is how to ensure the inclusion of marginalized or under-represented groups, including indigenous peoples, women, future generations and non-human entities such as animals and ecosystems. A further major area for earth system governance is whether and how multilateral environmental knowledge assessments should be democratized by opening up their practices to more diverse forms of knowledge (CORNELL ET AL., 2013; SANTOS, 2014, 2016).

4.2.3 Power

Power (as expressed in domination) might seem as though it is something to be resisted. However, power can embrace 'power to' overcome vested interests in order to bring about environmental reforms, as well as 'power over' marginalized groups exercised by elites. Thus Barnett and Duvall (2005:42) define power as the "production, in and through social relations, of effects that shape the capacities of actors to determine their circumstances and fate". In this light, dealing with power is inescapable in any kind of governance. An earth system governance perspective can add specific insights to more general debates about the role of power in governance, such as how the way in which environmental questions are constructed can serve some interests and repress others.

The previous Science and Implementation Plan contained power as a cross-cutting theme, but the role of power in earth system governance remains largely under-theorized. Power should be understood as a multi-dimensional concept that may be exercised through control over material as well as ideational resources; while some forms of power may be relational and exercised by particular agents, others are more diffuse and can take on structural or discursive dimensions (LUKES, 2005; BARNETT AND DUVALL, 2005; FUCHS, 2007). Different societies and social groups may conceptualize power in different ways.

Earth system governance raises questions of power across the dimensions just highlighted. Countries wielding greater economic or political power are often seen as having greater responsibility to act on global environmental concerns (BUKOVANSKY ET AL., 2012). Unequal power relations between the developing and industrialized countries have long been a key dynamic of global environmental governance (MARTINEZ-ALIER, 2002; CIPLET, ROBERTS AND KHAN, 2015). Global power relations also intersect with other kinds of power asymmetries, including gender and racial discrimination (SCHLOSBERG AND COLLINS, 2014) and the privileged position of some interest groups (e.g. business) over others (e.g. environmental groups) in domestic politics (FALKNER, 2008; BLOOMFIELD, 2017). New distributions of power may emerge where non-state actors become more closely involved in governance (BETSILL AND CORELL, 2008; GREEN, 2013), or where international organizations enter into relationships with other actors through delegation or orchestration (SCHLEIFER, 2013; ABBOTT ET AL., 2016; BÄCKSTRAND AND KUYPER, 2017).

Discursive power may be exercised, among other ways, through overarching discourses such as sustainability and the green economy, as well as through more specific concepts such as ecosystem services and natural capital (DRYZEK, 2013). Different discourses may privilege certain kinds of values (e.g. economic or cultural) with associated implications both for the power of certain actors (e.g. businesses or communities) as well as for policies to regulate power over environmental resources (e.g. markets in pollution permits or community-based natural resource management, see, e.g., RAIK, WILSON AND DECKER, 2008). Civil society actors lacking formal decision-

making power may nevertheless exercise 'framing power' by drawing attention to the concerns of vulnerable groups, as with civil society organizations' efforts to frame loss and damage resulting from climate change as a matter of justice rather than as a technical issue (ALLAN AND HADDEN, 2017). Issues of power also intersect with other themes of the Science and Implementation Plan, including justice.

The idea of the Anthropocene underscores the unprecedented power that humans exert over non-human nature, while at the same time cautioning that human interference with earth system processes has the potential to trigger major (and possibly catastrophic) state shifts in the entire system that elude human control. A key strand of optimistic narratives of the Anthropocene is that humanity has the power to shape the earth system for the better (BREAKTHROUGH INSTITUTE, 2015), notably through climate-related geoengineering. Yet others caution that geoengineering raises many unresolved questions of power, including that of whose hand is on the global 'thermostat' (RICKE, MORENO-CRUZ AND CALDEIRA, 2013). Some scholars have criticized the notion of the Anthropocene for its inattention to issues of power. Thus Baskin (2015:16) argues that "the term 'Anthropocene' reveals the power of humans, but it conceals who and what is powerful, and how that power is enacted". Others argue that it is possible to form a nuanced understanding of the Anthropocene that takes issues such as power and diversity into account (BIERMANN ET AL., 2016). The reconfiguration of global patterns of production and consumption in response to the challenges of the Anthropocene may provide opportunities for greater equality in global power relations. Not least, the rise of economies such as China and India is already reconfiguring power relations in global environmental governance (CIPLET, ROBERTS AND KHAN, 2015). While this trend may hold the promise of remedying long-standing inequalities between industrialized and developing countries, it also has the potential to generate new forms of inequality (e.g. through China's purchases of agricultural land in sub-Saharan Africa: see BRÄUTIGAM, 2009).

Many of the practices that could serve to democratize earth system governance may help simultaneously to alleviate power inequalities, particularly by empowering citizens and marginalized groups (see research question 4 below). However, a dedicated focus on power is required to illuminate how different forms of unequal power are generated and sustained in institutions for global environmental governance. So, for example, power analysis may help to uncover the relative power of actors in complex global supply chains over the environmental impacts of world trade (FUCHS ET AL., 2016). Power analysis can also serve to challenge prevailing orthodoxies about desirable architectures for earth system governance. Morrison et al. (2017), for example, argue that while polycentric governance is often seen as an antidote to excessive centralization of power, existing literature often overlooks that polycentric systems may embed other forms of power asymmetry. This kind of analysis may in turn shed light on how power inequalities could be alleviated and abuses of power curtailed. Research to identify power inequalities and abuses must be sensitive to the fact that these phenomena may manifest themselves differently depending on the type of power

in question (e.g. governmental or corporate power); the governance responses required may vary accordingly.

The invisibility (or undervaluation) of other ways of knowing and other ways of being (or 'worlds') is a result of historical processes that have evolved from imbalances in power relations, including global capitalism and colonization (ESCOBAR, 2007, 2016; TICKNER AND BLANEY, 2012, 2013). Considering these other knowledge systems in more equal terms will require changes in power relations and associated changes to participation in decision-making processes and to the co-production of knowledge.

Particular concerns include: how well do existing mechanisms (such as environmental and social safeguards, and legal or non-legal redress mechanisms) help to curb abuses of power? Does the transparency-driven approach of the Paris Agreement and other recent multilateral environmental agreements empower smaller states (through a capacity to hold larger ones to account) or does it merely perpetuate existing power inequalities? How does international financing for global environmental objectives alter power dynamics between contributor and recipient countries, and within recipient countries? How can inequalities of power be exposed and reduced through efforts to generate and synthesize knowledge about the earth system and how it is governed?

4.2.4 Interplay between Democracy and Power

Democracy and power are distinct but closely interlinked. Democracy promises a means of distributing political power among citizens and transferring power to their representatives without resorting to violence or coercion, as well as a means of curtailing the arbitrary exercise of power. Yet inequalities of power infuse democratic institutions, as demonstrated by the success of fossil fuel interests in shaping climate policy. Concern about preventing and remedying abuses of power may stem from a belief in the value of global democracy, but it need not: such a concern could be grounded in a more basic interest in ensuring the legitimate exercise of authority in global governance (GRANT AND KEOHANE, 2005).

4.2.5 Linkages with Contextual Conditions

Table 3 opposite illustrates how the two key elements of the new Earth System Governance Research Framework (contextual conditions and research lenses) can come together to generate timely and pressing research questions.

Democracy and Power

Contextual conditions

Transformation	Earth system democracy will require institutional and social transformation not only at the global level but at other scales as well; sustainability transformations in turn can pose challenges for democratic legitimacy
	Institutional transformation provides opportunities to reconfigure power relations, but may also reproduce existing power structures
Inequality	Democratizing earth system governance is essential for remedying unequal decision-making power on issues of global environmental concern
	Inequalities of power are closely linked to other forms of economic and social inequality; democracy can help to challenge and overcome multiple forms of inequality
Anthropocene	New forms of democratic practice – and new understandings of what democracy means – are required to come to terms with the challenges posed by the Anthropocene
	In the Anthropocene humans have unprecedented power over nature, accompanied by greater dangers that this power will be misused
Diversity	Where power is exercised to exclude minorities or marginalized groups, exclusion reduces diversity in representation and in the forms of knowledge brought to bear in decision-making
	Earth system democracy requires greater diversity of voices in decision-making

Table 3
The ESG Research Framework: interplay between research lenses and contextual conditions – Democracy and Power

4.2.6 Research Questions

Key questions for future research on democracy and power in earth system governance include:

- What is the nature of the relationship between democracy and sustainability in earth system governance?
- What kinds of institutions and practices may enhance or impede democratization in earth system governance?
- How can interlinkages between accountability, legitimacy and transparency as key qualities of governance arrangements be conceptualized and realized, and under what conditions does transparency contribute to more accountable and legitimate earth system governance?

- What kinds of institutions, practices and norms can alleviate inequalities and abuses of power in earth system governance?
- Does the Anthropocene exacerbate existing power inequalities or create new opportunities for the legitimate exercise of power?

4.3 Justice and Allocation

4.3.1 Introduction

As outlined in our contextual conditions relating to inequality, questions of justice and allocation are becoming central political discourses in a world with growing inequalities within and across national borders. Currently, governments and intergovernmental organizations formulate goals and set priorities for action that aim to address these issues on a global scale. For example, two of the goals of the recently adopted Sustainable Development Goals address reducing inequalities within and across countries (Goal 10) and promoting peace and justice (Goal 16). In addition, private actors, such as businesses and civil society organizations, create institutions that use the market to generate 'fair' distribution of environmental and/or social goods, such as the Ethical Trading Initiative and the Fairtrade Labelling Organization. Likewise, activist and grassroots networks such as Global Justice Now are also engaged with justice concerns. As justice, and its core demand of allocation, become fundamental political and social concerns, there is an urgent need to develop a systematic analytical, philosophical and empirical investigation thereby.

However, the concept of justice is elusive and means different things to different people. In its colloquial use justice is understood as 'the quality of being fair and reasonable' (Oxford Dictionary) as 'fairness in the way people are dealt with' (Cambridge Dictionary) or as 'the principle of fairness that like cases should be treated alike' (Collins Dictionary). Also, different disciplines refer to justice differently. While economists emphasize allocation, lawyers speak of equity, resource analysts of access, political scientists of fairness and sociologists of social justice (BIERMANN ET AL., 2009A). Likewise, political philosophers have developed different theories of justice. For example, while liberal-egalitarian theorists would stress 'fair distribution' of various goods resources as the central requirement for justice (e.g. RAWLS, 1971, 1999), capabilities theorists would propose to evaluate how these goods or resources are transformed into the capacity of individuals to function in lives of their own choosing (e.g. SEN, 1999, 2009; NUSSBAUM, 2000). While cosmopolitan theorists would extend liberal egalitarian concerns at the global level (e.g. BEITZ, 1979, 1999; CANEY, 2005), others would deny the possibility of global justice entirely (e.g. NAGEL, 2005).

4.3.2 Justice

"We do not live in a just world" (NAGEL, 2005). The fact that this proposition is uncontroversial does not mean that the concept of justice is not contested or elusive.

For the purpose of earth system governance, we find it useful to conceptualize justice in three dimensions (JERNECK ET AL., 2011): intergenerational (between generations), international (between states and regions) and intersectional (between groups/ categories in society).

Intergenerational justice is core to environmental concerns for both natural and social reasons. The inertia of many natural systems and phenomena is one obvious reason why inter-generational considerations are essential. For example, greenhouse gases are persistent over more than one generation, while the atmosphere responding to these gases interacts with oceans and icecaps operating at timescales of decades and millennia. Extraction of finite resources, be they oil, coal or minerals, is fundamentally a matter of intergenerational justice. So is the generation of long-lived hazardous materials, such as nuclear waste where one generation reaps the benefits of nuclear power while hundreds of generations will live with the waste. Irreversible processes, such as extinction of species or permanent depletion of resources are also of intergenerational importance. In practice however, it remains contested and difficult to accept that future generations may have moral rights with respect to us, and that we may have obligations with respect to them.

International justice has a long tradition of research and scholarship in earth system governance, often from the point of view of international relations. Many of our most pressing environmental challenges, be they climate change, loss of biodiversity, overfishing or depletion of water resources, have explicit and implicit international implications and drivers. Historically, those contributing most to climate change have been industrialized countries, though a changing climate will have much more severe negative impacts on developing countries. Similarly, many of the policies and mechanisms for addressing climate change are initiated by the industrialized countries but with significant implications for people in the developing countries.

Intersectional justice relates to the concept of intersectionality, expressing the multiple dimensions and modalities of social relations and subject formations we belong to (MCCALL, 2005). In earth system governance, intersectional justice can be understood in relation to multiple deprivations at context-specific intersections of age, class, caste, (dis)ability, gender, indigeneity and race. Examples of intersectional (in)justice are rife in regard to climate change impacts as well as impacts of climate change policies (OLSSON ET AL., 2014).

4.3.3 Allocation

Justice as allocation or distributive justice evaluates how and to what end a just society allocates the costs and benefits of social cooperation (RAWLS, 1971). This perspective emphasizes that justice fundamentally concerns the basic structure of society and how this defines and regulates social, economic and environmental equality and inequality. For earth system governance, distributive justice would pay attention to the institutions that are responsible for distributing such costs and benefits across different

generations, among nation states and among different groups in global societies. There is no widespread consensus on what is considered just distribution, however, and different principles apply (LUTERBACHER AND SPRINZ, 2001). To illustrate, utilitarians accept as just the distribution that on average produces more benefits than costs. Scholars in the liberal egalitarian tradition, in contrast, adopt a (global) 'difference principle' whereby inequality in the distribution of costs and benefits is acceptable as long as this benefits the least advantaged members of society (BEITZ, 1979; CANEY, 2001, 2005; MOELLENDORF, 2002). Still others advocate a needs-based minimum floor principle whereby basic needs should be satisfied first before any distribution is considered (BROCK, 2009). The plurality of distributive justice principles invites earth system governance research to clarify and unravel the principles that underline the multiple governance processes in which decisions regarding 'who gets what and why' are being negotiated and disputed.

For justice as allocation to materialize, however, scholars contend that two other elements are important, namely recognition and representation (FRASER, 2001). If a group or individual lacks recognition in the social or political structures within a society, it will contribute to maldistribution (YOUNG, 1990; FRASER, 1997, 2001). Lack of recognition occurs when people are devalued, dominated or disrespected due to their identity or status. Recognition and distribution are two distinct experiences of justice, but are intrinsically tied. Misrecognition manifests in the structures, practices, rules, norms and language. In turn, it is within this context that the maldistribution is instigated (FRASER, 1997). Recognition can be achieved when individuals are free of physical threats, offered complete and equal political rights, and have distinguishing cultural traditions free from various forms of disparagement (HONNETH, 2001).

Next to recognition, representation describes the democratic, fair and equitable processes in decision-making (SCHLOSBERG, 2007). It demands that all groups, especially those most affected, are fully provided the opportunity to participate in the decision-making process, and the decision-making should be shared. It also requires that all (affected) actors participate in an impartial way and ensure full disclosure so as to facilitate effective participation – this includes the content of the information, how it is provided, if it is provided in a timely manner and to whom it is given. In other words, representation emphasizes the importance of the political process through which existing injustices in distribution and recognition can be addressed (YOUNG, 1990). For earth system governance research, representation requires evaluating, for instance, the democratic character of the processes through which decisions affecting the distribution of environmental costs and benefits, as well as the economic costs and benefits of proposed solutions. It further entails questioning who are considered and recognized as legitimate participants and beneficiaries of cooperation and who are not (including nation states, social groups and different generations).

4.3.4 Interplay between Justice and Allocation

This section explores the interplay between debates and concepts of justice and allocation that can enrich and inform the next generation of earth system governance research.

In international forums, human rights are seen as one path to advance equity claims of disadvantaged and underserved peoples. Human rights to water, for example, are considered to have enormous mobilizing potential and may help redress the imbalance between the have and have-nots in water allocation and use (SULTANA AND LOFTUS, 2012). In those countries that have institutionalized the human right to water as a constitutional protection or through national legislation, it may serve as a moral articulation and as a basis for legal challenges, even if there are limitations in terms of implementation (GERLAK AND WILDER, 2012). Among other things, access to systems of implementation and justice at national and international levels are needed to ensure implementation of those rights for the poorest and most vulnerable (GUPTA AND LEBEL, 2010), and proper recognition.

Likewise, just and non-discriminatory legal and regulatory systems and institutional frameworks directly reduce human suffering and the causes of violence; resolve conflicts; and are indispensable for promoting and maintaining peaceful societies, for the fair distribution of environmental rights (to goods and services; GRIGGS ET AL., 2014; PALONIEMI ET AL., 2015; SCOVAZZI, 2016), risks (THALER AND HARTMANN, 2016) duties (including positive duties of care or negative duties to refrain from harming the environment; ASMELASH, 2015; BARRETT, 2011; DUUS-OTTERSTRÖM AND JAGERS, 2012; NORSTRÖM ET AL., 2014; SAARINEN, 2013) and for preserving delicate physical environmental systems (including genetic, historical and cultural assets).

More broadly, the good governance of complex global economic and environmental systems requires strong social, economic and legal institutions that are multilevel and hybrid (in types of actors, sectors, spaces and forms of relationships; BOEHMELT ET AL., 2014; KALFAGIANNI, 2014; NUNES ET AL., 2016; RAMOS, 2015; STRATOUDAKIS ET AL., 2016), context specific, flexible, participatory, representative, inclusive, accountable (DONALD AND WAY, 2016), transparent, resilient and effective (BRACKING, 2015; VAN BOMMEL ET AL., 2016).

Legitimate and transparent democratic processes, in particular, permit societies and communities to choose equitable policies to address environmental problems (BIERMANN ET AL., 2012). Justice can be achieved through public participation in decision-making, by empowering communities and seeking equitable distribution (ANAND, 2004). Mobilizing the agency of local communities, indigenous peoples and non-governmental organizations to help shift towards mutual learning and capacity-building approaches at different governance levels is a key part of promoting democracy in environmental governance (DRYZEK AND STEVENSON, 2011) and illustrates representative or procedural justice. New alternative discourses and social

movements are often necessary to promote a re-allocation of resources and shift to more just and equitable patterns of use (GUPTA AND LEBEL, 2010). The widespread anti-privatization movement around water in Latin America over the past two decades illustrates the power of social movements to protect marginalized populations and reverse neoliberal water reforms at national and local levels (BUSTAMANTE, CRESTO AND WALNYCKI, 2012). Increasingly, climate justice activists and movements, for instance, are relying on the local experience of increasing vulnerability and adaptive responses to climate change helping to shift beyond traditional distributive justice approaches to addressing injustice (SCHLOSBERG, 2013).

Economic tools typically focus on distributive justice. For example, some advocate for stronger financial support for poorer countries, through direct support payments for climate change mitigation and adaptation programmes based on international agreements or through international market mechanisms, like global emissions markets (BIERMANN, PATTBERG AND ZELLI, 2010, 2012). Carefully designed and monitored market mechanisms for climate change mitigation and technology transfer can help to address inequalities between industrialized and developing countries (DRYZEK AND STEVENSON, 2011). Internationally, ethical and environmentally friendly labelling strategies and financial instruments like tradable certificates or taxes have been promoted to better inform consumers, producers and institutions about resource usages and for example in the case of the water usage may help to shift the financial burden to customers of water-intensive products (HOFF, 2009).

Finally, personal religious and ethical world views (DASH, 2014; ESQUIVEL AND MALLIMACI, 2017) are often the drivers for solidarity and subsidiarity at global to local levels and in earth system governance form the overarching delivery framework and contexts for partnerships for ending poverty and inequality (FEYGINA, 2013), for sustainable financing, capacity building, technology sharing and transfer, and for quick responses to environmental shocks and crisis situations at national or local scales.

4.3.5 Linkages with Contextual Conditions

Table 4 opposite illustrates how the two key elements of the new Earth System Governance Research Framework (contextual conditions and research lenses) can come together to generate timely and pressing research questions.

Justice and allocation	
Contextual conditions	
Transformation	The conditions under which societal transformations are considered just and the distribution of costs and benefits of transformations
Inequality	How inequality may increase the salience of justice and allocation research; under what conditions inequality (in its multiple dimensions) is also considered unjust from an earth system governance perspective
Anthropocene	Whether new demands for justice and allocation are emerging as a result of the unpredictability of the Anthropocene era
Diversity	How diverse world views, contexts and knowledge systems may be harnessed to advance justice and allocation research and outcomes

Table 4
The ESG Research Framework: interplay between research lenses and contextual conditions – Justice and Allocation

4.3.6 Research Questions

Key questions for future research on justice and allocation in earth system governance include:

- How can we advance interdisciplinary approaches to justice and allocation?
- Which new demands for justice and allocation are emerging in the context of profound transformations of the earth system?
- What kind of trade-offs may be identified between the different dimensions of justice and allocation?
- What types of steering have been effective and not effective to channel personal, regional, national and global world views towards more sustainable approaches to environmental rights and duties?

4.4 Anticipation and Imagination

4.4.1 Introduction

Increasingly, earth system governance includes proliferating processes of anticipating and imagining diverse futures, including, among others, through modelling, integrated assessments, foresight and scenario building. There is an urgent need to examine how to govern such diverse anticipation processes, but also to scrutinize how anticipation itself becomes a site of politics and governance. Analysing these twin processes is a crucial and timely task for the social and interdisciplinary sciences, including for the

earth system governance community. This subsection identifies a research agenda relating to the increasingly central role of processes and tools of anticipation and imagination in earth system governance, keeping in mind the contextual conditions of transformation, inequality, the Anthropocene and diversity discussed in the previous section.

4.4.2 Anticipation

Seeking to steer (or govern) an unknown and largely unknowable future is fraught with *normative and scientific uncertainties and conflicts* (HULME, 2010; NORDMANN, 2014). Anticipatory governance entails the evolution of steering mechanisms in the present to govern future earth system transformations, in the face of *extreme normative and scientific uncertainty and conflict over the very existence, nature and distributive implications of such transformations* (GUPTA, 2001, 2011; GUSTON, 2010). As such, it is a politically charged and challenging endeavour. Governance is always anticipatory to a greater or lesser extent, particularly in policy domains such as military planning or budgeting. Increasingly, however, anticipatory governance is becoming central to the environmental and sustainability realm, with its long-standing tendency towards reactive or retrospective governance, given accelerating earth system transformations and their potentially disruptive societal and distributional consequences. This holds also for governance challenges associated with potentially transformative and powerful emerging technologies, characterized by strong claims of global benefit but also extreme uncertainties and contested risk, such as biotechnology, nanotechnology, geoengineering or synthetic biology. Anticipatory governance of novel technological trajectories or earth system transformations requires attention to contested aspects such as securing accountability, ascribing responsibility, determining liability or ensuring compensation for environmental risk or harm. Yet these contentious issues, long plaguing earth system governance, become vastly more complicated in the context of *ex-ante,* rather than *ex-post* governance, given uncertain and unknowable (future) risk and associated uncertain distributions of risk and harm.

The concept of anticipatory governance has rapidly acquired increased saliency in recent decades, with diverse social and interdisciplinary scientific communities addressing it. These include scholars of responsible research and innovation (STILGOE ET AL., 2013; MACNAGHTEN ET AL., 2014) science studies and the sociology of science (BORUP ET AL., 2006; JANSEN AND GUPTA, 2009; JASANOFF, 2015), sociology of the future (SELIN, 2008, 2014), risk governance (GUPTA, 2011), anticipatory technology assessment (FUERTH AND FABER, 2013), adaptive governance and resilience (QUAY, 2010; BOYD ET AL., 2015) and anticipation as a field in its own right (POLI, 2010). Yet the notion is understood and deployed within these communities in very different ways, with diverse normative starting points and research agendas (VERVOORT AND GUPTA, 2018). Similarly, elements such as forecasting, scenario-building, long-term strategizing, real-time technology assessment, information disclosure and citizen deliberation, are assumed to be important to anticipatory governance processes and institutional arrangements, yet how these function in contested geopolitical contexts of uneven

earth system transformations remains under-analysed. And an increasingly important site of anticipation are the burgeoning integrated assessments and modelling exercises that underpin future visions, whether of diverse climate trajectories, biodiversity futures or other processes and dynamics of large-scale environmental change (e.g. BECK AND KRUEGER, 2016). Critical social science perspectives on such diverse processes of anticipation are urgently needed.

Perspectives on anticipation and anticipatory governance vary in their conceptions of the future, including the extent to which the future is knowable (cf. EDWARDS AND BULKELEY, 2017) and subject to steering. As Jasanoff suggests, it is important to consider the political implications in the present of "fabrications of the future" (2015:337). *For some, anticipatory governance is less about guessing the future and more about developing* "a broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible" (GUSTON, 2014:219). For Guston, anticipatory governance is about *capacities* rather than knowing or predicting futures, with anticipation seen as "practicing, rehearsing, or exercising a capacity … [rather than] divining a future" (GUSTON 2014:226).

Anticipation processes thus increasingly entail imagining and 'pre-experiencing' pluralistic, challenging futures, in order to question limiting assumptions about what futures may be possible, and experiment with strategies aimed at transformational change (VERVOORT ET AL., 2015). Key tools here include foresight and scenario-building exercises, which are now proliferating in sustainability-related research and planning contexts (WILKINSON ET AL., 2011; VERVOORT ET AL., 2014A; see also Section 5.2 of this Science and Implementation Plan, on methods and methodologies). There has nonetheless been very little critical social science scrutiny of the multiple global, regional and national anticipation processes (centred around foresight, modelling and scenario building) now underway. There is thus an urgent need for meta-analyses of anticipation processes, including through a critical governance lens, by asking first-order questions of who governs, for whom and why, and examining how the content of anticipation processes is created in ways that shape and limit what futures can be imagined.

In particular, foresight initiatives function as sites of politics and governance, wherein potentially contested, alternative versions of environmental futures are imagined, negotiated, used and/or ignored (including the values that these futures embody). In the face of climate change and global pressures on the environment in the Anthropocene, governments and other actors are increasingly looking to foresight to help imagine, anticipate and experiment with potential futures (VERVOORT ET AL., 2014B). Global foresight efforts developed by relatively small groups of experts, such as those led by the Intergovernmental Panel on Climate Change community, often function as a global reference context for regional and national foresight efforts (PALAZZO ET AL., 2016).

However, there are important disconnects between, on the one hand, foresight research that is rooted mainly in environmental sciences, macroeconomics and business planning, and, on the other hand, research on climate policy and governance, rooted in the interpretive social sciences. There is a) a lack of understanding of foresight as a political intervention and hence the need to govern foresight processes and b) a lack of understanding of whether and to what extent foresight is integrated with earth system governance and policy processes. It is also important to take into account that foresight initiatives led by civil society or private sector actors may have very different characteristics to government-led initiatives in terms of how processes are organized and in terms of who is empowered to deliver on the process. The levels of governance at which foresight is aimed are also significant (ZUREK AND HENRICHS, 2007).

4.4.3 Imagination

To support the goal of anticipating and effectively preparing communities for the transformative social and ecological shifts that are already under way, and to move beyond the status quo, it is becoming clear that creative and therefore imaginative approaches to governance are required. Imagination is a particularly important ingredient of governance that addresses 'wicked problems', i.e. those challenges that appear to have no easy or 'right' solution, that seem to defy our attempts to define them, and that do not appear to be solvable using traditional modes of decision-making (RITTEL AND WEBBER, 1973). Imagination allows a transcending of such assumptions and long-established myths about problem-solving, including the assumption that wicked problems remain unsolved due to complexity, rather than because of the habitual, unimaginative or politically prescient filtering out of simple but unconventional solutions.

The challenges brought on by the scale of human impact on the planet, as captured by the concept of the Anthropocene, and the urgency of staying within planetary boundaries (STEFFEN ET AL., 2011), speak even more strongly in favour of radically new modes of governance that break conventional boundaries. However, social imaginaries, as the creative and symbolic dimensions of social worlds that frame imaginations (THOMPSON, 1984), play an important role in directing and limiting what new approaches to governance can be considered. Existing (and hegemonic) social imaginaries contribute, for example, to failures to imagine approaches to governance that are fit to deal with unprecedented challenges, or to maintaining institutionalized inequity and exclusion. While decision makers have long been tasked with producing effective strategies that address issues pertaining to the public good, it has been argued that "patterns of thought of a previous era can create serious problems for the next" (BROWN ET AL., 2010). The news and social media profoundly influence our collective imagination, including what is possible, what is desirable and what is necessary. The media captures a subset of our modern social imaginaries, the stories we tell about new ways of living, the sources of social malaise, and the new practices that might emerge to solve our problems (while possibly creating new ones; TAYLOR, 2002). The

entanglement of scientific claims in the media with ideological standpoints creates challenges for informed public conversations about issues like climate change, but also offers opportunities for a more engaged (and engaging) discourse (CARVALHO, 2007, 2010).

Without mechanisms for cultivating, governing and responding to imagination, anticipatory governance risks remaining hobbled by potentially out-dated modes of thinking and insufficient regard either for the complexities of wicked problems or the simplicity of non-considered solutions.

Governance that explicitly recognizes the need for imagination may thus have certain characteristics, yet this is clearly challenging on multiple levels. These characteristics include, among others, being reflexive about the constructed nature of existing social imaginaries and their limits, to recognize how these limits can be overcome; being inherently participatory, recognizing that different types and forms of knowledge enrich decision-making on complex issues; being iterative and flexible, i.e. allowing for social learning, changing course in the event of new information; and being systems-oriented, i.e. seeking connections between environmental and social issues, considering ripple effects, unintended consequences and emergent properties. The governance challenge is to direct this imagination towards collective aims, asking critical questions about who suffers and benefits from decisions over time.

Governing by imagination can be supported by emerging tools and methodologies that offer unique opportunities for the co-production of knowledge, thereby weaving together complex and interwoven issues that offer potential for both synergies and trade-offs. Diverse experiences are emerging that demonstrate the value of artistic approaches that allow for collective and cultural experimentation with new ideas (GABRYS AND YUSOFF, 2012), the use of memes, narratives and storytelling to anchor logic in cultural rationality (SPOEL ET AL., 2008; DAHLSTROM, 2014; RIEDY ET AL., 2018), and the power of visualizations, games and other media as ways to explore and convey complexity (MAYER, 2009; SHAW ET AL., 2009; FENNEWALD AND KIEVIT-KYLAR, 2013). While abundant case studies exist that delve into the promises and pitfalls of these new tools, earth system governance research may benefit from more coherent, theoretically grounded and comparative work that captures important emerging trends and lessons (VERVOORT AND MANGNUS, 2018).

4.4.4 Interplay between Anticipation and Imagination

The twin imperatives of anticipation and imagination are linked, insofar as anticipating uncertain futures is fundamentally also an act of the imagination. As such, in bringing these notions together, the research agenda becomes one of exploring the historical antecedents and understandings of anticipation, anticipatory governance and imagination within the social science and global change research communities, in order to ascertain whether and how these notions are being deployed, and with what political implications or uptake in environmental governance. A combined research

focus on the roles of anticipation and imagination in processes of governance is underdeveloped, but urgently needed. Research focusing on anticipation alone risks overlooking how human imagination fundamentally frames what futures are considered, both in terms of adapting to future challenges and in terms of what futures are desired and how they may be achieved. Such imagined futures have fundamentally political origins as well as political consequences and should be researched as such.

Therefore, an integrated research agenda requires bringing critical and interdisciplinary social science perspectives to bear on processes of anticipation and imagination, the futures they generate, and the ways in which they are integrated into earth system governance processes. This includes assessing the current state of play with regard to institutional arrangements and normative presumptions relating to anticipation and imagination in diverse areas of sustainability governance, including climate change, biodiversity, fisheries and marine governance, and governance of novel technologies such as geoengineering, nanotechnology, synthetic biology and modern biotechnology. A key research gap is to analyse how processes of anticipation (i.e. planning and research processes aimed at exploring alternative futures) relating to environmental transformations are themselves being governed, i.e. who is steering them, to what end, and through what deliberative or representative processes.

Through executing elements of the above research agenda, the aim is to shed light on the theoretical and empirical utility of an analytical lens on anticipation and imagination within earth system governance and the role of these processes in addressing (and redressing) the transformative sustainability challenges of our times.

4.4.5 Linkages with Contextual Conditions

Table 5 opposite illustrates how the two key elements of the new Earth System Governance Research Framework (contextual conditions and research lenses) can come together to generate timely and pressing research questions.

Anticipation and Imagination

Contextual conditions

Transformation	Social imaginaries (generated via processes of anticipation and imagination) guide and limit what transformative futures may be imagined Processes that organize societal actors in new ways and give them tools to go beyond or reframe existing social imaginaries may contribute to the imagination of novel transformative futures Processes of anticipation play an important role in framing the need for transformative change, and its direction. In turn, the imperative towards transformation might shape the politics of anticipation and imagination, including who has a say in imagining radically new and diverse futures
Inequality	Anticipatory capacities and their effects on governance processes help determine which societal actors are equipped to anticipate and therefore adapt to environmental impacts The social imaginaries that frame what futures may be imagined and who is considered important have impacts on how environmental risks are distributed. These inequalities in anticipatory capacities and who falls within scopes of concern exist across all scales Taking inequality seriously as a contextual condition of earth system governance research forces a consideration of who has access to, and who shapes and is empowered by processes of anticipation and imagination
Anthropocene	Capacities for anticipation and imagination determine what future challenges come to be associated with the Anthropocene, especially the 'mature Anthropocene' of future decades Equally, the Anthropocene as a contextual condition shapes the possibilities and demands for anticipation and imagination
Diversity	When diverse realities, world views and knowledge systems are taken into account in anticipating and imagining futures, these futures become more diverse, with the possibility that previously unconsidered risks may be taken into account, and creative, legitimate solutions identified From the perspective of legitimacy, processes of anticipation and imagination that are inclusive of diverse actors and their perspectives are more likely to take their concerns and needs into account. This holds especially for groups that are most vulnerable to environmental risks but least powerful to affect their impacts or responses to them From an instrumental point of view, the inclusion of more diverse actors and their perspectives entails that those who have the most power to take action in the face of future environmental risks are part of efforts to explore the future

Table 5
The ESG Research Framework: interplay between research lenses and contextual conditions – Anticipation and Imagination

4.4.6 Research Questions

Key questions for future research on anticipation and imagination in earth system governance include:

- How are proliferating foresight and scenario-building processes shaping and furthering anticipatory governance for sustainability?
- To what extent are ongoing processes of anticipation legitimate and inclusive? How can processes of anticipation be governed, and how does anticipation itself generate governing effects?
- How do processes and mechanisms of anticipation and imagination interact with each other in shaping efforts to steer societies towards more sustainable futures?
- What institutions and practices underpinning processes of anticipation and imagination in earth system governance are most effective in generating desired sustainability outcomes?
- What are the geopolitical implications of imagining and seeking to govern largely unknowable futures through diverse processes and practices of anticipatory governance?

4.5 Adaptiveness and Reflexivity

4.5.1 Introduction

This research lens focuses on understanding how societies can navigate change towards global sustainability. *Adaptiveness* is "an umbrella term for a set of related concepts – vulnerability, resilience, adaptation, robustness, adaptive capacity, social learning and so on – to describe changes made by social groups in response to, or in anticipation of, challenges created through environmental change" (BIERMANN ET AL., 2009A:45). This point of departure was established under the previous Earth System Governance Science and Implementation Plan and remains relevant moving forward but is now expanded to also give equal attention to the notion of *reflexivity*. In the context of earth system governance, reflexivity refers to the ability of actors and institutions to critically reflect on their own performance (especially their environmental impacts), and to reshape their goals, practices and values accordingly in order to wisely navigate complex, contested and changing human-environmental systems (VOSS AND KEMP, 2006; DRYZEK, 2016). While these two concepts overlap, adaptiveness emphasizes *responses* to changing social and ecological conditions (which may be coordinated, self-organized or emergent), while reflexivity emphasizes the centrality of *critical scrutiny* of prevailing values and practices in governing processes of change. This distinction is also helpful in light of increasing interest among both academics and policymakers in solutions-oriented activities in earth system governance, for example, as part of efforts to bring about transformations to sustainability. Furthermore, in a world of multiple unfolding changes and shifting boundary conditions, adaptiveness is recast in fundamental new ways.

The need for earth system governance research to study adaptiveness and reflexivity is tremendous: living in the Anthropocene destabilizes fundamental environmental boundary conditions upon which human societies depend, in ways that make unprecedented demands on global governance systems. Coping with unfolding climatic changes (IPCC, 2014), biodiversity loss (SECRETARIAT OF THE CBD, 2014), global urbanization (UN-HABITAT, 2016), infrastructure change (NCE, 2016), rapid technological change and instabilities in global economic and political systems (GALAZ, 2014; GALAZ ET AL., 2014) is only possible if human societies are able to both adapt and act reflexively at all scales from local to global. The observation that "most governance systems are largely unprepared for the expected magnitude and diversity of increased environmental challenges" (BIERMANN ET AL., 2009A:46) remains as true today as a decade ago, if not more acutely so.

4.5.2 Adaptiveness

Under the previous Science and Implementation Plan, adaptiveness was broadly construed to include both the "governance of adaptation to social-ecological change as well as the processes of change and adaptation within governance systems" (BIERMANN ET AL., 2009A:45). Adaptiveness (particularly adaptive governance) has been extensively studied since then, and continues to be at the forefront of environmental governance theory and practice (e.g. CONWAY ET AL., 2014). Adaptiveness has been studied from multiple angles, including collaborative governance (EMERSON AND GERLAK, 2014), learning (GERLAK ET AL., 2017; PAHL-WOSTL, 2009), complexity (BOOHER AND INNES, 2010) and agency (HUITEMA AND MEIJERINK, 2009, 2010). Adaptiveness has become particularly important in the context of climate change, which has served as the arena for much conceptual development over the last decade. This includes a focus on: climate adaptation governance (BAUER AND STEURER, 2014; HUITEMA ET AL., 2016; JORDAN ET AL., 2010; MASSEY ET AL., 2014; MASSEY AND HUITEMA, 2016), policy integration (BIESBROEK ET AL., 2014, 2015; DUPUIS AND BIESBROEK, 2013) and mainstreaming adaptiveness into existing activities within and beyond the state (DOVERS, 2009; UITTENBROEK, 2016). Maladaptation remains an important but under-explored topic, regarding the opening up and closing down of future opportunity space across diverse societies (BARNETT AND O'NEILL, 2010). Cities have become a prominent empirical domain for studying adaptiveness, stimulated by foundational work on urban systems (BAI ET AL., 2016A; BAI, ROBERTS AND CHEN 2010; BULKELEY AND BETSILL, 2013, 2005; BULKELEY AND CASTÁN BROTO, 2013) and policy advocacy on the importance of adaptation in cities (WORLD BANK, 2011, 2010). Recently, climate change adaptation research has taken a transnational turn (BIERMANN AND BOAS, 2010; BULKELEY ET AL., 2014A; DZEBO AND STRIPPLE, 2015; HALL AND PERSSON, 2017) in the shadow of intensifying climate policy debates about the role of adaptation within global agreements on climate change.

The *politics of adaptiveness* was identified as a key topic in the previous Science and Implementation Plan, and this remains a central research topic looking ahead over the next decade. Questions about winners and losers (e.g. involving distributions of

resources, risks and power), processes by which decisions are made and with what consequences, the role of power relations, and who decides – remain central in analysing adaptiveness and adaptive governance arrangements. These questions have received greater attention in recent years (ERIKSEN, NIGHTINGALE AND EAKIN, 2015; JAVELINE, 2014; SOVACOOL, LINNÉR AND GOODSITE, 2015). Yet on the whole, they remain vastly under-studied and must be a key priority in earth system governance research over the next decade, especially as the intensity of debates around climate change adaptation grow with more frequent climate impacts manifesting over time.

Social justice has also become a prominent theme in adaptiveness literature (ADGER, BUTLER AND WALKER-SPRINGETT 2017; ADGER ET AL., 2012; BULKELEY, EDWARDS AND FULLER, 2014B, 2013; KLINSKY ET AL., 2017; PAAVOLA AND ADGER, 2006; SCHLOSBERG, COLLINS AND NIEMEYER, 2017). Concerns about injustice and political disempowerment in the face of adaptation imperatives have seeded influential arguments about the need to pivot from adaptiveness (as responding to the impacts of climate change on various vulnerable groups) to transformation (of structural conditions that create vulnerability in the first place; MOSER AND EKSTROM, 2010; O'BRIEN, 2012; PARK ET AL., 2012; PELLING, 2011). A particular challenge for earth system governance research over the next decade will be to understand the politics of anticipatory adaptive action in all spheres, in climate change and beyond. For example, how to navigate the complex politics of adapting to climate and earth system changes in ways that pay attention to both effectiveness and social justice, particularly in contexts of failing global governance systems and weak political responses to growing problems.

Other enduring topics that will continue to be vibrant areas of study are interactions between adaptiveness and *agency*, *learning* and architectures of *polycentricity*. Agency has been shown to be central in processes of adaptiveness and anticipatory action in many domains of environmental governance (BIGGS, WESTLEY AND CARPENTER, 2010; HUITEMA AND MEIJERINK, 2009; WESTLEY ET AL., 2011, 2013), yet also lack of agency is a key challenge, such as within agencies of the state where agents navigate demands both for and against adaptiveness (WYBORN AND DOVERS, 2014). Understanding diverse forms of agency and their effects is vital in understanding the role of agency in adaptiveness and anticipatory action (BEUNEN, PATTERSON AND VAN ASSCHE, 2017; BEUNEN AND PATTERSON, 2016). Learning is typically seen as central to adaptiveness. Researchers examine the contexts, structures and tools that foster learning (CRONA AND PARKER, 2012; RAYMOND AND CLEARY, 2013; SIEBENHÜNER, 2008) and its contribution to improving environmental governance (HEIKKILA AND GERLAK, 2013). Understanding the role of individuals versus organizations in learning processes and across diverse scales in governance (RODELA, 2011; VINKE-DE KRUIJF AND PAHL-WOSTL, 2016), as well as the design of learning strategies to promote more effective governance (NEWIG ET AL., 2016), are also promising paths of research. Polycentricity is becoming a prominent topic in recent years (ALIGICA, 2014; DORSCH AND FLACHSLAND, 2017; MORRISON, 2017; OSTROM, 2010B), particularly concerning adaptiveness in a complex

and changing world. Polycentric systems are hypothesized to confer adaptiveness (and perhaps enable anticipatory action) through possessing multiple semi-autonomous centres of decision-making that allow action to be taken in timely and innovative ways. However, there is debate about the descriptive versus analytical potential of the concept of polycentricity, and empirical work to test hypotheses about polycentricity is sorely needed. Together these three topics (agency, learning, polycentricity) are increasingly viewed as complementary in the study of adaptiveness and anticipatory action. They also underpin extensive recent work on innovation in climate governance (JORDAN AND HUITEMA, 2014A, 2014B, 2014C; JORDAN ET AL., 2015), and ongoing work on reflexive governance (DRYZEK, 2016; VOSS, BAUKNECHT AND KEMP, 2006; VOSS AND BORNEMANN, 2011).

4.5.3 Reflexivity

Concerns about the limits of adaptation have prompted interest among researchers not only in the potential for transformative governance but also in new forms of reflexive governance (PICKERING, 2018). Dryzek (2016:942) argues for *ecological reflexivity* as a critical competence for reshaping institutions in the Anthropocene, where "reflexivity entails a capacity to be something different rather than just do something different, which distinguishes it from adaptive management and governance". Dryzek's recasting of reflexivity in ecological terms marks a new turn in several decades of research on reflexive governance. Earlier interest in reflexivity is often traced back to sociologists such as Giddens (1990) and Beck (1992), who invoked the term to help understand the implications of modernity. Scholars frequently distinguish between 'first-order' reflexivity (whereby institutions generate effects that feed back on themselves) and 'second-order' reflexivity (whereby institutions build a capacity to critically scrutinize their own practices; VOSS AND KEMP, 2006:6-7). For Dryzek, this kind of second-order reflexivity needs to take on a distinctively ecological character. Ecological reflexivity involves "listening more effectively to an active Earth system, capacity to reconsider core values such as justice in this light, and ability to seek, receive and respond to early warnings about potential ecological state shifts" (DRYZEK, 2016:953).

Scholars have applied ideas of reflexive governance to a range of aspects of earth system governance, including reflexive governance of sustainable development (VOSS, BAUKNECHT AND KEMP, 2006), energy transitions (HENDRIKS AND GRIN, 2007), global environmental governance (CHRISTOFF AND ECKERSLEY, 2013; DRYZEK AND PICKERING, 2017) and global climate governance (STEVENSON, 2016). Most of these studies find that signs of reflexivity in existing institutions are at best limited and yield varying findings on whether reflexivity can be cultivated from within existing institutions, or whether reflexive change requires some kind of external catalyst (such as ecological or economic crisis, or the emergence of new social movements). Key research challenges include developing more robust empirical measures of reflexivity (a task that has advanced considerably further in the field of adaptive governance), understanding why some institutions are more reflexive than others, and identifying strategies for enhancing reflexivity. Possible strategies include opening up formal and informal

spaces for knowledge creation, learning, experimentation and debate (DRYZEK AND PICKERING, 2017), or countering forces that seek to suppress reflexivity (e.g. actors who spread misinformation about environmental risks or threaten litigation against social movements that challenge the status quo; MCCRIGHT AND DUNLAP, 2010).

4.5.4 Interplay between Adaptiveness and Reflexivity

The preceding sections have discussed the notions of adaptiveness and reflexivity and some areas where they intersect, while illustrating their value as distinct concepts. Crucially, processes of reflexive scrutiny could create momentum for adaptive change. At the same time, some kinds of adaptive change could occur in non-reflexive ways, as where societies mount rapid responses to ecological disasters in timeframes that do not allow for extended processes of reflection. In addition, reflexive rethinking may result in the judgment that merely adapting existing systems will not suffice, instead, more thoroughgoing transformation may be necessary.

Drawing on these observations, three topics at the nexus of adaptiveness and reflexivity stand out as major new directions for earth system governance researchers over the next decade. These include: navigating tensions between stability and flexibility; dealing with globally-networked risks; and reshaping governance systems in the Anthropocene. First, an enduring challenge in understanding adaptiveness and reflexivity in governance is to *navigate tensions between stability and flexibility* (BIERMANN, 2007:331). This is because while "flexibility is important for governance systems to deal with uncertain, unpredictable, and non-linear forms of social and environmental change … governance systems [also] require stability to ensure that new policies persist over sufficient timeframes to bring about desired effects, and to stabilise expectations and enhance coordination over time" (BEUNEN, PATTERSON AND VAN ASSCHE, 2017). Stability can produce desirable effects (e.g. supporting legitimacy, fairness, democratic accountability, consistency in rule formation mechanisms), but also undesirable effects (e.g. lock-ins, democratic decay in changing circumstances); flexibility can produce desirable effects (e.g. allowing learning and innovation) but also undesirable effects (e.g. instability or superficiality in environmental policy and agreements; BEUNEN, PATTERSON AND VAN ASSCHE, 2017). Yet this core dilemma, surprisingly, still has not been robustly theorized. Dryzek and Pickering (2017) argue that deliberation can help to manage (if not fully resolve) tensions between stability and flexibility as drivers of ecological reflexivity.

A second key issue at the intersection of adaptiveness and reflexivity is *dealing with globally networked risks*. A critical empirical insight in recent years concerns the interconnected nature (in often hidden ways) of a plethora of causal forces and risk transmission pathways affecting environmental governance. Scholars pay increasing attention to the key causal role of factors that may be spatially, institutionally or temporally distant from a specific environmental issue of concern. For example, global trade agreements, financial investment decisions and technological change are increasingly recognized as playing a potentially decisive role in earth system

governance (GALAZ, 2014; GALAZ ET AL., 2014; VAN ASSELT, 2014; YOUNG, 2008). These issues are beginning to be studied in specific environmental governance domains, such as water (DE LOË AND PATTERSON, 2017) and biodiversity (SONTER ET AL., 2014). Physical sciences are also making new observations about global interconnections in earth system processes. For example, 'teleconnections' have been identified whereby land-use decisions made in one country can affect the hydrology of another country by causing disturbances in cross-continental atmospheric moisture flows (KEYS ET AL., 2017; ROCKSTRÖM, 2014). These issues are broadly being framed as "globally networked risks" (GALAZ ET AL., 2017), building on earlier work on cascading risks across scales (GALAZ ET AL., 2011). Altogether, this topic profoundly challenges existing environmental governance systems at all scales. It calls for attention to adaptiveness and reflexivity for governance systems to be fit for purpose in the face of ever more intensive global interconnectivity, where key causes of problems may originate outside of a particular focal domain yet have ramifications that are impossible to ignore. How such interconnectivity can be dealt with in environmental governance is a major open question for the next phase of earth system governance research.

Lastly, an issue which has potential to fundamentally reshape earth system governance research over the next decade is the need to *reshape governance systems at all scales within the Anthropocene*. Boundary conditions upon which existing environmental governance systems were developed are changing in profound ways. This includes climatic changes, impacts of transgressions in planetary boundaries and multiple simultaneous socio-economic-political transformations unfolding globally (e.g. urbanization, infrastructure, digital, geopolitical). Altogether this deeply challenges existing global environmental governance systems, possibly rendering them obsolete and wholly unprepared for the new challenges arising. Thus, a key frontier topic for earth system governance researchers is the question of what exactly it means to adapt global environmental governance systems in the Anthropocene. This involves dealing with issues such as path dependency (PIERSON, 2000, 2004), overcoming 'carbon lock-in' and other forms of unsustainable lock-in (SETO ET AL., 2016; UNRUH AND CARRILLO-HERMOSILLA, 2006), and understanding both gradual and abrupt institutional change (MAHONEY AND THELEN, 2010, 2015; STREECK AND THELEN, 2005). Dryzek (2016) highlights that reflexivity is crucially important for governing the Anthropocene because many of the institutions currently driving earth system risks evolved in the preceding epoch (the Holocene) in non-reflexive ways, in that they failed to recognize their ecological impacts.

4.5.5 Linkages with Contextual Conditions

Table 6 overleaf illustrates how the two key elements of the new Earth System Governance Research Framework (contextual conditions and research lenses) can come together to generate timely and pressing research questions.

Adaptiveness and Reflexivity

Contextual conditions

Transformations	Adaptiveness centres on responding to changes in the context of earth system governance including (unintentional) transformations that challenge governance systems Reflexivity embraces the potential need for transformation in response to critical scrutiny of prevailing practices and values
Inequality	Inequalities of resources and power may limit adaptiveness and reflexivity within marginalized communities and across societies more broadly
Anthropocene	Adaptiveness and reflexivity are critical in the Anthropocene because they centre on the challenge of how societies reshape earth system governance under shifting boundary conditions
Diversity	Adaptiveness and reflexivity rely on and are shaped by varied forms of diversity (e.g. in ideas, knowledge, capabilities, roles) While diversity could facilitate broad-based and sustained adaptation, it may also make adaptation more difficult because of the need for complex participatory processes

Table 6
The ESG Research Framework: interplay between research lenses and contextual conditions – Adaptiveness and Reflexivity

4.5.6 Research Questions

Key research questions for the adaptiveness and reflexivity research lens include:

- How can adaptiveness and reflexivity in existing forms of earth system governance be assessed and compared, and why are some forms of earth system governance more adaptive or reflexive than others?
- How do political, economic and social factors constrain or enable adaptiveness and reflexivity, including within transformations to sustainability?
- What kinds of governance attributes (e.g. polycentricity or centralization, flexibility or stability) are best suited to cultivating adaptiveness and reflexivity, and how can potential tensions between these attributes be managed?
- How can adaptiveness and reflexivity enable environmental governance systems to deal with globally networked risks and the challenges posed by the Anthropocene?
- Why, how and under which conditions do adaptiveness and reflexivity successfully occur, and what are the implications for improving performance in this area more generally?

5

Conducting Earth System Governance Research

Earth system governance researchers live and work in different contexts and come from different disciplinary backgrounds. This Science and Implementation Plan acknowledges diverse knowledge systems and practices and encourages dialogue among disciplines, sciences and other ways of knowing that often are not recognized as valid knowledge. This section explores the ways that different ontological and epistemological approaches affect the pursuit of knowledge about earth system governance, and the implications for researchers. Moreover, it brings a range of examples of methods that earth system governance researchers have been using over the years. The list is by no means exhaustive but a way to illustrate methodological pluralism in earth system governance.[1]

5.1 Ontology and Epistemology – Different Ways of Knowing

Methodological innovation is only one part of the challenge (and is addressed in the next section) of emerging earth system governance research. Other parts include ontological innovation and epistemological innovation. Ontology deals with questions concerning what constitutes reality and how we can understand existence. Epistemology deals with questions concerning what constitutes valid or relevant knowledge and how we obtain it.

In the social sciences, there are two broad dominant ontological and epistemological traditions or ideologies: positivism/empiricism/representationalism and constructivism/relativism/interpretivism (BERGER AND LUCKMANN, 1967; CARSON ET AL., 2001; CROTTY, 1998; MANNHEIM, 1936; RADNITZKY AND BARTLEY, 1987). Positivist ontology holds that the world is external, and that there is a single objective reality regardless of one's perspective or belief. In other words, it is assumed there is a truth beyond our senses that can be observed (truth as an attribute of existence). For positivists, the physical world, including society, operates according to absolute laws. Within the positivist paradigm, these laws can be captured by finding regularities or patterns in empirical evidence. Constructivist ontology, in contrast, holds that the world and reality are socially constructed. Thus, beliefs, perspectives, cultural backgrounds, and so on, influence what people consider to be truth and what not. For constructivists, there is no absolute truth but only an experienced or interpreted truth (truth as an attribute of discourse). Constructivists avoid looking for general laws in society, and the world more broadly, and argue that the experiences of events and other

1 It is beyond the scope of this Science and Implementation Plan to present an extensive overview of debates in and on ontology and epistemology. There are many more traditions, ideologies and applications – including combinations – than we can cover here. Good introductions and overviews are provided by Berto and Plebani (2015) and Audi (2011). Related, there are many more research methods applied in the earth system governance community than we can cover here. By no means do we wish to imply that the methods discussed here are of more value to earth system governance scholarship than methods we do not cover.

empirical observations need to be understood in terms of people's subjective meaning and social constructions before we can look for causal relationships.

Of course, these are simplified caricatures of the two dominant traditions or ideologies. Yet, in considering them as two ends of a spectrum, it is easier to understand ontological and epistemological innovations that have emerged (CARSON ET AL., 2001; LOSCONZ, 2017). For example, positivism is often critiqued for being too rigid for studies that involve social agents and social events, where contested values are inevitably present – a critique voiced in many studies by earth system governance scholars. While positivists may be able to find absolute laws in certain parts of the physical world, it is humans' capacity to learn and adapt that may put limits to their abstraction of absolute and unchanging law-like patterns in the social world. In addition, it is thinkable that our (social) world is not causally connected in the sense that positivists argue, and that only regular temporal successions are observed within the human time span of observation, but that are misinterpreted as absolute laws (RADNITZKY AND BARTLEY, 1987). Constructivism, on its terms, is often critiqued for reducing reality too much to experiences and interpretation. It may give too much power to agency, and too little to structure (or architecture) in how societies operate and evolve (ARCHER, 2003). For earth system governance scholars, the influence and limitations of existing institutions and the earth system, for example, may be relevant factors to acknowledge and include in their work.

It is out of these critiques that innovative traditions and ideologies have emerged. While it is beyond the scope of this Science and Implementation Plan to present a broad overview, two traditions are worth mentioning: critical realism and evolutionary epistemology. Critical realism recognizes there may exist an objective reality regardless of one's perspective or belief, but it acknowledges that people's knowledge of that reality is subject to their subjective meaning and social constructions (BHASKAR, 1978; DANERMARK, 2002). This is not a mere mixing of positivism and constructivism, but a fully different point of departure with implications for research. For critical realists, the aim is not to find general laws (as per positivism) or interpret experiences of events and other empirical observations considering social constructions as experienced by an individual or group of individuals (as per constructivism), but to study and seek to understand generative causal mechanisms that produce events, processes and phenomena (BHASKAR, 1978; DANERMARK, 2002). Such research may then result in analytical or moderatum generalization, which does not attempt to "produce sweeping sociological statements that hold good over long periods of time, or across ranges of cultures" but provide bounded "claims to basic patterns, or tendencies, so that other studies are likely to find something similar but not identical" (PAYNE AND WILLIAMS, 2005:297, 306).

Evolutionary epistemology rejects the notion of a 'final knowledge' or absolute truth and of a full social determination of knowledge. In addition, evolutionary epistemology does not a priori consider scientific knowledge superior to other forms of knowledge,

including folk beliefs and indigenous interpretations of the world (POPPER, 2002; RADNITZKY AND BARTLEY, 1987). Again, this is not a mere mixing of positivism and constructivism. Evolutionary epistemology emphasizes the importance of natural selection in knowledge creation, validation and replication. On the one hand, it is aware of the impact of our biological, social and technological evolution on how we make sense of and what we consider to be reality. On the other, it acknowledges that scientific (and other) theories have evolved in a process of trial and error and selection. That is, the theory that is the 'fittest' will survive those that are less fit – sometimes, even if the surviving one is the less valid one. Scholars may pursue finding the 'fittest' theories through processes of falsification (POPPER, 2002), but at the same time societal processes may affect the survival of some theories at the expense of others (RADNITZKY AND BARTLEY, 1987), for instance inequalities and power unbalance. The development of and resistance to theories of anthropogenic climate change are an illustrative and well-known example to earth system governance scholars (HOFFMAN, 2015).

In sum, there is a diversity of ways to know and represent the world. The ways in which we know and represent the world are inseparable from the ways in which we choose to live in it (JASANOFF, 2004). This Science and Implementation Plan does not force a specific knowledge-production practice on earth system governance research and scholars, nor does it consider some ontological and epistemological traditions or ideologies as worthier than others. It stresses that the earth system governance community's different geographical, academic and disciplinary backgrounds result in different knowledge-production practices. It therefore challenges scholars in this community to reflect on the traditions and ideologies they follow, and those of others. Such reflection may help to avoid natural and social determinism, and allows for understanding reality as a pluriverse or multiple realms (ESCOBAR, 2016; JASANOFF, 2004). Plural understandings of empirical reality help advance the field of earth system governance as a whole, and advances may be made specifically where and when different research traditions, ontologies and epistemologies come together.

5.2 Methodology and Methods of Analysis

Questions about *how* to know logically bring us to another essential part of enquiry: methodology and methods. While these terms are often used interchangeably, they mean essentially different things. In what follows, this Science and Implementation Plan offers some examples of how different methods might be used in the study of earth system governance. By no means are these methods prescriptive and indicative of what method should be used for addressing the analytical problems and research questions introduced in the earlier sections. They are meant to be illustrative of the variety of methods scholars have access to. We do encourage, however, that scholars make informed choices about the methods they choose as part of a methodology they see fitting within their own ontology and epistemology to address analytical problems

and research questions, and to share and elaborate on this rationale as part of their reporting and publication of results.

Methodology can best be understood as the underlying logic of doing research, while methods are the tools and instruments of research (CASTLES, 2012; GOERTZ AND MAHONEY, 2012). Phrased differently, methodology justifies the use of specific methods and by making clear the methodology underlying a research project one gives insight with "the rationale and the philosophical assumptions that underlie any natural, social or human science study, whether articulated or not" (MCGREGOR AND MURNANE, 2010:220). Methodology helps to "turn a research problem into a workable design" and challenges researchers to think of "the basic choices to be made about methods" (DELLA PORTA AND KEATING, 2008:1). Being clear about one's methodology reveals the strengths and limitations of one's research project and the knowledge created. It also allows the recipient of that knowledge to judge its validity within their understanding of the world. Seen in this light, providing clarity about the methodology underlying a research project and the knowledge that has resulted from it empowers both the knowledge creator as well as knowledge recipients (MCCARTHY, 1996).

There are a wide range of methodologies that underlie earth system governance research. It is beyond the scope of this Science and Implementation Plan to discuss these at great length. Consequently, there are a variety of research methods being used by earth system governance scholars. Much of their work is grounded in social science methods such as quantitative analysis, qualitative case studies, ethnographic approaches, grounded theory and action research (for introductions, see among others: DELLA PORTA AND KEATING, 2008; GERRING, 2001; GOERTZ AND MAHONEY, 2012; KING, KEOHANE AND VERBA, 1994; MOSES AND KNUTSEN, 2012). That is not to say these are the only or the best methods for earth system governance research. Much is to be expected from methodologies and methods that move away from a Eurocentric or Western understanding of knowledge creation (SMITH, 2012) as well as mixed method and experimental research methodologies that bridge tools of knowledge creation and push the boundaries of existing ones (BERG-SCHLOSSER, 2012; MASON, 2006; MARSH AND STOKER, 2010; TASHAKKORI AND TEDDLIE, 2003). It seems crucial to further explore the analytical value of these methodologies and methods and to integrate them into a larger research programme on earth system governance. Challenges raised in the original Science and Implementation Plan remain. There remains a need for better data collection and improved operational measures of key variables across research on earth system governance. The study of earth system governance would also still benefit from "improved tools for analyzing complex causalities, capturing the dynamics of complex systems, and accounting for thresholds and abrupt change" (BIERMANN ET AL., 2009A:77). This Science and Implementation Plan acknowledges different epistemological and methodological approaches to knowledge creation. Consequently, a diversity of research methods can and have been used. Below, we provide a few examples. The main challenge is to find new methods or to combine a set of methods

that can be used in inter- or transdisciplinarity research. This challenge will be explored in the next subsection.

5.2.1 Qualitative Comparative Analysis (QCA)

QCA was introduced by the social scientist Charles Ragin as a middle path between quantitative and qualitative social research (GOERTZ AND MAHONEY, 2012; RAGIN, 1987, 2008; RIHOUX AND RAGIN, 2009; SCHNEIDER AND WAGEMANN, 2012). QCA is a configurational comparative method grounded in set theory, a branch of mathematical logic that allows researchers to study in detail how causal conditions contribute to an outcome. Since the mid-1990s it has rapidly developed into an accepted research method for the type of studies carried out by scholars in the earth system governance community (e.g. VAN DER HEIJDEN, 2017). What makes QCA of interest is that it helps to gain a better understanding of equifinality and conjunctural causation in small- to medium-sized sets of cases (5-50). For example, when studying how various European Union member states seek to achieve carbon emission reduction targets QCA may help to uncover the multiple pathways ('equifinality') that lead to successful outcomes and those that lead to less successful ones. QCA further helps to uncover what conditions ('explanatory variables') are necessary and/or sufficient in these pathways, and how these conditions combine ('conjunctural causation') in affecting the outcome.

5.2.2. Forecasting and Scenarios

As this Science and Implementation Plan articulates, governing complex, emergent and rapidly evolving issues at the interface of human and natural systems requires anticipation, imagination (see Section 3.4 of this report), and powerful tools for exploring an uncertain future (BIZIKOVA ET AL., 2011). Traditionally, an emphasis was placed on calculating the most probable futures in an effort to reduce the uncertainty faced by decision makers in both private and public realms. Increasingly, however, it has been argued that the future presents multiple forms of radical (and irreducible) uncertainty: both through the unpredictability of socio-political systems and human behaviour, and the unknowability of the priorities of future humans (preventing us from even being able to confidently express the criteria for success against which futures will be judged; CF. EDWARDS AND BULKELEY, 2017, CITING OELS, 2013 AND WYNNE, 1992). Experiments, however, have been highlighted as spaces within which futures can be imagined, but also enacted in practice and contested (EDWARDS AND BULKELEY, 2017). Imagining the future may take the form of scenario-based tools, such as games, visualizations, stories and artistic representations that offer a coherent narrative about which futures are desirable and feasible (cf. ROBINSON ET AL., 2011; SCHROTH ET AL., 2014). Ultimately, telling stories about the future requires us to draw upon diverse sources of data, inter- and transdisciplinary approaches that weave these data together, and to pay attention to both expert and experiential ways of knowing.

5.2.3 Statistical Techniques/Regression Analysis

There is a large amount of data available in earth system governance. Scholars, governments and/or international organizations collect, produce and provide data for

a large number of entities such as states, firms or individuals. Additionally, surveys or coding of documents may lead to datasets with many observations. Statistical analysis helps us to analyse this data and understand patterns and relationships across a large number of observations. Regression analysis seeks to identify causal relationships between variables. While the exact modelling technique depends on the data structure at hand, the objective of regression analysis, in general, is to examine whether and how strongly a certain condition on average affects a specific outcome when other conditions are held constant. We can thus, for example, examine whether countries that are more vulnerable to climate change (condition) also receive more financial support for adaptation projects (outcome), even when we take into account that such support may also depend on other conditions such as the size of the country (see WEILER, KLÖCK AND DORNAN, 2018).

5.2.4. Social Network Analysis

Social Network Analysis (SNA) is a method that is used in many disciplines to investigate social structures and has become popular in the last two decades in the social sciences as well (BORGATTI ET AL., 2009). SNA analyses social structures made of nodes that are tied to each other by one or more interdependencies. The nodes within a network can be individuals, organizations or institutions who are connected via repeated patterns of interactions (WIDERBERG, 2016). SNA not only includes different kinds of interactions but also the strength of these relations, which allows the identification of central and/or marginal (clusters of) nodes (REED ET AL., 2009). As such, it is focused on patterns of social relations and aims to identify structural properties of a network and their implications of social action (SCOTT, 2017). Since the 1990s, SNA benefited first from advances in network visualization and later also from software that can be used to visualize networks (SCOTT, 2017). By combining network analysis with graph theory interconnections between social entities or actors and their social structure(s) can be visualized. Typically, SNA is a quantitative assessment of relations based on data gathered through interviews, observations and surveys. However, SNA can also be used in combination with case study and content analysis or ethnographic research.

5.2.5 Exponential Random Graph Models

Exponential random graph models (ERGMs) comprise a family of models for analysing social (and other) networks. They are thus related to Social Network Analysis (SNA), explained in more detail above. However, while SNA focuses on aspects of the structure and the strength of the relationships within the network, such as density or centrality (see e.g. WASSERMANN AND FAUST, 1994), the aim of ERGMs "is to describe parsimoniously the local selection forces that shape the global structure of a network" (HUNTER ET AL., 2008:2). In other words, ERGMs allow the researcher to hypothesize on the probability of tie formation between nodes given their attributes, and to test these hypotheses empirically. Thus, ERGMs are similar to regression analysis, with the social network serving as the dependent variable, and the nodal attributes serving as the independent or explanatory factors for tie formation. In earth system governance,

network structures form the basis for many data sources: countries cooperate and form ties to achieve their goals in the climate change negotiations, cities form collaborative networks to deal with the consequences of rising sea levels, climate aid donors and recipients form aid networks, etc. Regarding the last example, Klöck et al. (2018) find that climate aid donors coordinate their aid efforts, i.e. the likelihood of forming ties with additional recipient countries decreases for cases where more donors are already active. For another example, see Hollway and Koskinen (2016), who also use ERGM to show bilateral and multilateral clustering by states in global fisheries governance.

5.3 Disciplinary Depth, Interdisciplinarity and Transdisciplinarity

Earth system governance research builds on a combination of in-depth disciplinary research, interdisciplinary research that weaves together the social sciences with natural sciences and a growing transdisciplinary research effort in which broader society is engaged to address real-world problems. Interdisciplinary approaches integrate different disciplinary perspectives to better understand the nature of the challenges and the trade-offs in solutions (e.g. KHAGRAM ET AL., 2010; HOLM ET AL., 2013). Transdisciplinarity is a means to structure a research process that accounts for diverse perspectives on the problem and proposed solutions by tackling the relevance that these have – as an epistemic value – for the problem and context in question (JANTSCH, 1972; PROCLIM, 1997; POHL AND HIRSCH HADORN, 2007; ADLER ET AL., 2018). Both interdisciplinary and transdisciplinary approaches emphasize the co-design of research agendas and processes for the co-production of knowledge (e.g. LANG ET AL., 2012; MAUSER ET AL., 2013; BRANDT ET AL., 2013; MATTOR ET AL., 2014). Transdisciplinary research fundamentally diverges from tradition disciplinary and interdisciplinary work from the earliest stages of the research process (such as when defining the problem to be studied) by seeking engagement with non-academic partners. The Swiss Academies of Arts and Sciences (2017) reports a dramatic increase in interdisciplinary and transdisciplinary research in the past 15 years, which is a testament to the growing momentum behind these innovative and inclusive approaches.

In the previous Earth System Governance Science and Implementation Plan, interdisciplinarity was conceived of as a means to account for and consider human as well as ecological systems as part of the research or governance problem in question (BIERMANN ET AL., 2009A:82-85). Linking diverse disciplinary perspectives on a problem in an interdisciplinary manner was emphasized in the context of collaboration between social and natural sciences, providing examples for contexts or problem types, and proposed methodologies through which social and natural sciences could cooperate and work together. Such interdisciplinary collaborations were also described as a means to reassess claims of feasibility for solutions to problems. We further extend

this in the current plan by also noting the need for engagement with broader societal actors outside of academia who also hold key knowledge and perspectives on what is both feasible and desirable as solutions to societal problems. A recognition of these other ways of knowing and plural perspectives on problems and solutions place a specific demand and need for research approaches that structure and facilitate this transcendence beyond interdisciplinarity, i.e. towards transdisciplinarity as well.

There is a continued need for in-depth disciplinary research especially given the increasingly fragmented and polycentric architecture of earth system governance. The need for inclusive, democratic and just decision-making processes – based on well-founded (scientific and non-scientific) knowledge to create legitimate governance efforts that are accountable to current and future generations – requires in-depth disciplinary research from a range of social sciences, including political science, sociology, public administration and law. Other disciplines in the social sciences and humanities, including geography, economics, planning and history, can provide valuable analyses when considering how different governance challenges impact particular groups of people, institutions and societies, and how these challenges can be overcome to achieve a more sustainable future.

Escalating socio-environmental problems challenge earth system governance researchers to go beyond their disciplinary boundaries. To keep earth systems' socio-ecological sustainability given their inherent complexity and cumulative effects of past and future environmental change – from climate change and freshwater availability to micro plastic pollution – highlights the growing need to engage in interdisciplinary and transdisciplinary research. The ability to cross disciplinary boundaries, analyse real-world sustainability challenges and opportunities in a way that captures system behaviour, and to engage in a two-way collaboration and co-production of knowledge with non-academic actors, is likely to become increasingly important.

The affiliation of the Earth System Governance Project with Future Earth is one pathway towards facilitating such interdisciplinary research in which the relationship between natural scientific understanding and ambiguity over environmental change (and futures) and earth system governance can be scrutinized. These uncertainties and ambiguities also point towards the need for transdisciplinary research in which different disciplines as well as broader society are included to create more holistic knowledge and understanding of earth system governance. Exercises on transdisciplinarity could include arts, practice and other ways of knowing. The earth system governance community can directly support transdisciplinary research by actively drawing non-academic stakeholders into networking activities, encouraging the reach of conference sessions and collaborative publications outside of academia, and advocating for transdisciplinary activities in the context of other international research forums and networks. The partnership of the Earth System Governance

Project with Stakeholder Forum for a Sustainable Future is one pathway towards increased interaction outside academia.

Although such collaborations can be time consuming and complex, an interdisciplinary and transdisciplinary vision can – and should – drive the next wave of earth system governance research. We draw from a variety of research to propose a few innovative pathways to help deliver both disciplinary depth and interdisciplinarity and transdisciplinarity research for earth system governance (LÉLÉ AND NORGAARD, 2005; ALVES ET AL., 2007; BLACKWELL, WILSON AND STREET, 2009; STÜER, HÜSIG AND BIALA, 2010; ADLER ET AL., 2018). These include:

- *Collaborative Arenas*: There is a need to develop arenas or spaces (i.e. series of workshops, conferences, 'hackathons', transformation labs, etc.) where earth system governance scholars can explore collaborations across disciplines, and with actors beyond the academic sphere. These arenas should be chosen strategically to avoid 'engagement fatigue', and demonstrate a clear added value to the earth system governance community's ambitions and goals.
- *Capacity and Skills*: Fruitful science across disciplinary boundaries requires a skill set that often is not taught at university departments. In addition, such capacities and skills are often tacit, and require actual engagement and practice to refine. The earth system governance community can play a key role as a mentoring network, and provide guidance to junior researchers on how to work in and negotiate interdisciplinary and transdisciplinary research.
- *Creativity and Experimentation*: Inter- and transdisciplinary work is risky. It takes time, outputs can be vague and may well fail. However, with proper leadership, the ability to learn from failure and a commitment to creativity and experimentation, such endeavours can be highly enriching. Novel methods (e.g. big data and machine learning) and collaboration with unexpected actors (like the arts), can provide exciting ways to collaborate across boundaries. The same degree of experimentation and creativity is needed in the design for tools and frameworks for assessment and evaluation in inter- and transdisciplinary research, thereby not only contributing with solutions to the problem at hand but also contributing with reflection on the co-created knowledge and its validity and legitimacy. Earth system governance is well placed to support such processes and, ultimately, to help researchers push scientific boundaries.

The value of transdisciplinarity for earth system governance is that it presents a means to define, account for and address problems and their complexity, particularly in situations where these are said to be 'wicked', thereby demanding a concerted consideration for trade-offs in the co-design of solutions, and stretching beyond reductionist approaches.

6

Earth System Governance in Society

This section explores the goals and mechanisms of interactions between earth system governance research and the broader society of which it is a part. We address what these goals are and how they have been and will continue to be pursued, as well as the new challenges that this research community faces in light of the contested credibility of science. We discuss a range of models for interactions between researchers and society, which grow out of a rich tradition of science-policy or scholar-social movement interactions, and respond to the growing demand for transparency, inclusion and explicit recognition of the positionality of scholars, and increased focus on responsible research and innovation (RRI). This section also considers the linkages between earth system governance research and researchers and our role as educators of the next generation of earth system governance scholars.

6.1 Science-Society Interactions: Goals and Approaches

It is impossible to divorce earth system governance research from its societal context: our research priorities, funding systems, methods and epistemologies emerge out of this cultural fabric. But as the world changes, the role of science is being questioned by some in the public discourse, and evidence accumulates for the breadth and scale of human impact on the planet. Earth system governance scholars are tasked with reflecting upon their role in supporting, examining and even influencing decision-making. It is clear that earth system governance research is being challenged by an increasingly complex, contested and interlinked global context, and that many of the issues that earth system governance researchers will grapple with over the next decade will need to be tackled from outside the box of solely the environmental governance domain. Earth system governance scholarship addresses rapidly changing issues that affect all sectors of society, and should be – and is – engaged with and relevant to society. Deepening and refining this relevance, however, is the ongoing task of the earth system governance community.

It is clear that a variety of goals for interactions between scholars and society exist, ranging from scientific research that examines issues of societal significance, to directly advising or influencing decision-making processes, and engaging in social movements through support, advocacy and activism. A stark dichotomy between scholars as analysts versus scholars as activists no longer captures the rich, iterative interplay that characterizes much of the earth system governance research community.

It is difficult to make progress on environmental issues if we don't also recognize and engage with their fundamental interdependence with other social and economic issues. There is extensive and growing experience, however, about how major power asymmetries can thwart, block or subvert ostensibly open participatory processes in various situations (e.g. BRISBOIS AND DE LOË, 2016). Dealing with this issue might not always involve 'more participation', but instead demand more thoughtful and savvy

approaches to dealing with power imbalances in context-specific ways. This unavoidably calls to attention uncomfortable questions of how earth system governance researchers recognize, study and act in the face of real and present power relations, both in our own work as well as in the kinds of governance solutions that we advocate.

Taking note of the increasing emphasis on demonstrating impact by scientific institutions and research funders, we propose that a key goal for the earth system governance community is to *make active contributions to communities of practice*. To be effective, contributions typically need to be sustained over a longer period of time, something which short-term measures of impact may fail to capture.

Another goal is to *provide evidence for robust decision-making*. There is a potential for further engagement of earth system governance scholars and their research findings in formal scientific assessments and policy consultation processes, at international, national and sub-national levels. Examples include IPCC assessments, submissions to UN processes, national policy consultation rounds and local town hall meetings. Importantly, though, earth system governance research should not be limited to identifying and informing formal decisions, but should also expose and examine instances and contexts of informal decision-making and non-decision-making (BACHRACH AND BARATZ, 1963).

Finally, earth system governance scholars are *exploring and refining models for public engagement* that are inclusive, and equitable. Existing ideas about co-design/co-production/co-dissemination – central to Future Earth, for example – may look very different at different scales (e.g. community vs subnational/national vs international governance arenas). This may not always be about local level engagement, but many other, often more subtle ways of interacting with society are also needed. This might also include better identification, targeting and exchange between researchers with the earth system governance network and outside entities such as business organizations, non-government organizations and also policymakers from both the developing and industrialized countries.

In the next phase of earth system governance research and its interaction with society, we aim to continue to build on the many opportunities and mechanisms, some of those discussed above, to innovate in our understanding and practices, while continually striving for critical awareness of how our research interacts with society at different scales, sectors and times. Researchers cannot be naïve to adverse impacts on society from their work, but we also need to be ever more acutely aware of potential misapplications of our work in societal debates, particularly in a so-called 'post-truth' world and ongoing climate and culture wars in many countries. As a community of researchers who study governance and politics of sustainability problems, we aim to be critical and conscious of the political interplay of our work in society. The earth system governance community will continue to experiment with and capture our diverse

experiences regarding interactions of earth system governance research in society in order to help our community and the broader social sciences to learn and innovate, based on our collective experiences and practices.

6.2 Integrating Earth System Governance Research into Education

Educational processes are fundamental to imagine, understand and help realize just and sustainable futures. The growth of undergraduate and graduate programs and short-term courses on environmental studies, sustainable development, sustainability science and so on provides evidence for the increasing global awareness and demand for knowledge and skills to engage in academia, policy or business. Most earth system governance research centres and research fellows are linked to universities, which offer undergraduate and graduate programmes in these fields. Over the past decade (2007-2017), the faculty of these research centres, the staff of the International Project Office and earth system governance researchers have been involved in teaching and educational activities, including teaching at summer schools as well as short-term courses and delivering guest lectures around the world. Semi-plenaries and workshops on innovative ways to teach have been held during the annual Earth System Governance conferences.

This Science and Implementation Plan pays special attention to teaching and pedagogy and calls for more reflection and knowledge exchange on this important dimension of our work as scholars. We see teaching as a means to reach out to society and contribute, through our students, to building sustainable futures. Moreover, we see teaching and learning as horizontal relations, in which there is always mutual learning. Students always contribute to knowledge-building processes, as they bring their questions, concerns and reflections. Particularly, we need to reflect on the extent to which teaching earth system/environmental governance, policy and politics requires new approaches to teaching. More specifically, the goal of sustainability education is not just for learners to have knowledge, but to take action.

6.2.1 Teaching about Earth System Governance in a Shifting Context

Broad contextual changes need to be considered in teaching earth system governance, sustainability and environmental studies in general. Globalization and the technological revolutions in the information and communication field result in more and rapid information, high mobility and time-space compression. Now there is free and abundant information that actors can create, transfer and access globally. In this context, classrooms and students are rapidly changing and so are the teachers' roles. So, how can we teach earth system governance in the information age? More information does not mean more knowledge (SIMMONS, 2011). The so-called 'paradox of plenty' – when information is plentiful and accessible yet attention has become

scarce (KEOHANE AND NYE, 1998) – challenges teachers to engage students in a more deliberate manner.

New contextual conditions, such as the Anthropocene and diversity, but also inequality and the politics of transformation, bring not only new research questions and epistemological and ontological challenges but also pedagogical ones. Instructors now need to prepare courses that cover interdisciplinarity, complexity, system-thinking, problem-driven and solution-oriented contents, and are, above all, inspiring. Ultimately, instructors want to provide students with knowledge and motivation, which in turn should encourage action. The challenge is to be able to teach inter- and transdisciplinarity, interconnectedness and integrative understandings of ecological and social systems in a way that is simultaneously place- and planet-based. This requires continued innovation with regard to teaching methods that develop critical thinking, problem-solving and decision-making skills. The Earth System Governance Project aims to continue to strive to make our teaching more meaningful and engaging in a way that balances normative and analytical thinking, awareness of the urgent threats that we face, and individual and collective wellness. Similarly we will continue to aim for earth system governance education to also account for multiple and diverse ways of knowing, and imagining diverse sustainable futures.

A number of institutions of higher education have incorporated sustainability education (BRUNDIERS AND WIEK, 2011). Sustainability education requires new approaches to teaching and learning that foster critical thinking, emotional engagement, change of attitudes and behaviour, and problem- and solution-oriented research (BRUNDIERS AND WIEK, 2011:108). A concept that comes from the sustainability education literature is sustainability literacy. It indicates an individual "having the understanding, skills, attitudes and attributes to take informed action for the benefit of oneself and others, now and into a long-term future" (DIAMOND AND IRWIN, 2012:339). It requires an individual's "ability and disposition to engage in thinking, problem solving, decision making, and actions associated with achieving sustainability" (NOLET, 2009:421). Teaching innovation is needed to create a society with sustainability-literate individuals. Learning approaches that are student-centred and that consider students as agents of their own learning processes seem particularly well suited in this context. Instead of lectures, instructors use creative approaches both inside and outside the classroom.

6.2.2 Methods and Approaches for Earth System Governance Education

Environmental and sustainability scholars have used a myriad of active-learning approaches that include case-based teaching, simulations, games, movies and experiential learning. We provide a list of examples that by no means is exhaustive, but aims at stimulating reflection and creativity. Teaching is a science – and also an art.

Active-learning encompasses a set of student-centred teaching practices that can help to overcome classroom attention deficits (INOUE AND VALENÇA, 2016) and includes simulations, role-playing, games and case studies that use written or audio materials, films or documentaries, service learning, alternative texts like TV shows, comics and other popular culture materials (ASAL, 2005; CHASEK, 2005; KILLE, 2002; KILLE, KRAIN AND LANTIS, 2008; LANTIS, KUZMA AND BOEHRER, 2000; LANTIS, KILLE AND KRAIN 2010). Simulations, role-playing and games allow teachers to reproduce real-life experiences. Thus, besides the traditional cognitive capacities of reading, analysing and discussing readings, these approaches engage students through their emotions and senses (ASAL, 2005; CHASEK, 2005; KILLE, 2002; SHAW, 2006; SHELLMAN AND TURAN, 2003).

Case-based instruction has been widely used to teach the concept of sustainability in higher education as it encourages engagement in deep discussions around moral choices (TIMPSON AND HOLMAN, 2011). Case studies are also very useful for introducing students to complexity, interdisciplinarity and to the interconnections between social-cultural-economic and ecological systems. Cases can be found on the web, there are journals specializing in cases in environmental politics, and people can design cases according to their learning goals. Earth System Governance scholars have also used simulations to teach students about the complexities and puzzles of multilateral environmental agreements negotiations.

Experiential learning refers to learning through experience. Fahs (2015) and Nicholson and Wapner (2015) use experiential learning to make students reflect on waste and consumption patterns. They require students to complete a 'trash-bag' assignment, which asks students to collect the rubbish they personally produce and carry the bag of rubbish with them at all times during a certain period. The purpose includes three goals for students, 1) to be aware of their personal production of rubbish and the political dynamics of who ultimately handles one's waste, 2) to encourage discussions around rubbish generation and disposal and 3) to focus attention on the relationship between their own behaviours and choices and larger global issues, such as climate change (FAHS, 2015:32).

Problem-based learning is a focused, experiential learning approach that addresses a specific problem through investigation and explanation often through use of small collaborative groups (HMELO-SILVER, 2004:236). With the teamwork approach students work to create a solution for a problem as a group. Korkmaz and Singh (2012) advocate using team projects to teach the concept of sustainability. They find "that integrated student teams produce more comprehensive outputs for sustainable projects" (KORKMAZ AND SINGH, 2012:290). Additionally, they report certain variables are meaningful in project performance including "project communication, information exchange, experience, reliance, trust, and value sharing" (KORKMAZ AND SINGH, 2012:293). Most importantly, the teamwork approach supports interdisciplinary "leadership, teamwork, and communication" (KORKMAZ AND SINGH, 2012:294).

The Bicycle Revolution[1] is a problem-based experiential learning undergraduate course facilitated by Paul Steinberg[2]. It involves riding bicycles in urban settings to explore the challenge of creating bike-friendly cities and the politics of social change. Each week the professor and students ride along bike routes meeting local officials and advocacy groups. A major goal is empowerment – understood as the belief that one can make a difference – and a passion for doing so, as well as a clear understanding of the strategies that such endeavour requires. The students have assigned readings on social change, listen to stories of successful change, interact with advocates and decision makers, and immerse themselves in action arenas. The course spawns new relationships between the college and surrounding communities, among community leaders across and within communities. The words that summarize the impacts of the course are *engagement*, *learning* and *sheer inspiration*[3].

Considering the urgency, complexity and scale of the planetary socio-environmental changes, a number of scholars have argued that solely cognitive pedagogical approaches tend to generate fatalism and paralysis (LIFTIN, 2016:115), or that we need to change our understandings of who we are as a species and how we fit in the broader, more-than-human world (WAPNER, 2016:68). Moreover, we, as scholars, should help our students to imagine diverse and just sustainable futures. Contemplative approaches to sustainability education consider students as whole persons and not disembodied minds (LIFTIN, 2016:116), complex beings with bodies and hearts as well as minds (WAPNER, 2016:68).

Contemplative practices include journaling, meditation, yoga or any exercise that creates spaces for pause, silence, self-awareness, sense of sufficiency, exploration of emotions and creativity, allowing students to go beyond singular problem-solving into expansive orientations (LIFTIN, 2016; WAPNER, 2016). In pedagogical terms, the classroom is a place where intersubjectivity balances the inwardness of contemplative enquiry (LIFTIN, 2016:117), and where contemplative pedagogy can contribute to sharpening the pursuit of understanding, and to questioning what counts as knowledge, the purpose of education and the place of the self in scholarly enquiry (WAPNER, 2016:72).

Fast global transformations, growing inequality within and among societies, and diversity in ways of being and knowing, as well as the Anthropocene's planetary changes and the information revolution, require teachers to be more creative and to engage students in the classroom and beyond. Considering these contextual changes and the need to foster sustainability education, the Earth System Governance Project encourages new teaching practices that develop critical thinking, cultivate self-awareness, are inspirational and promote transformational action.

1 See https://thebicyclerevolution.org/, accessed Nov 14, 2017
2 Text written based on questions answered by Paul Steinberg, email Nov 13, 2017.
3 The experience was captured by a team of documentary filmmakers at the Claremont Colleges, United States. (The trailer is available at https://thebicyclerevolution.org/see-the-film/.)

7

Modus operandi of the earth system governance network

This section describes the organization of the earth system governance network and how the International Project Office will continue to serve the earth system governance research community. It identifies general activities for the coming decade that will achieve the goal of creating an enabling environment for earth system governance research; for ideas to be cultivated, for collaborations and networking to flourish and for research impact to be leveraged. This Science and Implementation Plan will be complemented with shorter-term action plans developed by the Scientific Steering Committee in consultation with the community.

7.1 Organization

A research programme on earth system governance requires a particular research practice. The study of earth system governance encompasses all the world's regions and must be internationally organized to make use of local knowledge, values and insights. Diversity within the research community together with strong networking is a prerequisite for studying earth system governance. A research programme on earth system governance hence requires a global approach to the organization of research. This section outlines the practical aspects of this research programme: the governance and institutionalization of the study of governance and institutions.

The Earth System Governance Project is an autonomous, international, interdisciplinary research alliance of individual researchers and academic institutions

The Earth System Governance Project was established as a core project of the International Human Dimensions Programme on Global Environmental Change (IHDP) in 2009. In its first decade, it evolved from a traditional research project into its current alliance structure, which is characterized by the dense network of connections between individual researchers, a stable growing base of institutional partners and continuous efforts to innovate research practice and research organization to meet the academic and institutional challenges of earth system governance research.

Building on and leveraging small but stable base funding for the International Project Office (2009-2010 IHDP; 2011-2018 Lund University; and from 2019 Utrecht University) the Earth System Governance Research Alliance is decentrally funded predominantly through funding acquired in competitive calls from national and international research funding agencies.

7.1.1 People

The Earth System Governance Research Alliance reflects the interdisciplinary, international and multi-scale challenge of developing effective systems of governance to ensure sustainable development. It draws on support from many of the most prominent scientists in the field, along with numerous PhD students, early-career to mid-career researchers, and is open to all scientists who are engaged in research on the governance of environmental change at all levels. For the next phase of earth system governance research, we will identify priority research communities to interact more intensively with (e.g. computer science, biotechnology, anthropology).

Scientific Steering Committee

The network operates under the direction of a Scientific Steering Committee. The role of the Scientific Steering Committee is to guide implementation of the Earth System Governance Science and Implementation Plan. Members serve for a limited term, and new members are appointed by the committee, taking into account the academic standing and potential contribution to the project of individual members as well as an overall balanced composition of the committee in terms of disciplines, geographical backgrounds, gender and seniority.

Lead Faculty

The Earth System Governance Lead Faculty is a small group of scientists of highest international reputation who take (shared) responsibility for the development of research on particular elements of the research agenda, for example by convening task forces. The Lead Faculty is the academic backbone of the Earth System Governance Project. Members are invited by the Scientific Steering Committee taking into account academic criteria while striving for geographical, disciplinary and gender balance.

Senior Research Fellows and Research Fellows

Senior research fellows are senior scientists and faculty members who seek to link their own research with the broader themes and questions of earth system governance, and co-lead activities within the Earth System Governance Project. Research fellows are early to mid-level career scientists who seek to link their own research with the broader themes and questions of earth system governance. Through a bottom-up, dynamic and active network, senior research fellows and research fellows collaborate on research, debate ideas and disseminate information on relevant events and opportunities in the field. Any interested researcher with relevant research activities or interest can apply to become a research fellow. Regional coordinators seek to strengthen the network and support dissemination of information and opportunities.

7.1.2 Places

A core element of the network is the Global Alliance of Earth System Governance Research Centres. These Centres in Africa, Asia, Australia, the Americas and Europe are research hubs that support the implementation of specific parts of the Earth System Governance Science and Implementation Plan and act as focal points for earth

system governance research in their geographical and thematic area. In addition, strong networks on earth system governance research exist in many countries and regions in addition to or in lieu of a Research Centre. Research Centres have, or potentially will (co-) host the annual Conference on Earth System Governance, and an emerging role of the Research Centres is in teaching earth system governance.

7.1.3 Projects

Task Forces

Through task forces, the Earth System Governance Project seeks to push the frontiers of research in specific areas of its research agenda. Task forces are led by the Lead Faculty or senior research fellows, with numerous research fellows participating. Task forces are open for all and often interact with other research communities, organizing events, webinars and publications, and facilitating research all over the world.

Affiliated Projects

Affiliated projects are research efforts relevant to advancing the earth system governance research agenda, undertaken by earth system governance researchers. Affiliated projects interact closely with the Earth System Governance Project but are not under the guidance of the Scientific Steering Committee. Usually, these are traditional research projects and research consortia funded by national funding agencies.

Research Projects

The Earth System Governance Project occasionally develops or facilitates smaller-scale research projects and research consultancies that are managed directly by the project through its International Project Office. These projects are smaller in scope and community involvement, and more oriented to specific deliverables than the broad dynamic task forces, and more closely integrated than the affiliated projects. Hence such projects can be developed and steered to strategically benefit the Earth System Governance Project and in particular generate opportunities for earth system governance research fellows. Careful further development of this portfolio could strengthen the impact and strategic directions of the Earth System Governance Project.

7.1.4 The International Project Office

The International Project Office is the focal point for management and administration, as well as for the communication and network development efforts of the Earth System Governance Project. The office with a small staff is headed by the executive director. From 2009 until 2011 the office was hosted at IHDP in Bonn, Germany and between 2011 and 2018 by Lund University, Sweden. From 2019, Utrecht University, the Netherlands, will host the office.

7.1.5 Stakeholder Forum for a Sustainable Future

In 2017, the Earth System Governance Project joined forces with Stakeholder Forum for a Sustainable Future in a global partnership to jointly work towards better governance for global sustainability. The aim of the partnership is to strengthen understanding of transformative governance for sustainability through integrating scientific research and multi-stakeholder advocacy. The partnership will strengthen the evidence base of the multi-stakeholder processes facilitated by Stakeholder Forum, and the impact of the novel policy solutions that are developed by researchers from the Earth System Governance Project. Management of Stakeholder Forum is integrated in the Earth System Governance International Project Office.

7.1.6 Annual Conference on Earth System Governance

The annual conferences on Earth System Governance are mid-size annual events of about 200-450 international participants. Each conference has a clear thematic focus that allows for intensive exchange and discussion. Conference themes are selected with a view to bringing new and emerging topics to the global debate, thus ensuring the continuous innovative thrust of the conference series. The series of conferences has become a landmark in the calendar of the earth system research community. Conferences have been held in Amsterdam (2007 and 2009), Colorado (2011), Lund (2012 and 2017), Tokyo (2013), Norwich (2014), Canberra (2015), Nairobi (2016) and Utrecht (2018).

7.2 Enabling Environment

The earth system governance network is unique in its mixture of levels of researchers, from students to emeritus professors, the scope of disciplines that it covers, as well as the inclusive approach it uses in its development of research activities. Taking into account the existing organization described above, the earth system governance network will continue to provide opportunities for affiliated researchers to catalyse research initiatives in response to emerging research problems and needs for knowledge generation and synthesis. These initiatives include the established forms of projects outlined above, but the next phase of earth system governance research will also consider new forms of research collaborations and interactions with society.

With more rapid earth system change, we expect that the empirical context of the earth system governance network will remain dynamic. This dynamism could involve rapid response to myriad issues unfolding at different scales, such as extreme weather events, technological innovation and deployment, shocks and crises in global supply chains, institutional and political breakthroughs, ecological and socio-economic tipping points as well as creeping changes in demographics. The accelerating nature of change requires that the Earth System Governance Research Alliance remains flexible and continues to provide a facilitating and enabling environment. The rise of digital

developments and social media in academia and scientific publishing has facilitated improved communication around new topics, self-organization of scholars (and practitioners) and enhanced the creation of networks. The Earth System Governance Project will continue to innovate, test and reap benefits from these digital developments.

Building on the international reach of the network, including through its Research Centres around the world, the network will strive to become further globalized. Inclusiveness towards less well-represented regions remains a priority, which will be further pursued, inter alia, through the location of annual conferences.

In addition, the Earth System Governance Project in its next phase acknowledges the need to facilitate meetings and exchanges between people who want to connect within or through the network with no or low-carbon travel or to facilitate access to people with limited travelling resources. To this end, the network will explore remote participation in its activities, for example via webinars and online reading groups. As we consider face-to-face interaction very important, however, the Earth System Governance Project also encourages the physical involvement of its members, particularly in the annual conferences.

Contributing to the creation of an enabling environment, the Research Alliance will use several tools such as, *regular communication* from the International Programme Office about ongoing and upcoming activities, through existing means like newsletters and social media channels and any novel means that may emerge. Such information sharing and awareness raising is a prerequisite for effective collaboration and coordination.

To enable scientific discussion and joint learning, the Earth System Governance Project will continue to organize, facilitate and endorse different kinds of meetings:

- *Annual conferences*, as high-level gatherings of earth system governance researchers from all over the world, are important occasions to learn about research that is going on, to network with peers and to find ways to collaborate. To globalize the network, special attention will be paid to encouraging and facilitating the presence of researchers from developing countries.
- *Regional meetings,* as ways to ensure the regional relevance of the earth system governance research agenda and facilitate regional interactions. These meetings will continue to be organized on demand.
- *Endorsed events,* organized by specific research projects and groups of scholars. These have mutual benefits for the earth system governance network and event organizers, by ensuring a connection to and implementation of the Earth System Governance Science and Implementation Plan and better outreach before and after the event through the network.

- The promotion of earth system governance research networks targeting *early-career scholars* for their professional development will continue, potentially through more structured *mentoring schemes*. We expect this to contribute to the goal of globalizing the network, when taking place across regions and academic traditions.
- Another means to promote professional development is the development of *short courses* or summer schools/workshops on topics that bridge the research agenda and practical skills of researchers. Such topics could address issues such as teaching, how to plan and implement interdisciplinary/transdisciplinary research, science communication, fundraising and proposal-writing, or diverse methods.
- Hosting and coordinating *publication series* is another way of enabling communication and collaboration within and outside of the earth system governance network, such as the book series on Earth System Governance with the MIT Press and Cambridge University Press, as well as the Earth System Governance journal with Elsevier. The landscape of scientific publishing is changing fast, with an exponential increase in the number of peer-reviewed articles published and new journals established. Calls and requirements for open-access publishing are becoming more common and, for that reason, the flagship journal Earth System Governance has been made fully open access for all articles. We expect that it will become more important for the network to keep abreast of these changes and identify the best opportunities for high-quality and impactful publication practices.

References

Abbott, K. W. 2012. The Transnational Regime Complex for Climate Change. *Environment and Planning C: Government and Policy* 30 (4): 571-90.

Abbott, K.W., P. Genschel, D. Snidal and B. Zangl. 2012. *Orchestration: Global Governance through Intermediaries.* SSRN. [Online: https://dx.doi.org/10.2139/ssrn.2125452]

Abbott, K. W. and S. Bernstein. 2015. The High-Level Political Forum on Sustainable Development: Orchestration by Default and Design. *Global Policy* 6 (3): 222-33.

Abbott, K. W., P. Genschel, D. Snidal and B. Zangl, editors. 2015. *International organizations as orchestrators*. Cambridge: Cambridge University Press.

Abbott, K. W., P. Genschel, D. Snidal and B. Zangl. 2016. Two Logics of Indirect Governance: Delegation and Orchestration. *British Journal of Political Science* 46 (4): 719-29.

Adger, W. N., T. Quinn, I. Lorenzoni, C. Murphy and J. Sweeney. 2012. Changing social contracts in climate-change adaptation. *Nature Climate Change* 3 (4): 330-33.

Adger, W. N., C. Butler and K. Walker-Springett. 2017. Moral reasoning in adaptation to climate change. *Environmental Politics* 26 (3): 371-90.

Adler, C., G. Hirsch Hadorn, T. Breu, U. Wiesmann and C. Pohl. 2018. Conceptualizing the transfer of knowledge across cases in transdisciplinary research. *Sustainability Science* 13 (1): 179-90.

Aligica, P. D. and V. Tarko. 2012. Polycentricity: From Polanyi to Ostrom, and Beyond. *Governance* 25 (2): 237-62.

Aligica, P.D. 2014. *Institutional diversity and political economy: the Ostroms and beyond*. Oxford: Oxford University Press.

Allan, J. I. and J. Hadden. 2017. Exploring the Framing Power of NGOs in Global Climate Politics. *Environmental Politics* 26 (4): 600-620.

Alves, J., M. J. Marques, I. Saur and P. Marques. 2007. Creativity and Innovation through Multidisciplinary and Multisectoral Cooperation. *Creativity and Innovation Management* 16 (1): 27-34.

Anand, R. 2004. *International Environmental Justice: A North-South Dimension*. Aldershot: Ashgate Publishing.

Andersson, K. and A. Agrawal. 2011. Inequalities, institutions, and forest commons. *Global Environmental Change* 21 (3): 866-75.

Archer, M. S. 2003. *Structure, Agency and the Internal Conversation*. Cambridge: Cambridge University Press.

Archibugi, D., M. Koenig-Archibugi and R. Marchetti, editors. 2011. *Global Democracy: Normative and Empirical Perspectives*. Cambridge: Cambridge University Press.

Arias-Maldonado, M. 2007. An Imaginary Solution? The Green Defence of Deliberative Democracy. *Environmental Values* 16 (2): 233-52.

Asal, V. 2005. Playing Games with International Relations. *International Studies Perspectives* 6 (3): 359-73.

Ash, M., J. Boyce, G. Chang, J. Scoggins and M. Pastor. 2009. *Justice in the Air: Tracking Toxic Pollution from America's Industries and Companies to Our States, Cities, and Neighborhoods*. PERI Working Paper Series. Political Economy Research Institute.

Asmelash, H. B. 2015. Energy Subsidies and WTO Dispute Settlement: Why Only Renewable Energy Subsidies Are Challenged. *Journal of International Economic Law* 18 (2): 261-85.

Audi, R. 2011. *Epistemology: A Contemporary Introduction to the Theory of Knowledge.* New York: Routledge.

Auld, G., A. Mallett, B. Burlica, F. Nolan-Poupart and R. Slater. 2014. Evaluating the

effects of policy innovations: Lessons from a systematic review of policies promoting low-carbon technology. *Global Environmental Change* 29: 444-58.

Auld, G., S. Renckens and B. Cashore. 2015. Transnational private governance between the logics of empowerment and control. *Regulation & Governance* 9 (2): 108-24.

Autin, W. J. and J. M. Holbrook. 2012. Is the Anthropocene an issue of stratigraphy or pop culture? *GSA Today* 22 (7): 60-61.

Baber, Walter F, and Robert V Bartlett. 2015. *Consensus and Global Environmental Governance: Deliberative Democracy in Nature's Regime*. Cambridge, MA: MIT Press.

Bachrach, P. and M. S. Baratz. 1963. Decisions and Nondecisions: An Analytical Framework. *American Political Science Review* 57 (3): 632-42.

Bäckstrand, K. 2006. Multi-stakeholder partnerships for sustainable development: rethinking legitimacy, accountability and effectiveness. *European Environment* 16 (5): 290-306.

Bäckstrand, K., J. Khan, A. Kronsell and E. Lövbrand, editors. 2010. *Environmental Politics and Deliberative Democracy: Examining the Promise of New Modes of Governance.* Cheltenham: Edward Elgar.

Bäckstrand, K. and M. Kylsäter. 2014. Old Wine in New Bottles? The Legitimation and Delegitimation of UN Public–Private Partnerships for Sustainable Development from the Johannesburg Summit to the Rio+20 Summit. *Globalizations* 11 (3): 331-47.

Bäckstrand, K. and J. W. Kuyper. 2017. The democratic legitimacy of orchestration: the UNFCCC, non-state actors, and transnational climate governance. *Environmental Politics* 26 (4): 764-88.

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. *Environmental Politics* 26 (4): 561-79.

Bai, X., B. Roberts and J. Chen. 2010. Urban sustainability experiments in Asia: patterns and pathways. *Environmental Science & Policy* 13 (4): 312-25.

Bai, X., A. Surveyer, T. Elmqvist, F. W. Gatzweiler, B. Güneralp, S. Parnell, A. H. Prieur-Richard, P. Shrivastava, J. G. Siri, M. Stafford-Smith, J. P. Toussaint and R. Webb. 2016a. Defining and advancing a systems approach for sustainable cities. *Current Opinion in Environmental. Sustainability* 23: 69-78.

Bai, X., S. van der Leeuw, K. O'Brien, F. Berkhout, F. Biermann, E. S. Brondizio, C. Cudennec, J. Dearing, A. Duraiappah, M. Glaser, A. Revkin, W. Steffen and J. Syvitski. 2016b. Plausible and Desirable Futures in the Anthropocene: A New Research Agenda. *Global Environmental Change* 39: 351-362.

Barker, T., Ş. Scrieciu and D. Taylor. 2008. Climate Change, Social Justice and Development. *Development* 51 (3): 317-24.

Barnett, J. and S. O'Neill. 2010. Maladaptation. *Global Environmental Change* 20 (2): 211-13.

Barnett, M. and R. Duvall. 2005. Power in International Politics. *International Organization* 59 (01): 39-75.

Barrett, S. 2011. Rethinking Climate Change Governance and Its Relationship to the World Trading System. *The World Economy* 34 (11): 1863-82.

Baskin, J. 2015. Paradigm Dressed as Epoch: The Ideology of the Anthropocene. *Environmental Values* 24 (1): 9-29.

Bauer, S., S. Andresen and F. Biermann. 2012. International Bureaucracies, in *Global Environmental Governance Reconsidered*, edited by F. Biermann and P. Pattberg, 28-44. Cambridge, MA: MIT Press.

Bauer, A. and R. Steurer. 2014. Innovation in climate adaptation policy: are regional partnerships catalysts or talking shops? *Environmental Politics* 23 (5): 818-38.

Beck, M. and T. Krueger. 2016. The epistemic, ethical, and political dimensions of uncertainty in integrated assessment modeling. *WIREs Climate Change* 7 (5): 627-45.

Beck, U. 1992. *Risk Society: Towards a New Modernity*. London: Sage.

Beitz, C. 1979. *Political Theory and International Relations*. Princeton, NJ: Princeton University Press.

Berger, P. L. and T. Luckmann. 1967. *The Social Construction of Reality*. New York: Doubleday.

Berg-Schlosser, D. 2012. *Mixed Methods in Comparative Politics. Principles and Applications*. New York: Palgrave.

Bernauer, T. and C. Betzold. 2012. Civil Society in Global Environmental Governance. *The Journal of Environment & Development* 21 (1): 62-66.

Bernstein, S. and M. Hoffmann. 2018. The politics of decarbonization and the catalytic impact of subnational climate experiments. *Policy Sciences* 51: 189-211.

Berto, F. and M. Plebani. 2015. *Ontology and Metaontology: A Contemporary Guide*. London: Bloomsbury Academic.

Betsill, M. M. and E. Corell. 2008. *NGO Diplomacy: The Influence of Nongovernmental Organizations in International Environmental Negotiations.* Cambridge, MA: MIT Press.

Beunen, R. and J. Patterson. 2016. Analysing institutional change in environmental governance: exploring the concept of 'institutional work'. *Journal of Environmental Planning and Management* 1-18.

Beunen, R., J. Patterson and K. Van Assche. 2017. Governing for resilience: the role of institutional work. *Current Opinion in Environmental Sustainability* 28: 10-16.

Bhaskar, R. 1978. *A Realist Theory of Science.* Brighton: Harvester Press.

Biermann, F., M. M. Betsill, J. Gupta, N. Kanie, L. Lebel, D. Liverman, H. Schroeder and B. Siebenhüner with contributions from K. Conca, L. da Costa Ferreira, B. Desai, S. Tay and R. Zondervan. 2009a. *Earth System Governance: People, Places and the Planet. Science and Implementation Plan of the Earth System Governance Project.* Earth System Governance Report 1, IHDP Report 20. Bonn, IHDP: The Earth System Governance Project.

Biermann, F., P. Pattberg, H. van Asselt and F. Zelli. 2009b. The Fragmentation of Global Governance Architectures: A Framework for Analysis. *Global Environmental Politics* 9 (4): 14-40.

Biermann, F. and B. Siebenhüner, editors. 2009c. Studying the Influence of International Bureaucracies: A Conceptual Framework. In *Managers of Global Change: The Influence of International Environmental Bureaucracies*. Cambridge, MA: MIT Press.

Biermann, F., P. Pattberg and F. Zelli, editors. 2010. *Global Climate Governance beyond 2012. Architecture, Agency and Adaptation.* Cambridge: Cambridge University Press.

Biermann, F. and A. Gupta. 2011. Accountability and legitimacy in earth system governance: A research framework. *Ecological Economics* 70 (11): 1856-64.

Biermann, F., K. Abbott, S. Andresen, K. Bäckstrand, S. Bernstein, M. M. Betsill, H. Bulkeley, B. Cashore, J. Clapp, C. Folke, A. Gupta, J. Gupta, P. M. Haas, A. Jordan, N. Kanie, T. Kluvánková-Oravská, L. Lebel, D. Liverman, J. Meadowcroft, R. B. Mitchell, P. Newell, S. Oberthür, L. Olsson, P. Pattberg, R. Sánchez-Rodríguez, H. Schroeder, A. Underdal, S. C. Vieira, C. Vogel, O. R. Young, A. Brock and R. Zondervan. 2012. Transforming governance and institutions for global sustainability: key insights from the Earth System Governance Project. *Current Opinion in Environmental Sustainability* 4 (1): 51-60.

Biermann, F., X. Bai, N. Bondre, W. Broadgate, C.-T. Arthur Chen, O. P. Dube, J. W. Erisman, M. Glaser, S. van der Hel, M. C. Lemos, S. Seitzinger and K. C. Seto. 2016. Down to Earth: Contextualizing the Anthropocene. *Global Environmental Change* 39: 341-50.

Biermann, F., N. Kanie and R. E. Kim. 2017. Global governance by goal-setting. The novel approach of the UN Sustainable Development Goals. *Current Opinion in Environmental Sustainability* 26: 26-31.

Biermann, Frank. 2007. 'Earth system governance' as a crosscutting theme of global change research. *Global Environmental Change. Human and Policy Dimensions* 17: 3–4, 326–337.

Biermann, Frank. 2014. *Earth System Governance: World Politics in the Anthropocene.* Cambridge, MA: MIT Press.

Biesbroek, G. R., C. J. A. M. Termeer, J. E. M. Klostermann and P. Kabat. 2014. Rethinking barriers to adaptation: Mechanism-based explanation of impasses in the governance of an innovative adaptation measure. *Global Environmental Change* 26: 108-18.

Biesbroek, R., J. Dupuis, A. Jordan, A. Wellstead, M. Howlett, P. Cairney, J. Rayner and D. Davidson. 2015. Opening up the black box of adaptation decision-making. *Nature Climate Change* 5 (6): 493-94.

Biggs, R., F. R. Westley and S. R. Carpenter. 2010. Navigating the back loop: fostering social innovation and transformation in ecosystem management. *Ecology and Society* 15 (2): 9.

Bizikova, L., S. Burch, J. Robinson, A. Shaw and S. R. J. Sheppard. 2011. Adaptation, climate change, and uncertainty, in *Dealing with Uncertainty: Insights into the Calculability of Climate Change and its Influence on Society*, edited by G. Gramelsberger and J. Feichter. London: Springer.

Blackwell, A., L. Wilson and A. Street. 2009. *Radical innovation: crossing knowledge boundaries with interdisciplinary teams.* Technical Report 760. University of Cambridge Computer Laboratory.

Bloomfield, Michael J. 2017. *Dirty Gold: How Activism Transformed the Jewelry Industry*. Cambridge, MA: MIT Press.

Böhmelt, T. 2014. Political Opportunity Structures in Dictatorships? Explaining ENGO Existence in Autocratic Regimes. *The Journal of Environment & Development* 23 (4): 446-71.

Böhmelt, T., V. Koubi and T. Bernauer. 2014. Civil society participation in global governance: Insights from climate politics. *European Journal of Political Research* 53 (1): 18-36.

Bomberg, E. 2017. Environmental politics in the Trump era: an early assessment. *Environmental Politics* 26 (5): 956-63.

Bonneuil, C. and J. Fressoz. 2016. *The Shock of the Anthropocene: The Earth, History and Us.* London: Verso.

Booher, D. E. and J. E. Innes. 2010. Governance for resilience: CALFED as a complex adaptive network for resource management. *Ecology and Society* 15 (3): 35.

Borgatti, S. P., A. Mehra, D. J. Brass and G. Labianca. 2009. Network analysis in the social sciences. *Science* 323 (5916): 892-895.

Borup, M., N. Brown, K. Konrad and H. van Lente. 2006. The sociology of expectations in science and technology. *Technology Analysis and Strategic Management* 18: 285-298.

Bowen, K. J., N. A. Cradock-Henry, F. Koch, J. Patterson, T. Häyhä, J. Vogt and F. Barbi. 2017. Implementing the "Sustainable Development Goals": towards addressing three key governance challenges—collective action, trade-offs, and accountability. *Current Opinion in Environmental Sustainability* 26-27: 90-96.

Boyd, E., B. Nykvist, S. Borgstrom and I. A. Stacewicz. 2015. Anticipatory governance for social-ecological resilience. *Ambio* 44: 149-61.

Bracking, S. 2015. The Anti-Politics of Climate Finance: The Creation and Performativity of the Green Climate Fund. *Antipode* 47 (2): 281-302.

Brandt, P., A. Ernst, F. Gralla, C. Luederitz, D. J. Lang, J. Newig, F. Reinert, D. J. Abson and H. von Wehrden. 2013. A review of transdisciplinary research in sustainability science. *Ecological Economics* 92: 1-15.

Bräutigam, D. 2009. *The Dragon's Gift: The Real Story of China in Africa*. New York: Oxford University Press.

Breakthrough Institute. 2015. *An Ecomodernist Manifesto.* Oakland, CA: Breakthrough Institute.

Brisbois, M. C. and R. C. de Loë. 2015. Power in Collaborative Approaches to Governance for Water: A Systematic Review. *Society & Natural Resources* 29 (7): 775-90.

Brock, G. 2009. *Global Justice: A Cosmopolitan Account*. Oxford: Oxford University Press.

Brondizio, E. S., K. O'Brien, X. Bai, F. Biermann, W. Steffen, F. Berkhout, C. Cudennec, M. C. Lemos, A. Wolfe, J. Palma-Oliveira and C.-T. A. Chen. 2016. Re-conceptualizing the Anthropocene: A call for collaboration. *Global Environmental Change* 39: 318-27.

Brown, V. A., P. M. Deane, J. A. Harris and J. Y. Russell. 2010. Toward a Just and Sustainable Future in *Tackling Wicked Problems through the Transdisciplinary Imagination*, edited by V. A. Brown, J. A. Harris and J. Y. Russell. London: Earthscan.

Brundiers, K. and A. Wiek. 2010. Educating Students in Real-world Sustainability Research: Vision and Implementation. *Innovative Higher Education* 36 (2): 107-24.

Bukovansky, M., I. Clark, R. Eckersley, R. Price, C. Reus-Smit and N. J. Wheeler. 2012. *Special Responsibilities: Global Problems and American Power*. Cambridge: Cambridge University Press.

Bulkeley, H. and M. Betsill. 2005. Rethinking Sustainable Cities: Multilevel Governance and the 'Urban' Politics of Climate Change. *Environmental Politics* 14 (1): 42-63.

Bulkeley, H. and M. M. Betsill. 2013. Revisiting the urban politics of climate change. *Environmental Politics* 22 (1): 136-54.

Bulkeley, H. 2014. *Transnational climate change governance*. New York: Cambridge University Press.

Bulkeley, H., L. Andonova, M. M. Betsill, D. Compagnon, T. Hale, M. Hoffman, P. Newell, M. Paterson, C. Roger and S. Vandeveer. 2014. *Transnational climate change governance.* New York: Cambridge University Press.

Bulkeley, H., G. A. S. Edwards and S. Fuller. 2014. Contesting climate justice in the city: Examining politics and practice in urban climate change experiments. *Global Environmental Change* 25: 31-40.

Burch, S., M. Andrachuk, D. Carey, N. Frantzeskaki, H. Schroeder, N. Mischkowski and D. Loorbach. 2016. Governing and accelerating transformative entrepreneurship: exploring the potential for small business innovation on urban sustainability transitions. *Current Opinion in Environmental Sustainability* 22: 26-32.

Burke, A., S. Fishel, A. Mitchell, S. Dalby and D. J. Levine. 2016. Planet Politics: A Manifesto from the End of IR. *Millennium* 44 (3): 499-523.

Bustamante, R., C. Crespo and A.M. Walnycki. 2012. Seeing through the concept of water as a human right in Bolivia, in *The right to water: politics, governance and social struggles*, edited by F. Sultana and A. Loftus, 223-240. London: Routledge.

Caney, S. 2001. International Distributive Justice. *Political Studies* 49 (5): 974-997.

Caney, S. 2005. Justice Beyond Borders. Oxford: Oxford University Press.

Carbon Disclosure Project (CDP). 2017. *Tracking corporate action on climate change.* [Online: https://www.cdp.net/en/research/global-reports/tracking-climate-progress-2017]

Carson, D., A. Gilmore, C. Perry and K. Gronhaug. 2001. *Qualitative Marketing Research*. London: Sage.

Carvalho, A. 2007. Ideological cultures and media discourses on scientific knowledge: re-reading news on climate change. *Public Understanding of Science* 16 (2): 223.

Carvalho, A. 2010. Media(ted) discourses and climate change: a focus on political subjectivity and (dis)engagement. *WIREs Climate Change* 1 (2): 172.

Castles, S. 2012. Understanding the relationship between methods and methodology. In *Handbook of research methods in migration*, edited by C. Vargas-Silva, 15-36. Cheltenham: Edward Elgar.

Chan, S., H. van Asselt, T. Hale, K. W. Abbott, M. Beisheim, M. Hoffmann, B. Guy, N. Höhne, A. Hsu, P. Pattberg, P. Pauw, C. Ramstein and O. Widerberg. 2015. Reinvigorating International Climate Policy: A Comprehensive Framework for Effective Nonstate Action. *Global Policy* 6 (4): 466-73.

Chapin, F. S., S. R. Carpenter, G. P. Kofinas, C. Folke, N. Abel, W. C. Clark, P. Olsson, D. M. S. Smith, B. Walker, O. R. Young, F. Berkes, R. Biggs, J. M. Grove, R. L. Naylor, E. Pinkerton, W. Steffen and F. J. Swanson. 2010. Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends in Ecology & Evolution* 25 (4): 241-49.

Chasek, P. S. 2005. Power Politics, Diplomacy and Role Playing: Simulating the UN Security Council's Response to Terrorism. *International Studies Perspectives* 6 (1): 1-19.

Chasek, P. S. and L. M. Wagner. 2016. Breaking the mold: a new type of multilateral sustainable development negotiation. *International Environmental Agreements: Politics, Law and Economics* 16 (3): 397-413.

Christoff, P. and Eckersley, R. 2013. *Globalization and the Environment.* Lanham, MD: Rowman & Littlefield.

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*. Cambridge, MA: MIT Press.

Clapp, J. and P. Dauvergne. 2005. *Paths To A Green World: The Political Economy of the Global Environment*. Boston: The MIT Press.

Clarke, L., K. Jiang, K. Akimoto, M. Babiker, G. Blanford, K. Fisher-Vanden, J. C. Hourcade, V. Krey, E. Kriegler and A. Löschel. 2014. Assessing Transformation Pathways, in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J. C. Minx. Cambridge, UK and New York: Cambridge University Press.

Coenen, L., P. Benneworth and B. Truffer. 2012. Toward a spatial perspective on sustainability transitions. *Research Policy* 41 (6): 968-79.

Comim, F. 2008. Climate Injustice and Development: A capability perspective. *Development* 51: 344-349.

Conway, D., J. Barnett, M. M. Betsill, L. Lebel and K. C. Seto. 2014. Global Environmental Change: Taking stock at a time of transition. *Global Environmental Change* 25: 1-4.

Cornell, S., F. Berkhout, W. Tuinstra, J. D. Tàbara, J. Jäger, I. Chabay, B. de Wit, R. Langlais, D. Mills, P. Moll, I. M. Otto, A. Petersen, C. Pohl and L. van Kerkhoff. 2013. Opening up knowledge systems for better responses to global environmental change. *Environmental Science & Policy* 28: 60-70.

Crona, B. I. and J. N. Parker. 2012. Learning in Support of Governance: Theories, Methods, and a Framework to Assess How Bridging Organizations Contribute to Adaptive Resource Governance. *Ecology and Society* 17 (1).

Crotty, M. 1998. *The Foundations of Social Research: Meaning and Perspective in the Research Process*. London: Sage.

Crutzen, P. J. 2002. Geology of mankind. *Nature* 415: 23.

Dahlstrom, M. F. 2014. Using narratives and storytelling to communicate science with nonexpert audiences. *Proceedings of the National Academy of Sciences* 111: 13614-20.

Danermark, B., M. Ekström, L. Jakobsen and J. C. Karlsson. 2002. *Explaining Society: Critical Realism in the Social Sciences.* London: Routledge.

Dash, A. 2014. The moral basis of sustainable society: the Gandhian concept of ecological citizenship. *International Review of Sociology* 24 (1): 27-37.

de Haan, J. and J. Rotmans. 2011. Patterns in transitions: Understanding complex chains of change. *Technological Forecasting and Social Change* 78 (1): 90-102.

de Loë, R. C. and J. J. Patterson. 2017. Rethinking Water Governance: Moving Beyond Water-Centric Perspectives in a Connected and Changing World. *Natural Resources Journal* 57 (1): 75-99.

Della Porta, D. and M. Keating, editors. 2008. *Approaches and Methodologies in the Social Sciences. A Pluralist Perspective*. Cambridge: Cambridge University Press.

Dennis, M., R. P. Armitage and P. James. 2016. Social-ecological innovation: adaptive responses to urban environmental conditions. *Urban Ecosystems* 19 (3): 1063-1082.

Detraz, N. 2017. *Gender and the Environment.* Cambridge: Polity Press.

Deutz, P. 2014. A Class-Based Analysis of Sustainable Development: Developing a Radical Perspective on Environmental Justice. *Sustainable Development* 22 (4): 243-52.

Diamond, S. and B. Irwin. 2013. Using e-learning for student sustainability literacy: Framework and review. *International Journal of Sustainability in Higher Education* 14 (4): 338-348.

Donald, K. and S. A. Way. 2016. Accountability for the Sustainable Development Goals: A Lost Opportunity? *Ethics & International Affairs* 30 (2): 201-13.

Dorsch, M. J. and C. Flachsland. 2017. A Polycentric Approach to Global Climate Governance. *Global Environmental Politics* 17 (2): 45-64.

Dovers, S. 2009. Normalizing adaptation. *Global Environmental Change* 19 (1): 4-6.

Dryzek, J. S. 1987. *Rational Ecology: Environment and Political Economy*. Oxford: Blackwell.

Dryzek, J. S. and H. Stevenson. 2011. Global Democracy and Earth System Governance. *Ecological Economics* 70 (11): 1865-1874.

Dryzek, J. S. 2013. *The Politics of the Earth: Environmental Discourses*. 3rd edition. Oxford: Oxford University Press.

Dryzek, J. S. 2016. Institutions for the Anthropocene: Governance in a Changing Earth System. *British Journal of Political Science* 46 (4): 937-56.

Dryzek, J. S. and J. Pickering. 2017. Deliberation as a Catalyst for Reflexive Environmental Governance. *Ecological Economics* 131: 353-360.

Dryzek, J. S. and J. Pickering. Forthcoming. *The Politics of the Anthropocene*. Oxford: Oxford University Press.

Duca, J. V. and J. L. Saving. 2016. Income Inequality and Political Polarization: Time Series Evidence Over Nine Decades. *Review of Income and Wealth* 62 (3): 445-66.

Duit, A. and V. Galaz. 2008. Governance and Complexity-Emerging Issues for Governance Theory. *Governance* 21 (3): 311-35.

Duit, A., V. Galaz, K. Eckerberg and J. Ebbesson. 2010. Governance, complexity, and resilience. *Global Environmental Change* 20 (3): 363-368.

Dupuis, J. and R. Biesbroek. 2013. Comparing apples and oranges: The dependent variable problem in comparing and evaluating climate change adaptation policies. *Global Environmental Change* 23 (6): 1476-87.

Duus-Otterström, G. and S. C. Jagers. 2012. Identifying burdens of coping with climate change: A typology of the duties of climate justice. *Global Environmental Change* 22 (3): 746-53.

Dzebo, A. and J. Stripple. 2015. Transnational adaptation governance: An emerging fourth era of adaptation. *Global Environmental Change* 35: 423-35.

Eckersley, R. 1992. *Environmentalism and Political Theory: Toward an Ecocentric Approach*. London: UCL Press.

Eckersley, R. 2017. Geopolitan Democracy in the Anthropocene. *Political Studies* 65 (4): 983-999.

Edwards, G. A. S. and H. Bulkeley. 2017. Heterotopia and the urban politics of climate change experimentation. *Environment and Planning D: Society and Space* 36 (2): 350-69.

Ehresman, T. and C. Okereke. 2015. Environmental justice and conceptions of the green economy. *International Environmental Agreements: Politics, Law and Economics* 15 (1): 13-27.

Elmqvist, T., M. Fragkias, J. Goodness, B. Güneralp, P. J. Marcotullio, R. I. McDonald, S. Parnell, M. Schewenius, M. Sendstad, K. C. Seto and C. Wilkinson, editors. 2013. *Urbanization, biodiversity and ecosystem services: challenges and opportunities: a global assessment.* Dordrecht: Springer.

Emerson, K. and A. K. Gerlak. 2014. Adaptation in Collaborative Governance Regimes. *Environmental Management* 54: 768-781.

Eriksen, S. H., A. J. Nightingale and H. Eakin. 2015. Reframing adaptation: The political nature of climate change adaptation. *Global Environmental Change* 35: 523-533.

Escobar, A. 2007. World and Knowledge Otherwise. *Cultural Studies* 21 (2): 179-210.

Escobar, A. 2016. Thinking-feeling with the Earth: Territorial Struggles and the Ontological Dimension of the Epistemologies of the South. *Revista de Antropología Iberoamericana* 11 (1): 11-32.

Esquivel, J. C. and F. Mallimaci. 2017. Religión, medioambiente y desarrollo sustentable: la integralidad en la cosmología católica. [Religion, environment and sustainable development: integrality in Catholic cosmology]. *Revista de Estudios Sociales* 60: 72-86.

Fahs, B. 2015. The weight of trash: Teaching sustainability and ecofeminism by asking undergraduates to carry around their own garbage. *Radical Teacher* 10230-34.

Falkner, R. 2008. *Business power and conflict in international environmental politics.* Basingstoke: Palgrave Macmillan.

Fan, M. F. 2016. Environmental Justice and the Politics of Risk: Water Resource Controversies in Taiwan. *Human Ecology* 44 (4): 425-434.

Farbotko, C. and H. Lazrus. 2012. The First Climate Refugees? Contesting Global Narratives of Climate Change in Tuvalu. *Global Environmental Change*, 22 (2): 382-90.

Fennewald, T. J. and B. Kievit-Kylar. 2013. Integrating climate change mechanics into a common pool resource game. *Simulation and Gaming* 44: 427-451.

Feola, G. 2014. Societal transformation in response to global environmental change: a review of emerging concepts. *Ambio* 44: 376-390.

Feygina, I. 2013. Social Justice and the Human–Environment Relationship: Common Systemic, Ideological, and Psychological Roots and Processes. *Social Justice Research* 26 (3): 363-381.

Finnemore, M. and K. Sikkink. 2005. International Norm Dynamics and Political Change. *International Organization* 52 (4): 887-917.

Folke, C., S. R. Carpenter, B. H. Walker, M. Scheffer, F.S.I. Chapin and J. Rockström. 2010. Resilience thinking: Integrating resilience, adaptability and transformability. *Ecology and Society* 15 (20).

Food and Agriculture Organization of the United Nations (FAO). 2016. *The State of World Fisheries and Aquaculture 2016: Contributing to Food Security and Nutrition for All*. Rome: FAO.

Frantzeskaki, N., D. Loorbach and J. Meadowcroft. 2012. Governing transitions to sustainability: transition management as a governance approach towards pursuing sustainability. *International Journal of Sustainable Development* 15: 19-36.

Fraser, N. 1997. *Justice Interruptus: Critical Reflections on the 'Postsocialist' Condition*. New York: Routledge.

Fraser, N. 2001. Recognition without Ethics? *Theory, Culture, and Society* 18: 21-42.

Fuchs, D. A. 2007. *Business Power in Global Governance*. Boulder: Lynne Rienner.

Fuchs, D., A. Di Giulio, K. Glaab, S. Lorek, M. Maniates, T. Princen and I. Røpke. 2016. Power: The Missing Element in Sustainable Consumption and Absolute Reductions Research and Action. *Journal of Cleaner Production* 132: 298-307.

Fuerth, L. S. and E. M. H. Faber. 2013. Anticipatory governance: Winning the future. *Futurist* 47: 42-46, 48-49.

Fukuyama, F. 2014. *Political Order and Political Decay: From the Industrial Revolution to the Globalization of Democracy*. New York: Farrar, Straus and Giroux.

Gabrys, J. and K. Yusoff. 2012. Arts, Sciences and Climate Change: Practices and Politics at the Threshold. *Science as Culture* 21: 1-24.

Galaz, V., F. Moberg, E. K. Olsson, E. Paglia and C. Parker. 2011. Institutional and Political Leadership Dimensions of Cascading Ecological Crises. *Public Administration* 89: 361-380.

Galaz, V., B. Crona, H. Österblom, P. Olsson and C. Folke. 2012. Polycentric Systems and Interacting Planetary Boundaries: Emerging Governance of Climate Change–Ocean Acidification–Marine Biodiversity. *Ecological Economics* 81: 21-32.

Galaz, V. 2014. *Global Environmental Governance, Technology and Politics: The Anthropocene Gap*. Cheltenham: Edward Elgar.

Galaz, V., D. Galafassi, J. Tallberg, E. Hey, A. Boin, C. Ituarte-Lima, J. Dunagan, F. Westley, P. Olsson and R. Österbergh. 2014. *Connected Risks, Connected Solutions*. Stockholm: Stockholm Resilience Centre, Stockholm University, and the Global Challenges Foundation.

Galaz, V., H. Österblom, Ö. Bodin and B. Crona. 2014. Global networks and global change-induced tipping points. *International Environmental Agreements: Politics, Law and Economics* 16 (2): 189-221.

Galaz, V., J. Gars, F. Moberg, B. Nykvist and C. Repinski. 2015. Why Ecologists Should Care about Financial Markets. *Trends in Ecology and Evolution* 30 (10): 571-580.

Galaz, V., J. Tallberg, A. Boin, C. Ituarte-Lima, E. Hey, P. Olsson and F. Westley. 2017. Global Governance Dimensions of Globally Networked Risks: The State of the Art in Social Science Research. *Risk, Hazards & Crisis in Public Policy* 8 (1): 4-27.

Geels, F. W. and J. Schot. 2007. Typology of sociotechnical transition pathways. *Research Policy* 36: 399-417.

Gellers, J. C. 2016. Crowdsourcing Global Governance: Sustainable Development Goals, Civil Society, and the Pursuit of Democratic Legitimacy. International Environmental Agreements: Politics, *Law and Economics* 16 (3): 415-432.

Gerlak, A. K. and M. Wilder. 2012. Exploring the textured landscape of water insecurity and the human right to water. *Environment: Science and Policy for Sustainable Development* 54 (2): 4-17.

Gerlak, A. K., T. Heikkila, S. L. Smolinski, D. Huitema and D. Armitage. 2017. Learning our way out of environmental policy problems: a review of the scholarship. *Policy Sciences* 51 (3): 335-71.

Gerring, J. 2001. *Social Science Methodology*. Cambridge: Cambridge University Press.

Geyer, R., J. R. Jambeck and K. L. Law. 2017. Production, use, and fate of all plastics ever made. *Science Advances* 3 (7): e1700782-e82.

Giddens, A. 1990. *The Consequences of Modernity.* Cambridge: Polity Press in association with Basil Blackwell.

Global Carbon Project. 2017. *Carbon budget and trends 2017.* [Online: www.globalcarbonproject.org/carbonbudget]

Goertz, G. and J. Mahoney. 2012. *A Tale of Two Cultures.* Princeton: Princeton University Press.

Goodin, R. E. 1992. *Green Political Theory.* Cambridge: Polity.

Gordon, D. J., and C.A. Johnson. 2017. The Orchestration of Global Urban Climate Governance: Conducting Power in the Post-Paris Climate Regime. *Environmental Politics*, 26(4): 694-714.

Gosepath, S. 2011. Equality. In *The Stanford Encyclopedia of Philosophy*, edited by E. N. Zalta. [Online: https://plato.stanford.edu/archives/spr2011/entries/equality/]

Gould, E. D. and A. Hijzen. 2016. *Growing Apart, Losing Trust? The Impact of Inequality on Social Capital.* IMF Working Paper 16/176. Washington D.C.: IMF.

Grant, R. W. and R. O. Keohane. 2005. Accountability and Abuses of Power in World Politics. *American Political Science Review* 99 (1): 29-43.

Green, J. F. 2013. *Rethinking Private Authority: Agents and Entrepreneurs in Global Environmental Governance*. Princeton, NJ: Princeton University Press.

Green, J. F. 2014. *Rethinking Private Authority: Agents and Entrepreneurs in Global Environmental Governance*. Princeton, NJ: Princeton University Press.

Griggs, D., A. Nilsson, A. Stevance and D. McCollum, editors. 2017. A guide to SDG interactions: from science to implementation. Paris: International Council for Science (ICSU).

Griggs, D., M. S. Smith, J. Rockstrom, M. Ohman, O. Gaffney, G. Glaser, N. Kanie, I. Noble, W. Steffen and P. Shyamsundar. 2014. An integrated framework for sustainable development goals. *Ecology and Society* 19 (4): 49.

Guha-Sapir, D., P. Hoyois, P. Wallemacq and R. Below. 2017. *Annual Disaster Statistical Review 2016: The Numbers and Trends.* Brussels: CRED.

Gupta, A. 2001. *Searching for Shared Norms: Global Governance of Biosafety*. PhD dissertation, Yale University Graduate School of Arts and Sciences (UMI No. 3030777).

Gupta, A. 2010. Transparency in Global Environmental Governance: A Coming of Age? *Global Environmental Politics* 10 (3): 1-9.

Gupta, J. and L. Lebel. 2010. Access and allocation in earth system governance: water and climate change compared. *International Environmental Agreements* 10: 377-395.

Gupta, A. 2011. An evolving science-society contract in India: The search for legitimacy in anticipatory risk governance. *Food Policy* 36: 736-741.

Gupta, A. and M. Mason. 2014. *Transparency in Global Environmental Governance: Critical perspectives*. Cambridge, MA: MIT Press.

Gupta, J., N. R. M. Pouw and M. A. F. Ros-Tonen. 2015. Towards an Elaborated Theory of Inclusive Development. *The European Journal of Development Research* 27 (4): 541-59.

Gupta, J. and C. Vegelin. 2016. Sustainable development goals and inclusive development. *International Environmental Agreements: Politics, Law and Economics* 16 (3): 433-48.

Gupta, A. and H. van Asselt. 2017. Transparency in multilateral climate politics: Furthering (or distracting from) accountability? *Regulation & Governance.*

Guston, D. 2010. The Anticipatory Governance of Emerging Technologies. *Journal of the Korean Vacuum Society* 19: 432-441.

Hackmann, H. and A. L. St. Clair. 2012. *Transformative Cornerstones of Social Science Research for Global Change*. Paris: International Social Science Council.

Hajer, M., M. Nilsson, K. Raworth, P. Bakker, F. Berkhout, Y. de Boer, J. Rockström, K. Ludwig and M. Kok. 2015. Beyond Cockpit-ism: Four Insights to Enhance the Transformative Potential of the Sustainable Development Goals. *Sustainability* 7 (2): 1651-1660.

Hall, N. and A. Persson. 2018. Global climate adaptation governance: Why is it not legally binding? *European Journal of International Relations* 24 (3): 540-66.

Hall, P. 2010. Chapter 7: Historical institutionalism in rationalist and sociological perspective. In *Explaining Institutional Change: Ambiguity, Agency, and Power*, edited by J. Mahoney and K. Thelen. Cambridge: Cambridge University Press.

Hamilton, C. 2017. *Defiant Earth: The Fate of Humans in the Anthropocene*. Cambridge: Polity.

Hansen, M., V. Ramasar and K. Buchanan. 2014. Localising global environmental governance norms: implications for justice In *Environmental Governance for Social Justice—Lessons Across Natural Resource Sectors in Southern Africa*, edited by M. Sowman and R. Wynberg. Cape Town: Routledge.

Heikkila, T. and A. K. Gerlak. 2013. Building a Conceptual Approach to Collective Learning: Lessons for Public Policy Scholars. *Policy Studies Journal* 41 (3): 484-512.

Held, D. 1995. *Democracy and the Global Order: From the Modern State to Cosmopolitan Governance*. Stanford: Stanford University Press.

Hendriks, C. M. and J. Grin. 2007. Contextualizing Reflexive Governance: The Politics of Dutch Transitions to Sustainability. *Journal of Environmental Policy & Planning* 9 (3-4): 333-350.

Hickmann, T. 2016. *Rethinking Authority in Global Climate Governance: How Transnational Climate Initiatives Relate to the International Climate Regime*. London: Routledge.

Hickmann, T. 2017. The Reconfiguration of Authority in Global Climate Governance. *International Studies Review* 19 (3): 430-45.

Hmelo-Silver, C. E. 2004. Problem-based learning: What and how do students learn? *Educational Psychology Review* 16 (3): 235-266.

Hoff, H. 2009. Global water resources and their management. *Current Opinion in Environmental Sustainability* 1: 141-147.

Hoffmann, A. 2015. *How Culture Shapes the Climate Change Debate.* Stanford: Stanford University Press.

Hollway, J. and J. Koskinen. 2016. Multilevel Embeddedness: The Case of the Global Fisheries Governance Complex. *Social Networks* 44: 281-294.

Holm, P., M. E. Goodsite, S. Cloetingh, M. Agnoletti, B. Moldan, D. J. Lang, R. Leemans, J. O. Moeller, M. P. Buendía, W. Pohl, R. W. Scholz, A. Sors, B. Vanheusden, K. Yusoff and R. Zondervan. 2013. Collaboration between the natural, social and human sciences in Global Change Research. *Environmental Science & Policy* 28: 25-35.

Honneth, A. 2001. Recognition or Redistribution: Changing Perspectives on the Moral Order of Society. *Theory, Culture, and Society* 18 (2-3): 43-55.

Huitema, D. and S. V. Meijerink, editors. 2009. *Water policy entrepreneurs: a research companion to water transitions around the globe*. Cheltenham: Edward Elgar.

Huitema, D., E. Mostert, W. Egas, S. Moellenkamp, C. Pahl-Wostl and R. Yalcin. 2009. Adaptive water governance: assessing the institutional prescriptions of adaptive (co-)

management from a governance perspective and defining a research agenda. *Ecology and Society* 14 (1): 26.

Huitema, D. and S. Meijerink. 2010. Realizing water transitions: the role of policy entrepreneurs in water policy change. Ecology and Society 15 (2): 26.

Huitema, D., W. N. Adger, F. Berkhout, E. Massey, D. Mazmanian, S. Munaretto, R. Plummer and C. C. J. A. M. Termeer. 2016. The governance of adaptation: choices, reasons, and effects. Introduction to the Special Feature. *Ecology and Society* 21 (3): 37.

Hulme, M. 2010. Cosmopolitan climates: Hybridity, foresight and meaning. *Theory, Culture and Society* 27: 267-276.

Hunter, D. R., M. S. Handcock, C. T. Butts, S. M. Goodreau and M. Morris. 2008. ergm: A package to fit, simulate and diagnose exponential-family models for networks. *Journal of Statistical Software* 24 (3): 1-29.

Hyle, M. A. 2016. Conceptual Reflection on Responsive Environmental Governance. *International Journal of Public Administration* 39 (8): 610-19.

Ikeme, J. 2003. Equity, environmental justice and sustainability: incomplete approaches in climate change politics. *Global Environmental Change* 13 (3): 195-206.

Inoue, C. Y. A. and M. M. Valença. 2016. *Paradox of plenty or plenty of information? An overview of active teaching and learning literature on the challenges of the information era.* Paper prepared for delivery at the 57th International Studies Association Annual Convention March 16-19, 2016. Atlanta.

Intergovernmental Panel on Climate Change (IPCC). 2014. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Core Writing Team, R.K. Pachauri and L.A. Meyer. Geneva.

Intergovernmental Panel on Climate Change (IPCC). 2018. *Global warming of 1.5°C: Summary for policy-makers*. Geneva: WMO and UNEP.

International Energy Agency (IEA). 2017. *Global EV Outlook 2017: Two Million and Counting.* Paris: IEA.

International Organization for Migration (IOM). 2017. *Global Migration Trends Factsheet.* [Online: http://gmdac.iom.int/global-migration-trends-factsheet]

International Tanker Owners Pollution Federation (ITOPF). 2018. *Oil tanker spill statistics 2017.* [Online: https://www.itopf.org/fileadmin/data/Photos/Statistics/Oil_Spill_Stats_2017_web.pdf]

International Union for Conservation of Nature (IUCN). 2017. *The IUCN Red List of Threatened Species: Summary Statistics.*

ISSC, IDS and UNESCO. 2016. *World Social Science Report 2016, Challenging Inequalities: Pathways to a Just World*. Paris: UNESCO Publishing.

Jansen, K. and A. Gupta. 2009. Anticipating the future: 'Biotechnology for the poor' as unrealized promise? *Futures* 41: 436-445.

Jantsch, E. 1972. Inter- and transdisciplinary university: A systems approach to education and innovation. *Higher Education* 1 (1): 7-37.

Jasanoff, S., editor. 2004. *States of knowledge: the co-production of science and the social order*. London: Routledge.

Jasanoff, S. 2015. Future Imperfect: Science, Technology, and the Imaginations of Modernity in *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power*, edited by S. Jasanoff and S. Kim. Chicago: University of Chicago Press.

Javeline, D. 2014. The Most Important Topic Political Scientists Are Not Studying: Adapting to Climate Change. *Perspectives on Politics* 12 (2): 420-34.

Jerneck, A., L. Olsson, B. Ness, S. Anderberg, M. Baier, E. Clark, T. Hickler, A. Hornborg, A. Kronsell, E. Lövbrand and J. Persson. 2010. Structuring sustainability science. *Sustainability Science* 6 (1): 69-82.

Jinnah, S. 2014. *Post-treaty Politics: Secretariat Influence in Global Environmental Governance.* Cambridge, MA: MIT Press.

Jinnah, S. and A. Lindsay. 2016. Diffusion through Issue Linkage: Environmental Norms in U.S. Trade Agreements. *Global Environmental Politics* 16 (3): 41-61.

Jinnah, S. 2017. Makers, Takers, Shakers, Shapers: Emerging Economies and Normative Engagement in Climate Governance. *Global Governance* 23 (2): 285-306.

Jordan, A., D. Huitema, H. van Asselt, T. Rayner and F. Berkhout, editors. 2010. *Climate change policy in the European Union: confronting the dilemmas of mitigation and adaptation?* Cambridge: Cambridge University Press.

Jordan, A. and A. Lenschow. 2010. Environmental policy integration: a state of the art review. *Environmental Policy and Governance* 20 (3): 147-58.

Jordan, A. and D. Huitema. 2014a. Innovations in climate policy: the politics of invention, diffusion, and evaluation. *Environmental Politics* 23 (5): 715-34.

Jordan, A. and D. Huitema. 2014b. Innovations in climate policy: conclusions and new directions. *Environmental Politics* 23 (5): 906-25.

Jordan, A. and D. Huitema. 2014c. Policy innovation in a changing climate: Sources, patterns and effects. *Global Environmental Change* 29: 387-94.

Jordan, A., D. Huitema, M. Hildén, H. van Asselt, T. J. Rayner, J. J. Schoenefeld, J. Tosun, J. Forster and E. L. Boasson. 2015. Emergence of polycentric climate governance and its future prospects. *Nature Climate Change* 5 (11): 977-82.

Jordan, A., D. Huitema, H. van Asselt and J. Forster. Forthcoming. *Governing Climate Change: Polycentricity in Action?* Cambridge, MA: Cambridge University Press.

Kalfagianni, A. 2013. Addressing the Global Sustainability Challenge: The Potential and Pitfalls of Private Governance from the Perspective of Human Capabilities. *Journal of Business Ethics* 122 (2): 307-20.

Kanie, N. and F. Biermann, editors. 2017. *Governing through Goals: Sustainable Development Goals as Governance Innovation*. Cambridge, MA: MIT Press.

Karlsson-Vinkhuyzen, S. I. and J. McGee. 2013. Legitimacy in an Era of Fragmentation: The Case of Global Climate Governance. *Global Environmental Politics* 13 (3): 56-78.

Kates, R.W., W. R. Travis and T. J. Wilbanks. 2012. Transformational adaptation when incremental adaptations to climate change are insufficient. *Proceedings of the National Academy of Sciences* 109: 7156-7161.

Keeley, B. 2015. *Income Inequality: The Gap between Rich and Poor.* OECD Insights. Paris: OECD Publishing.

Keohane, R. O. and J. S. Nye Jr. 1998. Power and Interdependence in the Information Age. *Foreign Affairs* 77 (5): 81-94.

Keohane, R. O. and D. G. Victor. 2011. The Regime Complex for Climate Change. *Perspectives on Politics* 9 (1): 7-23.

Keohane, R. O. 2015. Nominal Democracy? Prospects for Democratic Global Governance. *International Journal of Constitutional Law* 13 (2): 343-353.

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 Research & Social Science* 22: 13-17.

Keys, P. W., L. Wang-Erlandsson, L. J. Gordon, V. Galaz and J. Ebbesson. 2017. Approaching moisture recycling governance. *Global Environmental Change* 45: 15-23.

Khagram, S., K. A. Nicholas, D. M. Bever, J. Warren, E. H. Richards, K. Oleson, J. Kitzes, R. Katz, R. Hwang, R. Goldman, J. Funk and K. A. Brauman. 2010. Thinking about knowing: conceptual foundations for interdisciplinary environmental research. *Environmental Conservation* 37 (4): 388-97.

Kille, K. J. 2002. Simulating the Creation of a New International Human Rights Treaty. *International Studies Perspectives* 3: 271-290.

Kille, K. J., M. Krain and J. S. Lantis. 2008. Active Learning Across Borders: Lessons from an Interactive Workshop in Brazil. *International Studies Perspectives* 9 (4): 411-429.

Kim, R. E. 2013. The emergent network structure of the multilateral environmental agreement system. *Global Environmental Change* 23 (5): 980-91.

Kim, R. E. and K. Bosselmann. 2015. Operationalizing Sustainable Development: Ecological Integrity as a Grundnorm of International Law. *Review of European, Comparative & International Environmental Law* 24 (2): 194-208.

King, G., R. O. Keohane and S. Verba. 1994. *Designing Social Inquiry. Scientific inference in qualitative research*. Princeton: Princeton University Press.

Klinke, A. 2013. Postnational discourse, deliberation, and participation toward global risk governance. *Review of International Studies* 40 (2): 247-75.

Klinsky, S., T. Roberts, S. Huq, C. Okereke, P. Newell, P. Dauvergne, K. O'Brien, H. Schroeder, P. Tschakert, J. Clapp, M. Keck, F. Biermann, D. Liverman, J. Gupta, A. Rahman, D. Messner, D. Pellow and S. Bauer. 2017. Why equity is fundamental in climate change policy research. *Global Environmental Change* 44: 170-73.

Klöck, C., N. Molenaers, and F. Weiler. 2018. Responsibility, Capacity, Greenness or Vulnerability? What Explains the Levels of Climate Aid Provided by Bilateral Donors? *Environmental Politics* 27 (5): 892–916.

Kolbert, E. 2011. Anthropocene: Age of Man. *National Geographic.* [Online: https://www.nationalgeographic.com/magazine/2011/03/age-of-man/]

Korkmaz, S. and A. Singh. 2012. Impact of team characteristics in learning sustainable built environment practices. *Journal of Professional Issues in Engineering Education & Practice* 138 (4): 289-295.

Kothari, A. 2014. Radical Ecological Democracy: A Path Forward for India and Beyond. *Development* 57 (1): 36-45.

Kotzé, L.J., 2016. *Global Environmental Constitutionalism in the Anthropocene*. Bloomsbury Publishing

Kraas, F., C. Leggewie, P. Lemke, E. Matthies, D. Messner, N. Nakicenovic, H. J. Schellnhuber, S. Schlacke and U. Schneidewind. 2016. *Humanity on the move: Unlocking the transformative power of cities: Flagship report.* Berlin: Wissenschaftlicher Beirat d. Bundesregierung Globale Umweltveränderungen.

Kramarz, T. 2016. World Bank Partnerships and the Promise of Democratic Governance. *Environmental Policy and Governance* 26: 3-15.

Kramarz, T. and S. Park. 2016. Accountability in Global Environmental Governance: A Meaningful Tool for Action? *Global Environmental Politics* 16 (2): 1-21.

Kuyper, J. W. and K. Bäckstrand. 2016. Accountability and Representation: Nonstate Actors in UN Climate Diplomacy. *Global Environmental Politics* 16 (2): 61-81.

Lang, D., A. Wiek, M. Bergmann, M. Stauffacher, P. Martens, P. Moll, M. Swilling and C. J. Thomas. 2012. Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustainability Science* 7: 25-43.

Lantis, J. S., L. Kuzma and J. Boehrer. 2000. *The New International Studies Classroom: Active Teaching, Active Learning.* Boulder: Lynne Reinner.

Lantis, J. S., K. J. Kille and M. Krain. 2010. The State of the Active Learning and Teaching Literature. In *The International Studies Encyclopedia*, edited by R. A. Denemark. Blackwell Publishing.

Lauring, J. 2009. Managing Cultural Diversity in the Process of Knowledge Sharing. *Scandinavian Journal of Management* 25 (2): 385-394.

Lawrence, T., R. Suddaby and B. Leca. 2009. *Institutional Work: Actors and Agency in Institutional Studies of Organizations*. Cambridge: Cambridge University Press.

Leach, M., I. Scoones and A. Stirling. 2010. *Dynamic Sustainabilities: Technology, Environment, Social Justice*. Abingdon: Earthscan.

Leach, M., J. Rockström, P. Raskin, I. Scoones, A. C. Stirling, A. Smith, J. Thompson, E. Millstone, A. Ely, E. Arond, C. Folke and P. Olsson. 2012. Transforming innovation for sustainability. *Ecology and Society* 17(2): 11.

Leach, M. 2013. *Democracy in the Anthropocene? Science and Sustainable Development Goals at the UN.* Huffington Post. [Online: https://www.huffingtonpost.co.uk/Melissa-Leach/democracy-in-the-anthropocene_b_2966341.html]

Leach, M., K. Raworth and J. Rockström. 2013. *Between social and planetary boundaries: navigating pathways in the safe and just space for humanity*. ISSC/UNESCO World Social Science Report 2013: Changing Global Environments. OECD Publishing and UNESCO Publishing.

Lélé, S. and R. B. Norgaard. 2005. Practicing Interdisciplinary. *BioScience* 55 (11): 967-975.

Lenton, T. M. 2011. Early Warning of Climate Tipping Points. *Nature Climate Change* 1 (4): 201-209.

Lewis, S. L. and M. A. Maslin. 2015. Defining the Anthropocene. *Nature* 519 (7542): 171-80.

Liftin, K. T. 2016. Person/Planet Politics: Contemplative Pedagogies for a New Earth. In *New Earth Politics. Essays from the Anthropocene*, edited by S. Nicholson and S. Jinnah. Cambridge, MA: MIT Press.

Liu, J., H. Mooney, V. Hull, S. J. Davis, J. Gaskell, T. Hertel, J. Lubchenco, K. C. Seto, P. Gleick, C. Kremen and S. Li. 2015. Systems integration for global sustainability. *Science* 347 (6225): 1258832.

Loorbach, D. 2010. Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework. *Governance* 23 (1): 161-83.

Losconz, I. 2017. Methodological approaches and consideration in regulatory research. In *Regulatory Theory*, edited by P. Drahos, 77-95. Canberra: Australian National University Press.

Lövbrand, E., S. Beck, J. Chilvers, T. Forsyth, J. Hedrén, M. Hulme, R. Lidskog and E. Vasileiadou. 2015. Who speaks for the future of Earth? How critical social science can extend the conversation on the Anthropocene. *Global Environmental Change* 32: 211-18.

Lukes, S. 2005. *Power: A Radical View*. 2nd edition. Basingstoke: Palgrave Macmillan.

Luterbacher, U. and D. Sprinz. 2001. *International Relations and Global Climate Change*. Cambridge: MIT Press.

Macnaghten, P., R. Owen, J. Stilgoe, B. Wynne, A. Azevedo, A. de Campos, J. Chilvers, R. Dagnino, G. di Giulio, E. Frow, B. Garvey, C. Groves, S. Hartley, M. Knobel, E. Kobayashi, M. Lehtonen, J. Lezaun, L. Mello, M. Monteiro, J. Pamplona da Costa, C. Rigolin, B. Rondani, M. Staykova, R. Taddei, C. Till, D. Tyfield, S. Wilford and L. Velho. 2014. Responsible innovation across borders: tensions, paradoxes and possibilities. *Journal of Responsible Innovation* 1: 191-199.

Mahoney, J. and K. Thelen. 2010. *Explaining Institutional Change: Ambiguity, Agency, and Power*. New York: Cambridge University Press.

Mahoney, J. and K. Thelen, editors. 2015. *Advances in Comparative-Historical Analysis*. Cambridge: Cambridge University Press.

Malm, A. and A. Hornborg. 2014. The Geology of Mankind? A Critique of the Anthropocene Narrative. *The Anthropocene Review* 1 (1): 62-69.

Mannheim, K. 1936. *Ideology and Utopia.* London: Routledge.

Marsh, D. and G. Stoker, editors. 2010. Theory and Methods in Political Science. 3rd edition. New York: Palgrave.

Martin, G., D. Mincyte and U. Münster, editors. 2012. Why Do We Value Diversity? Biocultural Diversity in a Global Context. *RCC Perspectives* 9.

Martinez-Alier, J. 2002. *The Environmentalism of the Poor: A Study of Ecological Conflicts and Valuation.* Cheltenham: Edward Elgar.

Mason, J. 2006. *Six strategies for mixing methods and linking data in social science research.* NCRM Working Paper. Economic & Social Research Council.

Mason, M. 2010. Information Disclosure and Environmental Rights: The Aarhus Convention. *Global Environmental Politics* 10 (3): 10-31.

Massey, E., R. Biesbroek, D. Huitema and A. Jordan. 2014. Climate policy innovation: The adoption and diffusion of adaptation policies across Europe. *Global Environmental Change* 29: 434-443.

Massey, E. and D. Huitema. 2016. The emergence of climate change adaptation as a new field of public policy in Europe. *Regional Environmental Change* 16 (2): 553-564.

Mattor, K., M. Betsill, C. Huayhuaca, H. Huber-Stearns, T. Jedd, F. Sternlieb, P. Bixler, M. Luizza, Matthew and A. S. Cheng. 2014. Transdisciplinary research on environmental governance: A view from the inside. *Environmental Science and Policy* 42: 90-100.

Matulis, B. S. and J. R. Moyer. 2017. Beyond Inclusive Conservation: The Value of Pluralism, the Need for Agonism, and the Case for Social Instrumentalism. *Conservation Letters* 10 (3): 279-287.

Mauser, W., G. Klepper, M. Rice, B. S. Schmalzbauer, H. Hackmann, R. Leemans and H. Moore. 2013. Transdisciplinary global change research: the co-creation of knowledge for sustainability. *Current Opinion in Environmental Sustainability* 5: 420-431.

Mayer, I. S. 2009. The gaming of policy and the politics of gaming: A review. *Simulation and Gaming* 40: 825-862.

McCall, L. 2005. The complexity of intersectionality. *Signs: Journal of women in culture and society* 30 (3): 1771-1800.

McCarthy, E. D. 1996. *Knowledge as Culture: The New Sociology of Knowledge.* London: Routledge.

McCright, A. M. and R. E. Dunlap. 2010. Anti-Reflexivity: The American Conservative Movement's Success in Undermining Climate Science and Policy. *Theory, Culture & Society* 27 (2-3): 100-133.

McGregor, S. L. and J. A. Murnane. 2010. Paradigm, methodology and method: Intellectual integrity in consumer scholarship. *International Journal of Consumer Studies* 34 (4): 419-427.

Meadowcroft, J. 2011. Engaging with the politics of sustainability transitions. *Environmental Innovation and Societal Transitions* 1: 70-75.

Meisch, S. 2016. Fair distribution in the Anthropocene: Towards a normative conception of sustainable development. In *Environmental Politics and Governance in the Anthropocene: Institutions and Legitimacy in a Complex World*, edited by P. Pattberg and F. Zelli, 62-78. Abingdon: Routledge.

Mignolo, W. D. 2002. The Zapatista's Theoretical Revolution: Its Historical, Ethical, and Political Consequences. *Utopian Thinking* 25 (3): 245-275.

Milanovic, B. 2011. *The Haves and the Have-nots: A Brief and Idiosyncratic History of Global Inequality.* Cambridge, MA: Harvard University Press.

Mitchell, R. B. 2013. Oran Young and international institutions. *International Environmental Agreements* 13: 1-14.

Moellendorf, D. 2002. *Cosmopolitan Justice.* Colorado: Westview Press.

Montana, J. 2017. Accommodating consensus and diversity in environmental knowledge production: Achieving closure through typologies in IPBES. *Environmental Science & Policy* 68: 20-27.

Moore, M. L., O. Tjornbo, E. Enfors, C. Knapp, J. Hodbod, J. A. Baggio, A. Norström, P. Olsson and D. Biggs. 2014. Studying the complexity of change: toward an analytical framework for understanding deliberate social-ecological transformations. *Ecology and Society* 19 (4): 54.

Morrison, T. H. 2017. Evolving polycentric governance of the Great Barrier Reef. *Proceedings of the National Academy of Sciences* 114 (15): E3013-E21.

Morrison, T. H., W. N. Adger, K. Brown, M. C. Lemos, D. Huitema and T. P. Hughes. 2017. Mitigation and Adaptation in Polycentric Systems: Sources of Power in the Pursuit of Collective Goals. *WIREs Climate Change* 8 (5): 1-16.

Moser, S. C. and J. A. Ekström. 2010. A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences* 107 (51): 22026-31.

Moses, J. and T. Knutsen. 2012. *Ways of Knowing: Competing Methodologies in Social and Political Research*. New York: Palgrave.

Murombedzi, J. C. 2016. Inequality and Natural Resources in Africa. In *World Social Science Report. Challenging Inequalities: Pathways to a Just World*, 59-62. Paris: UNESCO Publishing.

Nagel, T. 2005. The problem of global justice. *Philosophy & Public Affairs* 33 (2): 113-147.

Nagendra, H. and E. Ostrom. 2012. Polycentric governance of multifunctional forested landscapes. *International Journal of the Commons* 6: 104-133.

National Oceanic and Atmospheric Administration (NOAA). 2017. *Recent Global Monthly Mean CO2.* [Online: https://www.esrl.noaa.gov/gmd/ccgg/trends/global.html]

New Climate Economy (NCE). 2016. *The Sustainable Infrastructure Imperative: Financing for Better Growth and Development (The 2016 New Climate Economy Report).* The Global Commission on the economy and Climate. Washington D. C. and London: World Resources Institute and Overseas Development Institute.

Newell, P. 2005. Race, Class and the Global Politics of Environmental Inequality. *Global Environmental Politics* 5 (3): 70-94.

Newell, P. and M. Paterson. 2010. *Climate capitalism: global warming and the transformation of the global economy.* Cambridge: Cambridge University Press.

Newell, P., P. Pattberg and H. Schroeder. 2012. Multiactor Governance and the Environment. *Annual Review of Environment and Resources* 37: 365-387.

Newell, P. and D. Mulvaney. 2013. The Political Economy of the 'Just Transition'. *Geographical Journal* 179 (2): 132-40.

Newig, J., E. Kochskämper, E. Challies and N. W. Jager. 2016. Exploring governance learning: How policymakers draw on evidence, experience and intuition in designing participatory flood risk planning. *Environmental Science & Policy* 55: 353-360.

Nicholson, S. and P. K. Wapner. 2015. *Global environmental politics: from person to planet.* Boulder: Paradigm.

Nilsson, A. E., I. Bay-Larsen, H. Carlsen, B. van Oort, M. Bjørkan, K. Jylhä, E. Klyuchnikova, V. Masloboev and L. van der Watt. 2017. Towards extended shared socioeconomic pathways: A combined participatory bottom-up and top-down methodology with results from the Barents region. *Global Environmental Change* 45: 124-132.

Nilsson, M., D. Griggs and M. Visbeck. 2016. Policy: Map the interactions between Sustainable Development Goals. *Nature* 534: 320-322.

Nolet, V. 2009. Preparing sustainability-literate teachers. *Teachers College Record* 111 (2): 409-442.

Nordmann, A. 2014. Responsible innovation, the art and craft of anticipation. *Journal of Responsible Innovation* 1:87-98.

Norström, A. V., A. Dannenberg, G. McCarney, M. Milkoreit, F. Diekert, G. Engström, R. Fishman, J. Gars, E. Kyriakopoolou, V. Manoussi, K. Meng, M. Metian, M. Sanctuary, M. Schlüter, M. Schoon, L. Schultz and M. Sjöstedt. 2014. Three necessary conditions for establishing effective Sustainable Development Goals in the Anthropocene. *Ecology and Society* 19 (3): 8.

Nunes, F., R. Rajao and B. Soares. 2016. Boundary work in climate policy making in Brazil: Reflections from the frontlines of the science-policy interface. *Environmental Science & Policy* 59: 85-92.

Nussbaum, M. C. 2000. Aristotle, Politics and Human Capabilities: A Response to Antony Arneson, Charlesworth and Mulgan. *Ethics* 111 (1): 2000: 102-128.

Nye, J. S. 2011. *The Future of Power.* New York: Public Affairs Books.

O'Brien, K. 2011. Global environmental change II: From adaptation to deliberate transformation. *Progress in Human Geography* 36 (5): 667-76.

Oberthür, S. 2009. Interplay management: enhancing environmental policy integration among international institutions. *International Environmental Agreements: Politics, Law & Economics* 9 (4): 371-91.

Oberthür, S. and O. S. Stokke, editors. 2011. *Managing institutional complexity: regime interplay and global environmental change.* Cambridge, MA: MIT Press.

Oels, A. 2013. Rendering climate change governable by risk: from probability to contingency. *Geoforum* 45: 17-29.

Okereke, C. 2008. Equity Norms in Global Environmental Governance. *Global Environmental Politics* 8: 25-50.

Olsson, L., M. Opondo, P. Tschakert, A. Agrawal, S. H. Eriksen, S. Ma, L. N. Perch and S. A. Zakieldeen. 2014. Livelihoods and poverty. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea and L.L. White. Cambridge: Cambridge University Press.

Orsini, A., J. F. Morin and O. Young. 2013. Regime Complexes: A Buzz, a Boom, or a Boost for Global Governance? *Global Governance* 19: 27-39.

Ostrom, E. 2009. *A Polycentric Approach for Coping with Climate Change.* Policy Research Working Paper 5095, Background Paper to the 2010 World Development Report. Washington D.C.: World Bank.

Ostrom, E. 2010a. A Long Polycentric Journey. *Annual Review of Political Science* 13: 1-23.

Ostrom, E. 2010b. Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change* 20: 550-557.

Oxfam. 2016. An economy for the 1%: How privilege and power in the economy drive extreme inequality and how this can be stopped. *210 Oxfam Briefing Paper*. Oxford: Oxfam.

Paavola, J. and W. N. Adger. 2006. Fair adaptation to climate change. *Ecological Economics* 56: 594-609

Paehlke, R. 2001. Environment, Equity and Globalization: Beyond Resistance. *Global Environmental Politics* 1 (1): 1-10.

Pahl-Wostl, C. 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change* 19: 354-365.

Pahl-Wostl, C. and C. Knieper. 2014. The capacity of water governance to deal with the climate change adaptation challenge: Using fuzzy set Qualitative Comparative Analysis to distinguish between polycentric, fragmented and centralized regimes. *Global Environmental Change* 29: 139-154.

Palazzo, A., L. Rutting, R. Zougmoré, J. M. Vervoort, P. Havlik, A. Jalloh, E. Aubee, A. E. R. Helfgott, D. Mason-D'Croz, S. Islam, H. Valin, P. J. Ericksen, Z. Segda, A. S. Moussa, J. Bayala, H. A. Kadi Kadi, P. C. S. Traoré and P. K. Thornton. 2016. *The future of food security, environments and livelihoods in Western Africa*. CCAFS Working Paper 130. Copenhagen: CGIAR Programme on Climate Change, Agriculture and Food Security.

Paloniemi, R., E. Apostolopoulou, J. Cent, D. Bormpoudakis, A. Scott, M. Grodzińska-Jurczak, J. Tzanopoulos, M. Koivulehto, A. Pietrzyk-Kaszyńska and J. D. Pantis. 2015. Public Participation and Environmental Justice in Biodiversity Governance in Finland, Greece, Poland and the UK. *Environmental Policy and Governance* 25 (5): 330-42.

Park, S. E., N. A. Marshall, E. Jakku, A. M. Dowd, S. M. Howden, E. Mendham and A. Fleming. 2012. Informing adaptation responses to climate change through theories of transformation. *Global Environmental Change* 22 (1): 115-26.

Pattberg, P. 2010. Public-private partnerships in global climate governance. *WIREs Climate Change.*

Pattberg, P. and O. Widerberg. 2016. Transnational multistakeholder partnerships for sustainable development: Conditions for success. *Ambio* 45: 42-51.

Pattberg, P. and F. Zelli, editors. 2016. *Environmental Politics and Governance in the Anthropocene: Institutions and Legitimacy in a Complex World.* Abingdon: Routledge.

Patterson, J., K. Schulz, J. Vervoort, S. van der Hel, O. Widerberg, C. Adler, M. Hurlbert, K. Anderton, M. Sethi and A. Barau. 2017. Exploring the governance and politics of transformations towards sustainability. *Environmental Innovation and Societal Transitions* 24: 1-16.

Patterson, J., T. Thaler, M. Hoffmann, S. Hughes, A. Oels, E. Chu, A. Mert, D. Huitema, S. Burch and A. Jordan. 2018. Political feasibility of 1.5°C societal transformations: the role of social justice. *Current Opinion in Environmental Sustainability* 31: 1-9.

Payne, G. and M. Williams. 2005. Generalization in Qualitative Research. *Sociology* 39 (2): 295-314.

Pelling, M. 2011. *Adaptation to Climate Change: From Resilience to Transformation*. London: Routledge.

Pellow, D. 2000. Environmental inequality formation: Toward a theory of environmental justice. *American Behavioral Scientist* 43 (4): 581-601.

Pickering, J. 2018. Ecological reflexivity: characterising an elusive virtue for governance in the Anthropocene. *Environmental Politics* 1-22.

Pierson, P. 2004. *Politics in Time: History, Institutions, and Social Analysis.* Princeton, NJ: Princeton University Press.

Pierson, P. 2014. Increasing Returns, Path Dependence, and the Study of Politics. *American Political Science Review* 94 (2): 251-67.

Piketty, T. 2014. *Capital in the 21st Century*. Cambridge, MA: Harvard University Press.

Pinker, S. 2018. *Enlightenment now: The case for reason, science, humanism and progress.* New York: Allen Lane.

Pohl C. and G. Hirsch Hadorn. 2007. Principles for designing transdisciplinary research. Proposed by the Swiss Academies of Arts and Sciences. Munich: Oekom.

Poli, R. 2010. The many aspects of anticipation. *Foresight* 12: 7-17.

Popper, K. 2002. *The Logic of Scientific Discovery*. 2nd edition. London: Routledge.

Preston, C. J. 2015. Framing an Ethics of Climate Management for the Anthropocene. *Climatic Change* 130 (3): 359-369.

ProClim. 1997. Research on Sustainability and Global Change – Visions in Science Policy by Swiss Researchers. Berne: CASS/SANW.

Putnam, R. D. 2015. *Our Kids: The American Dream in Crisis*. Simon and Schuster.

Quay, R. 2010. Anticipatory governance: A tool for climate change adaptation. *Journal of the American Planning Association* 76: 496-511.

Radnitzky, G. and W. W. Bartley. 1987. *Evolutionary Epistemology, Rationality, and the Sociology of Knowledge*. Chicago: Open Court.

Ragin, C. 1987. *The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies.* Berkeley: University of California Press.

Ragin, C. 2008. *Redesigning Social Inquiry: Fuzzy Sets and Beyond*. Chicago: Chicago University Press.

Ragin, C. C. and P. C. Fiss. 2017. *Intersectional Inequality.* Chicago: The University of Chicago Press.

Raik, D. B., A. L. Wilson and D. J. Decker. 2008. Power in Natural Resources Management: An Application of Theory. *Society & Natural Resources* 21 (8): 729-39.

Ramos, H. 2015. Mapping the field of environmental justice: redistribution, recognition and representation in ENGO press advocacy. *Canadian Journal of Sociology* 40 (3): 355-375.

Rask, M. and R. Worthington. 2015. *Governing Biodiversity through Democratic Deliberation*. Abingdon: Routledge.

Rawls, J. 1971. *A Theory of Justice*. Oxford: Oxford University Press.

Rawls, J. 1999. *The Law of Peoples.* Cambridge, MA: Harvard University Press.

Raymond, C. M. and J. Cleary. 2013. A Tool and Process that Facilitate Community Capacity Building and Social Learning for Natural Resource Management. *Ecology and Society* 18 (1): 25.

Reed, M. S., A. Graves, N. Dandy, H. Posthumus, K. Hubacek, J. Morris, C. Prell, C. H. Quinn and L. C. Stringer. 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management* 90 (5): 1933-49.

REN21. 2017. *Renewables 2017: Global Status Report.* Renewable Energy Policy for the 21st Century. [Online: http://www.ren21.net/status-of-renewables/global-status-report/]

Ribot, J. 2011. Vulnerability before adaptation: Toward transformative climate action. *Global Environmental Change* 21: 1160-1162.

Ricke, K. L., J. B. Moreno-Cruz and K. Caldeira. 2013. Strategic Incentives for Climate Geoengineering Coalitions to Exclude Broad Participation. *Environmental Research Letters* 8 (1): 014021.

Riedy, C., J. Kent and N. Thompson. 2018. Meaning work: reworking institutional meanings for environmental governance. *Journal of Environmental Planning and Management* 1-21.

Rihoux, B. and C. Ragin. 2009. *Configurational Comparative Analysis.* London: Sage.

Rittel, H. W. and M. M. Webber. 1973. Dilemmas in a general theory of planning. *Policy Sciences* 4: 155-169.

Robinson, J., S. Burch, S. Talwar, M. O'Shea and M. Walsh. 2011. Envisioning sustainability: Recent progress in the use of

participatory backcasting approaches for sustainability research. *Technological Forecasting & Social Change* 78 (5): 756.

Rockström, J., W. Steffen, K. Noone, A. Persson, F. S. Chapin, E. F. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. J. Schellnhuber, B. Nykvist, C. A. de Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sörlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen and J. A. Foley. 2009. A safe operating space for humanity. *Nature* 461 (7263): 472-75.

Rockström, J., O. Gaffney, J. Rogelj, M. Meinshausen, N. Nakicenovic and H. J. Schellnhuber. 2017. A roadmap for rapid decarbonization. *Science* 355 (6331): 1269-1271.

Rodela, R. 2011. Social learning and natural resource management: the emergence of three research perspectives. *Ecology and Society* 16 (4): 30.

Rodrik, D. 2017. *Populism and the Economics of Globalization*. Working Paper 23559. National Bureau of Economic Research.

Ruddiman, W. F., E. C. Ellis, J. O. Kaplan and D. Q. Fuller. 2015. Defining the epoch we live in. *Science* 348 (6230): 38.

Rudy, A. P. and D. White. 2014. *Hybridity, In Critical Environmental Politics – Interventions*, edited by C. Death. London and New York: Routledge.

Saarinen, J. 2013. Critical Sustainability: Setting the Limits to Growth and Responsibility in Tourism. *Sustainability* 6 (1): 1-17.

Santos, B. d. S. 2014. *Epistemologies of the South: Justice against Epistemicide.* Boulder: Paradigm.

Santos, B. d. S. 2016. Epistemologies of the South and the future. *From the European South* 1: 17-29.

Schleifer, P. 2013. Orchestrating sustainability: The case of European Union biofuel governance. *Regulation & Governance* 7: 533-546.

Schlosberg, D. 2007. *Defining Environmental Justice*. Oxford: Oxford University Press.

Schlosberg, D. 2013. Theorising environmental justice: the expanding sphere of a discourse. *Environmental Politics* 22 (1): 37-55.

Schlosberg, D. and L. B. Collins. 2014. From Environmental to Climate Justice: Climate Change and the Discourse of Environmental Justice. *WIREs Climate Change* 5 (3): 359-374.

Schlosberg, D., L. B. Collins and S. Niemeyer. 2017. Adaptation policy and community discourse: risk, vulnerability, and just transformation. *Environmental Politics* 26 (3): 413-37.

Schmidt, J. J., P. G. Brown and C. J. Orr. 2016. Ethics in the Anthropocene: A Research Agenda. *The Anthropocene Review* 3 (3): 188-200.

Schneider, C. and C. Wagemann. 2012. *Set-Theoretic Methods for the Social Sciences.* Cambridge: Cambridge University Press.

Schroth, O., J. Angel, S. R. J. Sheppard and A. Duli. 2014. Visual climate change communication: From iconography to locally framed 3D visualization. *Environmental Communication* 8: 413-432.

Scobie, M. 2013. Climate Regulation: Implications for Trade Competitiveness in Caribbean States. In *Climate-Smart Technologies Integrating Renewable Energy and Energy Efficiency in Mitigation and Adaptation Responses*, edited by L. F. Walter, F. Mannke, R. Mohee, V. Schulte and D. Surroop, 33-49. Berlin: Springer Berlin Heidelberg.

Scobie, M. 2016. Policy coherence in climate governance in Caribbean Small Island Developing States. *Environmental Science & Policy* 58: 16-28.

Scobie, M. 2017a. Accountability in climate change governance and Caribbean SIDS.

Environment, Development and Sustainability 1-19.

Scobie, M. 2017b. Fossil fuel reform in developing states: The case of Trinidad and Tobago, a petroleum producing small Island developing State. *Energy Policy* 104: 265-273.

Scoones, I., M. Leach and P. Newell. 2015. *The Politics of Green Transformations.* London: Routledge.

Scott, J. 2017. *Social Network Analysis.* London: Sage.

Scovazzi, T. 2016. The negotiations for a binding instrument on the conservation and sustainable use of marine biological diversity beyond national jurisdiction. *Marine Policy* 70: 188-191.

Secretariat of the CBD. 2014. *Global Biodiversity Outlook 4.* Montréal: Secretariat of the Convention on Biological Diversity.

Selin, C. 2008. The Sociology of the Future: Tracing Stories of Technology and Time. *Sociology Compass* 2: 1878-1895.

Selin, C. 2014. On not forgetting futures. *Journal of Responsible Innovation* 1: 103-108.

Sen, A. K. 1999. *Development as Freedom.* New York: Knopf Press.

Sen, A. K. 2009. *The Idea of Justice.* London: Penguin Books.

Seto, K., S. Davis, R. Mitchell, E. Stokes, G. Unruh and D. Ürge-Vorsatz. 2016. Carbon Lock-In: Types, Causes, and Policy Implications. *Annual Review of Environment and Resources* 41: 425-452.

Shaw, A., S. Sheppard, S. Burch, D. Flanders, A. Weik, J. Carmichael, J. Robinson and S. Cohen. 2009. Making local futures tangible – Synthesizing, downscaling, and visualizing climate change scenarios for participatory capacity building. *Global Environmental Change* 19 (4): 447-463.

Shaw, C. M. 2006. Simulating Negotiations in a Three-Way Civil War. *Journal of Political Science Education* 2 (1): 51-71.

Shellman, S. and K. Turan. 2003. The Cyprus Crisis: A Multilateral Bargaining Simulation. *Simulation & Gaming* 34 (2): 281-291.

Siebenhüner, B. 2008. Learning in International Organizations in Global Environmental Governance. *Global Environmental Politics* 8: 92-116.

Simmons, B. 2011. International Studies in the Global Information Age. *International Studies Quarterly* 55: 589-599.

Smith, A. and A. Stirling. 2010. The politics of social-ecological resilience and sustainable socio-technical transitions. *Ecology and Society* 15 (1): 11.

Smith, L. T. 2012. *Decolonizing methodologies – Research and Indigenous peoples.* 2nd Edition. London and New York: Zed Books.

Sonter, L. J., D. J. Barrett, B. S. Soares-Filho and C. J. Moran. 2014. Global demand for steel drives extensive land-use change in Brazil's Iron Quadrangle. *Global Environmental Change* 26: 63-72.

Sovacool, B., B. O. Linnér and M. Goodsite. 2015. The political economy of climate adaptation. *Nature Climate Change* 5: 616-618.

Spagnuolo, F. 2011. Diversity and pluralism in earth system governance: Contemplating the role for global administrative law. *Ecological Economics* 70 (11): 1875-1881.

Spoel, P., D. Goforth, H. Cheu and D. Pearson. 2008. Public communication of climate change science: engaging citizens through apocalyptic narrative explanation. *Technical Communication Quarterly* 18: 49-81.

Steffen, W., P. J. Crutzen and J. R. McNeill. 2007. The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature? *Ambio* 36 (8): 614-621.

Steffen, W., Å. Persson, L. Deutsch, J. Zalasiewicz, M. Williams, K. Richardson, C. Crumley, P. Crutzen, C. Folke, L. Gordon, M. Molina, V. Ramanathan, J. Rockström, M. Scheffer, J. Schellnhuber and U. Svedin. 2011.

The Anthropocene: from global change to planetary stewardship. *Ambio* 40: 739-761.

Steffen, W., W. Broadgate, L. Deutsch, O. Gaffney and C. Ludwig. 2015a. The Trajectory of the Anthropocene: The Great Acceleration. *The Anthropocene Review* 2 (1): 81-98.

Steffen, W., K. Richardson, J. Rockström, S. E. Cornell, I. Fetzer, E. M. Bennett, R. Biggs, S. R. Carpenter, W. de Vries, C. A. de Wit, C. Folke, D. Gerten, J. Heinke, G. M. Mace, L. M. Persson, V. Ramanathan, B. Reyers and S. Sörlin. 2015b. Planetary boundaries: Guiding human development on a changing planet. *Science* 347 (6223): 1259855.

Stephens, T. 2017. Reimagining International Environmental Law in the Anthropocene. In *Environmental Law and Governance for the Anthropocene*, edited by L. Kotzé, 31-54. Oxford: Hart.

Stevenson, H. and J. S. Dryzek. 2014. *Democratizing Global Climate Governance.* Cambridge: Cambridge University Press.

Stevenson, H. 2016. The Possibility of Reflexive Global Climate Politics. *Revue de m*étaphysique et de *morale* 1: 55-69.

Stilgoe, J., R. Owen and P. Macnaghten. 2013. Developing a framework for responsible innovation. *Research Policy* 42: 1568-1580.

Stokes, B., R. Wike and J. Carle. 2015. *Global concern for climate change, broad support for limiting emissions*. Pew Research Centre.

Stratoudakis, Y., P. McConney, J. Duncan, A. Ghofar, N. Gitonga, K. S. Mohamed, M. Samoilys, K. Symington and L. Bourillon. 2016. Fisheries certification in the developing world: Locks and keys or square pegs in round holes? *Fisheries Research* 182: 39-49.

Streeck, W. and K. A. Thelen, editors. 2005. *Beyond continuity: institutional change in advanced political economies*. Oxford: Oxford University Press.

Stüer, C., S. Hüsig and S. Biala. 2010. Integrating art as a trans-boundary element in a radical innovation framework. *R&D Management* 40 (1): 10-18.

Sultana, F. and A. Loftus, editors. 2012. *The right to water: politics, governance and social struggles.* London: Routledge.

Swyngedouw, E. 2013. The Non-Political Politics of Climate Change. *ACME: An International E-Journal for Critical Geographies* 12 (1): 1-8.

Szulecki, K., P. Pattberg and F. Biermann. 2011. Explaining Variation in the Effectiveness of Transnational Energy Partnerships. *Governance* 24 (4): 713-36.

Tashakkori, A. and C. Teddlie, editors. 2003. *Handbook of Mixed Methods in Social & Behavorial Research.* London: Sage.

Task Force on Climate-Related Financial Disclosures (TCFD). 2017. *Final Report: Recommendations of the Task Force on Climate-Related Financial Disclosures*. [Online: https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Report-062817.pdf]

Taylor, C. 2002. Modern social imaginaries. *Public Culture* 14: 91-124.

Tengö, M., E. S. Brondizio, T. Elmqvist, P. Malmer and M. Spierenburg. 2014. Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach. *Ambio* 43 (5): 579-91.

Thaler, T. and T. Hartmann. 2016. Justice and flood risk management: reflecting on different approaches to distribute and allocate flood risk management in Europe. *Natural Hazards* 83 (1): 129-147.

The Economist. 2011. Welcome to the Anthropocene. [Online: http://www.economist.com/node/18744401]

The Swiss Academies of Arts and Sciences. 2017. *Publication Radar*. td-net. Network for Transdisciplinary Research. [Online: http://www.transdisciplinarity.ch/en/td-net/Publikationen/Publikationsradar.html]

Thelen, K. 2009. Institutional Change in Advanced Political Economies. *British Journal of Industrial Relations* 47 (3): 471-98.

Thompson, J. B. 1984. *Studies in the Theory of Ideology.* Polity Press.

Tickner, A. B. and D. Blaney, editors. 2012. Introduction: thinking difference. In *Thinking International Relations Differently*. London and New York: Routledge.

Tickner, A. B. and D. Blaney, editors. 2013. *Claiming the International: Worlding Beyond the West.* London and New York: Routledge.

Timpson, W. M. and D. K. Holman. 2011. *Case studies of classrooms and community: Integrating diversity, sustainability, and peace and reconciliation.* Madison, WI: Atwood.

Uittenbroek, C. J. 2016. From Policy Document to Implementation: Organizational Routines as Possible Barriers to Mainstreaming Climate Adaptation. *Journal of Environmental Policy & Planning* 18: 161-176.

Underdal, A. 2010. Complexity and challenges of long-term environmental governance. *Global Environmental Change* 20: 386-393.

Underdal, A., Kim, R.E., 2017. The Sustainable Development Goals and Multilateral Agreements, in: Kanie, N., Biermann, F. (Eds.), *Governing Through Goals: Sustainable Development Goals as Governance Innovation*. The MIT Press, Cambridge.

United Nations Development Programme (UNDP). 2013. *Humanity Divided: Confronting Inequality in Developing Countries.* New York: UNDP.

United Nations Development Programme (UNDP). *2016. Human Development Report 2016.* New York: UNDP.

United Nations Environment Programme (UNEP). 2017. *Frontiers 2017 Emerging Issues of Environmental Concern.* Nairobi: United Nations Environment Programme.

United Nations Environment Programme World Conservation Monitoring Centre, and International Union for Conservation of Nature (UNEP WCMC and IUCN). 2016. *Protected planet report 2016.* Cambridge and Gland: UNEP-WCMC; IUCN.

United Nations Human Settlements Programme (UN-Habitat). 2016. *World Cities Report 2016: Urbanization and development – emerging futures.* Nairobi: United Nations Human Settlements Programme.

Unruh, G.C. and J. Carrillo-Hermosilla. 2006. Globalizing carbon lock-in. *Energy Policy* 34: 1185-1197.

van Asselt, H. 2014. *The fragmentation of global climate governance: consequences and management of regime interactions, New horizons in environmental and energy law.* Cheltenham: Edward Elgar.

van Asselt, H. and F. Zelli. 2014. Connect the dots: managing the fragmentation of global climate governance. *Environmental Economics and Policy Studies* 16: 137-155.

van Bommel, S., C. Blackmore, N. Foster and J. de Vries. 2016. Performing and orchestrating governance learning for systemic transformation in practice for climate change adaptation. *Outlook on Agriculture* 45 (4): 231-37.

van den Bergh, J. C. J. M., B. Truffer and G. Kallis. 2011. Environmental innovation and societal transitions: Introduction and overview. *Environmental Innovation and Societal Transitions* 1 (1): 1-23.

van der Heijden, J. 2017. *Innovations in Urban Climate Governance: Voluntary Programs for Low Carbon Buildings and Cities.* Cambridge: Cambridge University Press.

van der Ven, H. 2015. Correlates of rigorous and credible transnational governance: A cross-sectoral analysis of best practice compliance in eco-labeling. *Regulation & Governance* 9 (3): 276-93.

van Leeuwen, J. 2016. Governing the Artic in the era of the Anthropocene: Does corporate authority matter in Arctic shipping governance? In *Environmental Politics and Governance in the Anthropocene,* 127-145. Routledge.

van Putten, I. E., C. M. Dichmont, L. X. C. Dutra, O. Thebaud, R. A. Deng, E. Jebreen, R.

Owens, R. Pascual, M. Read and C. Thompson. 2016. Objectives for management of socio-ecological systems in the Great Barrier Reef region, Australia. *Regional Environmental Change* 16 (5): 1417-1431.

Vervoort, J. M., P. K. Thornton, P. Kristjanson, W. Förch, P. J. Ericksen, K. Kok, J. S. I. Ingram, M. Herrero, A. Palazzo, A. E. S. Helfgott, A. Wilkinson, P. Havlík, D. Mason-D'Croz and C. Jost. 2014. Challenges to scenario-guided adaptive action on food security under climate change. *Global Environmental Change* 28: 383-394.

Vervoort, J. M., R. Bendor, A. Kelliher, O. Strik and A. E. R. Helfgott. 2015. Scenarios and the art of worldmaking. *Futures* 74: 62-70.

Vervoort, J. and A. Gupta. 2018. Anticipating climate futures in a 1.5°C era: the link between foresight and governance. *Current Opinion in Environmental Sustainability* 31: 104-111.

Vervoort, J. M. and A. C. Mangnus. 2018. *The roles of new foresight methods in urban sustainability transformations: a conceptual framework and research agenda.* Utrecht: Urban Futures Studio.

Vinke-de Kruijf, J. and C. Pahl-Wostl. 2016. A multi-level perspective on learning about climate change adaptation through international cooperation. *Environmental Science & Policy* 66: 242-249.

Voß, J.-P., D. Bauknecht and R. Kemp, editors. 2006. *Reflexive governance for sustainable development.* Cheltenham: Edward Elgar.

Voß, J.-P. and R. Kemp. 2006. Sustainability and Reflexive Governance: Introduction. In *Reflexive Governance for Sustainable Development*, edited by J.-P. Voß, D. Bauknecht and R. Kemp, 3-28. Cheltenham: Edward Elgar.

Voß, J.-P. and B. Bornemann. 2011. The Politics of Reflexive Governance: Challenges for Designing Adaptive Management and Transition Management. *Ecology and Society* 16 (2): 9.

Walker, B., C. S. Holling, S. R. Carpenter and A. Kinzig. 2004. Resilience, adaptability and transformability in social–ecological systems. *Ecology and Society* 9 (2): 5.

Wapner, P. 2010. *Living Through the End of Nature: The Future of American Environmentalism.* Cambridge, MA: MIT Press.

Wapner, P. 2014. The Changing Nature of Nature: Environmental Politics in the Anthropocene. *Global Environmental Politics* 14 (4): 36-54.

Wapner, P. 2016. Contemplative Environmental Studies: Pedagogy for Self and Planet. *The Journal of Contemplative Inquiry* 3 (1): 67-83.

Warner, K. 2010. Global Environmental Change and Migration: Governance Challenges. *Global Environmental Change* 20 (3): 402-13.

Wasserman, S. and K. Faust. 1994. *Social network analysis: Methods and applications*. Volume 8. Cambridge University Press.

Waters, C. N., J. Zalasiewicz, C. Summerhayes, A. D. Barnosky, C. Poirier, A. Galuszka, A. Cearreta, M. Edgeworth, E. C. Ellis, M. Ellis, C. Jeandel, R. Leinfelder, J. R. McNeill, D. Richter, W. Steffen, J. Syvitski, D. Vidas, M. Wagreich, M. Williams, A. Zhisheng, J. Grinevald, E. Odada, N. Oreskes and A. P. Wolfe. 2016. The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science* 351 (6269): aad2622.

Watts, N. et al. 2015. Health and climate change: policy responses to protect public health. *The Lancet* 386.10006: 1861- 1914.

Weiler, F., C. Klöck and M. Dornan. 2018. Vulnerability, good governance, or donor interests? The allocation of aid for climate change adaptation. *World Development* 104: 65-77.

Westley, F., P. Olsson, C. Folke, T. Homer-Dixon, H. Vredenburg, D. Loorbach, J. Thompson, M. Nilsson, E. Lambin, J. Sendzimir, B. Banerjee, V. Galaz and S. van der

Leeuw. 2011. Tipping Toward Sustainability: Emerging Pathways of Transformation. *Ambio* 40 (7): 762-80.

Westley, F. R., O. Tjornbo, L. Schultz, P. Olsson, C. Folke, B. Crona and Ö. Bodin. 2013. A Theory of Transformative Agency in Linked Social-Ecological Systems. *Ecology and Society* 18 (3): 27.

Wettstein, F. 2009. M*ultinational Corporations and Global Justice: Human Rights Obligations of a Quasi-Governmental Institution.* Stanford: Stanford University Press.

WBGU (German Advisory Council on Global Change). 2011. *World in transition: a social contract for sustainability.* Berlin: Wissenschaftlicher Beirat Globale Umweltveränderungen.

WBGU (German Advisory Council on Global Change). 2016. *Humanity on the move: unlocking the transformative power of cities.* Berlin: WBGU.

Widerberg, O. 2016. Mapping institutional complexity in the Anthropocene. In *Environmental Politics and Governance in the Anthropocene: Institutions and Legitimacy in a Complex World,* edited by P. Pattberg and F. Zelli, 81. Routledge.

Widerberg, O. and P. Pattberg. 2017. Accountability Challenges in the Transnational Regime Complex for Climate Change. *Review of Policy Research* 34 (1): 68-87.

Wilkinson, A., D. Mangalagiu and J. Selsky. 2011. *Challenges of using futures methods in sustainable development projects.* Academy of Management national meetings.

Wilkinson, R. and K. Pickett. 2009. *The Spirit Level: Why More Equal Societies Almost Always Do Better*. New York: Bloomsbury.

Wissenburg, M. 2016. In *Environmental Politics and Governance in the Anthropocene: Institutions and Legitimacy in a Complex World*, edited by P. Pattberg and F. Zelli, 15-30. Abingdon: Routledge.

Wong, J. K. 2016. A Dilemma of Green Democracy. *Political Studies* 64 (1): 136-155.

World Bank. 2010. *Cities and climate change: an urgent agenda. The International Bank for Reconstruction and Development.* Washington D.C.: The World Bank.

World Bank. 2011. *Guide to Climate Change Adaptation in Cities. The International Bank for Reconstruction and Development.* Washington D.C.: The World Bank.

World Bank. 2018. CO2 emissions (kg per PPP $ of GDP). [Online: https://data.worldbank.org/indicator/EN.ATM.CO2E.PP.GD]

World Social Science Report (WSSR). 2016. *Challenging Inequalities: Pathways to a Just World*. Paris: UNESCO Publishing.

Worthington, R., M. Rask and L. Minna. 2013. *Citizen Participation in Global Environmental Governance.* Abingdon: Routledge.

Wyborn, C. and S. Dovers. 2014. Prescribing adaptiveness in agencies of the state. *Global Environmental Change* 24: 5-7.

Wynne, B. 1992. Uncertainty and environmental learning: Reconceiving science and policy in the preventive paradigm. *Global Environmental Change* 2 (2): 111-27.

Young, I. 1990. *Justice and the Politics of Difference*. Princeton, NJ: Princeton University Press.

Young, O.R. 2008. Building regimes for socioecological systems: institutional diagnostics, in *Institutions and Environmental Change: Principle Findings, Applications, and Research Frontiers,* edited by O. R. Young, L. A. King and H. Schroeder. Cambridge, MA: MIT Press.

Young, O. R., L. A. King and H. Schroeder, editors. 2008. *Institutions and environmental change: principle findings, applications, and research frontiers*. Cambridge, MA: MIT Press.

Young, Oran R. 2002. *The Institutional Dimensions of Environmental Change: Fit, Interplay, and Scale*. Cambridge, MA: MIT Press

Young, O. R. 2010. Institutional dynamics: Resilience, vulnerability and adaptation in environmental and resource regimes. *Global Environmental Change* 20: 378-385.

Young, O. R. 2017. *Governing Complex Systems: Social Capital for the Anthropocene.* Cambridge, MA: MIT Press.

Young, O. R., A. Underdal, N. Kanie and R. E. Kim. 2017. Goal Setting in the Anthropocene: The Ultimate Challenge of Planetary Stewardship. In *Governing through Goals: Sustainable Development Goals as Governance Innovation*, edited by N. Kanie and F. Biermann. Cambridge, MA: MIT Press.

Zalasiewicz, J., C. N. Waters, A. P. Wolfe, A. D. Barnosky, A. Cearreta, M. Edgeworth, E. C. Ellis, I. J. Fairchild, F. M. Gradstein, J. Grinevald, P. Haff, M. J. Head, J. A. I. do Sul, C. Jeandel, R. Leinfelder, J. R. McNeill, N. Oreskes, C. Poirier, A. Revkin, D. deB. Richter, W. Steffen, C. Summerhayes, J. P. M. Syvitski, D. Vidas, M. Wagreich, S. Wing and M. Williams. 2017. Making the Case for a Formal Anthropocene Epoch: An Analysis of Ongoing Critiques. *Newsletters on Stratigraphy* 50 (2): 205-226.

Zelli, F. and H. van Asselt. 2013. Introduction: The Institutional Fragmentation of Global Environmental Governance: Causes, Consequences, and Responses. *Global Environmental Politics* 13: 1-13.

Zelli, F. and P. Pattberg. 2016. Conclusions: Complexity, responsibility and urgency in the Anthropocene. In *Environmental Politics and Governance in the Anthropocene: Institutions and Legitimacy in a Complex World*, edited by P. Pattberg and F. Zelli, 231-242. Abingdon: Routledge.

Zurek, M. B. and T. Henrichs. 2007. Linking scenarios across geographical scales in international environmental assessments. *Technological Forecasting and Social Change* 74: 1282-1295.

Zürn, M. and B. Faude. 2013. Commentary: On Fragmentation, Differentiation, and Coordination. *Global Environmental Politics* 13: 119-130.