Available online at www.sciencedirect.com
ScienceDirect
Global Environmental Change 17 (2007) 326–337
Global Environmental Change
www.elsevier.com/locate/gloenvcha

'Earth system governance' as a crosscutting theme of global change research

Frank Biermann*

Department of Environmental Policy Analysis, Institute for Environmental Studies, Vrije Universiteit Amsterdam, De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands

Received 22 August 2006; received in revised form 27 November 2006; accepted 28 November 2006

Abstract

In 2001, the four global change research programmes 'urgently' called for 'an ethical framework for global stewardship and strategies for Earth System management'. Yet this notion of 'earth system management' remains vaguely defined: It is too elusive for natural scientists, and too ambitious or too normative for social scientists. In this article, I develop an alternative concept that is better grounded in social science theory: 'earth system governance'. I introduce, first, the concept of earth system governance as a new social phenomenon, a political programme and a crosscutting theme of research in the field of global environmental change. I then sketch the five key problem structures that complicate earth system governance, and derive from these four overarching principles for earth system governance as political practice, namely credibility, stability, adaptiveness, and inclusiveness. In the last part of the article, I identify five research and governance challenges that lie at the core of earth system governance as a crosscutting theme in global change research. These are the problems of the overall *architecture* of earth system governance, of *agency* beyond the state, of the *adaptiveness* of governance mechanisms and of their *accountability* and legitimacy, and of the modes of *allocation* in earth system governance—in short, the five A's of earth system governance research.

Keywords: Global change; Climate policy; Global governance; Adaptation; Sustainability science; Earth system analysis; Research programmes; Earth system science partnership; International human dimensions programme on global environmental change; Equity; Accountability; Governance architectures; Institutions

1. Introduction

In 2001, the four global change programmes DIVERSITAS, International Geosphere-Biosphere Programme, World Climate Research Programme, and International Human Dimensions Programme on Global Environmental Change agreed to intensify co-operation through setting up an overarching Earth System Science Partnership. The research communities represented in this Partnership contend that the earth system now operates 'well outside the normal state exhibited over the past 500,000 years' and that 'human activity is generating change that extends well beyond natural variability—in some cases, alarmingly so—and at rates that continue to accelerate.' To cope with this challenge, the four global change research programmes have called 'urgently' for 'an ethical framework for global stewardship and strategies for Earth System management'.[1]

This concept of 'earth system management' is found more and more often in the literature,[2] yet it remains

*Tel.: +31 20 598 9959; fax: +31 20 598 9553.
E-mail address: frank.biermann@ivm.vu.nl.

[1] See the mission statement of the Earth System Science Partnership http://www.essp.org/about_essp.html. The text draws on the 2001 Amsterdam Declaration on Global Change, http://www.sciconf.igbp.kva.se/fr.html. For a comprehensive scientific treatment, see Steffen et al. (2004).

[2] One finds the term mostly in relation to natural science programmes, for example when it comes to providing data on earth system parameters that are influenced by human action. For instance, earth system management is one of the three research foci of the natural-science oriented Centre for Marine and Climate Research in Hamburg, Germany, there defined as provision of models and methods as instruments for information, planning and legislation on global, regional and local scales.

0959-3780/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.gloenvcha.2006.11.010

vaguely defined and operationalised. It appears elusive for natural scientists, and too ambitious or too normative for social scientists. For social scientists, 'management' is a term often related to notions of hierarchical steering, planning and controlling of social relations. From a social science perspective, 'earth system management' as an analytical or normative concept would be both infeasible and—in its connotation of hierarchical planning—undesirable.

In this article, I therefore develop an alternative concept that is better grounded in social science theory: 'earth system governance'. I introduce, first, the concept of earth system governance as a new social phenomenon, a political programme and a crosscutting theme of research in the field of global environmental change. I then sketch the five key problem structures that complicate earth system governance, and derive from these four overarching principles for earth system governance as political practice. In the last parts of the article, I identify five research and governance challenges that lie at the core of earth system governance as a crosscutting theme in global change research, and discuss problems of research practice. This conceptualisation of earth system governance is also meant to contribute to the current debates on the future of institutional research within the International Human Dimensions Programme on Global Environmental Change (IHDP) and the overarching Earth System Science Partnership.[3]

2. The concept

I understand 'earth system governance' as the interface of two broad strands of academic inquiry, earth system analysis and governance theory. This section briefly introduces these two research areas. I first review earth system analysis from the perspective of social science, and then continue with the proposal of a two-pillar model of research within the earth system science community and an outline of earth system governance as a subfield within social science.

2.1. Earth system analysis and social science

The notion of integrated 'earth system analysis' has emerged from the complexities of global environmental change that require the involvement of most academic disciplines at multiple spatial and temporal scales. Especially in the natural sciences that build on quantification and computer-based modelling, efforts have long been underway to combine and integrate models of different strands of research to gain understanding not of isolated elements of global change, but of the totality of processes in nature and human civilisation. Integrated earth system analysis as a scientific enterprise is the consequence of these efforts. Hans-Joachim Schellnhuber (1998, 1999), a key proponent of the concept, ascribes earth system analysis the status of a science in statu nascendi, because, as he writes (with Volker Wenzel), it has '1. a genuine subject, namely the total Earth in the sense of a fragile and "gullible" dynamic system, 2. a genuine methodology, namely transdisciplinary systems analysis based on, i.a., planetary monitoring, global modelling and simulation, 3. a genuine purpose, namely the satisfactory (or at least tolerable) coevolution of the ecosphere and the anthroposphere (vulgo: Sustainable Development) in the times of Global Change and beyond' (Schellnhuber and Wenzel, 1998, p. vii).

Earth system analysis relates to 'sustainability science', a closely connected concept that integrates different disciplines and communities in the larger quest for a transition to sustainability.[4] As Robert Kates, William Clark and colleagues argue, the challenge of sustainable development is so complex that it requires a 'sustainability science' as a new integrative field of study (Kates et al., 2001). A sustainability science shall improve collaboration of natural and social scientists as well as deliver research designs that better integrate all scales from local to global. It would also imply modifications of the traditional model of knowledge generation and a new way in which science is conducted (Social Learning Group, 2001; Siebenhüner, 2004).

Research on institutions and governance mechanisms is often viewed as part of earth system analysis and is formally included in most theoretical conceptualisations in this field. The physicist Schellnhuber, for example, has formalised the notion of a 'global subject' S, which he conceptualises as part of the human civilisation H together with the anthroposphere A (the totality of human life,

(*footnote continued*)
The first time the term has been used—to my knowledge—was at the Seventh International Remote Sensing Systems Conference in Melbourne in 1994 by a representative of the UN Environment Programme, Noel J. Brown, in his presentation *Agenda 21: Blueprint for Global Sustainability, New Opportunities for Earth System Management* (personal communication Heiner Benking, August 2005).

[3]See the information on the synthesis process of the IHDP core project 'Institutional Dimensions of Global Environmental Change'—which culminates in a Synthesis Conference in December 2006 in Bali, Indonesia—available at http://fiesta.bren.ucsb.edu/~idgec/ (last visit 18 July 2006). On the current science plan of the IDGEC project, cf. Institutional Dimensions of Global Environmental Change Project (1999) and Young (2002).

[4]Key texts are available at http://sustsci.harvard.edu/. See also Clark et al. (2005), Schellnhuber et al. (2004), as well as the reports of the Friibergh Workshop on Sustainability Science, held 11–14 October 2000 in Friibergh Manor, Örsundsbro, Sweden. The workshop concluded that sustainability requires a new field of sustainability science that would need to differ by structure, method and content from traditional science. Sustainability science would also require new forms of institutional organisation to support interdisciplinary research and to integrate such research in coherent systems of research planning, assessment and decision-support.

actions and products that affect other components of the earth system). Translated into social science language, this 'global subject' *S* could be seen as the political system at the global level including its national and subnational subparts, all of which share the collective ability to bring the 'human impact' in line with the needs of the ecosphere (Schellnhuber, 1999, pp. C20–C22; Schellnhuber and Biermann, 2000). Likewise, the Earth System Science Partnership asserts that 'the core' of its activities will be the 'in-depth analysis and advanced modelling of the Earth System as a whole, incorporating data and information from the diverse fields represented by the four global change programmes'.[5]

In practice, however, it remains unclear to what extent institutional and governance research can contribute to, and integrate with, these more model-driven research programmes, apart from problem-oriented, issue-specific collaboration. Quantifiable hypotheses and computer-based modelling are problematic for most students of institutions and governance—and are likely to remain so (Young et al., 2005). Social science research groups that attempt to use computer-modelling and quantification as a tool for integrating governance research into larger models have still to provide convincing results. Qualitative modelling projects to analyse international governance processes and institutions are in their infancy (Eisenack, 2003; Eisenack et al., 2006). Major problems in modelling governance processes remain, to name a few, the complexity of relevant variables at multiple levels, human reflexivity, and difficulties in conceptualising key social concepts such as 'power', 'interest' or 'legitimacy'.

Given this mismatch between formalised methods and fuzzy social realities, proponents of an integrated earth system analysis often relegate governance research to an auxiliary, advisory, and essentially non-scientific status. Quite typical is the conceptualisation of social science in the 23 questions that the Global Analysis, Integration and Modelling task force of the International Geosphere–Biosphere Programme has put forward as overarching questions for the earth system analysis community (Schellnhuber and Sahagian, 2002). Some of these questions relate to the social sciences. However, these social science questions are not viewed as part of the 'analytical' questions (which are exclusively related to natural science), but as part of the 'strategic' questions (for example question no. 23, 'What is the structure of an effective and efficient system of global environment and development institutions?'), or 'normative' questions (for example, question no. 18, 'What kind of nature do modern societies want?'). The value of institutional research as an *analytical* programme of inquiry is relegated to its policy-oriented, advisory dimensions. It appears that this is a logical outcome of an earth system analysis programme that is motivated by computer-modelling and quantification.

[5]See the Partnership's mission statement at ⟨www.essp.org⟩.

2.2. Towards a two-pillar model for global change research

Consequently, I argue that students of governance should resist subjecting their governance and institutional analysis of human–nature interactions to computer-modelling, quantification and epistemological uniformism and to methods that are unfeasible to implement and impossible to trust in the social sciences. Instead, social scientists will need to continue to develop *independent research programmes* that are interdisciplinary across the different social sciences—for example, linking international relations and law—but that follow the internal logic and particular theoretical, epistemological and methodological approaches of the social sciences and the humanities, which are essentially qualitative, case-based, context-dependent, and reflexive.

One overarching theme for such a research programme, I argue, is earth system governance. The study of earth system governance is thereby part of the larger project of global change research, yet must also remain autonomous in its distinct methodological and theoretical development.

Global change research therefore rests on two theoretical and methodological pillars: One is earth system analysis driven by an integrated computer-based approach that brings together models and modules of natural sciences as well as of some social sciences that are able to contribute models and quantified data, such as economics and some strands of geography. The other pillar is the development of an earth system governance theory that unites those social sciences that analyse organised human responses to earth system transformation, in particular the institutions and agents that cause global environmental change and the institutions, at all levels, that are created to steer human development in a way that secures a 'safe' co-evolution with natural processes. Both pillars are crowned by a common, collaborative roof that organises issue-specific co-operation between the pillars, for example in the various joint projects of the Earth System Science Partnership.[6]

2.3. Earth system governance and social science

This research programme on earth system governance not only contributes to the scientific understanding of global change. It is also inherently part of the larger discourse in the social sciences on new institutionalism and governance. Even though 'governance' is not uniformly defined in the social sciences (van Kersbergen and van Waarden, 2004), it usually denotes new forms of regulation that differ from traditional hierarchical state activity and implies some form of self-regulation by societal actors, private–public co-operation in the solving of societal problems, and new forms of multilevel policy. (Other

[6]For example the Global Environmental Change and Food Systems Project, the Global Water System Project, the Global Carbon Project, and the Global Environmental Change and Human Health Project. Information and links to all project websites at www.essp.org.

usages less relevant here are normative in the sense of 'good governance' and management-oriented in the sense of 'corporate governance'.)

Earth system governance thus also relates to the discourse on 'global governance' (Commission on Global Governance, 1995; Dingwerth and Pattberg, 2006; Kanie and Haas, 2004; Rosenau, 1995; Young, 1994, 1997). 'Global governance' is often used as a *description* of modern world politics, sometimes limited to traditional forms of international relations (Finkelstein, 1995, p. 369), sometimes broader to encompass a variety of social and political interactions at all levels (Rosenau, 1995, p. 13).The term is also used as a political *prescription* to cope with problems of modernity, for example in calls for 'global governance' as a counterweight to globalisation (Commission on Global Governance, 1995; Smouts, 1998). As a political project, global governance has also been criticised, for instance from the perspective of historical materialism (Overbeek, 2005) or of developing countries (South Centre, 1996, p. 32). Yet notwithstanding these differences in conceptualisation, much of the advance in theoretical and empirical knowledge on global governance will be fruitful also for the development of a theory of earth system governance.

In sum, earth system governance is not confined to states and governments as sole actors. It is marked by participation of myriad public and private non-state actors at all levels of decision-making, ranging from networks of experts, environmentalists and multinational corporations to agencies set up by governments. Earth system governance can therefore be defined as *the sum of the formal and informal rule systems and actor-networks at all levels of human society that are set up in order to influence the co-evolution of human and natural systems in a way that secures the sustainable development of human society*—that is, a development that meets the needs of present generations without compromising the ability of future generations to meet their own needs.

This notion of earth system governance is phenomenological inasmuch as it describes an emerging social phenomenon expressed in hundreds of international regimes, international bureaucracies, national agencies, local and transnational activists groups and expert networks. At the same time, earth system governance can be understood as a political project that engages more and more actors who seek to strengthen the current architecture of institutions and networks at local and global levels. And in both meanings, earth system governance is a demanding and vital subject of research for the social sciences.

As such, earth system governance bridges traditional levels of analysis in governance and policy studies. On the one hand, it goes beyond environmental policy analysis as it emerged in the 1970s with its focus on managing environmental problems of industrialised countries. The anthropogenic transformation of the earth system encompasses more puzzles and problems than have been traditionally examined within environmental policy studies, now ranging from changes in geophysical systems to the global loss of biological diversity. Key questions—such as how Bangladesh could adapt to rising sea levels, how deterioration of African soils could be halted or how land-use changes in Brazil could be analysed—have barely been covered by environmental policy research. Yet they are inevitably part of the study of earth system governance. On the other hand, earth system governance covers more than problems of the 'global commons', but also local problems from air pollution to the preservation of waters, waste treatment or desertification and soil degradation. Earth system governance thus requires the integration of governance research at all levels. It must bridge scales from global to local.

3. Problems and principles

This section further expands on the concept of earth system governance. It begins with laying out the *problem structure* of earth system governance that makes it a special and unprecedented challenge for both researchers and decision makers (Section 3.1). From this problem structure, I derive four general governance *principles* that could underpin an earth system governance system for the 21st century (Section 3.2). Section 4 then lays out the core *research questions* that, based on the current state of knowledge, flow from the identification of problems and principles.

3.1. Problem structure

Earth system governance must cope with at least five problem characteristics that make it a particular difficult governance challenge.

(1) First, the anthropogenic earth system transformation is marked by *persistent uncertainty* regarding the causes of global environmental change, its impacts, the interlinkage of various causes and response options, and the effects of possible response options. Most transformations, such as global climate change, are non-linear and might accelerate, or slow down, at any time. Surprises in system behaviour can be expected, but are by definition unforeseeable. The history of the belated and partially accidental scientific discovery of stratospheric ozone depletion and its human-made causes has been particularly well documented in the literature, with its intriguing story of computer systems that excluded high ozone depletion as measurement errors, of scientists who first did not report their findings, and of politicians who first refused to act (Litfin, 1994). Uncertainty has found its institutional response in repeated rounds of global environmental assessments that have brought together the world's leading scientists in complex institutional settings, with the Intergovernmental Panel on Climate Change as a prime example. Yet these scientific assessment and

research institutions cannot resolve the persistent uncertainty that continues to complicate earth system governance.

Uncertainty is not only analytical, but also normative. Most problems of earth system transformation are unprecedented. The adequate policies, polities and, especially, modes of allocation are uncertain, initially always contested, and need to be developed and agreed upon by societies over time. Uncertainty hence poses particular governance challenges. It requires governance to be stable over decades and centuries to withstand sudden changes of earth system parameters (or changes in our knowledge about these parameters), but also to be flexible enough to adapt to changes within the larger stable framework. Governance must be oriented towards the long term, but must also provide solutions for the near future. Normative uncertainty requires the development of new norms and conceptual frameworks for global collective action in uncharted territory. The global allocation of 'emissions rights' in climate governance, which oscillates between the extremes of equal per capita allocation and allocation according to existing use, is a prime example (Biermann, 2005). Analytical and normative uncertainty is part of any collective decision-making. In earth system governance, it is extreme.

(2) Second, the anthropogenic transformation of the earth system creates *intergenerational dependencies* that pose further exceptional governance challenges. Cause and effect of earth system transformations are usually separated by decades, often by generations. The same holds for the decoupling over decades of the costs of mitigation and the benefits of avoided harm. Sea-level rise, for example, is expected within a time-range of 100 years: such planning horizons exceed the tenure and even the lifetime of present decision-makers and stakeholders. Among other things, this poses the challenge of international credibility and trust that future governments will reciprocate and comply, and the problem of democratic legitimacy of policies in the intergenerational context. What rights and responsibilities do present generations, and their representatives in parliament, have towards their unborn successors? Intergenerational equity and responsibility is not confined to earth system governance—it is also, for example, part of many social security systems. Yet in earth system governance, intergenerational interdependence is at the core.

(3) Third, earth system governance must respond to the *functional interdependence* of earth system transformation and of potential response options. Functional interdependence relates to the interdependence of natural subsystems—linking, for instance, climate change to biodiversity or land degradation—as well as to the interdependence of social systems and policy areas. Response strategies in one problem area or one policy domain are likely to have repercussions for other areas. Functional interdependence also relates, in many problem segments, to the mutual substitutability of response options, which poses particular problems of international allocation. In climate governance, for example, for every global policy target there are an unlimited number of possible combinations of local responses across nations and time frames with equal degrees of effectiveness. Functional interdependence requires policy co-ordination and integration to the extent possible. It lies at the heart of the discourse on environmental policy integration at the national level as well as of recent attempts to cluster the plethora of international regimes into core groups, such as a 'chemicals cluster' or 'biodiversity cluster' (von Moltke, 2005).

(4) Fourth, the anthropogenic transformation of the earth system creates new forms and degrees of (global) *spatial interdependence*. This relates to both natural (direct) and social (indirect) interdependencies. Natural interdependencies are functions of the earth system that transform local environmental pollution into changes of the global system that affect other localities. Prominent examples are climate change, stratospheric ozone depletion, the global distribution of persistent organic pollutants, and the global spread of species with potential harm for local ecosystems. Social interdependencies are functions of the (global) social system that transform local environmental degradation into transregional or global social, economic and political crises. This includes negative influences on the world economy, for example because of large-scale flooding, drought or disease. It also includes negative influences on the material security of human populations, for example, when regional climatic change causes decreases in food production and thus increases in global food demand and food prices. Eventually, these social interdependencies will affect global and regional security. Economic crises or mass migration due to transformation of the earth system will not be confined to some states. They will affect all. Spatial ecological interdependence binds all nations. This creates a new dependence of states, even the most powerful ones, on the community of all others. This spatial interdependence is a defining characteristic as well as a key challenge of earth system governance that requires an effective institutional framework for global co-operation, more so than most other areas of foreign policy.

(5) Fifth, earth system governance has to cope with, and gains its particular relevance from, the *extraordinary degree of harm* that is possible, and that current governance systems might not be fully prepared for. Sea-level rise, food shortage, drought, storms, land degradation, reproductive disorder and many other consequences of earth system transformation—if unchecked—are conceivable. Some might be catastrophic, such as changes in monsoon patterns or in the

thermohaline circulation, large-scale breakdown of ecosystems, or rising sea levels in low-lying countries. Developing countries in particular are ill prepared to adapt to these changes that might require in some cases large-scale migration and transnational food assistance. Earth system governance is challenged in many ways. Extreme impacts could exceed the regulatory capacity of individual states, both in affected regions and in less affected potential donor regions. Global assistance, including globally co-ordinated planning and preparing, is needed. Global solidarity led states and private citizens to transfer substantial funds to victims of disasters in the past, from the flood assistance to the Dutch in 1953 to the Tsunami aid programmes in early 2005. Yet the extent of potential impacts of earth system transformation will put global solidarity to the test, in particular when mass migration—for example from low-lying islands—is the only practical and financially viable option.

3.2. Governance principles

These problem characteristics of the global transformation of earth system parameters through human action—high analytic and normative uncertainty, high temporal, functional and spatial interdependence, and potentially extreme impacts—are unprecedented in the governance of human affairs. From these characteristics of earth system transformation, I derive four core principles of earth system governance.

(1) *Credibility*. First, effective earth system governance requires governments to commit resources both domestically and through transnational transfer mechanisms for mitigation and increasingly adaptation policies. Given the uncertainty and temporal and spatial interdependence of anthropogenic earth system transformation, governments will need to commit these resources based on the assumption that other governments will reciprocate when it is their turn—including the still unknown future governments of other nations. Earth system governance must thus produce the necessary credibility for governments and others to believe in this reciprocity of interaction partners over time and space.

(2) *Stability*. High uncertainty and high temporal, functional and spatial interdependencies require that earth system governance is stable enough over decades to withstand political changes in participating countries or changes in the world political system. Governments that commit resources within a global normative framework in the present must rely on the perseverance of this framework over time. Yet effective transnational institutions and governance systems with a time-horizon of centuries are rare—the Catholic Church with its 2000-year stable leadership succession and decision-making mechanisms is probably the only transnational empirical example. It will be a key task for analysts to chart ways for such stable systems of earth system governance in the 21st century.

(3) *Adaptiveness*. Within this stable framework, actors must have the ability to change governance elements to respond to new situations, without harming both credibility and stability of the entire system. The tension between stability and credibility, on the one hand, and the need to respond quickly to new scientific findings and new interest constellations is one of the key challenges for earth system governance. Governing has always implied a degree of social learning and of adaptation to changed circumstances. Earth system transformation brings with it new challenges regarding the degree and speed of potential change. The conditions for effective and equitable 'adaptive governance' are increasingly discussed at the local and regional levels, for example concerning water system governance (Huitema et al., 2006). The conditions for effective global adaptive governance of large-scale earth system transformations during the 21st century within a stable and credible global institutional order are less understood.

(4) *Inclusiveness*. The interdependence of earth system governance, as well as the complexity and uncertainty of the entire system that may change the overall interest constellation within a few years, require the governance system to be as inclusive as possible regarding the stakeholders involved. This requirement of 'participatory governance' includes weaker states that might lack influence in world politics but are important both for mitigation and adaptation efforts. In particular developing countries are significantly more relevant, and hence more powerful, in key issue areas of earth system governance, from climate change to biodiversity governance. Participatory governance is also the challenge of including non-state stakeholders in decision-making at local and global levels, since the complexity and uncertainty of earth system governance cannot be resolved through action by public agents alone. However, this inclusion of private actors and 'civil society' requires methods and mechanisms that are perceived by all stakeholders as legitimate, effective, and fair.

4. Research challenges

Earth system governance is an emerging empirical phenomenon as well as a political project of the 21st century. In both dimensions, it is a demanding challenge for the study of the human dimensions of global environmental change and for social science in general, which must generate theoretical insights and practical tools to develop effective structures of earth system governance. In the following section, I develop five key clusters of questions

that could guide a focussed research effort in earth system governance theory as a crosscutting theme of global change research.[7] These are the research problems of the overall *architecture* of earth system governance, of *agency* beyond the state, of the *adaptiveness* of governance mechanisms and of their *accountability* and legitimacy, and of the mode of *allocation* in earth system governance—in short, the five A's of earth system governance research.

4.1. Architecture

First, I argue that the governance principles of stability, credibility and inclusiveness require refocusing research efforts on the overall 'architecture' of earth system governance. Most research in this field in the last 30 years has focussed on single institutions. We now have a better understanding of the creation, maintenance, and effectiveness of international environmental regimes, as well as better methodological tools to study these phenomena (for overviews, cf. Helm and Sprinz, 2000; Mitchell, 2003; Young, 2001). It has been shown, for example, that different international norms and verification procedures, compliance management systems, modes of regime allocation as well as external factors, such as the structure of the problem, all influence regime effectiveness. Most of these studies have focussed on the effectiveness of single institutions, often within larger comparative projects (e.g., Gupta and Falkner, 2006; Haas et al., 1993; Keohane and Levy, 1996; Miles et al., 2002; Victor et al., 1998; Young, 1997; Young et al., 1999). More recently, the increasing number and scope of international environmental institutions has led to new research on their interaction, for example in studies on regime interlinkages, regime 'clusters' or regime 'complexes' (van Asselt et al., 2005; Chambers, 2001; Oberthür and Gehring, 2006; Rosendal, 2001a, b; Stokke, 2000; Velasquez, 2000). Institutional interplay is also one of the three research themes of the Institutional Dimensions of Global Environmental Change project of IHDP (Institutional Dimensions of Global Environmental Change Project, 1999; Young, 2002; on IDGEC and interplay see Schröder, forthcoming).

These approaches to understanding the effectiveness and the interaction of different institutions had to be methodologically reductionist to be successful. Distinct institutions, sometimes distinct elements of larger institutions, have been analysed regarding their effectiveness and their relationship to other institutions or institutional elements. The macro-level—that is, the system of institutions that address aspects of earth system governance—has remained largely outside the focus of the major research programmes. Given the advances in regime theory and institutional analysis, further progress now requires a complementary research programme that analyses this macro-level. I call this the '*architecture*' of earth system governance, that is, the interlocking web of principles, institutions and practices that shape decisions by stakeholders at all levels.

The structure and effectiveness of this overall architecture still remains a research frontier. Key questions are, for example, the extent to which such an architecture must restrict state sovereignty; the kind and character of the universally accepted constitutional norms needed to support such an architecture; the kind of mechanisms that guarantee effective vertical interaction of governance systems across levels and scales; and the need for universal inclusion and participation among states. The quest for an overarching architecture of earth system governance relates also to recent debates on strengthening the UN system in this field, in particular with a view to policy proposals for a larger integrated organisation such as a 'world environment organisation' or a 'UN environment organisation' (Biermann and Bauer, 2005; Rechkemmer, 2005).

4.2. Agency beyond the state

Second, credible, stable, adaptive, and inclusive earth system governance requires the consent and involvement of actors beyond governments and state agencies. Many vital institutions of earth system governance are therefore today inclusive of, or even driven by, non-state actors, ranging from public non-state actors such as intergovernmental bureaucracies (Biermann and Bauer, 2004; Bauer, 2006; Busch, 2006) to purely private actors such an environmentalist alliances, scientific networks, and business associations (Arts, 1998, 2002; Betsill and Corell, 2001; Conca, 1995; van der Grijp and Brander, 2004; Gupta, 2003; Levy and Newell, 2004; Princen et al., 1995; Raustiala, 1997; Wapner, 1996). These activities of non-state actors are no longer confined to lobbying or advising governments in the creation and implementation of international rules. Increasingly, non-state actors now participate in global institutions and negotiate their own standards, as in the Forest Stewardship Council, the Coalition for Environmentally Responsible Economies, or the Marine Stewardship Council (Falkner, 2003; Pattberg, 2005, 2006b). Public–private co-operation has received even more impetus with the 2002 Johannesburg World Summit on Sustainable Development and its focus on partnerships of governments, non-governmental organisations and the private sector—the so-called Partnerships for Sustainable Development (Glasbergen et al., forthcoming).

The effectiveness of such public–private or fully private initiatives, however, is insufficiently understood. Most advances in the study of earth system governance have traditionally been linked to inter-*governmental* co-operation and to states as core actors. We have an elaborate literature on the foreign policy of states, including their environmental foreign policy, and on institutions created and regulated by states. We still lack comparable

[7]While I believe that these five A's are the key current research questions, the list is not meant to be exhaustive. The five A's are related to, and draw on, the current debate on a new research phase for the IHDP core project 'Institutional Dimensions of Global Environmental Change'.

knowledge on the behaviour of non-state actors and on the institutions that they create. Moreover, most recent literature on private co-operation still builds on single-disciplinary case-study research with case selection often influenced by practical considerations or flawed through case-selection on the dependent variable, in particular where only 'success stories' are chosen (e.g. Reinicke and Deng, 2000). The major effort of the 1990s on analysing inter-governmental environmental regimes thus needs to be complemented by a similar research programme on 'global participatory governance' that explores the public–private and private institutions in earth system governance.

4.3. Adaptive governance and the 'adaptive state'

Third, the five problem characteristics of earth system governance developed above place new burdens on the core functions of the state, which needs to evolve into an 'adaptive state'. The adaptive state will be challenged in three ways: by decreased autonomy through increased dependence on other states, increased need for legitimacy, and increased stress through the need to adapt to sudden alterations of the natural environment.[8]

First, the spatial interdependence—regarding both natural and social interdependence—of global environmental problems has made states directly dependent on the activities of other states. The guarantee of security and the protection of citizens are now possible only in a governance system that transcends state boundaries. Unlike economic interdependence that was debated in the 1960s and 1970s (e.g., Keohane and Nye, 1977), ecological interdependence is inescapable even for the most powerful nations. Ecological interdependence binds all nations, which creates a new dependence of all nations on the community of all others.

Second, spatial and temporal interdependence as well as analytical and normative uncertainty create new problems for the legitimacy of state action. Drastic mitigation programmes today will mainly benefit—through reduced harm—future generations, which will suffer less from floods, droughts or breakdowns of ecosystems. In addition, most beneficiaries will live beyond a state's borders. Normative uncertainty inevitably requires current generations to work towards a model of earth system governance and, implicitly, towards a future state of the earth system whose desirability for future generations remains unknown. Known are merely the costs for current generations, which need to be legitimised if drastic actions are taken. All this places new burdens on the legitimacy of state action.

Third, adaptation to earth system transformations poses additional burdens on *state capacities*. The more environmental change puts stress on societies—for instance through drought, regional climate changes or sea-level rise, but also through new mitigation requirements—the more will state capacities be in danger of becoming overstretched, with local and regional crises as a possible consequence. Given the uneven geographic distribution of adverse consequences of global environmental change, some states will face more demands for adaptation than others. Since developing countries will suffer most from a lack of capacities to address the social, economic and environmental problems within their boundaries, their capacities are likely to be stretched most by global environmental change. The added stress that earth system transformation places on states limits their options to fulfil other functions such as guaranteeing political participation and creating minimal social conditions. Earth system change requires states to prepare for and adapt to its consequences and thus increases the demand for the administrative, organisational, technological and financial capacity of the 'adaptive state'—a demand that some states will find easier to meet than others.

While much research has focused on the role of the state in the advancement of public goals and public goods—economic development, individual freedom, democracy—a key question of earth system governance will be the analysis of the 'adaptive state': a state able to adapt internally and externally to large-scale transformations of its natural environment.

4.4. Accountability

The three research themes of earth system governance that I have described create problems of accountability and legitimacy. Credible, stable and inclusive governance must be perceived as legitimate by all stakeholders, and its actions and representatives must be accountable to their constituencies. In the 20th century, legitimacy and accountability was a problem of national governments. In the 21st century and its new needs of earth system governance, accountability and legitimacy appear in a different context. Eventually, this comes down to the quest for *democratic* earth system governance.

There are two broad types of research needs: First, a theoretical one. In purely intergovernmental norm-setting processes, legitimacy is conferred indirectly through the accountability of governments to their voters. Likewise, international bureaucracies can derive legitimacy through their principals, the governments, which are accountable to their voters. However, such long lines of accountability have been questioned in recent years (e.g., Dingwerth, 2005; Dryzek, 1999; Held, 1997; Scholte, 2002). Many authors see a solution in the participation of private actors in global governance. David Held, for example, recognises '"new" voices of an emergent "transnational civil society" … in the early stages of development … [that] point in the direction of establishing new modes of holding transnational power systems to account, that is, they help open up the possibility of a cosmopolitan democracy' (Held, 1999, p. 108).

[8]See here the special issue of *Global Environmental Politics*, 'Global Environmental Change and the Nation State', vol. 4 (1), 2004, and in particular the introduction to the issue by Biermann and Dingwerth (2004).

Problematic is, however, the accountability and legitimacy of these private actors themselves. In the domestic context, private organisations derive legitimacy through their members or donors—even though members and donors often have no formal means to decide the policies of the organisation. They can also gain legitimacy from the environmental good that they seek to protect. In the Philippines, for example, non-governmental groups have successfully claimed in court to derive legitimacy and *locus standi* by representing the interests of future generations. In the international context, however, with its high disparities in wealth and power, accountability and legitimacy of private actors is more complicated. Most philanthropic organisations are headquartered in industrialised countries, and most funds donated to their cause stem from the North, both public and private. It is likely that this influences the agenda of these groups and makes them more accountable to Northern audiences (Commission on Global Governance, 1995; South Centre, 1996).

This leads to the second, practical challenge: Because of these disparities, researchers need to design, and practitioners to develop, institutions that guarantee participation of civil society in earth system governance through mechanisms that vouchsafe a balance of opinions and perspectives. For example, networks of transnational private actors can seek to balance views and interests through self-regulation, including financial support for representatives from developing countries. This is done for instance through North–South quotas in meetings and alliances of non-state activists within the UN Commission on Sustainable Development. Also the Intergovernmental Panel on Climate Change, as a form of institutionalised participation of non-state actors in earth system governance, could serve as a model for the effective participation of both developing countries and non-state actors from the South (Agrawala, 1998a, b; Siebenhüner 2002, 2003; Biermann, 2002). Another option to increase legitimacy and accountability of earth system governance by strengthening private participation in a balanced way could be a 'quasi-corporatist' institutionalisation. The Commission on Global Governance (1995, p. 258), for example, proposed an international Forum of Civil Society within the United Nations, which would comprise of 300–600 'organs of global civil society' to be self-selected from civil society.

4.5. Allocation

Finally, earth system governance must be perceived as fair and equitable by all stakeholders in order to be effective. Politics is about the distribution of resources and values, and earth system governance is no different. Modes of allocation are key factors for its stability, credibility and inclusiveness.[9] With the increasing relevance of earth system governance in the 21st century, allocation mechanisms and criteria will thus become central questions to be addressed by social scientists as well as decision-makers. This is particularly pertinent for the relationship between North and South, which has defined the central conflict line in many areas of earth system governance, ranging from global climate (Gupta, 1997; Biermann, 2005) to forest policies (Pattberg, 2006a).

At stake are not only the costs of mitigation. Given the potential disastrous consequences of earth system transformations, questions of fairness in adaptation will arise (Adger et al., 2006). Compensation and support through the global community of the most affected and most vulnerable regions, such as small island states, will not only be a moral responsibility. It will also be politically and economically prudent.

Yet despite this central relevance of allocation, research in this field has been scarce in the past, in particular regarding empirical research programmes that could lend substance to the more policy-oriented, philosophical treatises on equity. Few research efforts have yet been directed at understanding the causal pathways that lead to specific allocation mechanisms, and the consequences of different allocation mechanisms in earth system governance are equally insufficiently understood. Little systematic analysis has been devoted to studying allocation as independent variable and to analysing allocation mechanisms in relation to variant effectiveness of the core institutions of earth system governance. In short, given the growing relevance of earth system governance in the 21st century in terms of both mitigation and adaptation costs, allocation is certain to become a major concern for researchers and practitioners alike.

5. Earth system governance as research practice

Eventually, earth system governance as a research field in the social sciences necessitates a particular analytical approach and research practice. It requires, to begin with, its own methodology. Research on earth system governance will need to be an interdisciplinary effort that links all relevant social sciences, but draws on findings from natural science as well. In particular when it comes to adaptation, earth system governance is called upon to analyse and design governance systems that respond to emergencies that are so far only predicted for the future, but are likely to exceed in scope and quality most of what is known today. Adaptive governance systems that take account of changes in monsoon patterns, large-scale breakdowns of ecosystems or modifications in the thermohaline circulation will need to deal with scales of change that are unprecedented. While traditional social science builds on the development and testing of theories and hypotheses through historical experience, earth system governance, which is inherently future-oriented, has to rely on new forms of evidence and new forms of validity and reliability of empirical knowledge.

[9] See similarly Adger et al. (2005), who write in their editorial to *Global Environmental Change* that a 'more explicit concern with equity and justice will be important in furthering the study of global environmental change'.

Likewise, research on earth system governance has to cope with normative uncertainty. We do not know what governance systems and governance outcomes future generations want. This calls at the very least for participatory research and assessment methods that integrate lay-experts in academic research programmes (Hisschemöller et al., 2001; van de Kerkhof, 2004). Stakeholder dialogues or citizens juries are key elements in the larger effort to understand and strengthen earth system governance.

Added to this is the general problem that all science is context-bound in the person of the scientist. When it comes to earth system governance, this contextual embeddedness of the researcher relates to both time and (cultural) space. Regarding time, we need to develop and 'test' today, with the knowledge of today, governance systems that will help to achieve a safe human–nature co-evolution over the course of the century.

Regarding space, the cultural-normative embeddedness of social scientists requires new forms of diversity-management in global science in the form that is supported today in many global environmental assessment institutions (Jasanoff and Long Martello, 2004; Mitchell et al., 2006). In particular, it requires a global approach to the organisation of research. The study of earth system governance encompasses all the world's regions, but must also be internationally organised to make use of local knowledge, values and insights. As Kates and colleagues argued in their blueprint of a sustainability science, 'a comprehensive approach to [scientific] capacity building will have to nurture…global institutions in tandem with locally focused, trusted, and stable institutions that can integrate work situated in particular places and grounded in particular cultural traditions with the global knowledge system' (Kates et al., 2001, p. 642). Such diversity within the research community together with stronger networking is a prerequisite for studying earth system governance. The globalisation of problems can be countered only by the globalisation of research. Given the dominance of Northern science in global change research programmes, however, this will eventually call for more than quotas for developing country experts in large-scale scientific projects and assessments. It will also require increased efforts in strengthening Southern research capacities on earth system governance (Biermann, 2001, 2002).

6. Conclusion

This article has sketched the emerging field of earth system governance as an empirical phenomenon of world politics and as a crosscutting programme for the global change research community. I have laid out the key problem characteristics and governance principles, as well as five major research challenges: architecture, agency, adaptiveness, accountability, and allocation (cf. Table 1).

More than anything else, this makes earth system governance one of the most challenging, but thus also one of the most exciting research fields in the social sciences. As a political programme, it is no less daunting. The bolder visions of the earlier philosophers, such as Seneca's idea of a res publica whose boundaries would be 'the sun alone' (*De Otio*, § IV, 1) or Kant's proposal of a global federation of states for 'the eternal peace', seem hardly more realistic today than they were in their days. Yet earth system governance is emerging. More than 900 international environmental agreements are in force. Many harmful substances, such as the ozone-depleting chlorofluorocarbons, have been phased out through international co-operation. Mitigation and adaptation projects against global warming are mushrooming in many places, from India to the Netherlands, often inspired, guided or co-ordinated by global collaborative programmes.

Yet how to create a global and effective architecture for earth system governance that is adaptive to changing circumstances, participatory through involving civil society at all levels, accountable and legitimate as part of new democratic governance beyond the nation state, and at the same time fair for all participants: this research and governance challenge still lies ahead.

Table 1

Problem structures	Governance principles	Research challenges
• Uncertainty • Functional Interdependence • Spatial interdependence • Temporal Interdependence • Extreme effects	• Credibility • Stability • Adaptiveness • Inclusiveness	• Architecture • Agency • Adaptive state • Accountability • Allocation

Acknowledgements

This text is the abbreviated version of the author's inaugural lecture at the Vrije Universiteit Amsterdam. Many thanks for useful comments on earlier versions of this text to Ries Bode, Joop de Boer, Jan Boersema, Klaus Dingwerth, Klaus Eisenack, Nicolien van der Grijp, Aarti Gupta, Dave Huitema, Robert Marschinski, Hans Opschoor, Philipp Pattberg, Heike Schröder, Uta Schuchmann, Bernd Siebenhüner, Frans van der Woerd, Oran R. Young, as well as two anonymous reviewers and the editors of *GEC*.

References

Adger, W.N., Brown, K., Hulme, M., 2005. Redefining global environmental change (editorial). Global Environmental Change: Human and Policy Dimensions 15, 1–4.

Adger, W.N., Paavola, J., Huq, S., Mace, M.J. (Eds.), 2006. Fairness in Adaptation to Climate Change. MIT Press, Cambridge, MA.

Agrawala, S., 1998a. Context and early origins of the Intergovernmental Panel on Climate Change. Climatic Change 39, 605–620.

Agrawala, S., 1998b. Structural and process history of the Intergovernmental Panel on Climate Change. Climatic Change 39, 621–642.

Arts, B., 1998. The Political Influence of Global NGOs. Case Studies on the Climate Change and Biodiversity Conventions. International Books, Utrecht.

Arts, B., 2002. Green alliances of business and NGOs. New styles of self-regulation or dead-end roads? Corporate Social Responsibility and Environmental Management 9, 26–36.

van Asselt, H., Gupta, J., Biermann, F., 2005. Advancing the climate agenda: exploiting material and institutional linkages to develop a menu of policy options. Review of European Community and International Environmental Law 14 (3), 255–264.

Bauer, S., 2006. Does bureaucracy really matter? The authority of intergovernmental treaty secretariats in global environmental politics. Global Environmental Politics 6 (1), 23–49.

Betsill, M.M., Corell, E., 2001. NGO influence in international environmental negotiations: a framework for analysis. Global Environmental Politics 1 (4), 65–85.

Biermann, F., 2001. Big science, small impacts—in the South? The influence of global environmental assessments on expert communities in India. Global Environmental Change 11, 297–309.

Biermann, F., 2002. Institutions for scientific advice: global environmental assessments and their influence in developing countries. Global Governance 8 (2), 195–219.

Biermann, F., 2005. Between the United States and the South. Strategic choices for European climate governance. Climate Policy 5, 273–290.

Biermann, F., Bauer, S., 2004. Assessing the effectiveness of intergovernmental organisations in international environmental politics. Global Environmental Change. Human and Policy Dimensions 14 (2), 189–193.

Biermann, F., Bauer, S. (Eds.), 2005. A World Environment Organization. Solution or Threat for Effective International Environmental Governance? Ashgate, Aldershot, UK.

Biermann, F., Dingwerth, K., 2004. Global environmental change and the nation state. Global Environmental Politics 4 (1), 1–22.

Busch, P.-O., 2006. The secretariat of the climate convention: make a living in a straitjacket. Global Governance Working Paper No. 22, The Global Governance Project, Amsterdam, etc. Available at 〈http://www.glogov.org〉.

Chambers, W.B. (Ed.), 2001. Inter-Linkages: The Kyoto Protocol and the International Trade and Investment Regimes. United Nations University Press, Tokyo.

Clark, W.C., Crutzen, P.J., Schellnhuber, H.-J., 2005. Science for global sustainability. Toward a new paradigm. Center for International Development Working Paper No. 120. Harvard University, Cambridge, MA.

Commission on Global Governance, 1995. Our Global Neighbourhood. The Report of the Commission on Global Governance. Oxford University Press, Oxford.

Conca, K., 1995. Greening the United Nations: environmental organizations and the UN system. Third World Quarterly 16 (3), 441–457.

Dingwerth, K., 2005. The democratic legitimacy of public–private rule-making. What can we learn from the World Commission on Dams? Global Governance 11 (1), 65–83.

Dingwerth, K., Pattberg, P., 2006. Global governance as a perspective on world politics. Global Governance 12 (2), 185–203.

Dryzek, J.S., 1999. Transnational democracy. The Journal of Political Philosophy 7 (1), 30–51.

Eisenack, K., 2003. Qualitative viability analysis of a bio-socio-economic system. In: Salles, P., Bredeweg, B. (Eds.), Working Papers of 17th Workshop on Qualitative Reasoning. Brasilia, pp. 63–70. Available at 〈http://www.pik-potsdam.de/%7Eeisenack/downloads/QR-2003.pdf〉.

Eisenack, K., Kropp, J., Welsch, H., 2006. A qualitative dynamical modelling approach to capital accumulation in unregulated fisheries. Journal of Economic Dynamics and Control 30, 2613–2636.

Falkner, R., 2003. Private environmental governance and international relations: exploring the links. Global Environmental Politics 3, 72–87.

Finkelstein, L.S., 1995. What is global governance? Global Governance 1 (3), 367–372.

Glasbergen, P., Biermann, F., Mol, A. (Eds.), Partnerships for Sustainable Development. Reflections on Theory and Practice. Edward Elgar, Cheltenham, forthcoming.

van der Grijp, N.M., Brander, L., 2004. The role of the business community and civil society. In: Campins Eritja, M. (Ed.), Sustainability Labelling and Certification. Marcial Pons, Barcelona, pp. 223–243.

Gupta, J., 1997. The Climate Change Convention and Developing Countries—From Conflict to Consensus? Kluwer Academic Publishers, Dordrecht.

Gupta, J., 2003. The role of non-state actors in international environmental affairs. Heidelberg Journal of International Law 63 (2), 459–486.

Gupta, A., Falkner, R., 2006. The influence of the Cartagena Protocol on Biosafety: comparing Mexico, China and South Africa. Global Environmental Politics 6 (4), 23–55.

Haas, P.M., Keohane, R.O., Levy, M.A. (Eds.), 1993. Institutions for the Earth: Sources of Effective International Environmental Protection. MIT Press, Cambridge, MA.

Held, D., 1997. Democracy and globalization. Global Governance 3 (3), 251–267.

Held, D., 1999. The transformation of political community. In: Shapiro, I., Hacker-Cordon, C. (Eds.), Democracy's Edges. Cambridge University Press, Cambridge, UK.

Helm, C., Sprinz, D.F., 2000. Measuring the effectiveness of international environmental regimes. Journal of Conflict Resolution 44 (5), 630–652.

Hisschemöller, M., Hoppe, R., Dunn, W.N., Ravetz, J.R. (Eds.), 2001. Knowledge, Power and Participation in Environmental Policy Analysis. Transaction Publishers, New Brunswick and London.

Huitema, D., Egas, W., Moellenkamp, S., Mostert, E., Pahl-Wostl, C., Yalcin, R., 2006. Adaptive water governance. Assessing adaptive management from a governance perspective. Unpublished manuscript. On file with author.

Institutional Dimensions of Global Environmental Change Project, 1999. Science Plan, by Young, O.R., with contributions from Agrawal, A., King, L.A., Sand, P.H., Underdal, A., Wasson, M. (= IHDP Report No. 9). IHDP, Bonn. Available at 〈www.ihdp.org〉.

Jasanoff, S., Long Martello, M. (Eds.), 2004. Earthly Politics. Local and Global in Environmental Governance. MIT Press, Cambridge, MA.

Kanie, N., Haas, P.M. (Eds.), 2004. Emerging Forces in Environmental Governance. United Nations University Press, Tokyo.

Kates, R.W., Clark, W.C., Corell, R., Hall, J.M., Jaeger, C.C., Lowe, I., McCarthy, J., Schellnhuber, H.-J., Bolin, B., Dickson, N.M., Faucheux, S., Gallopin, G.C., Grübler, A., Huntley, B., Jäger, J., Jodha, N.S., Kasperson, R.E., Mabogunje, A., Matson, P., Mooney, H., Moore III, B., O'Riordan, T., Svedin, U., 2001. Sustainability science. Science 292, 641–642.

Keohane, R.O., Levy, M.A. (Eds.), 1996. Institutions for Environmental Aid: Pitfalls and Promise. MIT Press, Cambridge, MA.

Keohane, R.O., Nye, J.S., 1977. Power and Interdependence: World Politics in Transition. Little, Brown, Boston.

van de Kerkhof, M., 2004. Debating Climate Change. A Study of Stakeholder Participation in an Integrated Assessment of Long-Term Climate Policy in the Netherlands. Lemma, Utrecht.

van Kersbergen, K., van Waarden, F., 2004. 'Governance' as a bridge between disciplines: cross-disciplinary inspiration regarding shifts in governance and problems of governability, accountability and legitimacy. European Journal of Political Research 43, 143–171.

Levy, D.L., Newell, P.J., 2004. The Business of Global Environmental Governance. MIT Press, Cambridge, MA.

Litfin, K.T., 1994. Ozone Discourses: Science and Politics in Global Environmental Cooperation. Columbia University Press, New York.

Miles, E.L., Underdal, A., Andresen, S., Wettestad, J., Skjaerseth, J.B., Carlin, E.M. (Eds.), 2002. Environmental Regime Effectiveness. Confronting Theory with Evidence. MIT Press, Cambridge, MA.

Mitchell, R.B., 2003. International environmental agreements. A survey of their features, formation and effects. Annual Review of Environment and Resources 28, 429–461.

Mitchell, R.B., Clark, W.C., Cash, D.W., Dickson, N.M. (Eds.), 2006. Global Environmental Assessments. Information and Influence. MIT Press, Cambridge, MA.

von Moltke, K., 2005. Clustering international environmental agreements as an alternative to a World Environment Organization. In: Biermann, F., Bauer, S. (Eds.), A World Environment Organization. Solution or Threat for Effective International Environmental Governance? Ashgate, Aldershot, UK, pp. 175–204.

Oberthür, S., Gehring, T. (Eds.), 2006. Institutional Interaction in Global Environmental Governance. Synergy and conflict among international and EU policies. MIT Press, Cambridge, MA.

Overbeek, H., 2005. Class, hegemony and global governance: a historical materialist perspective. In: Hoffmann, M., Ba, A. (Eds.), Contending Perspectives on Global Governance: Coherence, Contestation, and World Order. Routledge, London, pp. 39–56.

Pattberg, P., 2005. The institutionalization of private governance: how business and non-profit organizations agree on transnational rules. Governance: An International Journal of Policy, Administration, and Institutions 18 (4), 589–610.

Pattberg, P., 2006a. Private governance and the South: lessons from global forest politics. Third World Quarterly 27 (4), 579–593.

Pattberg, P., 2006b. The influence of global business regulation: beyond good corporate conduct. Business and Society Review 111 (3), 241–268.

Princen, T., Finger, M., Manno, J., 1995. Nongovernmental organizations in world environmental politics. International Environmental Affairs 7 (1), 42–58.

Raustiala, K., 1997. States, NGOs, and international environmental institutions. International Studies Quarterly 42 (4), 719–740.

Rechkemmer, A. (Ed.), 2005. UNEO–Towards an International Environment Organization. Approaches to a Sustainable Reform of Global Environmental Governance. Nomos, Baden-Baden.

Reinicke, W., Deng, F. (Eds.), 2000. Critical Choices. The United Nations, Networks, and the Future of Global Governance. International Development Research Centre, Ottawa.

Rosenau, J.N., 1995. Governance in the twenty-first century. Global Governance 1 (1), 13–43.

Rosendal, G.K., 2001a. Impacts of overlapping international regimes: the case of biodiversity. Global Governance 7 (1), 95–117.

Rosendal, G.K., 2001b. Overlapping international regimes: the case of the Intergovernmental Forum on Forests (IFF) between climate change and biodiversity. International Environmental Agreements: Politics, Law and Economics 1 (4), 447–468.

Schellnhuber, H.-J., 1998. Earth system analysis: the scope of the challenge. In: Schellnhuber, H.-J., Wenzel, V. (Eds.), Earth System Analysis: Integrating Science for Sustainability. Springer, Berlin, pp. 3–195.

Schellnhuber, H.-J., 1999. Earth system analysis and the Second Copernican Revolution. Nature 402 (= Millennium Supplement, 2 December 1999), C19–C23.

Schellnhuber, H.-J., Biermann, F., 2000. Eine ökologische Weltordnungspolitik: globales Umweltmanagement statt Untergangskultur. Internationale Politik 55 (12), 9–16.

Schellnhuber, H.-J., Sahagian, D., 2002. The twenty-three GAIM questions. Global Change Newsletter (International Geosphere–Biosphere Programme) 49, 20–21.

Schellnhuber, H.-J., Wenzel, V., 1998. Preface. In: Schellnhuber, H.-J., Wenzel, V. (Eds.), Earth System Analysis: Integrating Science for Sustainability. Springer, Berlin, pp. vii–xvi.

Schellnhuber, H.-J., Crutzen, P., Clark, W.C., Claussen, M., Held, H., 2004. Earth System Analysis for Sustainability. MIT Press, Cambridge, MA.

Scholte, J.A., 2002. Civil society and democracy in global governance. Global Governance 8 (3), 281–304.

Schröder, H., forthcoming. The IDGEC approach to analyzing institutional interplay between the biosafety and trade regimes. In: Chambers, W.B., Kim, J.A., Young, O.R. (Eds.), Institutional Interplay: The Case of Biosafety. United Nations University Press, Tokyo.

Siebenhüner, B., 2002. How do scientific assessments learn? Part 1. Conceptual framework and case study of the IPCC. Environmental Science and Policy 5, 411–420.

Siebenhüner, B., 2003. The changing role of nation states in international environmental assessments: the case of the IPCC. Global Environmental Change 13, 113–123.

Siebenhüner, B., 2004. Social learning and sustainability science. Which role can stakeholder participation play? International Journal of Sustainable Development 7 (2), 146–163.

Smouts, M.-C., 1998. The proper use of the governance in international relations. International Social Science Journal 155, 81–89.

Social Learning Group—Clark, W.C., Jäger, J., van Eijndhoven, J., Dickson, N. (Eds.), 2001. Learning to Manage Global Environmental Risks, 2 vols. MIT Press, Cambridge, MA.

South Centre, 1996. For a Strong and Democratic United Nations: A South Perspective on UN Reform. South Centre, Geneva.

Steffen, W., Sanderson, A., Tyson, P.D., Jäger, J., Matson, P.M., Moore III, B., Oldfield, F., Richardson, K., Schellnhuber, H.-J., Turner II, B.L., Wasson, R.J., 2004. Global Change and the Earth System: A Planet under Pressure. Springer, New York.

Stokke, O.S., 2000. Managing straddling stocks: the interplay of global and regional regimes. Ocean and Coastal Management 43 (2–3), 205–234.

Sustainability Science—Statement of the Friibergh Workshop on Sustainability Science, 2000. Friibergh, Sweden, 11–14 October 2000. Available at 〈http://ksgnotes1.harvard.edu/BCSIA/sust.nsf/pubs/pub3〉.

Velasquez, J., 2000. Prospects for Rio + 10: the need for an inter-linkages approach to global environmental governance. Global Environmental Change 10 (4), 307–312.

Victor, D.G., Raustiala, K., Skolnikoff, E.B. (Eds.), 1998. The Implementation and Effectiveness of International Environmental Commitments. Theory and Practice. MIT Press, Cambridge, MA.

Wapner, P., 1996. Environmental Activism and World Civic Politics. State University of New York Press, Albany.

Young, O.R., 1994. International Governance. Protecting the Environment in a Stateless Society. Cornell University Press, Ithaca.

Young, O.R. (Ed.), 1997. Global Governance. Drawing Insights from the Environmental Experience. MIT Press, Cambridge, MA.

Young, O.R., 2001. Inferences and indices: evaluating the effectiveness of international environmental regimes. Global Environmental Politics 1 (1), 99–121.

Young, O.R., 2002. The Institutional Dimension of Environmental Change: Fit, Interplay and Scale. MIT Press, Cambridge, MA.

Young, O.R., Levy, M.A., Osherenko, G. (Eds.), 1999. Effectiveness of International Environmental Regimes: Causal Connections and Behavioral Mechanisms. MIT Press, Cambridge, MA.

Young, O.R., Lambin, E.F., Alcock, F., Haberl, H., Karlsson, S.I., McConnell, W.J., Myint, T., Pahl-Wostl, C., Polsky, C., Ramakrishnan, P.S., Scouvart, M., Schröder, H., Verburg, P.H., 2005. Beyond Regression. Methods for Analyzing Complex Human-Environment Interactions. Unpublished manuscript (on file with author).