

## Preface

The transition to more sustainable development paths requires new advances in human knowledge: knowledge about the social causes that affect global environmental change and unsustainable production systems, knowledge about the characteristics of the earth system and the likely consequences of global environmental change, and knowledge about policy options that allow human societies to achieve the transition to greater sustainability. The scientific community has responded to this challenge through the creation of new research programmes designed to bring together global researchers with a variety of backgrounds and from all world regions for joint research, notably the International Human Dimensions Programme on Global Environmental Change (IHDP). Despite all efforts, however, the existing knowledge base and its political implementation remain insufficient. But how can we do better? Do we need new kinds of knowledge or new ways to generate knowledge? How can social and scientific institutions be designed, and possibly reformed, to generate sustainability-relevant knowledge? And what are the implications of the current knowledge base, and the ways it is generated and distributed, on societal decision-making for global environmental protection?

These themes stood at the centre of the 2002 Berlin Conference on the Human Dimensions of Global Environmental Change, held 6-7 December 2002 in Berlin with the endorsement of two IHDP core projects, Institutional Dimensions of Global Environmental Change (IDGEC) and Industrial Transformation (IT). The conference has been organised on behalf of the German Political Science Association by the joint Global Governance Project of the Potsdam Institute for Climate Impact Research, the Environmental Policy Research Unit of the Free University of Berlin and Oldenburg University ([glogov.org](http://glogov.org)), with additional endorsement by the Federation of German Scientists and the German Association for the United Nations, Berlin-Brandenburg Chapter.

About 220 colleagues from 29 countries participated in the Conference, with altogether 111 plenary and panel presentations. Key note speakers included the

chairs of four major research and assessment programmes, Rajendra Pachauri (IPCC), Coleen Vogel (IHDP), Oran Young (IHDP/IDGEC) and John Schellnhuber (IGBP/GAIM), as well as two leading decision-makers and practitioners in this field, Christian Patemann, director of the Environment and Sustainable Development Programme of the European Union's directorate-general for research, and Hansvolker Ziegler, the chair of the International Group of Funding Agencies for Global Change Research. The conference was supported by the German Federal Ministry for Education and Research, with additional contributions by the Volkswagen Foundation and the Heinrich Böll Foundation. A luncheon in honour of Dr. Pachauri was hosted by the Ambassador of India in Germany.

This Proceedings volume presents the thirty papers of the 2002 Berlin Conference that we saw as the most useful and valuable within the context of the conference. All contributions have been reviewed for publication, and not all papers submitted could be included in the final Proceedings volume. We hope that the Proceedings of the 2002 Berlin Conference will enrich the academic debate on generating sustainability science and its influence on politics, and will carry a flavour of the lively and thought-provoking debates during the 2002 Berlin Conference. Last but not least, we would like to thank Steffen Behrle and David Wabnitz for their dedicated support.

We look now forward to the upcoming 2004 Berlin Conference, which will be chaired by Dr. Klaus Jacob of the Environmental Policy Research Unit of the Free University of Berlin, will address the theme "Greening of Policies – Interlinkages and Policy Integration" and will be held 3-4 December 2004.

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# Knowledge for the Sustainability Transition and the Challenge for Social Science: An Introduction

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## 1. Introduction<sup>+</sup>

Climate change, the loss of biological diversity at unprecedented rates, the continuing emission of thousands of persistent organic pollutants and the staggering degradation of our soils and forests illustrate a fundamental change in the relationship of nature and humankind. Clearly, the world is far away from the transition to sustainable development that the Brundtland Commission urged in 1987—a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.<sup>1</sup>

This transition to sustainability poses a special challenge for the social sciences, since it will also require new advances in knowledge about human societies—knowledge about the social causes that affect global environmental change and unsustainable production systems, knowledge about the characteristics of the earth system and the likely consequences of global environmental change, and knowledge about policy options that allow human societies to achieve the transition to greater sustainability.

The scientific community has responded to this challenge through the creation of new research programmes designed to bring together global researchers with a variety of backgrounds and from all world regions for joint research. In 1990, the International Social Science Council set up the Human Dimensions Programme (HDP) as a global framework for interdisciplinary international research on global change. Since 1996 the programme has been supported by the International Council of Scientific Unions. As the International Human Dimensions Programme on Global Environmental Change (IHDP) it now serves as the main social science research network in the field. The notion of 'human dimensions of global environmental change' views societies as both cause

and effect, as the drivers of global environmental change and as the victims who are affected by looming global disasters such as global climate change. IHDP itself is supported by sub-programmes, or 'core projects', on specific questions, notably the Institutional Dimensions of Global Environmental Change project,<sup>2</sup> the Industrial Transformation project,<sup>3</sup> the Global Environmental Change and Human Security project<sup>4</sup> and the Land-Use and Land-Cover Change project.<sup>5</sup>

Despite all efforts, the existing knowledge base and its political implementation remain insufficient for a worldwide transition to sustainability. But how can we do better? Do we need new kinds of knowledge or new ways to generate knowledge, for instance through a fundamental overhaul of the way we conduct scientific research? How can social and scientific institutions be designed, and possibly reformed, to generate sustainability-relevant knowledge? And what are the implications of the current knowledge base, and the ways it is generated and distributed, on societal decision-making for global environmental protection?

These are the themes that stood at the centre of the 2002 Berlin Conference on the Human Dimensions of Global Environmental Change, held 6-7 December in Berlin. In the following, I will, first, introduce

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<sup>+</sup> Many thanks to Klaus Dingwerth and Aarti Gupta for valuable comments of previous drafts of this text.

<sup>1</sup> World Commission on Environment and Development 1987.

<sup>2</sup> Institutional Dimensions of Global Environmental Change Programme 1999. For contributions from German political science, see for example the work on international environmental regimes (Bedarff et al. 1995; Biermann 1998, 2002; Biermann and Wank 2000; Breitmeier 1996; Gehring 1994; Gehring and Oberthür 1997; Grundmann 1997, 1999; Hasenclever et al. 1997; Helm and Sprinz 2000; Jakobkeit 1998; Oberthür 1997; Rittberger 1995; Simonis 1996; Ulbert 1997; Zürn 1998b), studies on trade and environment (Altemöller 1998; Althammer et al. 2001; Biermann 2001b; Pfahl 2000), the edited volume on institutional arrangements by von Prittwitz (2000) or the research on comparative environmental politics (for example Conrad 1998; Jänicke 1990, 1996; Jänicke and Weidner 1997; Jänicke et al. 1997; Jänicke and Jörgens 1998, 2000; Jörgens 1996; Kern and Bratzel 1996; Zilleßen 1998.)

<sup>3</sup> Industrial Transformation Programme 1999. Most German research has focused on industrial transformation in industrialised countries (see for example Binder et al. 2001; Jänicke et al. 1993; Jacob 1999), on national environmental planning (Jänicke and Jörgens 1998, 2000; Jänicke and Weidner 1997) or on diffusion processes (for example Jänicke and Weidner 1995; Kern 2000; Kern et al. 2001; Tews, Busch and Jörgens 2003).

<sup>4</sup> GECHS 1999. For German contributions see the articles in the book edited by Carius and Lietzmann 1999.

<sup>5</sup> LUCC 1995.

into the manifold presentations that have been held at the Berlin Conference, a representative sample of which is included in this Proceedings volume (*section 2*). Second, since the conference was mainly centred on political science while remaining open for dialogue with other disciplines, I sketch below six propositions on the particular challenges that global environmental change poses for political science as a discipline (*section 3*).

## 2. The 2002 Berlin Conference

### 2.1 ORGANISATION OF THE CONFERENCE

All presentations at the 2002 Berlin Conference have addressed one (or more) of three main themes, which have structured the entire conference:

First, one group of papers has conceptualised the knowledge base for the sustainability transition as something that is affected by political decision-making. They analysed ways in which national and international politics and institutions influence the way sustainability knowledge is generated, distributed and used by actors, looking, for example, at ways in which political systems influence scientific research for the sustainability transition. Papers have examined, for example, the distribution and use of knowledge, from scientific information to technical expertise, and sought to explain the influence of political institutions and political and societal actors on these knowledge-generating processes.

Second, and interrelated with the first theme, a number of papers have viewed knowledge as a factor that influences political decision-making. It has long been argued that not only power and interests, but also ideas, discourses or belief systems shape the outcome of political decision-making. The 2002 Berlin Conference has presented cutting-edge research on the ways in which existing knowledge—from scientific information to more general discourses or belief systems—affects the ways in which political actors respond to the global environmental crisis. Are there dominant discourses and ideas that can facilitate or prevent us from reaching a more sustainable development? Does ‘science’ and modern technology in itself lead to unsustainable development paths—and how can democratic political institutions manage to live with, for example, the Genie of modern nuclear and molecular technologies?

Third, the 2002 Berlin Conference has featured presentations from social scientists that respond to the challenges raised by recent thinkers who argue for fundamental changes in the way science is con-

ducted—thinkers who have put forward integrative concepts such as ‘earth system analysis’, ‘syndromes of global change’ or ‘sustainability science’. It has been maintained, for example, that a new ‘sustainability science’ must bridge the local-global divide and must include interdisciplinary research on multiple scales and multiple actors. How would this affect social science, for example the divide between scholars of international relations and comparative environmental politics?

Despite their division into the three themes above, the 111 presentations at the 2002 Berlin Conference have also highlighted the intense interaction between knowledge, science and society at all levels. Scientists and other producers of knowledge are part of their societies, which shape the process of knowledge generation, while in turn being influenced by the continuous reorganisation and reinterpretation of knowledge. Rather than creating artificial boundaries that blur the co-evolution of science and society, this introduction—and the organisation of the conference—is intended to focus debate on different dimensions of the science/society interface, without denying their manifold interactions and mutual interdependencies.

### 2.2 THEME 1: GENERATING SUSTAINABILITY KNOWLEDGE

Political decision-making requires knowledge about the state of global environmental systems and about political options. Such an assessment of global environmental change and of the effectiveness of political responses is particularly challenging for researchers. The social sciences are involved in this field in a twofold manner: as active participant in the integrative assessment of global environmental change in close collaboration with colleagues from the natural sciences, and as a critic of these very assessment processes from a social science perspective.

Most scientific assessments include measurements that allow comparisons between objects of study or between different points of time. A crucial challenge here is the development of indicators for global environmental change that can help explain variation between regions or over time, thus assisting in the formulation of political response strategies. One way to include complex societal factors in the assessment of global environmental change is the development of specific indicators and indices for ‘sustainable development’ that go beyond the mere assessment of changes in natural systems—a challenge that several papers of the 2002 Berlin Conference has been devoted to. Presentations included a case study on Belgian efforts or on sustainable development indica-

tors in marine fisheries. Other case studies that link social and natural science in assessing global environmental change focussed on an Indonesian participatory model of satellite-based monitoring for community plantation forests, a recent non-state initiative to account for greenhouse gas emissions, and different political functions and potentials of environmental indicator systems.

Eventually, much of the indicator data acquired in these studies could be used in computer-assisted quantitative or qualitative modelling exercises. A number of such advanced models have been presented and discussed at the 2002 Berlin Conference, not only with a view to the actual information they provide but also as possible means of knowledge generation. Some participants presented their research on foresight methodologies to assess future European transportation systems, on participatory scenario analysis and on participatory technology assessment methodologies. Other researchers elaborated on scenarios for improving regime effectiveness for decision-making in multilevel political environments or reported new advances in computer-based modelling.

Any meaningful understanding of global environmental change cannot be generated and used without involving relevant stakeholders. While many studies presented at the 2002 Berlin Conference have addressed the role of stakeholders and dialogues between researchers and stakeholders, two panels have been explicitly focused on this question. Here, participants presented research on experiences with participatory approaches in scientific knowledge generation, on new practices for linking stakeholders and scientists (also with a view to integrating participatory methods into economic analysis and their role in climate impact assessment), on combining computer modelling with deliberative methods in assessing the transition to sustainable energy systems, on the role of civil society within sustainability science, or on participatory approaches.

Sustainability knowledge is, in most cases, no longer created by individual academics and by isolated professors in vaulted ivory towers. Instead, most advances in knowledge today are part of larger research groups and research programmes, ranging from multi-institutional or multinational research consortia to national research programmes and to global programmes that comprise thousands of researchers, such as the Intergovernmental Panel on Climate Change (which assesses and synthesises existing knowledge) and the International Human Dimensions Programme on Global Environmental Change.

These networks of researchers have, however, themselves become the object of intense academic debate. One panel at the 2002 Berlin Conference has therefore been devoted to the analysis of national research programmes, including case studies on Israel, on the European Union and its research programmes and a comparison of programmes in some member states.

Furthermore, the major research programmes have been directly or indirectly addressed in most plenary sessions. One plenary session featured the chairs of two major research and assessment programmes, Dr Pachauri of the Intergovernmental Panel on Climate Change and Professor Coleen Vogel of the International Human Dimensions Programme on Global Environmental Change. Another plenary panel has presented the chairs of two important sub-programmes, Professor Oran Young of the Institutional Dimensions of Global Environmental Change project of IHDP, and Professor John Schellnhuber of the Global Analysis, Integration and Modelling project of the International Geosphere-Biosphere Programme. A third plenary panel featured two leading decision-makers and practitioners in this field: Dr Christian Patemann, the director of the Environment and Sustainable Development Programme of the European Union's directorate-general for research, and Hansvolker Ziegler, the chair of the International Group of Funding Agencies for Global Change Research and special advisor on sustainability in the German Federal Ministry for Education and Research.

### 2.3 THEME 2: SUSTAINABILITY KNOWLEDGE IN POLITICAL DECISION-MAKING

Most scientific effort in the field of global environmental change will eventually inform decision-makers in the public and private spheres and the general public. The transition to sustainable development inevitably requires a 'knowledge transition' among various actor groups to enable them to better understand the dynamics of the earth system and the available policy options. However, the processes by which sustainability knowledge generated within science can reach societal actors remain insufficiently understood and have thus been a key concern of one of the 'Knowledge Conversations' at the 2002 Berlin Conference.

The studies on stakeholder dialogues and participatory approaches show how non-scientific actors and non-academic knowledge influence academic research programmes. In turn, the influence that these research programmes and their findings have on societies and, in particular, on political actors has been at the centre of a number of panels that analyse knowl-

edge flows in governing global environmental change. Some presenters, for example, examined the role of international and transnational institutions in the dissemination of sustainability knowledge, including the transnational network of local governments, Cities for Climate Protection, the Commission for Environmental Co-operation under the North American Free Trade Agreement, and the role of international organisations (such as convention secretariats or international agencies) in the generation and distribution of sustainability knowledge.

Others were particularly interested in the role of international institutions in raising the credibility of knowledge. This included case studies on the credibility of the Intergovernmental Panel on Climate Change and the scientific assessments under the long-range transboundary air pollution convention of 1979, as well as a study that focused on the North-South dimensions of knowledge transfer by international agencies. Some participants have presented research on the influence of scientific knowledge on environmental policy, including case studies on the impact of conflicts over values for the process of knowledge generation and the link between science and policy in various environmental policy areas.

Depicting another strand of research, some participants adopted a constructivist perspective and presented research on 'epistemological pluralism' based on the third assessment report of IPCC, on discourses in the Norwegian response to the global climate negotiations, and on the politics of climate change and the release of genetically modified organisms.

As with the global level, scientific and other systematic knowledge influences national and local environmental policies as well. Accordingly, a number of panels have been devoted to these issues. Participants focused on the role of knowledge in the integration of environmental policies in Germany, the European Union and the United States, and in the integration of biodiversity and climate policies. Others focused on capacity building for knowledge-generation through public agencies, with case studies on regions as diverse as Lower Saxony, western Australia and north-eastern Asia. Knowledge flows reach beyond public authorities. Private actors, too, are important consumers of sustainability knowledge. Through their own dissemination activities, and their involvement in knowledge-generating processes, they are also part of the process of knowledge generation. The 2002 Berlin Conference hence included several panels on the role of civil society in the generation, synthesis and dissemination of sustainability knowledge. Non-state

actors to which specific panels have been devoted include groups and associations of nongovernmental activists groups, the media, education institutions, national advisory boards, and local decision-makers.

Participants analysed, for example, the role of Greenpeace as a knowledge mediator in Japan's response to stratospheric ozone depletion, the interpretations of climate-change knowledge by business leaders in New Zealand, and the role of civil society in global environmental governance. In the panel on the role of the media, discussion focused on global climate change in the major national newspaper in the United States, the role of the media in the Czech republic and the role of specific communication strategies and the new media for knowledge transfer.

Similar to the media, education institutions play a crucial role in disseminating sustainability knowledge and in promoting sustainable life-styles. The 2002 Berlin Conference included detailed case studies in this field, on consumer citizenship education, on an event count analysis of the founding of scientific ecological organisations in 46 countries, and on the role of French business schools in surveying the dissemination of environmental knowledge. Important, too, are national advisory bodies, which are often mixtures of scientific self-administration and government-controlled scientific entities. Here, presentations at the conference examined national scientific advisory bodies in Belgium, Germany, the United Kingdom and the United States.

Other case studies explicitly focused on the local level, examining, for example, local platforms to promote scientific knowledge about biological diversity and other global change issues in Switzerland, the uptake of scientific information by local governments in New Zealand and the knowledgeable consumer as a precondition for sustainable development. Civil society can only make use of sustainability knowledge generated by experts, scientists or public agencies if the information is publicly available. This makes the 'right to know' ever more important. Its importance has been enshrined in several pieces of recent national and global legislation, including the 1966 United States Freedom of Information Act and the Aarhus Convention, as well as in the spread of voluntary or mandatory pollutant release and transfer registers. As argued by Professor Sand at the conference, these new forms of access to information have led to a new third wave of environmental regulation that is replacing or supplementing traditional command-and-control and market-based instruments.

Access to information is also key to the uptake of new technologies—be they environmentally benign

or risky—in the domestic context. Within North-South relations, it remains critical to consider how a transition to global sustainability could be slowed down by ‘knowledge divides’ between North and South. Substantial attention has focused on greater access to new technologies as a way to bridge such divides.

Finally, understanding the interaction of all actors within a particular national setting, along with cross-national interlinkages, is at the centre of discourse studies, a number of which have been presented at the 2002 Berlin Conference. One panel discussed discourses in the field of energy and climate policy, with two regional case studies on South Africa and Australia and two studies on the role of assessments in global climate change policy.

#### 2.4 THEME 3: NEW CONCEPTUAL FRONTIERS: SUSTAINABILITY SCIENCE, EARTH SYSTEM ANALYSIS AND THE CHALLENGE FOR THE SOCIAL SCIENCES

The challenge of global environmental change has given rise to a variety of proposals for how the global scientific endeavour in this field could better be structured.<sup>6</sup> Researchers have advanced novel approaches to global change science, which call, among others, for a new integration of academic disciplines—in a sense a step back to the traditional *universitas* of the *facultates* as prescribed by the medieval ideal.

One such new approach is the Syndromes of Global Change concept advanced by the German Advisory Council on Global Change. Since its early versions in 1993,<sup>7</sup> the concept has been refined and empirically applied,<sup>8</sup> and in 2001, the United Nations Environment Programme has advised governments at its Global Ministerial Environment Forum to adopt the syndrome approach ‘to re-arrange the perspective and the perception of land use and land/soil degradation’.<sup>9</sup> The approach integrates different disciplines by reducing global change to a limited number of socio-economic and natural variables, which are conceived of as the *symptoms* of global change that interact with each other. Proponents of the approach assume certain dynamic patterns of interactions between symptoms, which are defined as the *syndromes* of global change. The assumption is that there are at least sixteen such syndromes.<sup>10</sup> These are clustered

into three classes that are related either to the over-exploitation of nature,<sup>11</sup> to failed development processes<sup>12</sup> or to the misuse of nature as a sink for pollutants.<sup>13</sup> In a sense, the syndromes of global change are a representation of typical place-based socio-economic and natural mechanisms of un-sustainable development with an interesting potential to guide interdisciplinary research.

Another comprehensive concept is earth system analysis, which has been presented by Hans-Joachim Schellnhuber at the 2002 Berlin Conference.<sup>14</sup> This approach focuses on a better understanding not of isolated elements of global change but of the totality of processes in nature and human civilisation. It eventually aims at developing analytical and political tools and instruments to assist in the challenge of global environmental governance and, particularly, to find ways to guarantee an acceptable long-term co-evolution of nature and civilisation.<sup>15</sup> Schellnhuber sees earth system analysis as ‘a science in statu nascenti’, arguing that:

It is a science as 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.<sup>16</sup>

At the highest level of abstraction, the basic formula of earth system analysis is  $E = (N, H)$ , with E being the earth system, N being the ecosphere (a function of atmosphere, biosphere et cetera), and H being human civilisation. H consists of the anthroposphere (A)—the totality of human life, actions and products that affect other components of the earth system—and the ‘global subject’ (S), which is, translated into social science language, the political system at the global level including its national and subnational subparts, all of which have collectively the ability to

<sup>6</sup> Sections V and VI of this introduction draw on Biermann and Dingwerth 2001 and forthcoming (in German).

<sup>7</sup> German Advisory Council on Global Change 1993.

<sup>8</sup> Schellnhuber et al. 1997.

<sup>9</sup> UNEP 2001, para. 16.

<sup>10</sup> See in more detail German Advisory Council for Global

Change 1993, 1995, 1996, 1997, 1999.

<sup>11</sup> Sahel Syndrome, Overexploitation Syndrome, Rural Exodus Syndrome, Dust Bowl Syndrome, Katanga Syndrome, Mass Tourism Syndrome and Scorched Earth Syndrome.

<sup>12</sup> Aral Sea Syndrome, Green Revolution Syndrome, Little Tiger Syndrome, Favela Syndrome, Suburbia Syndrome and Disaster Syndrome.

<sup>13</sup> Smokestack Syndrome, Waste Dumping Syndrome and Contaminated Land Syndrome.

<sup>14</sup> See in more detail Schellnhuber 1998, 1999.

<sup>15</sup> Schellnhuber 1998, 9.

<sup>16</sup> Schellnhuber and Wenzel 1998, vii.

bring the 'human impact' in line with the needs of the ecosphere.<sup>17</sup> Based on these ideas, Schellnhuber has advanced five paradigms of sustainable development as groundwork for further refinement in modelling and simulation exercises:<sup>18</sup> standardisation, the identification of long-term corridors for the co-evolution of nature and humankind; optimisation, the maximisation the nature-humankind welfare function through selection of an appropriate co-evolution segment; pessimisation, the acceptance of a certain distance to danger zones in order to leave room for mismanagement; equitisation, the preservation of options for future generations; and eventually stabilisation.<sup>19</sup>

For political science and other social sciences it seems difficult to relate to the model-oriented, integrated and interdisciplinary approach of earth system analysis, given that quantifiable hypotheses and computer-based modelling still pose severe challenges for many branches of social sciences. A link to political science could be the notion of a 'global subject' as an agent of earth system management, which is an area where political scientists can contribute their research on international regimes and organisations, as well as on national political systems.<sup>20</sup> However, since earth system analysis is still in its early stages, its specific information needs for the social sciences remain only vaguely defined.

One possible institutional link is the Earth System Science Partnership<sup>21</sup>—which includes the social science programme IHDP—and in particular the 23 GAIM questions that are seen, from the perspective of the Global Analysis, Integration and Modelling project of the International Geosphere-Biosphere Programme, as a set of overarching questions designed to challenge the entire global change research community. Some of these questions directly relate to the social sciences, for example analytical questions such as no. 23, 'What is the structure of an effective and efficient system of global environment and development institutions',<sup>22</sup> or normative questions such as no. 18, 'What kind of nature do modern societies want?'

Sustainability is also at the centre of a the concept of

'sustainability science'. The assumption of Robert Kates, William C. Clark and a number of other leading natural and social scientists is that the challenge of sustainable development is so daunting and complex that it has led to the emergence of a sustainability science as a new integrative field of study.<sup>23</sup> Sustainability science is, Kates, Clark and colleagues argue, different from traditional science in many respects. Ideally, sustainability science derives its questions and puzzles less from internal theoretical development than from actual problems of global change (in which it does not differ much from many branches of social science, with a its long history of responding to day-to-day political problems, for instance in the study of international relations). To answer the core question of sustainability science—how to make human-nature interactions sustainable—proponents of this concept call for several modifications and alterations of the traditional model of knowledge generation: They argue that co-operation between natural and social scientists needs to be improved and made more intense. Analysis should better strive to integrate all scales from local to global within one research design. Sustainability science shall integrate economy and ecology, global trends and local diversity, basic academic research and applied management.<sup>24</sup> It should resolve the dichotomy of scientific research and practical action and rather advance the notion of social learning through critical-reflexive practice.<sup>25</sup>

Proponents of sustainability science link this argument to explicit institutional reform proposals, especially with a view of the needs of developing countries, which are so far underrepresented in global expert networks.<sup>26</sup> Advocates of the concept emphasise that we need new initiatives to better integrate colleagues from developing countries and build-up independent research capacities in the South (which raises the question of how this would affect the way social science is conducted in the North). Likewise, sustainability science would require joint efforts of experts and stakeholders from a variety of regions and backgrounds.

All these challenges have been addressed at the 2002 Berlin Conference from a wide array of angles. One analysis, for example, focused on three aspects of the debate—interdisciplinarity, participatory research and development, and science-policy interlinkages. Others

<sup>17</sup> Schellnhuber 1999, C20-C22.

<sup>18</sup> Schellnhuber 1999, C23.

<sup>19</sup> Schellnhuber 1998, 176-81.

<sup>20</sup> Schellnhuber and Biermann 2000.

<sup>21</sup> See for a funder's perspective Ziegler and Röser 2002.

<sup>22</sup> GAIM puts this question in the cluster of the 'strategic', not of the 'analytical' questions. From a social science perspective, this question would well qualify as an analytical puzzle.

<sup>23</sup> Kates et al. 2001.

<sup>24</sup> Kates et al. 2001.

<sup>25</sup> Clark 2001.

<sup>26</sup> Biermann 2001a and 2002; Siebenhüner 2002a, b.

discussed appropriate research strategies in the field of sustainable farming and elaborated on the 'options and restrictions' tool developed in Switzerland. Two panels took up the challenge of sustainability science by elaborating principles for social science to assist in achieving sustainable development; conceptualising sustainable development as a joint fact-finding process; applying the idea of place-based sustainability to the Rio Grande basin in North America; analysing the separation of utility and truth of scientific knowledge; and analysing the flow of sustainability knowledge through a Canadian conservation authority. The conceptualisation and application of sustainability science and earth system analysis has also been at the centre of the second 'Knowledge Conversation' at the 2002 Berlin Conference, *Sustainability Science: What on Earth for?*

### 3. Global Environmental Change: Six Propositions on the Challenges for Political Science as a Discipline

What are the specific challenges that global environmental change poses for political science as an academic discipline? Both the looming prospect of far-reaching worldwide ecological perturbations and new integrative concepts with their calls for academic reform push political science to re-visit existing methods and research approaches in order to better contribute to the analysis of global environmental change. The final section of this introduction sketches six propositions on how political science could (and should, in my view) respond to this challenge. They focus on developing a separate field of study within political science—world environmental policy—that would enable political science to better link to the interdisciplinary research networks that have emerged.

#### 3.1 THE STUDY OF WORLD ENVIRONMENTAL POLICY ENCOMPASSES, BUT NEEDS TO GO BEYOND TRADITIONAL ENVIRONMENTAL POLICY

World environmental policy, as an object of study, integrates the field of traditional environmental policy, but needs to go beyond it. Environmental policy as an area of study within political science has emerged in the 1970s<sup>27</sup> and is had long been understood as identification and management of environmental problems of industrialised countries.<sup>28</sup> Such analyses have long required an interdisciplinary per-

spective that included insights from economics, sociology or law. The IHDP research plan as well as much of the literature on global change reveals, however, that research in this field encompasses more puzzles and problems than have been traditionally examined within the study of environmental policy. The analysis of the much broader problems of global change, which range from changes in geophysical systems to the loss of biological diversity, calls for a focus on a much wider set of issues. Key questions—such as how Bangladesh should adapt to raising sea-levels, how deterioration of African soils should be halted, how land-use changes in Brazil should be analysed or how the global transition to a solar society could be achieved—have barely been covered by environmental policy research so far, but will inevitably become part of the emerging field of the study of world environmental policy.

#### 3.2 THE STUDY OF WORLD ENVIRONMENTAL POLICY NEEDS TO BRIDGE INTERNATIONAL RELATIONS RESEARCH AND ENVIRONMENTAL POLICY

A similar argument applies to the academic discipline of international relations (IR) within political science. Whereas all environmental problems are local in their causes and consequences, many now require recourse to intergovernmental and eventually to global political solutions. Almost nine hundred international regimes have been set up to regulate the environmental behaviour of governments, and understanding these regime processes has become ever more important. Governance without government in the state system is a core problem not only of IR, but also of the study of world environmental policy. The IR community has produced a wide array of studies in this field. However, these have often been related to theory development within IR, not to the community of political scientists working on (national) environmental policy and to the global environmental change research community.

According to the emerging sustainability science paradigm, it is especially the bridging of the global with the local that is seen—for instance by Kates, Clark and colleagues<sup>29</sup>—as a crucial challenge that needs to 'span the range of spatial scales between such diverse phenomena as economic globalization and local farming practices'. Political science has not taken up this challenge sufficiently.<sup>30</sup> The German Political Science Association attempted to address the relative lack of interaction between IR and the envi-

<sup>27</sup> For Germany see in particular Jänicke 1978.

<sup>28</sup> Jänicke et al. 1999, 14.

<sup>29</sup> Kates et al. 2001, 641.

<sup>30</sup> Biermann and Dingwerth 2004ba.

ronmental policy community through the 2001 Berlin Conference on 'Global Environmental Change and the Nation State', which was meant to bring together specialists from IR and from environmental policy research.<sup>31</sup>

### 3.3 THE STUDY OF WORLD ENVIRONMENTAL POLICY NEEDS TO ADDRESS MORE THAN 'GLOBAL' PROBLEMS

Third, the study of world environmental policy must be more than research on problems that require solutions at the global level. Although 'global' is used in a variety of ways, in most cases it denotes systemic global interdependencies, for instance in the conceptualisation of the climate as a 'global common'. World environmental policy, however, needs to go beyond global problems. This is why I suggest using the term 'world environmental policy' instead of 'global environmental policy'. The Global Environment Facility of the World Bank, for example, has been tasked only with 'global' environmental problems, defined as climate change, biodiversity loss, stratospheric ozone depletion and the protection of international waters (a list to which soil degradation if related to the first four global environmental problems and persistent organic pollutants have been added). This excludes key environmental problems that must form part of a world environmental policy: issues such as local air pollution, the preservation of local waters, waste treatment, or desertification and soil degradation in Africa, Asia and Latin America. The difference is apparent when the Global Environment Facility is compared to agencies that use the word 'world', such as the World Health Organisation, which fights local *and* global health problems. Soil degradation and urban smog are local, whereas climate change and stratospheric ozone depletion are global environmental problems: the study of world environmental policy needs to include both.

### 3.4 THE STUDY OF WORLD ENVIRONMENTAL POLICY AS WORLD-WIDE RESEARCH PRACTICE

Fourth, the study of world environmental policy needs to adopt a holistic perspective that focuses on the entire globe, which also requires a global and holistic approach to the organisation of research. Understanding the political dimensions of the climate change problem, for example, requires synthesising a mosaic of local, national, regional and global political processes. While the traditional study of environmental policy has been devoted to cross-national

comparisons,<sup>32</sup> this is even more important for the study of world environmental policy. The implications for research practice are particularly key: the study of world environmental policy needs not only to encompass all the world's regions, but must also be internationally organised to make use of the comparative advantages of the local knowledges of particular regions and processes. This applies especially to the relation between development studies and African, Asian and Latin American area studies, on the one hand, and traditional environmental policy research that has focused on the rich countries in the North. Kates, Clark and colleagues have argued, in their blueprint of a sustainability science:

Generating adequate scientific capacity and institutional support in developing countries is particularly urgent as they are most vulnerable to the multiple stresses that arise from rapid, simultaneous changes in social and environmental systems. ... a comprehensive approach to 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.<sup>33</sup>

This call for diversity within the research community together with stronger networking applies also to world environmental policy as a specific field of study in political science. The globalisation of problems can only be countered by the globalisation of political science research.

### 3.5 THE STUDY OF WORLD ENVIRONMENTAL POLICY CANNOT ADDRESS EVERYTHING LINKED TO THE SUSTAINABILITY CONCEPT

Fifth, a caveat. Research practice requires the delineation of the study of world environmental policy from other neighbouring fields and terms. This is the case, in particular, with the term sustainable development, which usually describes the both normative and empirical triangle of an ecologically, economically and socially sustainable development. We need a sustainability transition as well as the guiding idea of an all-encompassing sustainability science, and in the long run, political science will need to play a major role in this endeavour. Yet it would be premature today to strive for the establishment of a counterpart to sustainability science within the discipline of political science and policy studies, such as the idea of 'sustainability policy/politics' as a separate sub-field. It seems more feasible, at this moment, to accept the sustainability transition as a normative leitmotif, even

<sup>31</sup> See Biermann, Brohm and Dingwerth 2001, and Biermann and Dingwerth 2004a, 2004b.

<sup>32</sup> On German contributions, see for example Conrad 1998; Jänicke 1990, 1996; Jänicke and Weidner 1997; Jänicke et al. 1997; Jörgens 1996; Kern and Bratzel 1996.

<sup>33</sup> Kates et al. 2001, 642.

if one continues to focus on the political analysis of discrete elements such as economic, social and ecological sustainability. On the other hand, the study of world environmental policy emphasises the need to take into account the interdependencies of policies. At the core of the study of world environmental policy should be socio-economic causes and consequences of local and global environmental change, including options for political reform. But this requires multi-scale and multi-disciplinary analyses that go beyond the traditional field of environmental policy.

### 3.6 REFORMING GERMAN SOCIAL SCIENCE: INTERNATIONALISATION, INTER- DISCIPLINARITY, PROFESSIONALISATION

Finally, I want to add a short remark on the host country of the 2002 Berlin Conference, Germany.<sup>34</sup> It seems that the analysis of world environmental policy requires specific reforms in the way in which political science is conducted in Germany and, arguably, also in other European countries.

First, German research contributes little to the global discourse on sustainability and world environmental policy compared to its potential, for most German research in the field is published in the German language and thus inaccessible to non-German readers. Global language diversity within academe might have benefits. For instance, it might allow for the decentralised emerging of new innovative ideas among the French, Italian, Arabic, Spanish or German research communities that later contribute, in English, to the global debate. However, it seems that the costs outweigh the benefits, and much work on global issues in Germany—and in other non-English language countries—is effectively lost to the larger academic community. I see here the need for reforms in the German research community as well as in its funding community. Therefore, the new series of Berlin Conferences—held as annual conventions of the Environmental Policy and Global Change section of the German Political Science Association, in co-operation with the Federation of German Scientists and others—are also meant to contribute to this internationalisation of German research.

Second, the study of world environmental policy must be interdisciplinary by design. Within the field of environmental policy, German research has already begun to link political science with economics and law; one example is the German-language standard text book on environmental policy written by the

political scientist Jänicke, the lawyer Kunig and the economist Stitzel.<sup>35</sup> With a view to the study of world environmental policy, however, the circle must be expanded. It must also include, at the least, insights from development studies, area studies and international relations research. Again, reforms are needed. One option could be multidisciplinary and international master degree programmes at German universities that unite a wide array of disciplines and backgrounds under the overall theme of the study of world environmental policy.

Third, Germany lacks a sufficiently elaborated policy science community within its university system, which is still structured along the three traditional political science chairs of political theory, domestic politics and international relations. In Germany there is no equivalent to the interdisciplinary schools of public policy and government that are common in many countries, and it is doubtful whether the German non-university research institutes can fully compensate for this lack of policy science in German university education.

## 4. Conclusion

Taken together, global environmental change challenges the way in which knowledge is generated, synthesised and distributed. This holds, too, for political science as an academic discipline. The role of knowledge in the societal response to global environmental change thus stood at the centre of the 2002 Berlin Conference on the Human Dimensions of Global Environmental Change.

This conference has been part of the series of Berlin Conferences, which we conceive of as a string of multidisciplinary dialogues among experts from all major regions of the world, with political science at its core and as its centre of gravity, and with a view to the solution of societal problems and to the adaptation of political science to the new challenges of global environmental change. Future Berlin Conferences will, we hope, remain faithful to this research programme. After a third successful Berlin Conference, in 2003, on the subject of industrial transformation, we are now in the process of planning the 2004 Berlin Conference on the theme of 'Greening of Policies—Interlinkages and Policy Integration' (3-4 December 2004). We hope that as many of our colleagues from abroad and from Germany will continue to participate as enthusiastically as they have in 2001, 2002 and 2003.

<sup>34</sup> In more detail, see our German-language study Biermann and Dingwerth 2001 and forthcoming.

<sup>35</sup> See Jänicke et al. 1999.

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## How to Observe and Model Transitions Towards Sustainability: the Geoscope Initiative

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### 1. Introduction

The 21<sup>st</sup> century will be characterized by global change at an unprecedented scale. Human activity on the planet has reached a dimension which alters the earth system as a whole, mainly as a combination of population growth, resource use, waste disposal, and technological advances. In order to meet the challenges of global change, human society has to develop a more comprehensive global information base to guide informed economic, social and environmental action in transitions to sustainability. This requires new theoretical concepts, continuous data streams with sufficient spatial coverage, and improved modelling activities for simulating complex scenarios of human-environment interactions. Major issues with a strong need for interdisciplinary approaches include transitions in the global energy system, regional and global water use, land use dynamics and soil erosion, and biodiversity loss.

First steps towards an integrated assessment of the earth system have been taken, based on research experience from global climate change and the International Geosphere-Biosphere Program (IGBP). These efforts were made possible through the development of global observation systems based on satellite remote sensing, weather stations and other monitoring tools. However, coverage of human activities and economic developments, especially technological change and lifestyle issues, have been unsatisfactory. The International Human Dimensions Program on Global Environmental Change (IHDP) has initiated several research projects to fill these gaps. In terms of economic modelling, the Global Trade Analysis Project (GTAP) provides an example of a joint international effort which has over the last years created a common database and a modelling framework for consistent global economic analysis. One of the major virtues of GTAP is the establishment of a harmonized economic information base on a wide range of diverse countries and data sources. So far, however, coverage of environmental factors has been rather

limited, thus restricting the application of truly integrated modelling approaches.

An emerging sustainability science and its cross-disciplinary theoretical concepts will require more integrated data sets and modelling tools to provide systematic, structured analyses of global transitions towards sustainability. Integrated modelling efforts will contribute to bridging the traditional gaps between natural and social sciences, and this will in turn raise the demand for data of a new quality, especially in economics and social sciences. At the Potsdam Institute for Climate Impact Research (PIK) recently the idea of a "Sustainability Geoscope" has evolved. The Geoscope will provide a framework for an observation and monitoring system on a global scale, comprising economic, social, environmental and institutional issues. It will be built upon well established efforts and experiences in economics and social sciences, like IHDP and GTAP, and the natural sciences, like IGBP, as well as numerous activities for the development of sustainability indicators. Data sources will be a combination of satellite remote sensing with on-the-ground observations.

The objective of this paper is to discuss challenges in analysing transitions to sustainability and present the Geoscope concept as a tool for understanding and managing these transitions.

### 2. Challenges in understanding transitions to sustainability

The present global economic and social development path is in many respects not sustainable. It cannot be maintained in this form without irretrievably destroying the natural life support systems for human society. Humankind has entered the "Anthropocene", an era in which the tight inter-linkages between human society and the natural environment have become inseparable and are being taken into consideration in an integrated worldview (Crutzen, 2000).

The following list provides examples of unsustainable society-nature interactions which are usually confined to certain regions, but which are embedded in global change processes:

- Water use beyond recharge levels and water quality

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- Food insecurity, land use and soil erosion
- Biodiversity loss
- Public health
- Urbanization and mega-cities
- Fossil-fuel based energy systems and increase in global mobility
- Technology development and global technology diffusion
- Changes in lifestyles and their global diffusion
- Dynamics of conflicts

In order to better understand these interactions and to identify sustainable development paths, human societies need appropriate instruments and methods which go beyond the tools that are presently available. These new methods are being developed and combined under the umbrella of an emerging "sustainability science". Sustainability science seeks to understand the fundamental character of interactions between nature and society (Kates et al., 2001). Hence it understands and treats the Earth system as a whole. This requires that the Earth system is being observed in its entirety, that there are methods for an integrated analysis of the Earth system, and that – proceeding from this analysis – recommendations can be given to politics and the wider public which will lead to sustainable development once they are applied (Schellnhuber and Wenzel, 1998; Schellnhuber, 1999). Some kind of integrated "Earth system management", which is not necessarily meant in a centralized manner, may be the overall objective.

Earth system observation can build on a wide range of diverse methods that have been developed in different scientific disciplines, including remote sensing, weather stations, national economic accounting, surveys and household panels. The combination of these methods in a meaningful way is a major task in itself. A thorough Earth system mapping would be required, because spatial extension and explicitness matters when it comes to analysing nature-society interactions. Geographical information systems (GIS) provide a powerful toolkit for combining a wide variety of data and qualitative information and for conducting multi-layered analyses. Based on this information, Earth system analysis may provide a new understanding and new images of our world. This may create a new mindset and something like a "global subject" which is already emerging (Schellnhuber, 1999). Humankind has developed a range of models and simulation tools and begins to understand the Earth system as a whole. The emerg-

ing "global subject" manifests itself e.g. in new global treaties on climate protection. Eventually, this will lead to a new form of global decision-making or Earth system management which will have to deal with questions like: "What kind of world do we want to live in?" Decisions on required actions involve all levels, from individuals and small social groups to nations and ultimately the global society. The "global subject" will express itself in numerous political activities and measures with global relevance.

Any kind of Earth system management has to deal with the necessary transition processes. Humankind has to decide on *how* to actually achieve sustainability, i.e. what are the paths available and what could a transition to a sustainable state of the Earth look like. A structured analysis of the related transition processes is required which deals specifically with the time dimension, i.e. the connections and switching points between different phases of transition. Even if the achievement of sustainable development remains only a long-term perspective, starting points of the required transitions can already be observed now and should be identified and studied, as the path dependence of our current actions could have significant impacts in the medium and long run.

Since the future remains uncertain and even the most sophisticated and theory-based computer models will never provide exact predictions of future developments, human society should continuously observe the presence and learn from the past, in order to decide on appropriate future steps. This iterative learning-by-doing approach to finding a sustainable development path may include the following questions and steps which have been developed during a recent workshop on the emergence of a sustainability science (ISTS, 2002):

- Where and how do transitions start? Are there triggers to be observed which should not be ignored?
- Do transitions follow certain underlying rules and patterns which can be identified and which repeat themselves over time or under different circumstances?
- Are there typical barriers to transitions which prevent or delay required changes?
- What kind of actions and interventions can be taken to direct, accelerate or slow down transitional changes according to social objectives?

The study of transition processes with respect to important society-nature interactions will be a key challenge and research task for an emerging sustain-

ability science. This will have to be a science of design, i.e. instead of providing engineering-type blueprints for sustainability, it will rather build on successful examples and learn from instructive failures in the past. By pursuing a learning-by-doing approach it will continuously observe human actions and try to identify, document and analyse patterns of sustainable development. Martens and Rotmans (2002) provide a conceptual framework for describing and analysing transitions by distinguishing phases of predevelopment, take-off, acceleration, and stabilisation. Recent research efforts on syndromes of global change as well as vulnerability and adaptation provide first insights in this direction (Kates et al. 2001).

### 3. Critical aspects in Earth system modelling and analysis

The concept of "sustainability" is difficult to define and is not rooted in a homogeneous theory. This concept was created in a public-political process and is dynamically progressing in a way that the requirements with respect to explanation patterns for sustainability are likely to change constantly in the future. Nevertheless, a sound observation of the Earth system requires a theoretical background which puts society in a position to ask relevant questions and to manage the complexity of the object of observation – the Earth system as a whole.

In different scientific disciplines, prevailing theories are reflected in formalized models. These formalized models usually have well-defined information requirements in order to represent certain aspects of a more complex formulation of a problem. Models are important to comprehend complex chains of argumentation. In sustainability science, the integrated modelling of nature-society interactions is of special importance. However, integrated modelling, with both natural and social scientific methods being included, is not a trivial process. In the relatively new field of Integrated Assessment studies strong efforts have been made to develop integrated modelling tools, primarily for analysing effects of energy consumption and global climate change. In the future, these efforts have to be extended to new thematic fields, like the ones mentioned in the previous chapter. At the Potsdam Institute for Climate Impact Research (PIK) a core project deals with the development of a next generation of Integrated Assessment modules, which comprise a range of modelling tools from both natural and social sciences that may be combined in various constellations according to the actual problem to be analysed (Jaeger et al. 2002). This decisively modular approach is in contrast to the

construction of a single mega-model. The crucial challenge here is to come up with efficient methods for consistent coupling of a variety of models, from comparative-static economic models to fully dynamic models of vegetation development or climatic change.

Truly integrated modelling means that e.g. models of the biosphere have to take human action explicitly into account, while in the other direction socio-economic models have to treat the natural environment as more than just a static set of boundary conditions and constraints. The current state of the art in global dynamic vegetation modelling does not include any human management decisions, e.g. in agriculture, forestry or urban development. However, it is obvious that human action is considerably shaping the Earth surface and there are no longer distant places to refer to as "fully natural". On the other hand, most economic models do not take the natural environment endogenously into account, but rather as exogenous constraints to human behaviour. This shows that by lowering the disciplinary boundaries and approaching each other in a constructive manner, both sides could benefit from the knowledge gained in the other research community.

The following issues are of special concern for future integrated modelling efforts:

- Spatial explicitness: one of the major differences between biosphere and climate models on the one hand, and socio-economic models on the other is the treatment of spatial dimensions. Whereas economic analysis is mostly agent-based and usually takes transportation costs as the only spatial aspect into account, models of the biosphere and climate conditions put a strong focus on spatial distribution and dynamics, place-based phenomena and scaling problems. This goes down all the way to data gathering and observation, as economic data are usually only available as summary indicators related to specific administrative units, whereas environmental data are regularly collected in a GIS compatible format at various grid sizes all over the globe.
- Long-term dynamics: the definition of "long-term" differs significantly between e.g. climate models and economic models. While climate projections over a century or more are regularly conducted, the forecast of political and economic trends beyond a decade quickly enters the area of pure speculation.
- Equilibrium theory vs. Critical thresholds: is

it realistic to model the interactions between the human sphere and the environment as a system which always returns to a stable equilibrium? Or are there critical thresholds which must not be surpassed without the risk of irreversible damages to natural life support systems for humankind? Recent advancements in economic theory and modelling which deal with lock-in effects, path dependence and bifurcations should be further explored in order to become more compatible with modelling approaches on biosphere and climate dynamics which include possible structural breaks and necessary guardrails.

- Diffusion of lifestyle patterns: individual preferences and lifestyles have a strong influence on human action and hence their effects on the natural environment. However, "lifestyle" is a rather diffuse concept which is not easily defined and consistently modelled. It is clear that changes and diffusions of lifestyles are at the heart of all globalisation processes which heavily shape our present state of the world. But very little is understood of how certain preference changes emerge, how they are amplified and how they spread locally as well as on a global scale. It may be the case that any kind of transition which involves human action can only be understood if the underlying causes of preference changes can be explained.
- Induced innovation: The true nature and potential of technological change and innovation, including institutional design, has to be further explored as it crucially defines the adaptive capacity of human society to global environmental problems and challenges. This aspect has by far not fully taken into account in the assessments of global environmental impacts on human welfare. The question of how resilient social and economic systems are to external shocks from changing environmental conditions, is viewed very differently in the socio-economic disciplines and the natural sciences.
- Optimising behaviour vs. learning-by-doing: In the past a worldview has dominated human action, which was based on the assumption that, based on scientific theory and the derived measures and technologies, most problems could be solved by some kind of engineering solution to be con-

structed on the drawing board. This also corresponds with economic models which centre around human actors with perfect foresight and a set of preferences which are applied to optimise their behaviour in a given environment. While this approach is very powerful in explaining economic processes under many different circumstances, it is questionable whether this style of thinking will suffice to guide political and economic action in a transition to sustainability. The challenges ahead imply high uncertainty about future conditions and potential critical thresholds. It is likely that instead of a "geo-engineering approach" humankind needs to cope with continuous transitions and needs to adopt an adaptive management attitude which involves learning by doing, trial and error as well as permanent feedback loops between decision-making, observation, and analysis or assessment.

#### 4. The concept of a Sustainability Geoscope

The prerequisite for a better analysis and understanding of long-term transition processes is an appropriate empirical base, i.e. long time series of key variables describing all relevant aspects of society-nature interaction. Currently available observation and monitoring systems are often restricted to a specific disciplinary background, e.g. weather stations and remote sensing satellites collect spatially explicit global information for the natural sciences, while statistical data for the social sciences are often confined to nation states. Moreover, key indicators are not available at all, or only with insufficient coverage over time or space. For example, global data on water use are often spotty or based on rough estimates, in rich and poor countries alike (Brown, 2002). For the analysis of transitions to sustainability the existing gaps have to be overcome and integrated observation procedures have to be developed.

Such a global monitoring and observation system which covers environmental as well as social and economic conditions has been proposed as a "Sustainability Geoscope" (Lucht and Jaeger 2001). The Geoscope vision aims at an instrument for systematic collection and analysis of congruent natural-scientific and socio-economic data that enable a validation of integrated views of society-nature dynamics. In brief, the Geoscope shall investigate selected regions on a global scale with regard to actions related to sustainable development by using remote sensing as well as

observations on the ground.

The process of "geoscoping" transitions to sustainable resource use would involve the following steps and actions. In order to facilitate a well-structured learning process, a sufficient set of comparative regional case studies has to be defined which covers the global hot spots of unsustainable nature-society interactions. Within these sample regions a common protocol for empirical research has to be established with a focus on key actors, i.e. who are they, what are their

the initial phase thematic areas of investigation may be restricted to certain topics, like regional water use, land use change, and biodiversity loss. To give an example of water-related problems, possible parameters to be continuously observed may be related to human lifestyles and preferences, general education, perception of water shortages and risks, access to water-saving technology, technology adoption and diffusion, allocation of water abstraction rights, demographic changes and other early warning signs,

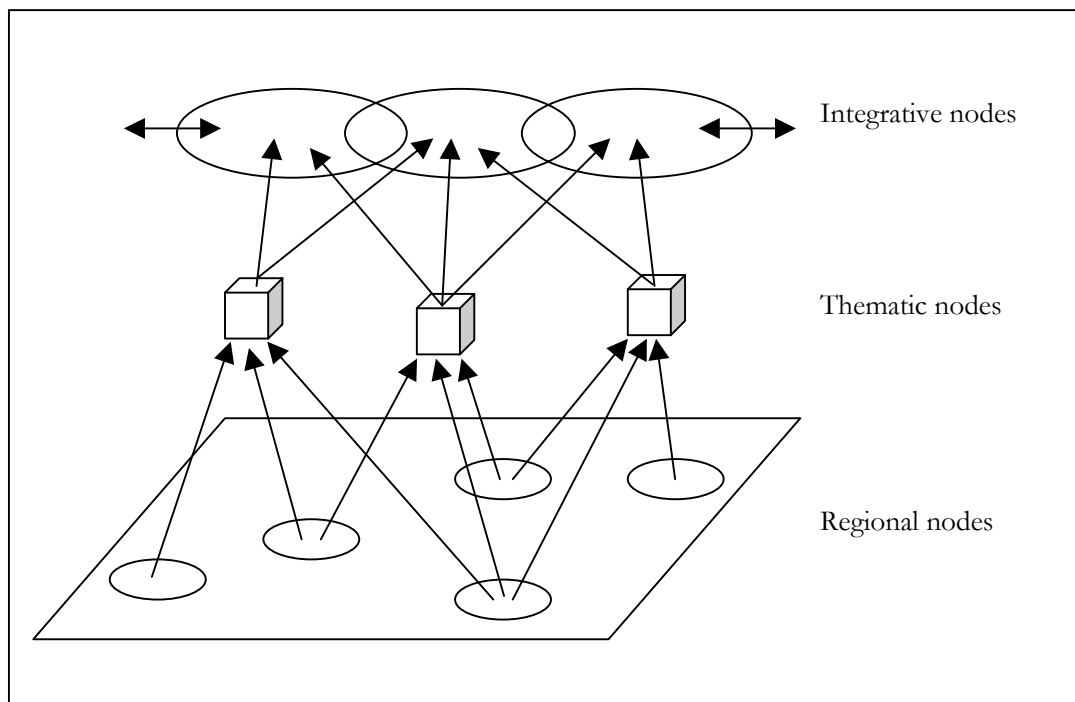


Figure 1: Structure of a Geoscope for conducting comparative regional case studies

intentions and constraints, what are the consequences of their actions, and what mechanisms and patterns can be identified among different regions.

Figure 1 illustrates a possible structure of such a monitoring system. It consists of regional nodes, where various thematic issues are investigated using a wide range of methods which are applied to the same regional context. Thematic nodes will focus on a certain topic and methodology, but will apply these to various regions in a comparative manner. Integrative nodes will summarise thematic research, provide overall evaluations, establish the necessary research infrastructure like database management and coordination, as well as communicate results.

The organising principle for measuring material and energy flows between society and the environment may be provided by the concept of socio-economic metabolism (Fischer-Kowalski and Weisz 1999). This could be used as a unified accounting standard for nature-society interactions. For practical reasons, in

specific agricultural production and market conditions, and management of irrigation and water distribution. In addition to these sampled ground-based observations, continuous large-area monitoring of water use, especially agricultural irrigation activities, has to be intensified through remote sensing satellites (Droogers 2002). Ground-based and remotely sensed observations should be combined, in order to link social and economic activities to the spatial dimension of specific environmental changes and to determine society's adaptive capacity in view of these changes.

If the envisaged comparative regional case studies are chosen carefully and a sufficient time period will have been covered, it should be possible to identify certain patterns of sustainable development. In a next step, these results would have to be linked to simulation models on different scales, so as to allow for generalisation and comparison. This will in turn create the demand for even more advanced, operational methods of monitoring and observation with global cover-

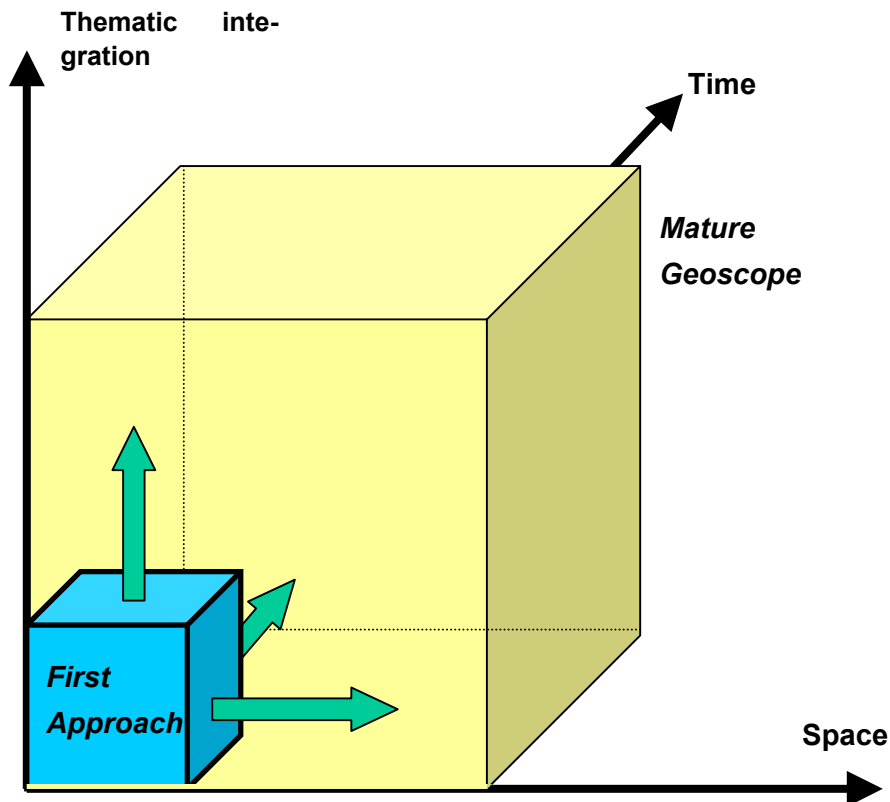


Figure 2: Step-by-step approach to developing a Sustainability Geoscope

age over extended time periods. A major challenge will be the combination of a synoptic global worldview with a local, site-specific, case-dependent perspective. Top-down and bottom-up approaches have to be combined through a suitable connection of global models with inter-linked regional case studies. Similar approaches can be found in projects like LUCC, HERO or DEVECOL. The development of corresponding data sets from satellite remote sensing on the one hand and ground observations on the other is generally desirable, however, it is still a great challenge to actually implement it.

From the very beginning, the Geoscope has to prepare for two different tasks. First, it has to provide data for integrated scientific analysis of Global Change processes (theory building, modelling, scenario development) and, second, it has to support public and political decision processes within the framework of Earth system management activities (communication of results, highly aggregated representations, decision support tools). Since these two areas may have very different information requirements, it has to be clarified more precisely how this can be organized within the framework of a potentially multi-stage Geoscope or even several Geoscopes.

Given the vision of a Geoscope as it has been out-

lined here, it is clear that such an endeavour can only be achieved in a step-by-step approach which might take several decades to be completed. The design and construction process itself will involve a lot of uncertainty and requires continuous learning by doing in addition to well-structured planning. In any case, a start has to be made with a core set of activities and a clear focus on manageable problems. Over time this core set of activities may then be extended in the dimensions of temporal and spatial coverage as well as disciplinary and thematic integration (see Figure 2).

An important task for creating the necessary resource base is to define appropriate funding structures in an international context. In the initial phase, this will be a pure research effort which will have to coordinate various funding sources on the national level. The 6<sup>th</sup> Framework Programme as initiated by the European Union will be an important initial step for a supranational funding structure. In the long term, possibilities for continuous funding through infrastructure investments have to be explored, if such a global information and monitoring system is to become fully operational.

In parallel to these structural efforts which have been recently initiated around the Geoscope idea, a research team at the Potsdam Institute for Climate Impact Research has announced an Internet-based

competition for Geoscope-related ideas and findings.<sup>1</sup> In the spirit of the famous mathematician Stefan Banach, who in the early 20<sup>th</sup> century announced symbolic prizes for the solution of various mathematical problems he had defined, several international institutions have agreed to sponsor a similar procedure to create a research community around the Geoscope. A number of symbolic prizes have been made available and will be awarded to individuals or institutions who contribute substantially to the development of the envisaged monitoring instrument. Achievements to be accepted for the award will include project ideas, recent findings and completed studies, or relevant data sets, which relate to comparative regional case studies on sustainability questions on a global scale.

The Geoscope initiators hope that this competition will create the right spirit and scientific atmosphere, in which fundamental inter-disciplinary discoveries related to Global Change are being made and important contributions to an emerging sustainability science may evolve.

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<sup>1</sup> For more details see [www.sustainability-geoscope.net](http://www.sustainability-geoscope.net).