

Chapter 31

Climate Change as a Global Challenge – and its Implications for Knowledge Generation and Dissemination

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Climate change as a global challenge has facilitated the emergence of global structures in knowledge generation and dissemination that stand out in their level of integration. Even against a world that has been subject to the forces of globalization, this process seems unparalleled. In this context, we argue that a democratization of climate change knowledge has taken place, coupled with bottom-up processes in generating new knowledge that can help advance the scientific understanding of and response strategies to this complex issue.

To understand the magnitude of the science effort in this area over the past decades, we set out with a succinct presentation of the natural science basis of climate change and possible impacts of the change processes on ecosystems as well as on human civilization. The scale and scope of the phenomena at play require a global approach to tackling this challenge and demand a sound scientific basis to underpin far-reaching societal choices on how to shape the future. Here, the Intergovernmental Panel on Climate Change (IPCC) continues to play a critical role in providing an objective, fact-driven evaluation of the state of knowledge as an analysis and decision tool for policymakers, but whose reach in knowledge dissemination is much broader.

The geographical integration of research cooperation and the cross-disciplinary nature of research are features that we highlight based on the example of recent publications released ahead of the Copenhagen climate negotiations. From the scientific results presented there, the chapter draws the link to the need for global governance and highlights the emergence of local action. We conclude that the knowledge generation process has succeeded in giving all the information necessary to make informed decisions—will humankind act in time?

31.1 The Global Character and Phenomenology of Climate Change

Climate change has emerged as an issue that touches virtually every aspect of society on a global basis. For science, analyzing the problem from all relevant angles has required an unprecedented integration of efforts, both geographically across the globe and topically across disciplines: studying the natural science basis has allowed to evaluate risks, impacts and vulnerabilities and—most importantly—to

connect future climatic conditions to individual behavior and collective choices made today.¹

31.1.1 The Natural Science Basis

There is overwhelming scientific evidence that an increase in the concentration of carbon dioxide (CO₂) and other greenhouse gases in the atmosphere is associated—according to the laws of physics—with an average global temperature increase. Since the late 1950s, instrumental measurements have demonstrated beyond doubt that the CO₂ concentration in the atmosphere is on a steep rise, and that this development is driven almost exclusively by human activities, especially the combustion of fossil fuels and changes in land use. CO₂ concentrations have actually risen from 280 ppm (parts per million) in pre-industrial times to over 385 ppm today—this constitutes by far the highest concentration since at least two million years ago.

Natural changes can also influence the climate, but they do not diminish the relevance of anthropogenic greenhouse gas emissions with respect to climate change. In fact, over the past fifty years, natural effects alone would have had a slightly cooling effect on the planet. For instance, satellite measurements have confirmed a certain decrease in solar activities during the last decades.

Anthropogenic emissions have already considerably affected the heat balance of the planet. Yet the full effects on global warming have so far been masked by local air pollution that, if abated, would lead to a rapid catch-up effect in warming. So-called radiative forcing, measured in watts per square meter of the Earth's surface (Wm⁻²), constitutes the determining factor for global average temperature. Human activities have already amplified radiative forcing by 1.6 Wm⁻². The contribution of carbon dioxide stands at 1.7 Wm⁻²; other greenhouse gases add an additional 1.3 Wm⁻², whereas cooling effects through air pollution (most notably aerosols) reduce forcing by 1.4 Wm⁻². Besides particles with cooling effects, soot emissions also contribute to warming but, on balance, a net negative cooling from particle emissions remains. This factor masks almost half of the overall warming already caused by past emissions. Note that most of the numbers presented in this paragraph come with fairly large margins of error.

With a simple conversion, changes in radiative forcing can be translated into an increase in global average temperature. The best estimate of this so-called climate sensitivity parameter is 0.8°C per Wm⁻². This translates into a warming of around 3°C for a doubling of carbon dioxide concentrations over pre-industrial times, which would be equivalent to an increase in radiative forcing of 3.7 Wm⁻².

The current human-induced radiative forcing of 1.6 watts per square meter thus corresponds to an already “programmed” warming of 1.3°C—if local air pollution and emissions of aerosols are not further reduced below their current levels!

¹For data references on the natural science basis as well as on impacts and vulnerabilities detailed in this section, refer to (WBGU 2009, 9–14).

The thermal inertia of the oceans will delay the establishment of a new equilibrium for several decades, thus explaining the relatively modest global average temperature increase of 0.8°C that has been measured so far. Natural variability in other factors, for example, solar activity, is too small to have a significant impact on these first-order effects.

31.1.2 Impacts and Vulnerabilities: “Avoiding the Unmanageable and Managing the Unavoidable”

The previous discussion has highlighted that even the most ambitious emissions reduction measures on a global scale will not prevent fairly drastic climate change from occurring. What humankind can do, however, is take action to prevent the worst possible consequences and to limit the risks arising from a “business-as-usual” pathway. As one report by the Scientific Expert Group on Climate Change and Sustainable Development to the United Nations put it, the task ahead is “avoiding the unmanageable and managing the unavoidable” (Scientific Expert Group on Climate Change 2007).

Among the risks arising from climate change, the following areas stand out in their potential for large-scale disruptions in nature and society:

1. Sea level rise due to thermal expansion of the oceans and water runoff from melting glaciers and ice sheets. This will take place at an increasing pace as global warming progresses. The average sea level has already risen by 20 centimeters since the 1880s and could rise by over 1 meter by 2100, if greenhouse gas emissions grow unabated. In the long run, the new equilibrium sea level could be many meters higher than today.
2. A higher frequency of extreme weather events, such as heat waves, droughts, strong precipitations, and tropical storms has already been observed. Continued climate change is likely to lead to an increase in their magnitude and occurrence.
3. Global warming of above 2°C will accelerate the loss of genetic diversity, species, and ecosystems, since in many regions temperatures that have not been witnessed for millions of years will be reached over a very short period of time. This would exceed the capacity for adaptation and regeneration of nature and lead to an irreversible loss of entire ecosystems.
4. Anthropogenic carbon dioxide emissions are already contributing to ocean acidification today. This process affects marine organisms that rely on calcium carbonate for their shells and structures. Coral reefs, and thereby an entire food chain on which millions of humans depend, are among the first and most severely affected.
5. Lastly, yet perhaps most importantly, “tipping elements” (PNAS 2009) in the climate system are large-scale components of the planetary machinery which may be pushed into new states or operational modes if critical thresholds of crucial ambient parameters (temperature, precipitation, salinity, etc.)

are crossed. These phase transitions would be in part abrupt, in part irreversible and sometimes both. The consequences in all their magnitude and ramifications are difficult to predict, but are likely to exceed human capacity for a managed and orderly adaptation. Key risks that have been identified are, for example, the potential transformation of the Amazon rainforest into a seasonal forest or a steppe, disruptive changes in ocean currents, erratic behavior of Indian and African monsoon systems, and the destabilization of large ice sheets.

The risks from unmitigated climate change for human civilization, which developed under the remarkably stable environmental conditions of the Holocene, are vast. They include threats to freshwater supplies from melting glaciers, weather extremes, and shifting precipitation patterns. World food production is likely to decrease if temperatures rise beyond 2°C, thus provoking regional food crises. Health risks tend to increase due to the spreading of disease vectors and the amplification of heat waves and extreme weather events. Droughts and soil degradation combined with rising sea levels are contributors to environmental migration, which could reach an unprecedented scale. In addition, the loss of “ecosystem goods and services,” which are central to supporting the current economic system, will affect global well-being and particularly nations that depend on agriculture, forestry, and fishing industries. Finally, unmitigated climate change could become a genuine security risk, as it undermines the living conditions and livelihoods of people in many world regions. So the adaptive capacities of many countries could be overstretched, leading to political destabilization, mass migrations and more “failed states” left behind in the process.

31.1.3 The Need for Global, Coordinated Action to Address Climate Change Risks

The dangers depicted above are still avoidable, or at least many of them. The magnitude of the future global temperature increase still depends mainly on *future* anthropogenic greenhouse gas emissions, most importantly carbon dioxide. These are dependent on population increase and economic growth, but can be influenced directly by emissions mitigation measures and climate protection policies. Future emissions can be projected by making assumptions about a range of possible scenarios. If a number of current trends continue without major changes in magnitude and direction, the global average temperature in 2100 could be 3–7°C higher than in the period before the Industrial Revolution. Even in an optimistic scenario—but without strong climate policy—temperatures would rise by 2–3°C. Ambitious climate protection measures are thus required in any case to counter the threats to nature and humankind that science has identified.

Greenhouse gases are global pollutants whose effects on radiative forcing are independent of where they were released. Abatement in one region therefore generates global benefits, but only if this abatement effort is not overridden by rising

emissions elsewhere. And the necessary transformation process for every country directly or indirectly touches virtually every aspect of production and consumption, as the current energy system underlying all major economies is based on the combustion of fossil fuels. The modern lifestyle, including the possibility for mobility around the globe, is deeply intertwined with greenhouse gas-emitting processes. Changing the contemporary patterns of unsustainable energy supply will also have far-reaching social implications, since without innovations in the behavioral and institutional spaces no deep industrial transformation can take place.

For the scientific process of knowledge generation and dissemination, the scene is set for a Herculean task with two main dimensions: First, advancing our understanding of the natural processes underlying climate change, from the global scale down to the regional level, in order to deliver assessments of possible impacts and vulnerabilities. Second, mobilizing the vast array of social science disciplines to study potential response strategies to climate change in terms of mitigation and adaptation. Generating actionable recommendations with respect to a global, coordinated effort to address climate change risks is the critical outcome of this integrated effort.

31.2 Responding to a Global Challenge with a Global Scientific Assessment Effort: The IPCC

When attempting to understand the globalization of climate change knowledge and its diffusion beyond the scientific community, one organization stands out as the foremost driver of this process: the Intergovernmental Panel on Climate Change (IPCC). Since its inception over twenty years ago, the IPCC has become the premier scientific review authority on climate change science. Through its work, the organization chiefly contributes to informing decision makers on all levels and to shaping global climate policy.

31.2.1 History and Structure

The IPCC was set up in 1989 by the World Meteorological Institution (WMO) and the United Nations Environment Program (UNEP) to provide the governments of the world and other stakeholders with a balanced and comprehensible scientific view on climate change and its implications for nature and man. Its initial task as defined by UN General Assembly Resolution 43/53 of 6 December 1988 is “to provide internationally co-ordinated scientific assessments of the magnitude, timing and potential environmental and socio-economic impact of climate change and realistic response strategies.” Specifically, the IPCC was tasked to undertake comprehensive reviews and to work out recommendations with respect to:

1. The state of knowledge of the science of climate and climatic change;
2. Programs and studies on the social and economic impacts of climate change, including global warming;

3. Possible response strategies to delay, limit or mitigate the impact of adverse climate change;
4. The identification and possible strengthening of relevant existing international legal instruments having a bearing on climate;
5. Elements for inclusion in a possible future international convention on climate (United Nations 1988).

The IPCC is open to all member countries of the United Nations and the World Meteorological Organization. Its work is overseen by the Panel, which is comprised of government delegations of all member countries, and meets approximately once a year at the plenary level. These sessions are attended by a multidisciplinary group of officials and experts from various national ministries, but also agencies and research institutions. All major decisions, such as, for example, the election of the IPCC Chair and the structure and mandate of the IPCC Working Groups and Task Forces, are made by the Panel. This is meant to ensure the global democratic legitimation of the IPCC. The approval process by the Panel is also designed to shield the analytic efforts from particular national interests and to enhance its political relevance. However, in practice, the close interrelation with the political process is a double-edged sword, because the expectations and demands of decision makers (for instance, in the nomination process for senior IPCC positions) are not always entirely commensurate with the purist scientific attitude maintaining that excellence is the only relevant criterion for picking people and topics. As regards the recent discussion about certain shortcomings in the latest IPCC Assessment Report, the challenge of safeguarding scientific integrity will be discussed later.

From an organizational standpoint, the IPCC is both large and small: while it draws on published science from thousands of researchers around the globe as well as on the voluntary authoring and review efforts of hundreds of high-caliber researchers, as a formal structure the IPCC is relatively small, with a central secretariat planning and overseeing all activities and some professional staff supporting the Working Groups and Task Forces.

The overarching and transdisciplinary nature of the Panel's assessment effort is reflected in the three Working Groups dealing with distinct dimensions of climate change. Working Group I focuses on "The Physical Science Basis of Climate Change," Working Group II on "Climate Change Impacts, Adaptation and Vulnerability," and Working Group III on "Mitigation of Climate Change." The primary products of the groups are the well-known Assessment Reports (ARs) published by the IPCC at regular intervals. The First Assessment Report of 1990 highlighted the importance of climate change as a challenge on a planetary scale and the need for global action to mitigate its long-term consequences. AR1 served as a principal input for the creation of the United Nations Framework Convention on Climate Change (UNFCCC) at the Rio Earth Summit in 1992. To date, the Convention remains the basis for an international approach to tackling climate

change, and the role of the IPCC in providing sound scientific underpinnings in this endeavor has been instrumental.

So far, the IPCC has produced four Assessment Reports, which constitute the most comprehensive science review on climate change produced worldwide. The AR2 of 1995 provided decision support in the negotiations leading to the adoption of the Kyoto Protocol in 1997. Reflecting an ongoing process of scientific knowledge production, AR3 and AR4 followed in 2001 and 2007, respectively, and sharpened the world's understanding of climate change risks and its options for action.

In addition to the Assessment Reports, the IPCC has published a range of focused Special Reports on pertinent questions of interest. Further, a Task Force has developed methodologies and guidelines for parties to the UNFCCC in establishing national greenhouse gas inventories. These initiatives complement the Assessment Reports by providing actionable scientific advice on options in policy design.

31.2.2 From Earth System Analysis to Mitigation Economics: Combining Natural and Social Sciences to Derive Policy-Relevant Recommendations

The structure of the Working Groups testifies to the broad mandate for analysis the United Nations conferred to the IPCC in 1988. The task is not only the assessment of the natural science phenomena underlying climate change. The IPCC also has an express mandate to study the role of humans both as driving forces and victims of climate change processes. A third task is to focus on possible mitigation pathways and their environmental, economic, and social implications. The breadth of this mission requires transdisciplinary collaboration to a degree that few, if any, scientific problems have ever called for. In practice, a highly interactive process with a number of discursive feedback loops is necessary to connect the main findings from the three Working Groups and to reflect their interdependencies. Since the "real" future cannot be predicted, as it depends on social choices made today and tomorrow in a self-referential way, scenario analysis covering a wide range of consistent global developments is a useful approach employed by the IPCC. Establishing consensus within and across Working Groups is a challenging process, exemplified in the scenario process: developing integrated scenarios initially involves defining a set of so-called representative concentration pathways (RCP) drawn from peer-reviewed studies and based on a number of socioeconomic assumptions about possible futures. These RCPs serve as inputs into a parallel but interlinked work process among three principal research communities: the climate modeling community (CMC); those concerned with impacts, adaptation and vulnerability (IAV); and integrated assessment modeling (IAM) groups. These research communities from different Working Groups contribute to integrated scenarios that actively take into account a host of feedback loops in the area of human-environment interaction.

The long lag times of the interactive scenario process, along with the requirement to base the modeling effort and the science review only on well-established findings, makes for a certain conservatism in the conclusions of Assessment Reports. As a corollary, it may not be possible to incorporate the most recent scientific results. For example, AR4 included only the sea-level rise due to thermal expansion of the oceans but—explicitly—excluded consideration of melting land ice in its sea level projections. This important additional factor will be incorporated into AR5, thanks to a deeper scientific understanding and quantification of the processes at play.

The role of uncertainty inherent in scientific assessments of most climate change processes leads to probabilistic estimates concerning the biogeophysical phenomena and their resulting impacts on human civilization. Here, the IPCC has linked probabilities to qualitative statements (e.g., “virtually certain” corresponding to a probability level greater than 99%, “very likely” from 90–99%, etc.) to provide better guidance. As progress in science has allowed uncertainties to be lowered over time, one fundamental insight emerges for decision makers: humankind simply holds the future in their hands—for better or worse.

The detailed scientific review and analysis, covering hundreds of pages for every Working Group, is freely accessible, but in its comprehensiveness it is directed above all to an expert audience. A critical communication tool of the IPCC toward the general audience is the Synthesis Report, along with the so-called Summary for Policymakers. These publications focus on the essential findings of the IPCC assessment effort and give an overview on the current state of knowledge across the three Working Groups. Since scientific analysis of a question as complex as climate change often has to operate with probability estimates, these summary documents also indicate the level of confidence that science can attribute to various phenomena. Highlighting the uncertainties, but also the degree of confidence reached in many areas over time, is a critical input into policy-making and of highest relevance for formulating appropriate response strategies.

In analyzing the many dimensions of climate change as well as options for mitigation and adaptation, the IPCC has to be policy-relevant but not policy-prescriptive. This principle is a cornerstone of its work: with its main function being to analyze and to inform, decisions as to actions based on its insights need to be taken elsewhere. As has been mentioned, previous Assessment Reports have prompted landmark agreements, such as the UNFCCC and the Kyoto Protocol. In the current international negotiations for a follow-up agreement to the Kyoto Protocol, the findings of the IPCC continue to play an important role.

Beyond the international and national policy-making arena, the work of the IPCC has had a broad influence on other stakeholders, from worldwide non-governmental organizations dealing with various aspects of climate change, over regional and local initiatives for action on greenhouse gas emissions reductions, to the level of individual citizens. This development is closely linked to the emer-

gence of change agents and, as we will argue, the *democratization of climate change knowledge* that will be discussed later in this chapter.

31.2.3 Learning from Experience: Preparing the IPCC for the Future

The work of the IPCC remains of the highest significance for the process of review, aggregation, and dissemination of climate change knowledge on a global scale. From the viewpoint of history of science, its contribution to broadening the understanding of the complex phenomena associated with anthropogenic global warming cannot be underestimated.

However, thorough external scrutiny of the findings presented in the last Assessment Report has led to the identification of a small number of errors that had escaped the complex peer-review process associated with IPCC work. Without doubt, the shortcomings identified, for example relating to the timescale for Himalayan ice cover loss, require rectification.² Yet, when put into the necessary perspective of the several thousands of pages the AR4 is composed of, the public outrage over the mistakes indicates a more severe problem: the public perception of the necessity and credibility of climate change science appears to be highly fragile and susceptible to contrarian campaigns. Obviously, a handful of incorrect details that do not affect any of the main conclusions of the IPCC's work are sufficient to call into question the entire process of this international assessment endeavor along with its scientific bottom lines. This observation shows that, despite all optimism about the globalization of scientific knowledge, a sustainable contract between science and society as reflected by a vital dialogue based on mutual respect and trust is still a distant goal.

It is nevertheless important to point out that on the part of the IPCC the errors made cannot simply be passed over. Three scenarios are possible: the first, and clearly the least desirable, would be to declare its work done and to dismantle the institution. A second option would be to learn from these mistakes, replace some of the responsible authors and make sure to follow the self-imposed strict scientific standards even more thoroughly. In addition, there is a third option worth exploring that would lead to a deeper structural transformation of the IPCC. Such a reform would make the panel even stronger and enhance its scientific results. Currently, due to the role of state actors and political influences, authors are not always selected solely according to their scientific competencies. While its architects mean well in embedding the IPCC to some degree in political processes, hoping to strengthen the link from research findings to decision making, its scientific excellence is partially at risk.

A way out of this dilemma would be to depoliticize the IPCC by putting it under the oversight of the most credible and noble institutions of the scientific community at large, namely the national academies. An important step in this direction was taken in March 2010 when UN Secretary-General Ban Ki-moon

²See (IPCC 2010).

together with Panel Chair Pachauri charged the InterAcademy Council (IAC) with an independent review of the processes and procedures of the IPCC. An ad hoc Independent Evaluation Group (IEG) will be formed to conduct this review and to submit recommendations on how to ensure that the highest standards to which the IPCC subscribes will be met today and in the future.

The IAC is well equipped for this task: created in the year 2000 by all science academies around the world, the mission of this institution is to mobilize the leading scholars worldwide with the objective of providing high-quality scientific advice to international bodies around the world. The IAC is led by two co-chairs, both presidents of national academies of science, currently from China and the Netherlands. In preparation of the review process, the IAC will appoint members to the Independent Evaluation Group who will serve as volunteers on a pro bono basis—following close scrutiny of their expertise and after ensuring that no conflicts of interest exist. The review effort will be completed in a timely manner so that the recommendations can guide work on the Fifth Assessment Report, due in 2013.

In this context, we urge that scientific excellence must be the one and only benchmark for the selection of the senior officers and authors of the IPCC and of the quality of the assessed body of information. The IAC could play the role of honest guardian in this context. Finally, another consequence of the errors discovered with immediate practical implications for the work of the IPCC would be to limit the assessment to investigations and data published in first-tier peer-reviewed journals. While such a reform would render the report more fragmentary and imply that a number of important issues are left unaddressed, the scientific standards could be raised further.

31.3 Recent Findings in Climate Change Science Through World-Class Cooperation

The international science review process by the IPCC draws on research activities on a truly global scale. Whereas the policy responses to the climate change problem remain largely in the domain of national initiatives with as yet rather limited global integration and cooperation, climate change science has been fully globalized. This applies both to the natural sciences and the social sciences. The former deal principally with Earth system analysis and climate change impact research; the latter evaluates, for example, climate change policies and their economic implications, but also social and political transformation processes in response to climate change.

The scientific landscape concerning the climate problem—and indeed the structure of eminent science in other disciplines—is much more globalized than many of the other components of society that also have been subjected to the forces of globalization. The political system was already mentioned, but not even the economic system, with its ever-deeper transnational integration can compare to the almost universalistic character of worldwide scientific production. Beyond

the requirement for appropriately quoting previously published work, science follows an “open source” process in which arguments of other researchers are critically reflected and developed further. Whereas in the economic sphere intellectual property rights prevent the public use of many ideas and processes, having free access to previous scientific work is the very precondition for advancing our understanding in the breadth and depth that has been achieved over time.

Climate change science is driven by a global community of researchers, in which national boundaries become less and less meaningful. Crucial factors enabling this development are, among others, English as the working language of international scientific exchange, a set of principles for assessing and citing previous work, as well as anonymous peer review to guarantee the quality of the publication and dissemination of knowledge in academic journals. The Internet revolution has made it possible to access this knowledge almost anywhere on the planet and to speed up the process of current and future knowledge generation.

Further reasons for the globalization process in the climate change sciences are to be found in the nature of the problem as well as in the response strategies required. Concerning the nature of climate change, the Earth *system* consists of a large number of coupled processes whose study necessitates global data acquisition and integration. This is especially relevant in understanding the climate system and in developing climate models with explanatory as well as predictive capabilities. Moreover, regional impact studies with a higher resolution that allow possible vulnerabilities to be discerned and contribute to developing appropriate adaptation responses need to be embedded in a systemic view. The fact that every region on the globe will be affected in specific ways, under various emissions and climate scenarios, also explains the interest in local research efforts that help create a dense web in global knowledge production.

When it comes to response strategies to climate change, successful mitigation measures require an aggregate effort by all major emitters in order to have a meaningful impact on global emissions, and on limiting the damages resulting from unmitigated climate change. The task at hand is the successive decarbonization of energy systems on a national, regional, and—in aggregate—global scale.³ The heterogeneous structure of energy systems around the globe, as well as the far-reaching economic and social implications of these processes of change in different countries, constitute factors that privilege decentralized research efforts. In turn, the results complement and serve in part as inputs into larger-scale global assessments that are heavily model-driven. Not unlike climate models, the complexity achieved with current energy-economy models encourages international cooperation in comparing and evaluating models.

Amidst these ongoing processes, synthesizing knowledge and disseminating it outside the scientific community are two critical tasks related to the climate change problem. They are so important because an adequate response to the challenge involves a far-reaching transformation of our societies that can be driven only by

³See chapter 30.

a deeper understanding of the human role in climate change and the risks and opportunities involved. As detailed in the previous section, the IPCC remains the major international institution for this endeavor, being directed at policymakers but also, and equally importantly, at a variety of stakeholders and citizens in general. The complexity of the science review process results in long publication cycles between assessment reports, typically of five to six years. Yet scientific understanding evolves constantly, as does the latitude for making policy.

Two recent scientific publications highlight the latest findings in climate science, and simultaneously testify to the global nature of climate change research. Published ahead of the Copenhagen climate conference in December 2009, they also fulfill a knowledge dissemination function, with the next IPCC Assessment Report not due before 2013. These two documents are *The Copenhagen Diagnosis* (2009) and *A Copenhagen Prognosis* (2009)—both titles being emblematic for the reports' envisaged policy relevance.

31.3.1 The Copenhagen Diagnosis

This synthesis report was co-authored by twenty-six leading experts in various fields of climate change science, most of them previous or current IPCC Lead Authors. The focus is on the physical science basis of climate change, corresponding to the range of topics evaluated by Working Group I of the IPCC. Consequently, the areas of expertise of the authors range from ocean physics and ice sheet dynamics to complex systems analysis, including the study of large-scale tipping elements in the climate system.

Beyond the breadth of disciplines of the scholars involved, the Copenhagen Diagnosis testifies to the global nature of research cooperation in the field of climate science: published by the Climate Change Research Center of the University of New South Wales, Australia, the report was co-authored by scientists based in the United States, the United Kingdom, Germany, Austria, France, Switzerland, and Canada.

What is more, the nearly 300 references to recent research articles from scientists working around the globe mirror the decentralized, global knowledge generation process in this domain. Yet, although the research community may be widely dispersed geographically, the publication of the Copenhagen Diagnosis report highlights that knowledge dissemination can nevertheless happen in a coordinated and structured way. In addition, the insights generated are often targeted at a global audience of stakeholders dealing with climate change, in particular policymakers. This is especially true for this science review effort, which was released to inform decision makers at the Copenhagen climate summit about the latest findings in natural science.

In more than one aspect, the conclusions of the Copenhagen Diagnosis indicate that humankind has to act swiftly and forcefully in order to avoid a severe perturbation of the Earth's climate system, likely with unmanageable consequences. Drawing on the latest scientific findings, the report goes significantly beyond the

2007 IPCC Fourth Assessment Report in a number of key areas. Taken together, there is greater scientifically justified urgency than ever to take action on a global scale—if the goal is to confine anthropogenic global warming to a manageable level. Among the key findings, the report cites the following areas of concern, while quantifying the magnitude of the challenge (The Copenhagen Diagnosis 2009, 7).

1. *Surging greenhouse gas emissions*: Despite all previous efforts in climate protection policy, global carbon dioxide emissions from fossil fuels in 2008 are 40% above 1990 levels.
2. *Recent global temperatures demonstrate human-induced warming*: The temperature rise over the past twenty-five years has been 0.19°C per decade, which is in line with model results based on the measured increases in atmospheric greenhouse gas levels.
3. *Acceleration of melting of ice sheets, glaciers and ice caps*: A wide array of different observation and recording techniques demonstrates that the Greenland and Antarctic ice sheets are losing mass at an increasing rate. Melting of glaciers and ice caps around the world has also accelerated.
4. *Rapid Arctic sea ice decline*: Summertime melting of Arctic sea ice has increased far beyond the expectations of climate models. The area of summertime sea ice cover during 2007–2009 was about 40% less than the average predicted by the climate models of the fourth IPCC Assessment Report. This means that the current cryosphere models are too conservative with respect to the responsiveness of the systems in question and need to be improved.
5. *Current sea level rise underestimated*: Satellite measurements peg recent global average sea level rise at 3.4 mm per year over the past fifteen years, around 80% above previous IPCC predictions (which do not account for the full dynamics of the big shelf and inland ice bodies).
6. *Sea level predictions revised*: By 2100, the global sea level is likely to rise at least twice as much as projected by Working Group I of the IPCC AR4. In the case of unmitigated emissions growth, it may well exceed one meter. Even after global temperatures have been stabilized, sea level will continue to surge and several meters of sea level rise can be expected over the next few centuries.
7. *Delay in action risks irreversible damage*: The risk of transgressing critical thresholds, so-called tipping points, grows strongly with unmitigated climate change. Delaying action while waiting for higher levels of scientific certainty could trigger irreversible processes before they are recognized.
8. *The turning point in global emissions must come soon*: If the global average temperature increase is to be limited to 2°C above pre-industrial levels, the peak of global emissions needs to occur between 2015 and 2020, with a rapid and sustained decline of emissions thereafter. To stabilize climate, a decarbonized global society needs to be achieved well within this century.

The main findings of the Copenhagen Diagnosis paint a picture of rapid, human-induced global climate change already happening today and with far-reaching consequences in the future. What is more, the report does not stop at presenting isolated research results, but puts them into the context of an ensemble of global trends with respect to greenhouse gas emissions. It thereby draws the link to societal choices that need to be made today and that will determine the world we will live in tomorrow. The Copenhagen Diagnosis indicates the degree to which global climate science can be a critical input into societal change processes. These can be anywhere in the domain of policy-making, from the international level (for example within the UNFCCC regime) to national or local initiatives. The knowledge generated can also inform lifestyle choices on the level of individual citizens and thus be an input into cultural change over time.

What is important—and mirrors the principles of the IPCC—is the fact that the results presented and the implications drawn are perceived as policy-relevant but not policy-prescriptive. Science can only work with a set of assumptions about *possible* future developments and evaluate the likely consequences of a set of future pathways. In this sense, the principal function, beyond the process of generating knowledge within the scientific community, remains one of informing all other stakeholders. Ultimately, deciding which path the world will take is up to a multitude of actors from various levels, as indicated above. These are the addressees of the Copenhagen Diagnosis.

31.3.2 The Copenhagen Prognosis

Ahead of the Copenhagen negotiations, the Copenhagen Prognosis report (2009) was released as a further science review effort, spearheaded by TERI (The Energy and Resources Institute, India), SEI (the Stockholm Environment Institute), and PIK (the Potsdam Institute for Climate Impact Research). This joint effort by one Asian and two European research institutes takes the most recent findings summarized in the Copenhagen Diagnosis report as a well-defined starting point. The focus, however, is now on possible mitigation strategies as well as on conceivable schemes for sharing the costs of transforming the world's energy system in an equitable way.

The report underscores once again that climate change is a fundamentally global challenge that is intimately linked to development aspects: global carbon dioxide and other greenhouse gas emissions have to peak during this decade and decline rapidly thereafter in order to maintain a realistic chance of confining global warming below 2°C. Concurrently, the majority of a growing world population still has inadequate access to basic energy services. The challenge therefore is not only a decarbonization of the contemporary energy system within its present dimensions, but also the large-scale expansion of energy services on a global level without further aggravating the climate change problem.⁴

⁴See chapter 30.

Science has recognized this conundrum and modeling studies are being undertaken to assess global transformation pathways that take the relevant dynamics into account. The focus is on top-down energy-economy models that rely on a host of technology-specific assumptions along with optimization algorithms. The Copenhagen Prognosis highlights key results of these complex modeling efforts undertaken by a number of international teams. These macro-studies are complemented by more regional, bottom-up analyses that can better take geographically explicit factors into account. Through these complementary approaches, science can help evaluate and manage change processes from a global to a regional level. By assessing possible development scenarios, policymakers receive critical inputs as to the feasibility of alternative emissions pathways, thus enabling them to make informed decisions.

Drawing on the conclusions of the modeling work, the report underscores that, despite the magnitude of the challenge, a global transformation that respects the 2°C guardrail is possible and the economic costs are affordable indeed. This, however, is conditional on timely global action to reverse emissions growth trends. If, in contrast, the world were to delay action until the next decade, future required rates for emissions reductions would result in steep cost increases for mitigation measures.

Yet even if the world acts in good time, the global scope of the transformation process and the need for massive capital investments to deploy more expensive low-carbon technologies requires addressing equity issues. Here, the social sciences have important contributions to make. The Copenhagen Prognosis reviews some previous analyses and concludes that a successful integration of developing countries needs to respond to two criteria: first, ensuring that these countries have the resources necessary to enable rapid and comprehensive decarbonization while, second, still allowing for rapidly improving access to energy services in order to improve the living conditions of millions of people. These requirements call for an unprecedented North-South cooperation, backed by substantial transfers of financial resources and technology.

Beyond agreeing on a global carbon budget for decades to come, the potentially more difficult question—at least politically—will be how to apportion the remaining atmospheric space among humans. At the same time, resolving this question would mean addressing financial transfers from the global “North” to the global “South.” Determining what constitutes an equitable distribution that is also politically acceptable is at the heart of the problem. The social sciences have put forward a number of distributional principles that translate the natural science findings with respect to the climate system into policies fit for international implementation. One group of proposals focuses on equal per-capita rights to the atmosphere. Examples include the budget approach (WBGU 2009) or the 2°max climate protection strategy (Wicke et al. 2010). The former will be discussed in the next section. Yet even these schemes with highly relevant distributional con-

sequences for the rich and the poor have been criticized for not sufficiently taking equity into consideration.

The Copenhagen Prognosis presents an alternative approach, termed Greenhouse Development Rights,⁵ which defines the development of poorer countries as a central objective. It strives to avoid the conflict and false choice between development and climate protection that could occur under different allocation rules in view of the very limited global carbon budget commensurate with climate stability. Climate protection obligations are defined as a function of capacity (income) and responsibility (past and current emissions) for all individuals who are above a certain “development threshold,” measured in GDP per capita. Under this scheme, developed countries would see their emissions allocations decline rapidly to zero and even become negative, which in turn would result in substantial financial flows to poorer countries to help finance a low-carbon development pathway.

By highlighting these policy implications, the Copenhagen Prognosis closes the loop ranging from the natural science foundations of climate change, over economic implications of a great transformation process, to questions of global equity and development. In its summary format, the report can only begin to outline what will need to happen on a planetary scale and where science will once again be an invaluable source of orientation. Indeed, while refining the world’s knowledge on the natural science phenomena surrounding climate change will remain an important research task, translating insights into actions is what will matter most when going forward. This is where the need for global governance combined with local action comes into play.

31.4 From Insights to Actions: The Need for Global Governance and the Emergence of Local Action

As has been shown exemplarily in the discussion of the IPCC and recent international science-review efforts, global knowledge generation and dissemination in the biogeophysical realm have solidified our understanding of anthropogenic climate change. Concurrently, interdisciplinary science has turned to proposing new forms of international cooperation designed to mitigate global greenhouse gas emissions in order to avert the worst climatic risks. Next to such top-down approaches, the widespread availability of scientific information together with its purposeful dissemination on various societal levels has also supported the emergence of local change agents with important roles in bottom-up processes. Beyond its globalization, what we have witnessed is indeed the *democratization* of climate change knowledge. Both levels of action—top-down and bottom-up—will be examined below.

⁵Initially developed by Baer et al. (2008).

31.4.1 Science-Based Models of International Cooperation: The Budget Approach

Based on the findings in climate science, a number of proposals have presented blueprints for crafting global climate protection architectures. Developing formulas to divide up the limited atmospheric space for future greenhouse gas emissions is a recurrent theme, and a number of proposals have focused on these distributional aspects.⁶ Yet only a relatively limited number of authors have advanced proposals for comprehensive architectures with more specific recommendations for implementation. Concerning a system focusing on the United States only, Stavins (2008) is one example. Addressing the problem on a global scale, the WBGU (2009) and Wicke et al. (2010) have developed overarching climate protection architectures. These proposals have in common a top-down orientation, in which allowable global emissions are determined *ex ante* and a series of mechanisms are proposed to implement this constraint.

The so-called budget approach (WBGU 2009) is a testimony to the interdisciplinary nature of research at the intersection of the natural and social sciences that is at the basis of scientific proposals for international cooperation to address climate change. The authors of the budget approach, who advise the German government on questions of global change, are experts in fields as diverse as economics, political science, physics, law, engineering and complex systems analysis.

The proposal (WBGU 2009) is based on the latest findings in climate science indicating that the global average temperature increase is determined predominantly by cumulative carbon dioxide emissions, given the long residence time of that greenhouse gas in the atmosphere and the offsetting effects of other emissions. Because of the variability in the natural carbon cycle, and since reversibility of purposeful carbon sequestration, for example, through afforestation, cannot be excluded, WBGU recommends focusing on emissions from fossil fuels. Reducing non-fossil emissions, for example, from land use change, is equally important but should be dealt with in a separate agreement.

The budget approach—*nomen est omen*—first calculates a residual global budget for carbon dioxide emissions from fossil fuel combustion that is compatible with limiting the global average temperature increase to 2°C over pre-industrial levels with a reasonable chance. So establishing the global carbon budget also requires the setting of a (political!) level for the likelihood that the temperature threshold will be respected. Even a modest probability level of 67% yields a total remaining budget for fossil fuel emissions of no more than roughly 750 gigatons of CO₂ during the timeframe 2010–2050. Without policy intervention, global emissions are expected to rise considerably, yet even if they were held constant at current levels the world’s “67%-budget” would be exhausted in less than twenty-five years. These facts highlight the transformational challenge that requires unprecedented cooperation on a global scale.

⁶See, for example, (Meyer 2000; Höhne et al. 2005; Baer et al. 2008; Frankel 2008).

What is needed is an equitable model for dividing up the remaining atmospheric space among humans as well as an institutional framework for managing the global carbon budget. In summarizing the Copenhagen Prognosis report, we highlighted several distributional principles discussed in the literature. The budget approach is based on an equal per-capita allocation key in order to determine the remaining carbon budgets on a country-by-country basis. This initial distributional principle results in an emissions allowances allocation that would make most developed countries “carbon bankrupt” in a matter of just a few years, even though the budget period runs until 2050. In contrast, countries with currently very low per-capita emissions—first and foremost a number of developing countries and the group of least developed countries—could still increase their emissions over time given their modest utilization of the atmosphere to date. Overall, however, even developing countries with lower emissions will eventually be constrained and could not duplicate the carbon-intensive and unsustainable development path pursued by other parts of the world.

In order to manage the transition process, it is essential for high emitters to purchase additional emissions certificates. In exchange, low emitters stand to benefit financially from sales of certificates, which would allow them to acquire the resources necessary to enter a sustainable development pathway. A new North-South partnership could thus emerge, in which low-emitting, often poorer countries are not the recipients of altruistic development assistance, but become valuable counterparts for high-emitting countries as sellers of scarce emissions rights. By virtue of the global carbon budget, low-carbon development is encouraged in all countries: nations with budget shortfalls will attempt to reduce emissions swiftly in order to limit allowances purchases, whereas countries with budget surpluses have an incentive to limit their emissions growth and to develop in a carbon-efficient way so as to benefit from the sale of unused allowances.

However, such a planetary partnership requires the existence of a global market for emissions allowances with appropriate oversight and a set of enforceable rules in order to ensure its integrity. The role of institutions is central in this context. WBGU proposes the establishment of a so-called World Climate Bank with statutory powers to ensure that the limits of the global carbon budget are observed. Its principal functions would be to serve as a clearinghouse for allowance transactions as well as to supervise the implementation of so-called national decarbonization roadmaps. These roadmaps lay out country-scale strategies for using the carbon budget in a way that ensures a successive transformation of the energy system while respecting overall emissions limits. Since the strategic behavior of individual countries could jeopardize the integrity of the system, the World Climate Bank needs to be equipped with review and modification powers with respect to national roadmaps.

Establishing an international authority with these relatively far-reaching competencies may seem ambitious or aspirational, perhaps even hopeless given the current status of climate negotiations and the role that national sovereignty plays

in the climate policies of a number of key countries. Yet strong arguments point to the need for a previously unknown degree of global cooperation for the world to rise to the challenge. The global emissions constraints derived from the natural science foundations of climate change are simply at odds with the emerging “business-as-usual” trends that cannot be accepted for the sake of humankind. It is more than doubtful whether an uncoordinated approach without overarching enforcement mechanisms can succeed in delivering climate stability.

In addition, economists have often highlighted the efficiency benefits of a global carbon market that leads to emissions abatement where it is least costly and that creates a level playing field for companies operating around the globe.⁷ Indeed, delivering climate protection at relatively low cost, as suggested by a number of economic models, depends not only on sustained technological innovation, but also on a geographical and intertemporal optimization of emissions abatements.

The science effort to design global architectures to address the climate challenge has been complemented by the emergence of numerous bottom-up initiatives to take action on a local scale. This development is highly relevant, as small-scale “laboratories of change” pioneer a transformation process that eventually will be scaled up. Given the current difficulties in establishing structures of global climate governance, such first steps also bear political relevance. In fact, the positive experience of rather localized transformation processes can help to overcome the diffuse resistance to more comprehensive efforts.

31.4.2 Emergence of Local Change Agents and the Democratization of Climate Change Knowledge

Path dependencies in the present configuration of institutions, technologies, and infrastructures impede far-reaching societal change.⁸ Yet without a deep transformation process, humankind will fail to address the climate change challenge in time, so a path shift is needed—the swift transition to a climate-friendly economy and society. This path shift requires complex learning processes that involve technological innovations but also social change. However, the transformation of societies toward climate-compatibility cannot succeed through top-down policies and new institutions alone. As will be detailed in the last section of this chapter, science-driven policy innovations that focus on incentives for a large-scale transformation are at risk of failure if they are countered by influential players whose approval is critical under constitutional law or in *realpolitik*. These so-called veto players are all the more effective the greater their number and the more heterogeneously and competitively they operate (Tsebelis 2002).

Change agents are pivotal in overcoming this potential for blockade and in breaking up the stagnation that could long persist. These strategic groups are the

⁷See, for example, (Edenhofer et al. 2008).

⁸The main ideas as to the following discussion of change agents are taken from (WBGU 2009, 46–47).

first to engage in social change and to proliferate an awareness of the opportunities involved. Concrete and positive real world examples can have powerful multiplier effects and are able to counter the gloom-and-doom scenarios spread by opponents to the change process ahead. Indeed, periods of “great transformation” historically have been characterized not only by the emergence of novel lead sectors and the diffusion of new technologies, but even more by the formation of aspiring groups of individuals who advanced change in institutions and mentalities (Rogers 2003). Strategic groups and alliances operate as role models and trendsetters across traditional boundaries—cultural and national—to break the ground for widespread innovation impulses that initially appeared isolated and without any prospects of success. In so doing, change agents call into question traditional and sclerotic worldviews and challenge the status quo. They engender motivation in others to join their cause and become allies.

Change agents can be found in virtually every societal group. Beyond the obvious suspects, such as non-governmental organizations and grassroots groups, they are present, for example, in academia, in companies, and also in policy-making and administrative bodies. The list of actors could be extended and differentiated, but what unites them all is the recognition of both the necessity and opportunity in the decarbonization of society, from the macro level down to the level of the individual citizen and consumer. Initially, change agents often work in isolation and on dispersed projects, which makes them unaware of the opportunities to forge political alliances. Yet elites in decision making positions oftentimes also lack the recognition that among these pioneers potential allies can be found in communicating and enforcing supposedly unpopular policies.

Research in the social sciences has described these phenomena succinctly and proposed ways to use the creative power of hitherto scattered groups to bring about change. This work is based on the recognition that the global climate negotiations will fail if people come to misconstrue climate protection as a purely top-down, state-run operation. While an overarching policy framework like the budget approach is critical in breaking path dependency and in reversing global trends, for every citizen it is equally essential to connect behavior to personal responsibility and agency for change. In other words, what is needed is to break down climate protection targets in a manner comprehensible to citizens, along with an interactive feedback on climate policy up to the highest policy-making level.

Science has proposed a multitude of actions to alert citizens to the far-reaching actions that are required to avoid dangerous climate change. Position papers by think tanks and expert parliamentary debates are important but not sufficient elements. Bottom-up processes also need to contain participatory components that include “non-experts” as people who themselves generate knowledge, take action, and propagate relevant messages. In this process, citizens play more than a passive role of merely absorbing scientific knowledge. They can themselves become sources of new insights relevant for science and society alike. An example of such an active

knowledge generation effort is the Reef Check program, in which amateur divers record the state of coral reefs around the world in regular intervals. This effort is a vital source of scientific data, but also an endeavor with social multiplier effects, since the volunteers involved in this program are active in very diverse societal roles and functions.

Further important inputs into the scientific process, especially in the social sciences, can be drawn from bottom-up initiatives in the areas of low-carbon lifestyles as well as projects of adapting to emerging climatic changes. Here, practical insights, sometimes following from trial and error processes, can be suitable for scientific formalization with the possibility for knowledge transfer and further applications. Indeed, the *bottom-up knowledge generation* will be an increasingly important element in responding to the climate change challenge and already plays a vital role in complementing more traditional research-driven science efforts.

That the emergence of change agents is neither directed nor controlled is also a reflection of a widespread science diffusion process that could be described as the *democratization of climate change knowledge*. The publicly available scientific information accessible through the Internet—first and foremost the work of the IPCC, but also recent reports like the The Copenhagen Diagnosis (2009) or the WBGU budget approach (WBGU 2009)—offer the latest insights of top-notch climate change research and point to the need for immediate action. This democratization of knowledge, in which the media and its many distribution channels also have an important role to play, has helped to start a bottom-up process that is essential for the transformation ahead. Change agents make creative use of the existing knowledge in the realm of climate change across all scientific disciplines. The natural science basis has served as an impetus for taking action and for challenging entrenched behavior. Findings in other domains, such as economics and the social sciences more broadly, have paved the way for implementing the critical first steps on a very long road.

31.5 The Limits to Science and Reason?

The previous discussion of climate change has highlighted the role of global science in analyzing the problem, in disseminating knowledge and in proposing action plans to respond to the challenge. Without the comprehensive science effort in this area over recent decades, humankind would be rather ill-equipped to deliver an adequate response: the consequences of our choices as a global community in this area materialize only over time and reach far into the future. In addition, the time lags between changes in behavior and tangible results are often very long. Yet humankind needs to act now in order to shape a future that averts potentially catastrophic changes to the Earth's climate system. Waiting until one looks directly into the abyss and deciding to act then is a fool's strategy.

31.5.1 Successive Decarbonization as a Response to the Climate Threat: Focused Impacts and Widely Shared Benefits

Science has not only pointed to the risks while narrowing remaining uncertainties over time. Science has also sketched a manageable transformation pathway toward a low-carbon society that is associated with only slightly lower GDP growth compared to a “business-as-usual” pathway, as robust modeling results indicate. In fact, as a frame of reference, the overall “growth penalty” of well-designed climate protection policies for the next decades is estimated to be smaller than the GDP losses already incurred through the recent financial crisis in a single year. The benefits of climate protection, i.e. avoided damages of all kind, are not even taken into account when looking solely at the cost of mitigation. Indeed, these benefits are vast and grow over time. They are widely shared among people around the globe—and among all future generations. In addition to the benefits that can be given a price tag since they are relevant for economic output, a host of non-market benefits stand to be reaped, like the preservation of ecosystems as a value in itself.

The path ahead is a successive and comprehensive decarbonization of the world’s energy system—which surely will have marked impacts on a number of powerful and influential industries that have been at the basis of the current carbon-intensive development model. It may seem a tautology, but we need to repeat that there can be no deep transformation—which the world urgently needs—without affecting the status quo and thereby a number of focused interest groups.

Indeed, the overall costs of the transformation process, which are small on an aggregate level, will not be spread evenly but will affect certain industries and groups of consumers more than others. Studies in the social sciences have shown that compact but strongly impacted interest groups tend to mobilize more effectively than extended groups that stand to benefit from the transformation process. This argument is particularly valid in the context of climate change, since in addition to uneven impacts from the economic transformation process, the timescales for incurring costs and reaping the benefits from climate protection are different, the latter materializing only over decades with increasing magnitude.

So fierce opposition arises to this envisaged transformation process that would benefit the vast majority of humans on this planet, especially people in poorer countries and those without a strong voice in the current global system. There is a lot at stake for resource holders of fossil fuels whose assets could be devalued substantially if the world were to accept the physical necessities and agree on a global carbon budget. As a consequence, many of these resources would need to remain in the ground and never reach the atmosphere as a combustion product.

31.5.2 An “Industry of Fear”: Threats and Misinformation Meant to Derail an Adequate Political Response to Scientific Findings

A great deal of money is being spent on influencing policy-making in a way that, if it does not stop the process of change, at least slows it down and deprives it of some of the momentum that would be crucial in rising to the challenge in time. The likely outcome is what some call “rational” policies that don’t rock the boat too much. If the overall level of ambition is not upped significantly, it remains to be seen how rational these policies will be judged only a few decades from now as the world’s climate system moves closer to crossing its stable operating boundaries.

The opposition to taking action is grounded in economic interests on the level of companies, but also countries. Oil-rich nations, for example, which generate important rents through resource exports, would be impacted through global climate policies. It therefore comes as little surprise that the chief negotiator for Saudi Arabia at the Copenhagen climate summit is also senior economic advisor to that nation’s Minister for Petroleum and Natural Resources. The negotiation strategy of this country strives to discredit scientific information and to call into question the natural science basis of understanding climate change as well as the degree of human influence on atmospheric dynamics. Yet the unanimity principle of the UNFCCC process requires the support of Saudi Arabia and other resource exporters for a global climate agreement. It is hard to see what an adequate regime architecture would have to look like to satisfy the conflicting interests of everyone impacted by the ensuing change process.

A less open but potentially even further-reaching lobbying effort has been carried out by a number of large corporations focusing on national policy-making efforts. The strategies have included, for example, financial support to “alternative scientific voices” attempting to lend credibility to dubious theories that have in common the downplaying of the human role in climate change and therefore the effort to deny the need for action. Direct financial contributions to politicians and parties advocating slower action or denying anthropogenic climate change altogether have also been administered.

In the case of the United States of America, the duet of special interests and key policymakers during the Bush-Cheney years has been aptly described and analyzed by Vanderheiden (2008). Now the arguments have turned toward generating fear of job losses and disadvantages in terms of economic competitiveness if strong climate policies were to be enacted. The recent economic crisis has refocused the attention of many people on the short term and the urgency of acting on climate change may have diminished against other priorities.

Yet against the fear-mongering and deliberate manipulation of the concerns and emotions of people, science has responded with analyses as to how the current crisis can be used productively to respond both to the needs for climate protection and economic recovery. It has been shown that the “either-or” picture that special interests advocate is not grounded in sound reasoning. Proposals for a “Green New Deal” (Edenhofer and Stern 2009) indicate that the crisis is a unique opportunity

to direct stimulus spending into low-carbon infrastructure and technologies and to support job creation in industries of the future.

31.5.3 The Jury is Still Out: Will Humankind Act in Time?

In view of the scientific efforts that have been so successful in advancing the knowledge about the world we live in, the outcome of the climate-policy process may look sobering up to now—at least in terms of aggregate results on a global scale. The notable influence of focused interest groups begs the question as to whether science will be confined to a largely descriptive function of global trends and their consequences and to what degree well-founded recommendations will actually lead to appropriate actions.

At the same time, it should be highlighted that science is only one input into the political process and wider processes of social change. Science can inform decision makers and the interested public, but decisions as to actual modifications of a “business-as-usual” development path are made elsewhere. The success of the truly global process of knowledge generation and dissemination with respect to climate change does not guarantee that humankind will draw reasonable conclusions and implement adequate actions in time. Indeed, the fundamental question is whether humans as a species are capable of acting rationally and cooperatively in a long-term perspective—or whether short-term individualistic considerations multiplied a million times render cooperation impossible and make us collectively worse off.

Game theory has explored these questions and attempted to explain human behavior as well as to give clues on how to overcome blockade situations. The prisoners’ dilemma is a classic case where mutual cooperation would be beneficial but unilateral defection—or free riding—is a dominant strategy (Nash equilibrium), with everyone losing out as a result. Building trust among parties and establishing enforcement devices, such as international institutions with statutory powers, are ways of breaking out of this dilemma and realizing the best possible outcome. Design proposals for global climate architectures, such as the one by WBGU (2009) take these requirements into account and delineate a way forward, in which nation states surrender some of their national sovereignty to create new global institutions in exchange for an enforceable, time-consistent, worldwide climate protection scheme.

Concurrently, the solution of the climate change problem through successive decarbonization provokes and invokes deliberate veto players who follow very narrow interests and obstruct change for the sake of the vast majority of people on this planet, let alone future generations. These forces are real and powerful; they constitute a serious threat to responding to the climate challenge. The jury is still out as to who will ultimately have more leverage and whether the vast majority of humankind will stand together and act as one.

The globalization process of climate change science and international research cooperation gives grounds for the hope that taking coordinated action on a plane-

tary scale will ultimately be possible. Perhaps the globalization processes observed in science are indeed a precursor to a renewed understanding of humans as a community with much more that unites than divides us. With a sense of shared purpose and destiny, solving the climate challenge is well within our reach.

References

- A Copenhagen Prognosis (2009). *A Copenhagen Prognosis. Towards a Safe Climate Future*. S. Kartha, C. Kehler Siebert, R. Mathur, N. Nakicenovic, V. Ramanathan, J. Rockström, H.J. Schellnhuber, L. Srivastava, and R. Watt. Potsdam Institute for Climate Impact Research (PIK), Stockholm Environment Institute (SEI), The Energy and Resources Institute (TERI).
- Baer, P., G. Fieldman, T. Athanasiou, and S. Kartha (2008). Greenhouse Development Rights: Towards an Equitable Framework for Global Climate Policy. *Cambridge Review of International Affairs* 21(4), 649–666.
- Edenhofer, O., G. Luderer, C. Flachsland, and H.-M. Fussel (2008). *A Global Contract on Climate Change*. Potsdam: Potsdam Institute for Climate Impact Research. www.global-contract.eu/content/file/GlobalContract_Backgroundpaper.pdf.
- Edenhofer, O. and N. Stern (2009). *Towards a Global Green Recovery: Recommendations for Immediate G20 Action*. Potsdam: Potsdam Institute for Climate Impact Research. London: Grantham Research Institute on Climate Change and the Environment. http://www.pik-potsdam.de/members/edenh/publications-1/global-green-recovery_pik_lse.
- Frankel, J. A. (2008). *An Elaborated Proposal for Global Climate Policy Architecture: Specific Formulas and Emission Targets for All Countries in All Decades*. Discussion Paper 08-08. Boston: Harvard Project on International Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School. http://belfercenter.ksg.harvard.edu/publication/18597/elaborated_proposal_for_global_climate_policy_architecture.html.
- Höhne, N., M. den Elzen, and M. Weiß (2005). Common but Differentiated Convergence. In N. Höhne (Ed.), *Options for the Second Commitment Period of the Kyoto Protocol*. Cologne: ECOFYS GmbH.
- IPCC (2010). *Intergovernmental Panel on Climate Change: IPCC Statement on the Melting of Himalayan Glaciers*. Geneva, 20 January 2010. www.ipcc.ch/pdf/presentations/himalaya-statement-20january2010.pdf.
- Meyer, A. (2000). *Contraction and Convergence: The Global Solution to Climate Change*. Totnes, Devon: Green Books for the Schumacher Society.

- PNAS (2009). Tipping Elements in Earth Systems: Special Feature Issue. *Proceedings of the National Academy of Sciences of the United States of America* 106(49), 20551–21008.
- Rogers, E. M. (2003). *Diffusion of Innovations*. New York: Free Press.
- Scientific Expert Group on Climate Change (2007). *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*. R.M. Bierbaum, J.P. Holdren, M.C. MacCracken, R.H. Moss, P.H. Raven (Eds.). Research Triangle Park, N.C., and Washington, D.C.: Report for Sigma Xi and the United Nations Foundation.
- Stavins, R. N. (2008). A Meaningful U.S. Cap-and-Trade System to Address Climate Change. *Harvard Environmental Law Review* 32(2), 293–371.
- The Copenhagen Diagnosis (2009). *The Copenhagen Diagnosis. Updating the World on the Latest Climate Science*. I. Allison, N.L. Bindoff, R.A. Bindshadler, P.M. Cox, N. de Noblet, M.H. England, J.E. Francis, N. Gruber, A.M. Haywood, D.J. Karoly, G. Kaser, C. Le Quéré, T.M. Lenton, M.E. Mann, B.I. McNeil, A.J. Pitman, S. Rahmstorf, E. Rignot, H.J. Schellnhuber, S.H. Schneider, S.C. Sherwood, R.C.J. Somerville, K. Steffen, E.J. Steig, M. Visbeck, A.J. Weaver. Sydney, Australia: The University of New South Wales Climate Change Research Centre (CCRC). www.copenhagendiagnosis.com.
- Tsebelis, G. (2002). *Veto Players: How Political Institutions Work*. Princeton, NJ: Princeton University Press.
- United Nations (1988). *General Assembly Resolution 43/53: Protection of Global Climate for Present and Future Generations of Mankind*. Brussels: United Nations. www.un.org/documents/ga/res/43/a43r053.htm.
- Vanderheiden, S. (2008). *Atmospheric Justice: A Political Theory of Climate Change*. Oxford: Oxford University Press.
- WBGU (2009). *Solving the Climate Dilemma: The Budget Approach*. Special Report. Berlin: German Advisory Council on Global Change (WBGU). <http://www.wbgu.de/en/special-reports/sr-2009-budget-approach>.
- Wicke, L., H. J. Schellnhuber, and D. Klingenföeld (2010). *Die 2°max-Klimastrategie - ein Memorandum*. Münster: LIT.