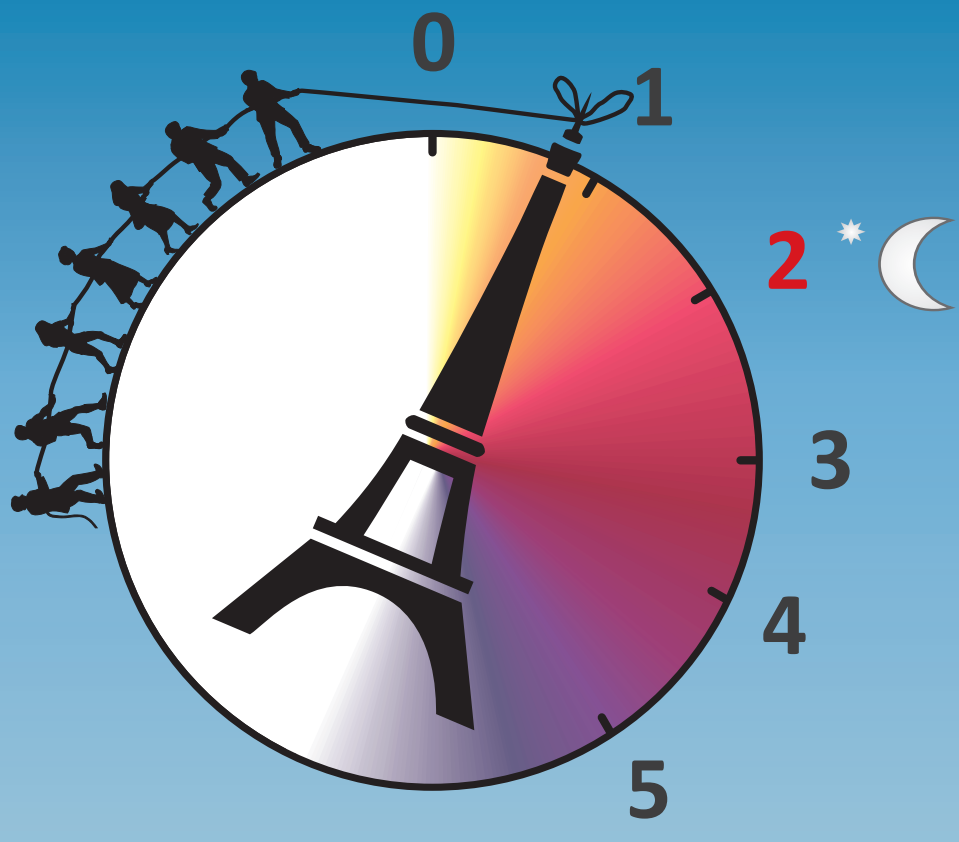
WBGU

German Advisory Council on Global Change

Special Report

Climate Protection as a World Citizen Movement



WBGU

German Advisory Council on Global Change

Special Report

Climate Protection as a World Citizen Movement

WBGU Council Members

Prof Hans Joachim Schellnhuber CBE (Co-chair)
Director of the Potsdam Institute for Climate Impact Research; Professor for Theoretical Physics at the University of Potsdam; External Professor at the Santa Fe Institute

Prof Dirk Messner (Co-chair)
Director of the German Development Institute (DIE), Bonn and Co-Director of the Center for Advanced Studies on Global Cooperation Research, University of Duisburg-Essen

Prof Frauke Kraas
Professor for Human Geography at the University of Cologne

Prof Claus Leggewie
Director of the Institute for Advanced Study in the Humanities, Essen (KWI) and Professor for Political Science, University of Gießen. Co-Director of the Center for Advanced Studies on Global Cooperation Research, University of Duisburg-Essen

Prof Peter Lemke
Professor of Physics of Atmosphere and Ocean, University of Bremen and Head of the Climate Sciences Division at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven

Prof Ellen Matthies
Professor for Enviromental Psychology, Otto-von-Guericke-University of Magdeburg

Prof Nebojsa Nakicenovic
Professor of Energy Economics at the Vienna University of Technology. Acting Deputy Director of the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria and Director of the Global Energy Assessment

Prof Sabine Schlacke
Professor of Public Law, Director of the Institute for Environmental Law and Planning Law, University of Münster

Prof Uwe Schneidewind
President and Chief Research Executive of the Wuppertal Institute for Climate, Environment and Energy as well as Professor for Sustainable Transition Management at the University of Wuppertal

WBGU

German Advisory Council on Global Change

Special Report

Climate Protection as a World Citizen Movement

The R&D project that generated this report was conducted on behalf of the German Federal Ministry of Education and Research and the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety under grant number 01RI0708A3. Responsibility for the content of this publication rests with the author.

ISBN 978-3-936191-43-1

Design: WERNERWERKE GbR, Berlin
Cover illustration: WBGU/PIK
Production: WBGU
Typesetting: WBGU
Printing and binding: AZ Druck und Datentechnik GmbH
Translation: Bob Culverhouse, Berlin

German Advisory Council on
Global Change (WBGU)
Secretariat
Luisenstraße 46
D-10117 Berlin

Phone: +49 (0)30 263948 0
Email: wbgu@wbgu.de
Internet: www.wbgu.de

Copy deadline: 18.07.2014

WBGU Staff

This Special Report would not have been possible without the excellent scientific and editorial work carried out by the WBGU office and the remarkable commitment of the speakers of the advisory boards.

Scientific Staff at the Secretariat

Dr Inge Paulini
(Secretary-General)

Dr Carsten Loose
(Deputy Secretary-General)

Dr Rüdiger Haum

Dr Astrid Ley

Dr Benno Pilardeaux
(Media and Public Relations)

Dr Astrid Schulz

Dr Kirsten Selbmann-Lobbedey

Dr Birgit Soete

Administration, Publishing and Secretariat

Martina Schneider-Kremer, MA
(Publishing and Event Management)

Mario Rinn, BSc (System Administration and Graphics)

Margot Weiß (Secretariat)

Vesna Karic-Fazlic (Accountant)

Scientific Staff to the Council Members

Dr Clara Brandi (German Development Institute – DIE, Bonn)

Dipl-Kfm Sebastian Busch (Vienna University of Technology)

Dr Carsten Butsch (Department of Geography, University of Cologne)

Frederic Hanusch, MA (Institute for Advanced Study in the Humanities – KWI, Essen)

Dr Melanie Jaeger-Erben (Otto-von-Guericke-University, Magdeburg)

Dipl-Jur Miriam Köster (Institute for Environmental Law and Planning Law, University of Münster)

Dipl-Phys Johannes Sutter (Alfred Wegener Institute, Bremerhaven)

Kira Vinke, MA (Potsdam Institute for Climate Impact Research)

Dipl-Psych Matthias Wanner (Wuppertal Institute for Climate, Environment and Energy)

Acknowledgments

WBGU wishes to thank all those who promoted the progress of this report through their comments and advice or by reviewing individual parts:

Britta Horstmann (German Development Institute – DIE, Bonn); Jennifer Morgan (World Resources Institute, Director Climate & Energy Program, Washington, DC); Hermann Ott (Wuppertal Institute for Climate, Environment and Energy); Pieter Pauw (German Development Institute – DIE, Bonn); Wolfgang Sterk (Wuppertal Institute for Climate, Environment and Energy); Lutz Weischer (Germanwatch e.V., Bonn).

The WBGU received valuable suggestions during the meeting with representatives of German climate science on 15 May 2014:

Dr Marie-Luise Beck, Dr Paul Becker and Prof Gernot Klepper, PhD (German Climate Consortium – DKK), Dr Susanne Kadner (IPCC Technical Support Unit of Working Group III), Dr Gudrun Rosenhagen (German Meteorological Society – DMG), Dr Christiane Textor (German IPCC Coordination Office – De-IPCC), Prof Dr Martin Visbeck (German Committee Future Earth), Vera Stercken (German Federal Ministry of Education and Research – BMBF).

The WBGU would like to thank Martin Wodinski (Potsdam Institute for Climate Impact Research – PIK) for his assistance with the graphics on the title page.

Contents

Boxes

Tables

Figures

Summary

The 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) makes it unmistakeably clear: unacceptable climatic impacts, which are likely to escalate beyond the 2 °C guard rail, can only be avoided if further increases in greenhouse gas concentrations are halted as soon as possible. The WBGU therefore recommends reducing CO_2 emissions from fossil fuels to zero by 2070 at the latest. This policy goal is both ambitious and incisive, because the zero target must be reached by every country, every municipality, every company and every citizen if the world as a whole is to become climate-neutral. However, the 2 °C line can only be held if a large proportion of actors – especially the OECD countries – start reducing their emissions much earlier. Global society as a whole has only a very limited carbon budget at its disposal; emissions should therefore peak by 2020 if possible, but certainly in the third decade at the latest. In this report the WBGU outlines a dual strategy for global climate protection based on interaction between multilateralism and civil society. To achieve this, on the one hand the Paris climate agreement targeted for late 2015 should exhibit certain characteristics set out by the WBGU. In particular, a process should be agreed to ensure compliance with the 2 °C guard rail. On the other hand, all civil-society actors should make their specific contributions towards decarbonization. In this way, an intricate responsibility architecture for the future of our planet can emerge in which vertical delegating and horizontal engagement are not contradictions, but complementary factors that reinforce each other.

The timely phasing out of fossil CO_2 emissions is absolutely essential

The conclusions of the IPCC's 5th Assessment Report are clear: climate change is taking place, and the influence of mankind is unequivocal. The evidence on global warming is overwhelming. Global temperatures could rise by more than 4 °C if greenhouse gas emissions continue unchecked up to the end of the century. Global warming of more than 2 °C already involves considerable risks, e.g. for food security, coastal regions, infrastructures and ecosystems. A global transformation towards a low-carbon society can be achieved without major consumption losses or huge costs for the global economy. Many studies even provide evidence of positive co-benefits of this transformation, for instance for health and energy security – in contrast to the humanitarian and economic losses to be expected if climate change continues unabated. Any further delay in the decarbonization of the world economy would make the required climate stabilization more difficult and considerably more expensive.

From the WBGU's point of view, it is therefore appropriate to make the 2 °C guard rail legally binding and to ensure compliance with it. This becomes possible if global greenhouse gas emissions peak – if possible by 2020, but certainly in the third decade of this century – and CO_2 emissions from fossil fuels are cut to zero by 2070 at the latest (the 'zero target'). In order not to exceed the global carbon budget, it is important that particularly the industrialized countries and emerging economies – and the upper and middle income groups worldwide – reduce their CO_2 emissions as quickly as possible.

Despite the ever-growing body of knowledge about climate change, and notwithstanding the increasingly attractive options for a transformation towards a low-carbon economy, emissions continue to rise almost unchecked worldwide. This suggests a dysfunctional responsibility architecture and barriers to action in global society that must be overcome. The refusal to enforce the required changes comes at the expense of future generations. Compliance with the 2 °C guard rail and a complete phasing out of emissions require both individual people and the community to take on responsibility.

The planned Paris climate agreement as a signpost

International climate protection within the framework of the United Nations remains indispensable, but it should be strengthened by civil society taking on responsibility. The collective assumption of responsibility should be operationalized in line with the following equity principles: the principle of equality, the precautionary principle and the polluter pays principle. The WBGU recommends that the Paris agreement should take the form of a legally binding protocol to the UNFCCC in which the 2 °C guard rail, based on the precautionary principle, is enshrined in international law. This should be fleshed out by agreeing a global zero target for fossil CO_2 emissions by 2070 at the latest.

The WBGU's budget approach offers an ideal orientation framework here, because it does justice both to the equality principle (equal emission rights within the budget for all people) and to the polluter pays principle (different responsibilities taking historical and current emissions into account). If many states are unable to comply with their national budgets for the 2 °C guard rail as a result of their historical responsibility and path dependencies, they should have to meet their responsibility through emissions trading, accelerating the spread of technology, or paying into technology and financing funds. A link can be made to existing mechanisms here.

In addition to this, the WBGU makes the following proposals for the Paris Protocol: (1) The scientific state of knowledge drawn up by the IPCC should be incorporated as a mandatory part of the negotiations. The transparency obligation and accountability towards the population, as well as the monitoring function of 'climate procurators', should be strengthened by improved participation (e.g. consultation, information and class action rights). This would contribute towards the democratization, acceptance and effectiveness of the Protocol. (2) Ambitious climate clubs – e.g. alliances of *Energiewende* countries and city networks – should be strengthened by mechanisms of the Protocol to promote incubators and climate-protection pioneers. In future, multilateral climate policy should take its orientation not from sluggish players, but from ambitious ones. China and the USA also seem to be becoming more open to a multilateral framework linked to a strengthening of pioneer alliances in the meantime. European players should use this window of opportunity to enshrine support for ambitious mitigation within the Protocol. (3) The WBGU recommends an ambitious pledge-and-review process whereby all member states commit themselves to submit self-selected targets for combating climate change up to 2030 and verifiable decarbonization roadmaps for reaching the zero target by 2070 at the latest. These are checked and enhanced by regular reviews conducted by UN institutions on the basis of binding measurement, reporting and verification mechanisms. (4) The industrialized countries should honour their pledges to mobilize US$100 billion every year from 2020 to support mitigation and adaptation in developing countries.

New momentum in climate protection

The collective responsibility called for by the WBGU has not been sufficiently embraced in the multilateral negotiations up to now. It is foreseeable that the Paris agreement alone will not be ambitious enough to ensure sufficient mitigation. However, the protection of Earth system services is essential for sustainable development. This is why a paradigm shift is needed in society and the economy. It is thus up to all actors – from individuals to businesses to nation states – to assume responsibility.

The WBGU uses both local and global examples to portray the range of instruments and initiatives, social movements, clubs and alliances with which attempts at climate protection are already being made. This is where the horizontal dimension of a responsibility architecture is forming, in which global civil society is taking on responsibility itself and supplementing the vertical delegation of responsibility to climate diplomacy. In this context, different initiatives can mutually reinforce each other and extend their impact to different actor levels. This world citizen movement increases the legitimation pressure on state actors in the international negotiation system and extends societies' horizon of values and standards.

This strengthens the democratically legitimized mandate of states for tasks that only they can take on: (1) promoting pioneers of climate protection, (2) translating self-commitments based on the Paris Protocol into concrete decarbonization roadmaps and monitoring their implementation, (3) honouring funding pledges and supporting global technology development. This ensures that arrangements agreed at the global level are implemented at the national and local levels.

Climate protection is a task for the whole of humankind and must be perceived and tackled as such. International climate policy and civil-society initiatives are not opposed to each other; rather, they can powerfully complement each other. A world citizen movement can show that climate protection in and with society can work and even generate economic benefits. This is the form of interaction in which global climate protection can and must succeed.

Introduction

Our knowledge of climate change, its causes and mainly dangerous impacts has expanded and deepened dramatically over the last few decades, while the number of climate-protection initiatives around the world has grown just as quickly. And yet, global greenhouse gas emissions continue to rise almost unabated. Solving this dilemma has become a key challenge for humankind.

There is a consensus in international climate diplomacy that global warming should be limited to a maximum of 2 °C. The aim should now be to enshrine this common goal in a comprehensive international agreement in December 2015 in Paris.

Expectations have been rather subdued, however, since the failure of the Copenhagen Climate Conference in 2009. Although some positive signals on climate policy have been coming from China, the USA and the EU recently, the question remains: How can a consensus be found between almost 200 states on an agreement that is both inclusive and ambitious?

Strong additional forces are therefore needed in the field of climate protection to urge the political decision-makers to act decisively and take complementary effective measures of their own. This special report therefore focuses on two main aspects and their interaction. *First*, the report investigates what strategic and operational elements a multilateral climate agreement should include if it is to have a realistic chance of having an impact big enough to overcome the stagnation of the past decade. *Second*, it highlights the rapidly growing importance of the contribution being made by civil-society alliances and actors and demonstrates this contribution using numerous examples.

In addition, the WBGU's study highlights the potential for progress that can grow from interactions between multilateral negotiations and civil-society activities. In this respect the report emphasizes the *common responsibility architecture* that should emerge after all the matching vertical and horizontal elements of climate protection have been pieced together.

Knowledge on anthropogenic climate change

1

The reports of the three Working Groups to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) were published in September 2013 and in March and April 2014; a Synthesis Report will follow in October 2014. Because of the size of the IPCC Assessment report (it has a total of several thousand pages), the WBGU follows the IPCC's suggestion and quotes the chapters of the report under the name of the respective lead author. In the following, the WBGU presents key, selected results from the report.

The report of Working Group I (IPCC, 2013a) deals with the physical science basis of climate change. Here, the WBGU emphasizes primarily the new findings since the IPCC's Fourth Assessment Report published in 2007 (IPCC, 2007a), and adds further topical research findings on climate change.

Working Group II's report (IPCC, 2014a) covers the vulnerability of socio-economic and natural systems to climate change and its impacts. Here, the WBGU highlights the issues that have particular potential to adversely affect natural life-support systems and pose a particularly serious risk to human societies.

The report of Working Group III (IPCC, 2014b) reveals political and technological climate-protection measures, and especially development pathways for stabilizing climate warming and achieving compliance with the 2 °C guard rail. The WBGU analyses these findings mainly in terms of their relevance to transformation and action. It then deduces from this the sectors and framework conditions that are necessary for the transformation to a low-carbon society and that help avoid path dependencies. Findings are also highlighted that are of particular importance for the planned Paris Climate Agreement and for climate-change initiatives in civil society. The scientific state of knowledge forms an indispensable foundation for decision-making under conditions of uncertainty.

While the IPCC's mission is to present policy-relevant findings without making policy recommendations, the WBGU has an explicit mandate to deduce policy recommendations from the scientific state of knowledge. After presenting the scientific state of knowledge, therefore, the WBGU formulates specific recommendations for policy-makers and shows possible forms of action that can be taken by civil-society.

1.1
Global warming is unequivocal: Observations of the climate system

There is no longer any doubt: the climate system is heating up. Observations of the atmosphere, oceans and ice reveal a progressive warming of the Earth, and the scale of some of the observed changes are without precedent in the past few decades or even millennia. The highest average temperatures for 1,400 years have been measured in the northern hemisphere in the 30 years between 1983 and 2012. The global mean surface temperature has risen by almost 0.9 °C since the end of the 19th century, and the Arctic sea ice continues to shrink drastically. Mountain glaciers and ice sheets are losing mass, and the rises in the mean ocean temperature and the sea level continue unabated (IPCC, 2013b). The snow cover of the northern continents is becoming smaller, and the frequency of temperature extremes is on the increase. The water cycle is intensifying, with the result that the wet areas of the Earth (the Tropics and middle latitudes) are receiving more precipitation, while the Earth's arid regions are becoming even drier.

Over time scales of between a few years and several decades, the trends in the climatic variables are superposed by short-term natural fluctuations in the climate system. These fluctuations are caused by interactions between the components of the climate system, which are characterized by feedback mechanisms. For example, global air temperatures are currently rising more slowly than in the nineteen-nineties. Nevertheless, the long-term trend of global warming – with globally rising atmospheric and ocean temperatures and melting polar ice masses – is unequivocal.

While the ongoing climatic trend compared to the Fourth IPCC Assessment Report is documented by many climatic variables, there are also some special features within the warming of the atmosphere and oceans and the melting of the ice. These differences and special features are explained in the following sections.

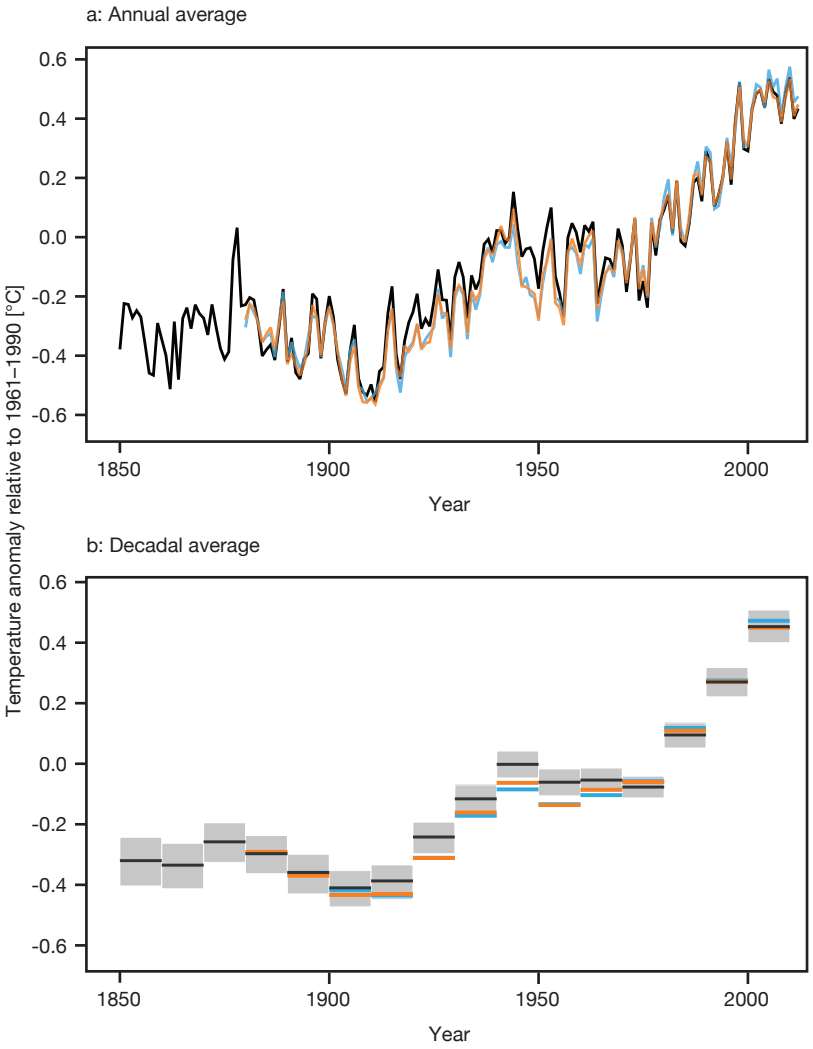


Figure 1.1-1
Observed development of the global surface temperature between 1850 and 2012 from three different data series. (A) Annual mean values, (b) Decadal mean values. The diagram shows anomalies relative to the mean of 1961-1990.
Source: IPCC, 2013b

1.1.1 Warming of the atmosphere

Between 1971 and 2010 the Earth climate system absorbed about 274x10^{21}J of additional energy. 93% of this went into the warming of the oceans, 3% into the melting of the ice and 3% into the warming of the continents. Only 1% remained for the warming of the atmosphere. The trend, i.e. the rate of energy absorption over the forty years, amounted to 213 terawatts (TW). Between 1993 and 2010 the trend was larger and came to 275 TW (Rhein et al., 2013). This corresponds to almost twenty times humanity's average energy use.

Despite the atmosphere' comparatively low level of energy absorption, global mean surface temperatures have risen by almost 0.9°C since the end of the 19th century (Hartmann et al., 2013). Each of the last three decades was warmer than any previous decade; 2001-2010 was the warmest decade for at least 1,400 years (Figure 1.1-1).

The global temperature trend is subject to considerable variability due to natural internal fluctuations in the climate system, caused for example by such phenomena as El Niño/Southern Oscillation (ENSO) or the Pacific Decadal Oscillation (PDO). This internal variability of the climate system is able to strengthen, weaken or even reverse the long-term climate trend for short periods of time. Such variations are often found in observations, but climate models can also simulate such cases. However, the models cannot predict the precise timing of such variations on a time scale of a few years.

The observations show that warming over the last 15 years was only half that of the previous 15 years. However, it must be emphasized that a trend over 15 years is not significant in climatological terms, especially if it is highly dependent on the beginning of the time period over which it is calculated. The trend for 1995-2009 amounts to 0.13°C per decade, the one for 1996-2010 is calculated at 0.14°C per decade. The result for 1997-2011 is 0.07°C per decade and for 1998-2012 only 0.05°C per decade.

This weaker rate of warming is an expression of natural climate fluctuations, which direct the additional heat generated by the increased greenhouse effect into other climate components such as the ocean or the ice masses. Further factors suggested include a minimum in the 11-year solar cycle and the effect of minor volcanic eruptions (Flato et al., 2013).

It can be concluded from the observations that the heat content of the ocean continues to rise, the ice

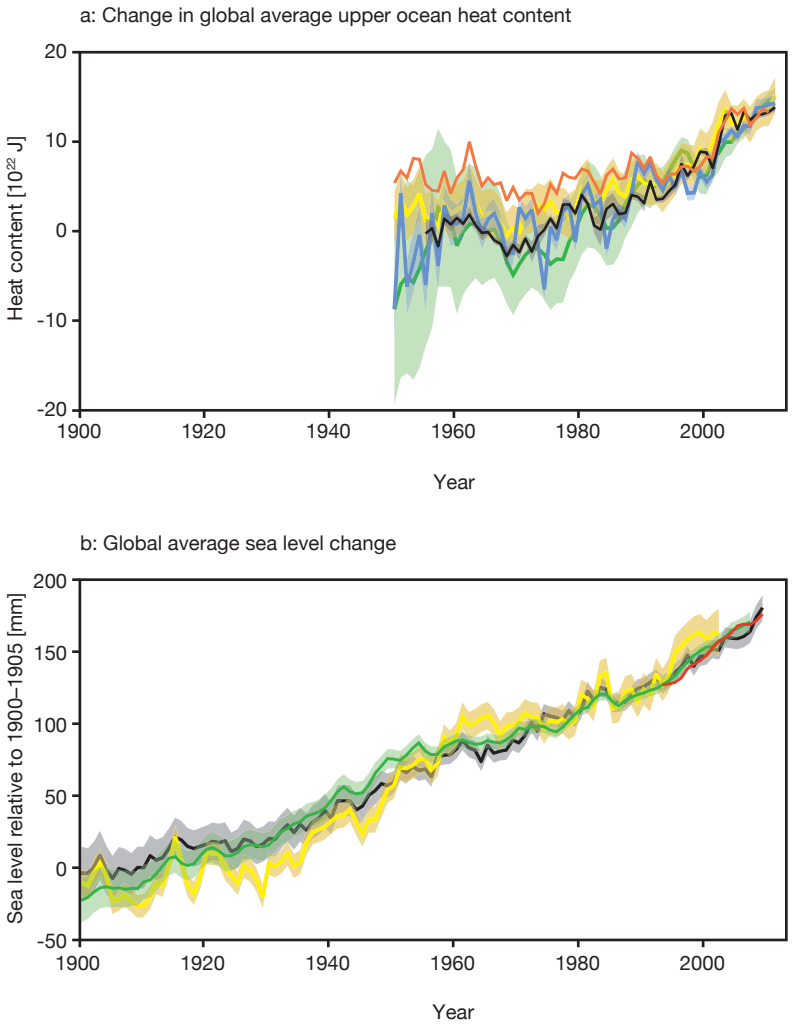


Figure 1.1-2
(a) Change in global average upper-ocean (0-700m) heat content relative to the average for 1970. (b) Global mean sea-level relative to the 1900-1905 mean. The different colours describe different data sets. The annual average, and, where available, areas of uncertainty (shaded areas) are shown in each case.
Source: IPCC, 2013b

masses on the continents are melting, and the sea level is rising as a result, currently at a rate of 3.2 mm per year, corresponding to 32 cm per century. According to the IPCC's assessment, therefore, one cannot speak of a pause in the warming process.

1.1.2 Warming of the ocean

The global energy balance is decisively influenced by the heat capacity of the oceans. Only in recent years have technological developments made it possible to determine the heat content of the ocean and how it is changing. Over the past 30 years, approximately 93% of the additional radiation energy caused by the increased greenhouse effect has been absorbed by the seas. As a result, the ocean has warmed up, especially at the surface. Since the 1970s, the top 75 metres of the ocean have warmed by about 0.11°C per decade (IPCC, 2013b: Figure 1.1-2). At greater depths, warming is not proceeding evenly because the water column in the oceans is highly stratified. Although warming has reached all depths in the meantime, its effect declines at greater depths. The trend is 0.04°C per decade at a depth of 200 m and 0.02°C per decade at 500 m.

Between 1993 and 2010, the thermal expansion of the seas as a result of this energy input led to an average rise in the sea level of about 1.1 mm per year (Rhein et al., 2013). This corresponds to one-third of the total rise in sea levels. Much of the remaining increase is due to the change in mass of the glaciers and ice sheets. The mean rise in the sea level since 1993 amounts to approx. 3.2 mm per year; this is twice the mean trend for the 20th century.

1.1.3 Ocean acidification

Another important role of the oceans in the climate system is their capacity to absorb CO_2 from the atmosphere. The CO_2 content of the seas is about fifty times higher than that of the atmosphere (Rhein et al., 2013). Small variations in the ocean's absorption of CO_2 can exert a major influence on concentrations of CO_2 in the atmosphere. The absorption of CO_2 from the atmosphere changes the chemical balance of the sea water. When the concentration of dissolved CO_2 rises, this leads to the formation of carbonic acid (H_2CO_3), which emits

hydrogen ions (protons) into the water column; this in turn leads to a reduction in the pH value. This process is termed ocean acidification. The average pH value of the oceans varies between 7.8 and 8.4; they are thus slightly alkaline. Increased absorption of CO_2 leads to a gradual acidification. Since the beginning of the Industrial Revolution, the pH value of the oceans has fallen by 0.1, i.e. the ocean has become markedly more acidic. A critical by-product of ocean acidification is the reduction in calcium carbonate saturation ($CaCO_3$). Aragonite, a form of calcium carbonate, is essential for exoskeleton formation in many marine organisms. Rising ocean acidification, coming in addition to the rising temperature and oxygen depletion of surface waters, could become another critical stressor threatening the biodiversity of the seas. In some countries, fish is the most important supplier of animal protein, and fisheries are an essential component of the economic system (WBGU, 2013). Coral reefs, which are particularly threatened by acidification, also represent an important source of revenue for the tourism industry. Although research into the possible consequences of ocean acidification for the ecosystems of the seas is still in its infancy, considerable problems must be feared if current trends remain constant or even intensify (WBGU, 2006, 2013).

1.1.4 Melting of the ice masses

The cryosphere comprises the areas of the Earth that are covered by snow and ice. A large proportion of the world's freshwater resources is stored here, for example in mountain glaciers, the ice sheets of Greenland and the Antarctic, and the permafrost of the Northern Tundra. Because snow and ice reflect more solar radiation than open ocean or land surfaces, the cryosphere acts as a natural counterbalance to the warming of the Earth's surface, since cold air is generated over its surfaces as a result of the lower level of energy absorption. Losses of parts of the cryosphere due to melting lead to positive feedback processes, causing an acceleration of climate change. This is why the regions of the Earth that are dominated by snow and ice react sensitively to climate warming.

Changes in the continental ice masses have a direct influence on the sea level, and mountain glaciers in many regions of the lower and middle latitudes represent an important source of drinking water and agricultural irrigation systems.

The new assessment of the contribution of glacier melt to sea-level rise has not changed substantially compared to the IPCC's Fourth Assessment Report (IPCC, 2007) and remains at 0.8 mm per year. Until recently, melt water from the largest mountain glaciers have contributed most to the increase in the sea level. According to the new estimate, the contribution of the two ice sheets of Greenland and the Antarctic is now greater than that of the glaciers: 1.0 mm of sea-level rise per year for the six years from 2005 to 2010.

The Northern Hemisphere's snow cover in March and April has receded by 1.6% per decade since the middle of the 20th century; the permafrost temperatures have also risen further, as already noted in the Fourth IPCC Assessment Report, by up to 3 °C since the mid-1980s in northern Alaska. These assessments have existed since the Fourth IPCC Assessment Report. By contrast, the Fifth IPCC Assessment Report also registers major changes in the sea ice and the two ice sheets. These are described in the following.

1.1.4.1 Sea ice, contrary trends at the two poles

Sea ice plays an integral role in the climate system. Changes in sea-ice cover in the polar regions have a whole series of knock-on effects on the regional and global climate. The high reflectivity of the sea ice means that a large proportion of incoming solar radiation is reflected, and when the ocean surface is covered by ice it is shielded from the atmosphere, leading to a corresponding reduction in both the exchange of heat and the substance input into the water column (e.g. CO_2 input). The formation and melting of sea ice changes the salinity of the underlying water layers. This can lead to changes in the circulation of ocean currents. In addition, the sea ice is a key component of the polar ecosystem, which, because it is adapted to the extreme conditions, reacts very sensitively to disturbances.

Data sets of the polar sea-ice cover with high temporal resolution have been available since the beginning of satellite-based measurements in 1973. The dynamics of ice cover are subject to large natural seasonal fluctuations. The average sea-ice cover in the Arctic fluctuates between 6 million km^2 in summer and 15 million km^2 in the winter months. Since 1979, the average extent of Arctic sea-ice cover has decreased by 3.8% per decade, with the strongest decline of 11.5% taking place in the summer months (Vaughan et al., 2013; Figure 1.1-3). This decline exceeds earlier model predictions. If the trend continues, a simple extrapolation suggests the sea surface will be completely ice-free during the Arctic summer by the early second half of this century, with far-reaching consequences for the eco- and climate system and the economic usability of the region.

In contrast to the Arctic sea ice, the Antarctic sea ice is growing slightly. The natural seasonal variability of the sea-ice cover is more pronounced in Antarctic waters and varies between a minimum ice cover of approx. 3 million km^2 in February and a maximum coverage of 18 million km^2 in September. The development of sea-ice cover since 1979 shows a positive trend on average with a growth rate of approx. 1.5% per decade (Comiso and Nishio, 2008). The increase in the areas covered by sea ice in the Antarctic can most probably be explained by increased sea-ice production in near-shore polynyas (Comiso et al., 2011) and an increase in the westerly wind circulation in the peripheral areas of the sea ice. Observations also show strong regional differences in these trends.

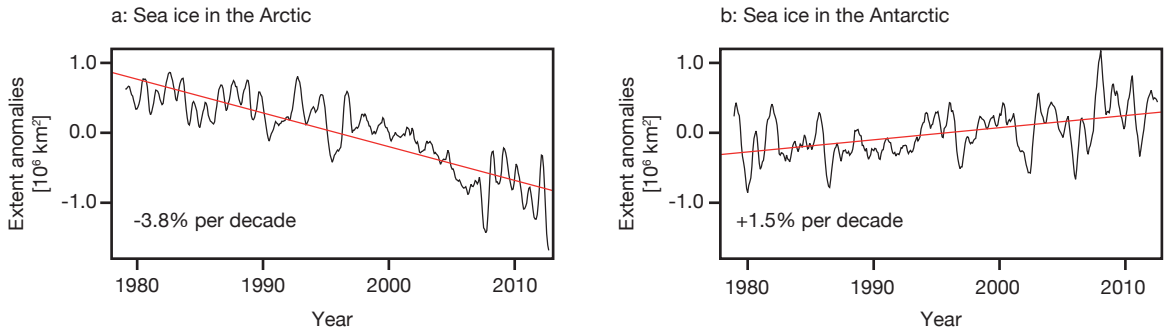


Figure 1.1-3
Change in the extent of sea-ice cover in the Arctic (a) and the Antarctic (b) between 1979 and 2012.
Source: Vaughan et al., 2013

1.1.4.2 The Greenland and Antarctic ice sheets

The massive Greenland and Antarctic ice sheets are highly sensitive components of the climate system. The strong acceleration in the flow speed of a large proportion of the Greenland glaciers, calving events like the collapse of the Antarctic Larsen B ice shelf in 2002, and the growing contribution of the ice sheets to sea-level rise speak a clear language: the polar ice sheets are adjusting to climate change. Since the Fourth IPCC Assessment Report, both the quality of data and the physical understanding of the dynamics of the ice sheets have improved significantly. As a result of the global warming trend, especially during the last few decades, the contribution of the ice sheets to sea-level rise has grown and now, together with thermal expansion and glacier melt, constitutes the largest component at 1.0 mm per year. A comparison between the estimates in the Fourth IPCC Assessment Report and measurements made between 2005 and 2010 (Vaughan et al., 2013) shows that Greenland's contribution (0.6 mm per year) has tripled and that of the Antarctic has doubled to 0.4 mm per year (Figure 1.1-4).

The possibility of rapid mass losses in the West Antarctic and Greenland remains worrying, should climate warming continue. In the medium term, this could lead to a much greater rise in sea levels. Positive feedback processes – e.g. the reduction in the albedo caused by melting ice, the expansion of the melt areas as a result of a decline in the ice surface, and the loss of ice shelves in the Antarctic leading to an acceleration of the glaciers behind them – could significantly increase the current loss rates.

1.1.5 Sea-level rise

Since the end of the last Ice Age 20,000 years ago, the sea level has risen by approximately 120 metres; it stabilized 2,000 to 3,000 years ago and then remained almost constant until 1900. During this period of a constant sea level, human settlements developed on the coasts, and there are now very many major cities there.

The sea level began rising again in 1900, and it has risen globally by about 17 cm over 100 years. Water-gauge measurements and satellite observations currently point to a global rise in the sea level of 3.2 mm per year.

Sea-level rise is caused by the inflow of water from the continents and the warming of the sea water, causing it to expand. In some regions, ocean currents and vertical movements of landmasses are also important. One example is the rise of Scandinavia, which began 20,000 years ago when, after the last Ice Age, the melting of the great ice sheet relieved the land of considerable weight.

The IPCC's Fifth Assessment Report (IPCC 2013b; Rhein et al., 2013) measured a sea-level rise at 3.2 mm per year for the period from 1993 to 2010. 1.1 mm per year of this total stemmed from thermal expansion, a figure deduced from temperature measurements in the ocean. Meltwater contributions come from mountain glaciers (0.8 mm per year) and the two major ice sheets in Greenland (0.3 mm per year) and the Antarctic (0.3 mm per year). Losses from water reservoirs on the continents raise the sea level by a further 0.4 mm per year. This makes it possible to explain the observed sea-level rise within the error bars by the individual contributions of ocean warming, continental reservoirs, glaciers and ice sheets (Church et al., 2013). The ice-mass losses increased between 2005 and 2010: in Greenland by up to 0.6 mm per year and in Antarctica by up to 0.4 mm per year (Vaughan et al., 2013). Expectations on the future sea-level rise are discussed in Section 1.5.

1.2 Capabilities and limits of climate models and scenarios

Climate models integrate the basic physical equations of the climate system on the basis of prescribed initial conditions and simulate climate fluctuations over a chosen period of time (which can range from a few months to many centuries). For this they need boundary conditions that can change over time: e.g. the seasonal changes in solar irradiation, or dust emissions into the atmosphere

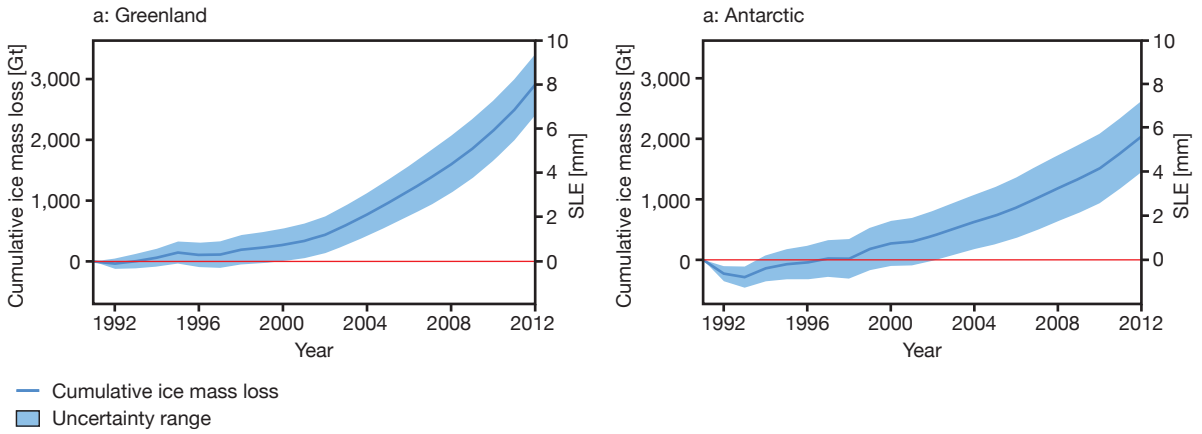


Figure 1.1-4
Cumulative ice-mass losses in Greenland (a) and the Antarctic (b) since 1992 and the corresponding contribution to sea-level rise (SLE). A comparison of the last two decades shows that Greenland's average contribution to sea-level rise has tripled and that of the Antarctic has doubled. This trend will continue unless the trend in global warming is reversed.
Source: Vaughan et al., 2013

after volcanic eruptions. Figures must also be given for anthropogenic emissions of greenhouse gases and aerosols as a result of land-use changes, cement production, and especially the use of fossil fuels. As far as the past is concerned, these figures are quite well known from the extraction, sale and production of fossil fuels. For scenarios of the future, a consistent set of emissions, concentrations and radiative forcings must be provided to enable the different climate models to calculate mutually comparable climate scenarios. This task is carried out by integrated assessment models (IAMs), which link socio-economic and technical developments with the use of fossil fuels in order to determine consistent figures for greenhouse gas and aerosol emissions, atmospheric concentrations and radiative forcings. Unlike the new scenarios (representative concentration pathways or RCPs), which were used in the IPCC's Fifth Assessment Report, the scenarios developed for the Third Assessment Report (SRES) did not take mitigation strategies into account.

1.2.1 Climate and Earth-system models

Climate models are complex computer programs that apply the current knowledge about the physics of the eco- and climate system. They are based on physical natural laws and simulate the interactions between the atmosphere, the oceans, land surfaces, snow and ice, the biosphere and various chemical and biological processes. The climate models have become much more complex since the IPCC's first climate report was published in 1990. Furthermore, the great improvements in computing power today mean that many processes can be resolved and described in much greater spatial detail.

Compared to the Fourth IPCC Assessment Report, most of the climate models in the Fifth IPCC Assessment Report have been expanded into full Earth-system models which not only contain an improved representation of the physics of the climate system, but also describe the global carbon and sulphur cycles and can thus simulate important biological and chemical processes. The new Earth-system models therefore provide a greatly extended description of the eco- and climate system. But have they also improved? This can only be decided by comparing their results with observations.

Systematic comparisons of simulations carried out by different climate models with observations in the Coupled Model Intercomparison Project (CMIP) have shown continuous improvements in model quality in the description of variations in temperature and precipitation patterns from the CIMIP2 models (2000) to the CMIP3 models (2005) and the present-generation CMIP5. These comparisons show that the models have not only become more complex and provide a more complete description of the eco- and climate system, but that they also actually provide a better simulation of reality (Flato et al., 2013). In addition to the marked increase in computing power, the main reasons for this improvement in the model systems are the new observation systems and analytical methods of climate research, which have led to a better understanding of the climate system.

Climate models can only be tested against observations, i.e. past climatic situations. Likewise, in the case of seasonal forecasts it is impossible to determine whether nature and model agree until after the forecast period. Such a comparison is impossible for long-term projections, especially of the human impact on the climate over decades and centuries. In this context, scientists assume that a good description of the past also simulates the essential processes for the future. In contrast to weather-forecasting models, the focus in climate models is on averages, their trends and the variability of the climatic variables, not on their value at a certain point in time.

The limits of climate models lie in particular in the simulation of clouds, which exert an influence on the Earth's radiation balance and water cycle which is dif-

ficult to describe because of the clouds' diversity and their fast-changing and complex shape. Regional characteristics of the more or less global CO_2 signal are a major challenge. This requires an improved understanding of regional processes, which in turn depends on new observation systems and models that are currently at the centre of national and international climate research.

Although they are not perfect, climate models are certainly some of our society's best tools for projecting certain aspects of the future. As such, they represent a sound basis for decision-making processes.

1.2.2 Integrated assessment models

Scenarios for limiting and mitigating climate change are primarily developed by large-scale integrated assessment models (IAMs), which are able to quantitatively describe major driving forces of greenhouse gas emissions and their long-term effects on the climate, even beyond the middle of the century. In addition, the models can describe transformation pathways, and in some cases also adaptation strategies. In order to cover all the emission sources of CO_2 and other greenhouse gases and radiatively active substances, IAMs usually include representations of the most important sectors of human activities (e.g. the economy, energy, transport, buildings, land use) and the interactions that exist between them. These sectors, especially the energy sector, are often represented 'bottom-up', which opens up many technology options and thus conversion and transformation pathways. One specific strength of IAMs, therefore, is that many transformation indicators are internal variables of the model, making it possible to show interactions and flexibilities across sectors and over long periods of time. In most cases, important physical processes of the Earth system that are relevant to climate change (e.g. the carbon cycle, radiative forcing) are also represented, at least in a rudimentary form.

The main application of these models lies in analysing transformation pathways that lead to a long-term stabilization of anthropogenic climate change, but also in studying future developments without mitigation. A recent refinement in the process of generating scenarios in this context is to embed qualitative assumptions into narrative storylines. This achieves an improved and more consistent formulation of scenario drivers that cannot be modelled with quantitative methods. It also helps with the interpretation of model results. Examples of such fundamental drivers include future cultural developments or changes in values (lifestyles).

IAMs are highly aggregated modelling frameworks. Abstracting from details allows them to represent the complex relationships between different sectors in a systematic way. Global models usually consist of about a dozen world regions, and they capture (physical) systems such as the climate system in a very stylized manner. This is why important model results, such as emissions or land-use activities, are often passed on as inputs into other specialized models, such as Earth-system and climate models, to study their influences in greater detail.

Generally, the IAMs are driven by the requirement of economic cost minimization, or multicriteria minimization, which can be represented by different target functions, but basically always has the effect that, for example, the total costs of emissions mitigation are minimized, taking into account any given constraints. The underlying assumption that justifies such a 'social planner's' perspective is that the markets are fully competitive, and that there are no information asymmetries between players, so the result would be an optimum allocation of resources. Since these conditions are often only partially met in reality, the model results should be seen more as an orientation. Ultimately, the aggregated decision-making is partly a result of numerical restrictions used to make it possible to solve the models at all. However, imperfect conditions and structural breaks can be shown indirectly by calibrating the model data.

In order to be able to interpret the model results, generally a large number of policy scenarios is developed; these are then contrasted with a reference case. The weaknesses of IAMs lie in the high degree of aggregation and the difficulty of representing a limited rationality of the decision-makers, or strategic behaviour by actors. A further limitation is that most models often implicitly assume perfect foresight. Recursive-dynamic models are a further development; they take new decisions at each point in time on the basis of the information that is then available. In spite of these shortcomings, IAMs are today an indispensable component of climate research for evaluating and understanding mitigation and adaptation strategies.

1.2.3 Emission scenarios

Future emissions will depend on economic, social and political trends. However, these cannot be predicted, but are determined by decisions that have not yet been taken. Emission scenarios therefore comprise a wide range of assumptions on the future development of humankind, from which different emission pathways are deduced; these, in turn, form the basis for projections on the future development of the climate and for adaptation and mitigation strategies (Section 1.5; Figure 1.2-1).

The IPCC Special Report on Emission Scenarios (SRES; IPCC, 2000) uses 40 alternative scenarios which differ in terms of their assumptions on the further development of global society. The 40 scenarios are based on a comprehensive literature review and designed to depict most of the variations in their underlying drivers (e.g. demography, economic and technological developments) and also in the scenario results (such as greenhouse gas emissions and other substances relevant to the climate). This

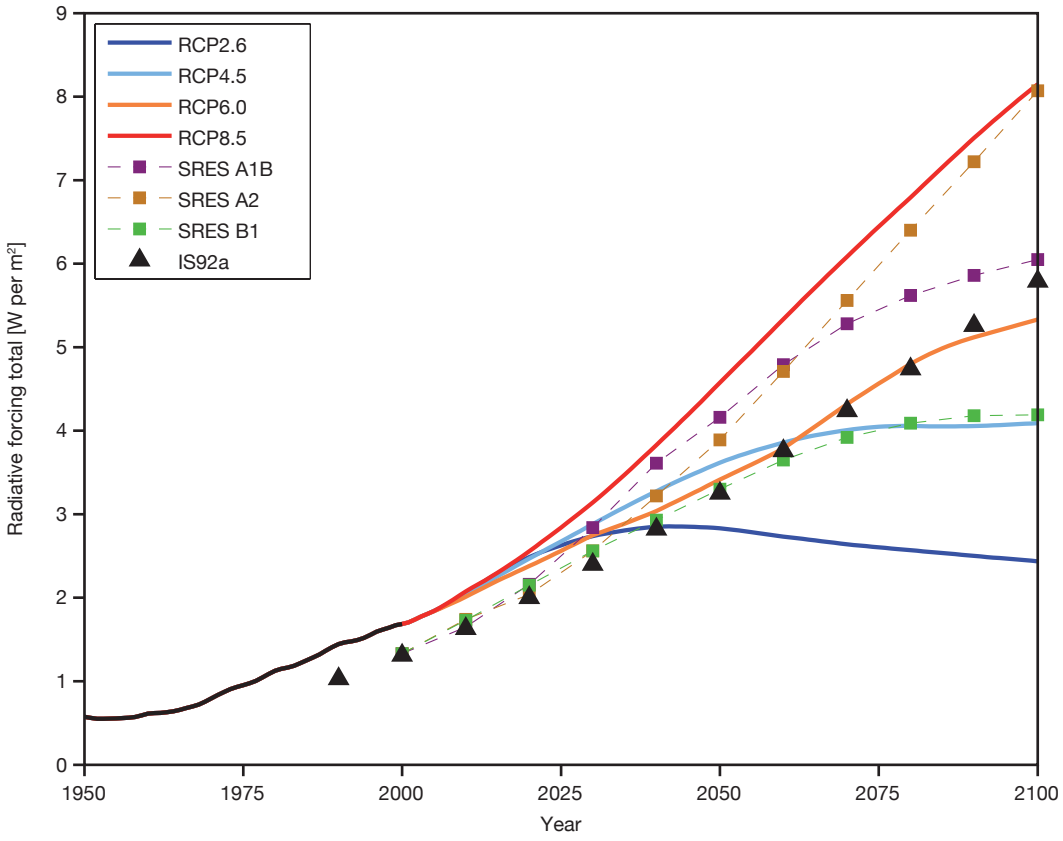


Figure 1.2-1
Old and new scenarios for the period 1950–2100. The diagram shows total anthropogenic radiative forcing (W/m^2) – both historical and projected for the different scenarios – relative to 1765 (pre-industrial). The IS92a scenario stems from the Second IPCC Assessment Report; scenarios SRES A1B, A2 and B1 were used in the Third and Fourth IPCC Assessment Reports. The scenarios marked RCP were developed for the Fifth IPCC Assessment Report. The scenarios differ, for example in the radiative forcing for the year 2000: the later scenarios take into account more recent findings on emissions in this period.
Source: Cubasch et al., 2013

was an innovation at the time, since before then most scenarios had focused only on CO_2, while the SRES scenarios also took into account all sources of CO_2 and other Kyoto gases such as CFCs, HFCs and sulphur aerosols. The authors also introduced a number of other innovations to develop the scenarios. The most important one related to the development of four narratives, which helped improve the interpretation and consistency of the scenarios. However, the SRES scenarios did not contain any mitigation measures or policies, as required by the IPCC at that time. As a first step, the resulting emissions of all relevant substances were integrated into the climate models in the form of four so-called 'Marker SRES scenarios'. The resulting climate projections were analysed in a large-scale Coupled Model Intercomparison Project (CMIP) and also analysed in detail in the Third (IPCC, 2001), Fourth (IPCC, 2007a) and to a lesser extent also in the Fifth IPCC Assessment Report (2013a). The scenarios and climate projections were used in turn by Working Group II to assess possible climate impacts and vulnerabilities. The SRES scenarios from the Third IPCC Assessment Report are still often used.

A new scenario-development process was initiated in 2006 with the aim of creating a new ensemble of scenarios. These are now called 'representative concentration pathways' (RCPs) and 'shared socio-economic pathways' (SSPs) and were used in the IPCC's Fifth Assessment Report (Figure 1.2-1). Unlike in the SRES process, these scenarios were not developed by the IPCC, but independently by the scientific community with the IPCC's support. Proceeding on the basis of predefined radiative forcings at the end of the 21st century (RCPs were named according to these radiative forcings of 2.6, 4.5, 6.0 and 8.5 W per m^2), IAMs were used in close cooperation with climate and impact modellers to develop possible ranges and trajectories of radiative forcings, as well as the associated developments of greenhouse gas emissions and chemical concentrations in the atmosphere. The development process was characterized by a 'parallel' approach: in a similar way as in the case of the 'marker SRES scenarios', the climate and Earth-system modellers were given the RCP emission pathways so that they could start work in parallel while other groups continued developing the socio-economic drivers. Four RCPs were made available for this purpose, and the climate projections in the Fifth IPCC Assessment Report are based on these scenarios. All RCPs are stabilization scenarios – the lowest complies with the 2 °C

guardrail (RCP2.6) with a probability of 66%, while the highest shows warming of more than 4 °C above pre-industrial levels (RCP8.5) by the end of the 21st century.

Parallel to this, 'shared socio-economic pathways' (SSPs) were developed with the help of integrated assessment models to deduce the driving forces for the analyses of Working Groups II and III. The results of this work were also published in the Fifth IPCC Assessment Report. It is to be expected that a large number of global and regional scenarios will emerge here that are consistent with the new RCPs.

1.3 The human impact on the climate is evident: Understanding recent changes

Direct measurements and analyses of climate archives and geological findings clearly show that climate changes take place naturally on all time scales, and that long-term changes are typically characterized by larger deviations. Changes can occur as a result of both external stimuli and internal interactions in the climate system. A typical internally generated form of variability can be seen for example in the El Niño phenomenon and in the Pacific Decadal Oscillation, both of which generate specific geographical and temporal patterns in the climate fluctuations. External stimuli include changes in the brightness of the sun (caused by sunspots), changes in the parameters of the Earth's orbit (orbital eccentricity, tilt and precession of the Earth's axis) and volcanic eruptions. These natural external stimuli have left clear traces during the history of the climate – from the ice ages to periods of short-term cooling caused by dust ejected during volcanic eruptions.

Ever since the beginning of industrialization, humankind has been impacting on the climate (mainly through CO_2 emissions, which can also be regarded as an external stimulus), adding a distinct anthropogenic contribution to natural climate changes. But how can this anthropogenic contribution be distinguished from the natural climate changes, which continue to occur? And how can it be quantified?

Every individual external stimulus, be it natural or anthropogenic, generates a specific response in the climate system. However, this is not simply superimposed over the internal variability, it also changes it, making it more difficult to attribute a cause to an observed change in the climate. This process of attributing causes is carried out by means of targeted climate-model experiments. To this purpose, the models must be good at describing both internal variability and the climate's response to external stimuli. A large number of model experiments have shown that the present-day generation of climate models is well-suited to the task of attributing certain causes to observed climate changes.

In the past few years, model experiments have been used to study the climate system's response patterns to different individual external stimuli, thus determining their *fingerprint* in the climate system. A comparison of these experiments clearly shows that the warming observed over the past 50 years cannot be explained either by internal variability or by natural external stimuli, but only by the increase in the concentration of CO_2 in the atmosphere generated by anthropogenic emissions (Figure 1.3-1). This also leads to the statement in the Fifth IPCC Assessment Report that it is extremely likely (> 95% probability) that more than half of the observed increase in the Earth's global mean surface temperature from 1951 to 2010 came about as a result of human activities.

The general question here is how sensitive the climate is to a change in the balance between the absorbed solar irradiance and the dissipation of heat from the Earth into space? Climate sensitivity is often defined as the change in the Earth's surface temperature associated with a doubling of the CO_2 concentration after equilibrium has been reached. According to new, sounder assessments by the IPCC (Collins et al., 2013), the figure lies between 1.5 and 4.5 °C, with a probability of more than 66%. The lower value has been reduced from 2.0 to 1.5 °C compared to the Fourth IPCC Assessment Report; the upper value is still the same. However, equilibrium sensitivity has only limited informative value, because the Earth is never in such a state of equilibrium. More important is the 'transient climate response' to disturbances in the radiation balance. This is defined by the simulated average annual global temperature when double the CO_2 concentration is reached after rising linearly for 70 years. This figure lies between 1.0 and 2.5 °C with a probability of more than 66%.

1.4 CO_2 from fossil fuels – the core of the climate problem

The IPCC's Fifth Assessment Report makes it clear that anthropogenic climate change can only be stopped by reducing net emissions of CO_2 to zero. In this context, the scale of climate change is largely determined by the total amount of CO_2 emitted by humanity.

1.4.1 The role of CO_2

Today, the atmospheric concentration of CO_2 is about 400 ppm; this is significantly higher than at any time during the whole of human history. Before industrialization it ranged between 180 ppm in cold periods and 300 ppm in warm periods (Ciais et al., 2013). Since the beginning of industrialization, i.e. between 1750 and 2011, a total of about 2,000 Gt of CO_2 has been released as a result of the use of fossil fuels and changes in land use; about 900 Gt is still in the atmosphere. The rest of the emitted CO_2 was absorbed partly by the terrestrial biosphere and partly by the oceans, where the input of CO_2

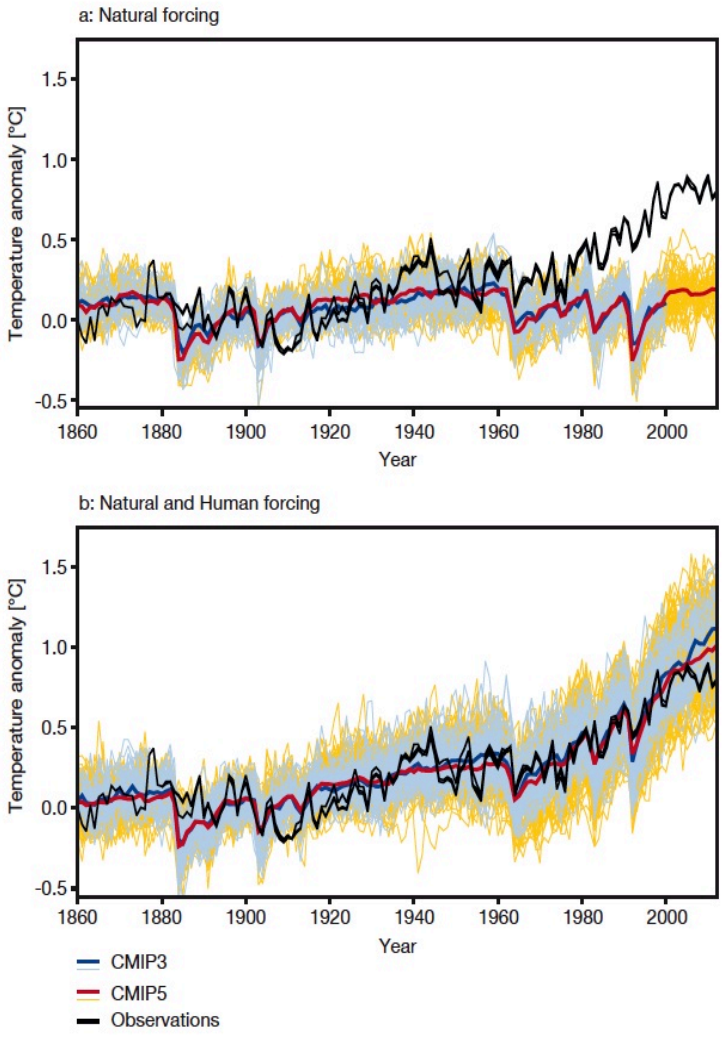


Figure 1.3-1
Time series of the global mean surface temperature between 1860 and 2010 (black line) compared to model results (coloured lines and areas of uncertainty). The upper panel (a) shows results from models driven by only natural forcings. The models in the lower panel (b) were driven by both natural forcing and human-induced changes in greenhouse gases and aerosols. It becomes clear that only models that take all impacting factors into consideration arrive at a realistic temperature development.
Source: Bindoff et al., 2013

has already led to a noticeable fall of 0.1 units in the pH value (ocean acidification, Section 1.1.3). The anthropogenic emissions have been unequivocally identified as the cause of the increase in atmospheric CO_2, e.g. by the parallel decline in the concentration of atmospheric oxygen, which is clearly measurable and is being caused by the combustion of the fossil fuels. CO_2 accumulates in the atmosphere. Even after a period of a thousand years, a considerable proportion of the emitted CO_2 will still be in the atmosphere. Depending on the total amount of emissions, the portion of the emitted CO_2 remaining in the atmosphere might be between 15 and 40%. If CO_2 emissions are eliminated completely, the warming that has taken place up to this point in time will remain for several centuries. In terms of human time scales, therefore, a considerable proportion of climate change is irreversible, unless CO_2 can be extracted from the atmosphere on a large scale. However, this is only possible to an extremely limited extent (Section 1.8.3; WBGU, 2010a). The results compiled in the IPCC's Fifth Assessment Report show that the extent of anthropogenic warming essentially depends on the total amount of CO_2 emitted and not so much on the exact timing of the emissions (Figure 1.4-1). In order to keep global warming below 2 °C with a probability of more than 66%, a total of only about 1,000 Gt of CO_2 may be emitted from anthropogenic sources as from 2011 (IPCC, 2013b). This already takes into account the fact that other greenhouse gases also contribute to climate change.

Currently, about 15% of anthropogenic CO_2 emissions stem from changes in land use (Clarke et al., 2014). The (relative) importance of CO_2 emissions from land-use changes is declining sharply at present, however, primarily because of the considerable increase in emissions from the use of fossil fuels (Figure 1.4-2). The main problem for the global climate is therefore CO_2 emissions from fossil fuels.

According to the IPCC's analyses, global CO_2 emissions from fossil sources in the emission scenarios that remain below 2 °C in 2050 are about 50% lower on average than the emissions measured in 1990; they decline to (round or below) zero in the second half of the 21st century. The earlier the CO_2 emissions are lowered, the less 'negative emissions' will be necessary, i.e. the active absorption of CO_2 from the atmosphere and its storage, a process that has not yet been commercially proven. The WBGU recommends halting global CO_2 emissions from fossil sources completely by 2070 at the latest in order to have a realistic chance of limiting global warming to 2 °C compared to pre-industrial levels (WBGU, 2014).

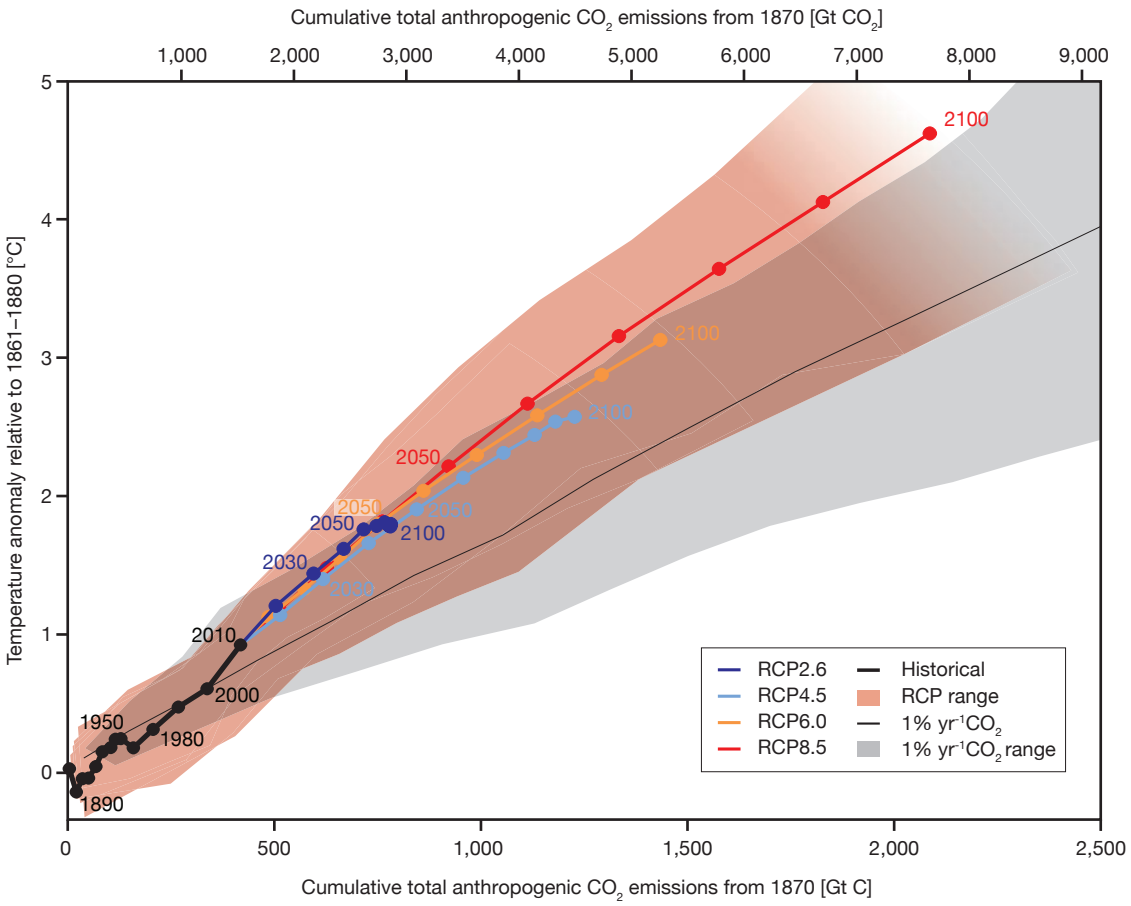


Figure 1.4-1
Global mean surface temperature increase as a function of cumulative CO_2 emissions. The chart summarizes results from various models. Depending on the scenario, certain figures are reached for cumulative emissions at different times (coloured bold lines and dots; the highlighted area shows the variance in the model results and scenarios). In these scenarios the effects of other greenhouse gases on the temperature are also taken into account. The thin black line with the grey-shaded area indicating the spread shows the extent of warming if no other greenhouse gases, i.e. only CO_2, were emitted; an increase in CO_2 of 1% per annum was assumed.
Source: IPCC, 2013b

The above scenarios also take the emissions of other long-lived greenhouse gases and radiatively active substances into account, although these contribute much less to climate change (Section 1.4.2).

1.4.2 Other climate-relevant gases and substances

Other greenhouse gases and radiatively active substances apart from CO_2 are also important for the development of the climate. They include, for example, gases listed in the Kyoto Protocol like methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFC), hydrofluorocarbons (HFC), sulphur hexafluoride (SF_6), as well as nitrogen trifluoride (NF_3) which was added for the second commitment period under the Kyoto Protocol. These gases are often considered together with CO_2, but they differ in terms of their behaviour in the atmosphere. Unlike CO_2, both methane (CH_4) and nitrous oxide (N_2O) belong to the chemically reactive greenhouse gases, which decompose in the atmosphere (Kirtman et al., 2013). The ozone-depleting chlorine and bromine compounds, e.g. CFCs, also contribute to climate warming. Their concentration in the atmosphere is already declining as a result of the regulations of the Montreal Protocol.

The role of short-lived substances in global climate protection has been under discussion for some time now; apart from CH_4, they include, for example, tropospheric ozone (which originates from precursor gases like nitrogen oxides or incompletely combusted carbon compounds) and aerosols (e.g. soot particles, organic carbon compounds, sulphate aerosols). The precise climate impact of many of these substances is scientifically controversial, as is their importance for mitigation (David et al., 2014). While tropospheric ozone causes warming, aerosols have an cooling effect overall; this is made up of a warming effect caused by soot particles and a cooling effect caused by other particles such as sulphate aerosols (IPCC, 2013b: 13).

A comparison of the different radiatively active substances is not easy, since they behave differently in the atmosphere and also have different effects on the climate. The greenhouse warming potential (GWP) is used to compare greenhouse gases regulated under the Kyoto Protocol; it compares the average radia-

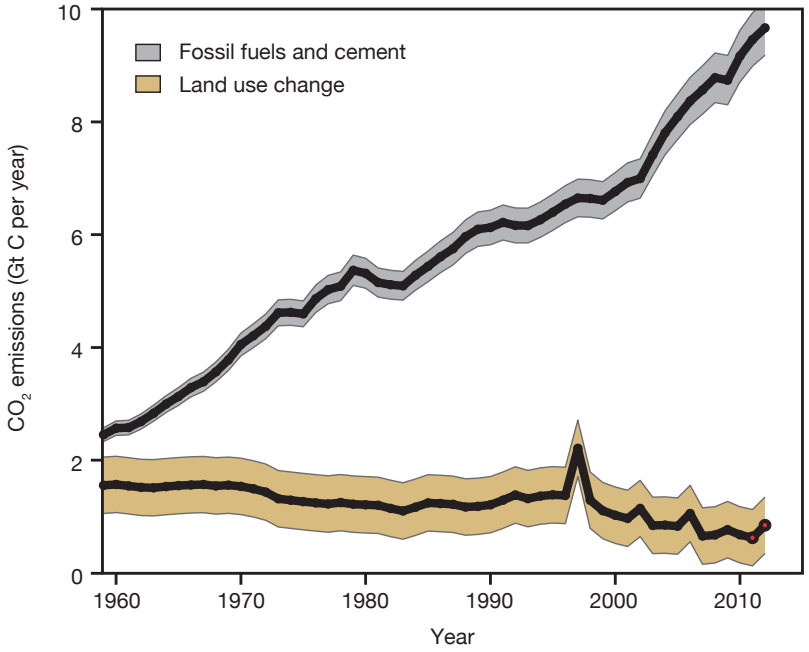


Figure 1.4-2
Land-use emissions and CO_2 emissions from fossil fuels according to the Global Carbon Project. The CO_2 emissions are shown in terms of GtC per year; 1 GtC corresponds to 3.67 Gt of CO_2.
Source: Le Quéré et al., 2013

tive effect of other greenhouse gases with that of CO_2 over a certain period. The total amounts of these greenhouse gases are shown on this basis as CO_2 equivalents (CO_2eq). Figure 1.4-3 shows the development of emissions of the different greenhouse gases that have been calculated with a GWP over 100 years. The global emission trend is dominated by CO_2, which comes from the energy sector (primarily from electricity generation) and the transport sector.

If a different time period is chosen, the relative contributions of the different gases shift significantly. For example, in 2010 CH_4 made up 16% global greenhouse gas emissions using a GWP over 100 years; over a shorter timescale of 20 years, however, it was 42%, and only 7% in the long term (500 years). The Kyoto Protocol uses a period of 100 years for GWP; this has no scientific justification, but was negotiated at the political level (David et al., 2014).

Due to their very short lifespan, the attribution of a 100-year greenhouse warming potential to aerosols and other very short-lived substances would not make sense. These substances do not accumulate in the atmosphere either. Their concentrations therefore vary considerably from region to region and fluctuate over time; they are not determined by historic emissions, but almost exclusively by emissions in the very recent past.

It is therefore by no means irrelevant for mitigation which greenhouse gases or radiatively active substances are reduced. Whereas the reduction of short-lived greenhouse gases, such as CH_4 or aerosols, has a primarily short-term impact on the climate, the long-term temperature development is dominated by the emissions of long-lived gases. The relative importance for global climate protection of different measures to reduce radiatively active substances ultimately depends on what target is pursued. For example, Bowerman et al. (2013) argue that, with a view to the 2 °C guard rail, reducing short-lived greenhouse gases is only of major importance at a point in time when the emissions of long-lived greenhouse gases are already falling. Although an immediate reduction in emissions of short-lived radiatively active substances – compared to the reduction in a future decade – could lengthen the time window for adaptive measures by weakening short-term global warming, it would not extend the time window for the necessary reduction in CO_2 (Bowerman et al., 2013).

1.5 The future development of the climate depends very much on humanity's actions

A relatively warm, stable climate has been benefiting the development of human civilization for over 10,000 years. Technological achievements have given humankind the ability to shape and manipulate the world both to their advantage and to their disadvantage. The massive use of fossil energy sources has had the effect that the CO_2 concentration in the atmosphere is now higher than it has been for several million years. As a result, more than half of the warming of the past 50 years is attributed to the rising CO_2 concentration.

Because of the immense inertia of the climate system in general – and the ocean in particular – and the fact that the rise in temperature is almost linearly dependent on the total amount of CO_2 emitted to date, warming will persist even if CO_2 emissions are immediately halted

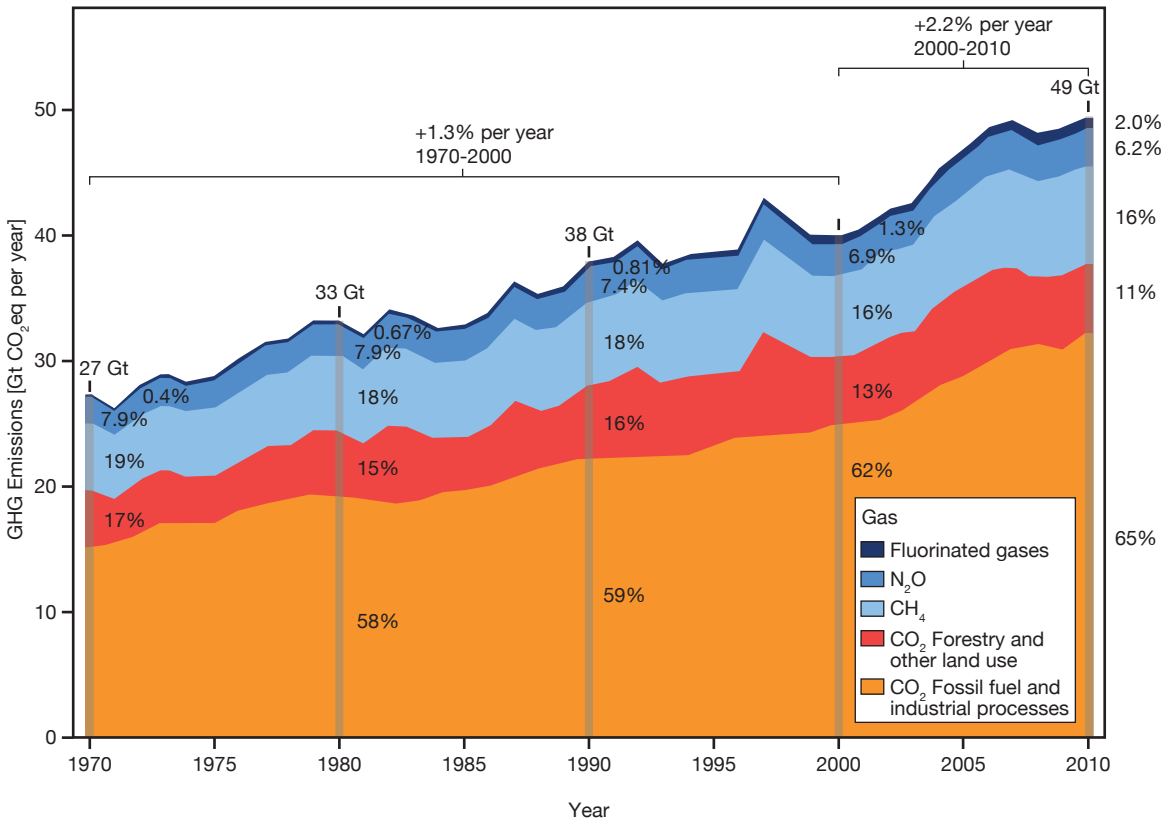


Figure 1.4-3
Total annual emissions of greenhouse gases listed in the Kyoto Protocol between 1970 and 2010. The emissions were converted to CO_2 equivalents (CO_2eq).
Source: IPCC, 2014d

all over the world. In such a situation, the temperature would remain approximately constant at the higher level for several centuries. The sea level would continue to rise for several centuries due to the ocean's great thermal inertia (IPCC, 2013b).

The future development of the climate will depend crucially on the will of the international community to drastically reduce CO_2 emissions.

1.5.1 Representative concentration pathways (RCPs) – a glimpse into the future

Projections into the future have always been subject to great uncertainty. Models designed to depict the climate dynamics of the next 100 years require assessments of socio-economic, technological and ecological developments that are as precise as possible. The future dynamics of climate change will be dominated by the development of greenhouse gas emissions, which is a function of a complex system of societal, political and economic processes (technological developments can also play an important role here, but are difficult to forecast). Representative concentration pathways (RCPs; Section 1.2.3), on which the IPCC's current climate projections are based, map possible greenhouse gas emissions up to the year 2100 (IPCC 2013a; Meinshausen et al., 2011; van Vuuren et al., 2011). The next two sections describe the most extreme scenarios RCP2.6 and RCP8.5 and what consequences they would have for the climate.

1.5.1.1 RCP2.6: Ambitious climate policies – negative emissions

In emissions scenario RCP2.6 (also called RCP 3PD, peak and decline), greenhouse gas emissions peak before 2030 and then fall continuously. Under this scenario, the temperature would rise by an average of 1 °C relative to the 1985-2005 average, or by 1.6 °C compared to pre-industrial levels (Figure 1.5-1; Collins et al., 2013), and in this way limit the longer-term damage due to climate change. The extent of the summer sea ice in the Arctic would shrink to about 3 million km² – i.e. to about half of today's figure – and the sea level would rise by about 40 cm compared to the 1985-2005 average (Figure 1.5-2, 1.5-3).

This scenario assumes that immediate measures will be taken to reduce greenhouse gas emissions and that an ambitious global climate policy will be pursued. In the second half of the century, many models show net negative emissions – i.e. the active removal of CO_2 from the atmosphere – in order to reach this scenario. The WBGU discusses this technical option in Section 1.8.3.

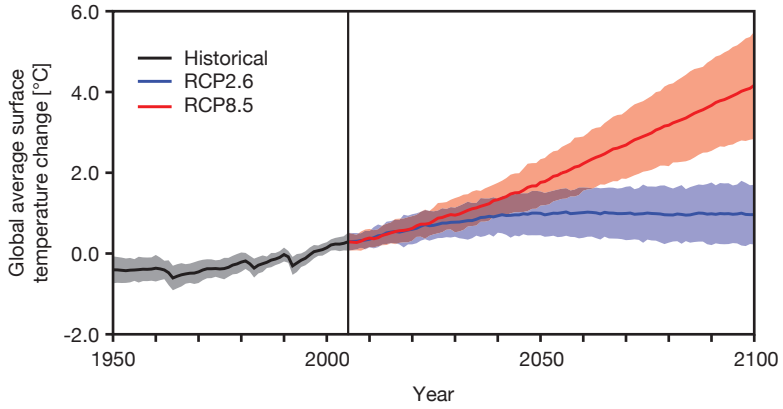


Figure 1.5-1
Model simulations of the change in the global annual mean surface temperature relative to the reference period 1986-2005. Approximately 0.61 °C must be added to the figures on the temperature scale to obtain the temperature change relative to pre-industrial levels. Shaded areas show the uncertainty range. Source: IPCC, 2013b, slightly changed

1.5.1.2 RCP8.5: The road to climate disaster – business as usual

RCP8.5 is based on the assumption that the current rate of increase in greenhouse gas emissions will continue, combined with population growth at the upper end of the UN projections (12 billion by 2100). A comparison of global greenhouse gas emissions since the publication of the RCPs shows that we are at the top end of this scenario. If this trajectory continues, it is highly likely (greater than 66%) that the global surface temperature will rise on average by more than 4 °C by 2100 (Figure 1.5-1). Because of the bigger rise in temperatures over the continents and polar amplification in the Northern Hemisphere, this could lead to regional increases in the average temperature of 6-10 °C. The Arctic Ocean would be ice-free in summer (Figure 1.5-2). The realization of this scenario would most likely lead to considerable risks for most of humanity. The rise in the sea level would average 63 cm in this century; weather extremes would be frequent, and non-linearities would lead the climate system into irreversible states (e.g. monsoon, ice sheets, permafrost, ocean circulation, ocean acidification; Section 1.5.2).

1.5.2 Potential instabilities of the climate system – the risk of triggering non-linear processes

Should climate warming continue beyond 2 °C, non-linear processes could trigger large-scale, irreversible changes in the climate system within a few decades. Such highly non-linear responses by system components are often referred to as 'tipping points' or 'tipping elements' of the climate system (WBGU, 2008; Lenton et al., 2008; Figure 1.5-4). They could have substantial effects on the natural life-support systems of a large proportion of the human race. Although many of these processes are not well understood at present, their risk potential demands that they be examined in greater detail.

Weakening of the North Atlantic Current

The thermohaline circulation spans the entire globe and transports energy in the form of heat into the North Atlantic. It is driven by temperature and salt concentration gradients and could be weakened or even stopped by increased freshwater influx due to climate warming. The model studies summarized in the Fifth IPCC Assessment Report confirm the estimates of the previous report on the potential weakening of the North Atlantic Current. A moderate degree of climate warming (RCP2.6) would cause it to weaken by 11% (1-24%). If CO_2 emissions continue rising unchecked, a weakening of 34% (12-54%) must be expected (Collins et al., 2013). A complete collapse is highly unlikely in the 21st century. However, this possibility cannot be ruled out in subsequent centuries, should humankind continue to emit greenhouse gases at the same rate. The consequences of such a collapse are difficult to assess. It is possible that the cooling of northern Europe that the collapse would cause could be largely offset by the warming of the atmosphere. A large-scale weakening, let alone collapse of the North Atlantic Current would most likely cause a considerable deterioration in living conditions in the North Atlantic region (WBGU, 2008).

Instability of the polar ice sheets

An accelerated decline in the size of the Greenland and Antarctic polar ice sheets can already be observed. An increasing climate change could speed this process up further – with potentially far-reaching consequences for sea-level rise, the regional ecosystems and the thermohaline circulation. A breaching of the 2 °C guard rail could lead to an irreversible decline in the Greenland Ice Sheet (e.g. Robinson et al., 2012). Even if such a dramatic decline is not expected in the course of the 21st century, positive feedback processes could lead to an almost complete disintegration of the massive Greenland Ice Sheet within a few centuries. This would cause a rise in the sea level of several metres (the complete melting of the Greenland Ice Sheet would raise the sea level by approximately 7 metres). The picture is different in the Southern Hemisphere. Climate warming is transporting more moisture to the Antarctic ice sheet, leading to an accumulation of snow on the surface. Nevertheless, the Antarctic ice sheet is also shrinking, caused by the melting of the surrounding ice shelves, which in turn accelerates the glaciers and ice flows. 'Marine ice sheet instability' (Schoof, 2007) could lead to an irreversible

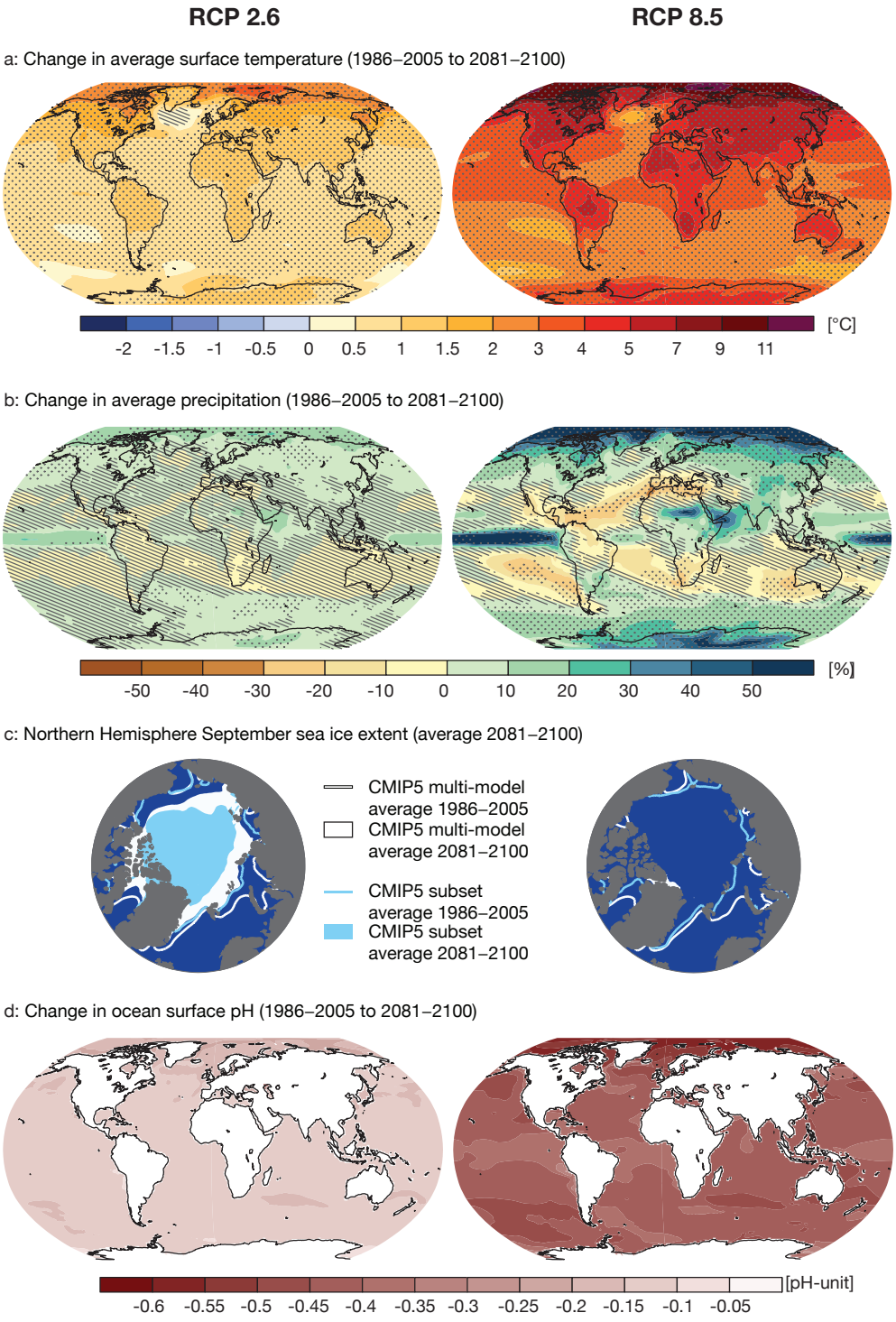


Figure 1.5-2
Model simulations for (a) the annual mean surface temperature change, (b) the average percentage change in annual mean precipitation, (c) the Northern Hemisphere September sea ice extent, and (d) the change in the ocean-surface pH. The simulations are based on the scenarios RCP2.6 and RCP8.5. With the exception of panel (c), the changes are shown for 2081–2100 relative to 1986–2005. In charts (a) and (b), hatching indicates regions where the changes in the multi-model mean are small compared to natural internal variability (i.e. less than one standard deviation in 20-year means). Stippling indicates regions where the changes determined by the models are large compared to natural internal variability (i.e. greater than two standard deviations in 20-year means) and where at least 90% of the models agree on the sign of the change. In panel (c) the lines show the extent of the ice cover for the period from 1986 to 2005; the filled areas show the extent of the ice cover for the end of the century. For further details see Stocker et al. (2013).
Source: Stocker et al., 2013

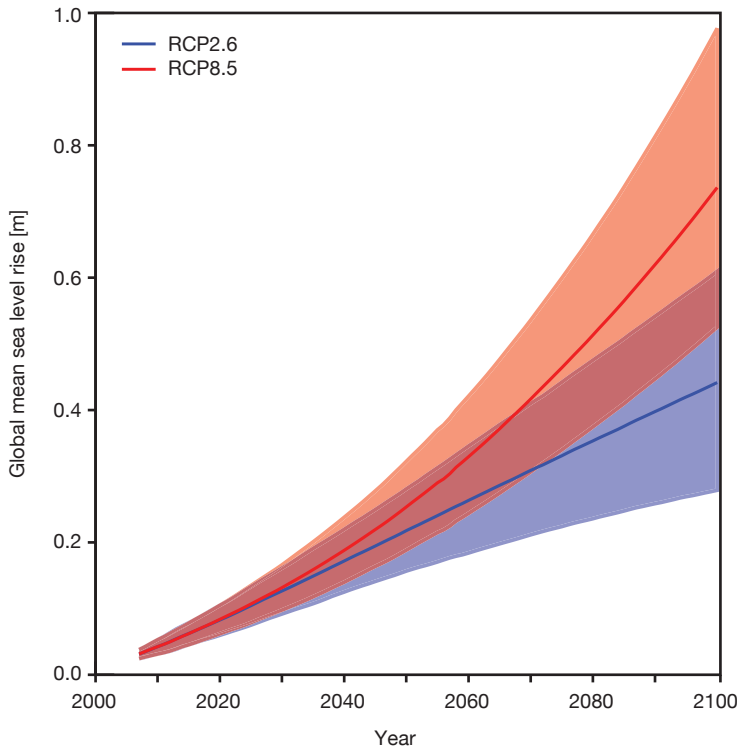


Figure 1.5-3
Projections of the global mean sea-level rise during the 21st century relative to 1986–2005. The simulations are based on the scenarios RCP2.6 (blue) and RCP8.5 (red). The assessed likely range is shown as a shaded band.
Source: IPCC, 2013b, slightly changed

disintegration of large areas of the West Antarctic and parts of the East Antarctic. The latest research (Joughin et al, 2014) indicates that parts of the West Antarctic ice sheet have already reached a stage of irreversibility and are possibly heading for collapse. This process, which is fortunately extremely lengthy (several centuries to millennia), could be accelerated by uncontrolled climate warming and also impact on the Greenland ice sheet.

Disappearance of the Arctic sea-ice cover in summer

In the case of the Arctic sea ice, the transition to a new state already seems to be emerging, with drastic consequences for the highly specialized ecosystem that is adapted to the sea ice. Projections on the shrinkage of the summer sea-ice cover in the Arctic range from 43% (RCP2.6) to 94% (RCP8.5), with potentially far-reaching consequences for the Arctic's economic viability, as well as for its vulnerability (Collins et al., 2013). The size of the Arctic sea ice could be reduced by half in the summer months even if a highly ambitious climate policy were implemented, keeping climate warming below 2 °C (RCP2.6; Section 1.5.1). This demonstrates to what extent the face of the Earth will change as a result of the burning of fossil fuels in the past. The continuation of an emissions-intensive economy would lead to the complete disappearance of the Arctic sea ice in the summer months and thus to a profound, unpredictable change in a large-scale ecosystem. The disappearance of the Arctic sea-ice cover is not irreversible by definition, because a sufficient fall in Arctic surface temperatures would lead to a return of sea-ice cover within a few years. However, such a drop in temperature would require an extreme reduction in atmospheric greenhouse gas concentrations within a short period of time. This is neither technically possible (at least at the present time), nor could it be achieved by the natural carbon cycle. In the case of the Arctic, serious upheavals in the ecological and climate system can already be expected by the end of this century.

Change in the monsoon circulation

Studies using conceptual models have shown that the Indian summer monsoon can take place in two stable states: a wet state with much rainfall and a drier one with little precipitation. These studies have also shown that disturbances in the radiation balance that reduce the air-pressure difference between the land and the sea could lead to abrupt changes in the monsoon.
Many studies using complex coupled climate models show an increase in precipitation in the summer monsoon if greenhouse gas emissions increase. Other studies show that anthropogenic aerosols have the opposite effect and weaken the monsoon. For these reasons, the IPCC's Fifth Assessment Report regards an abrupt transition of the monsoon to a dry phase as unlikely (Christensen et al., 2013).

Ocean acidification

About 30% of CO_2 from fossil fuels is absorbed by the ocean and leads to a decline its pH value (ocean acidification; Section 1.1.3). Since CO_2 remains in the atmosphere for many centuries, such a process is irreversible over civilizational time scales and could – in interaction with rising ocean temperatures, oxygen depletion, overfishing, and other stressors – have disastrous consequences for marine ecosystems and thus for the oceans as an economic region. If CO_2 emissions continue to rise (RCP8.5), this would intensify the process of ocean

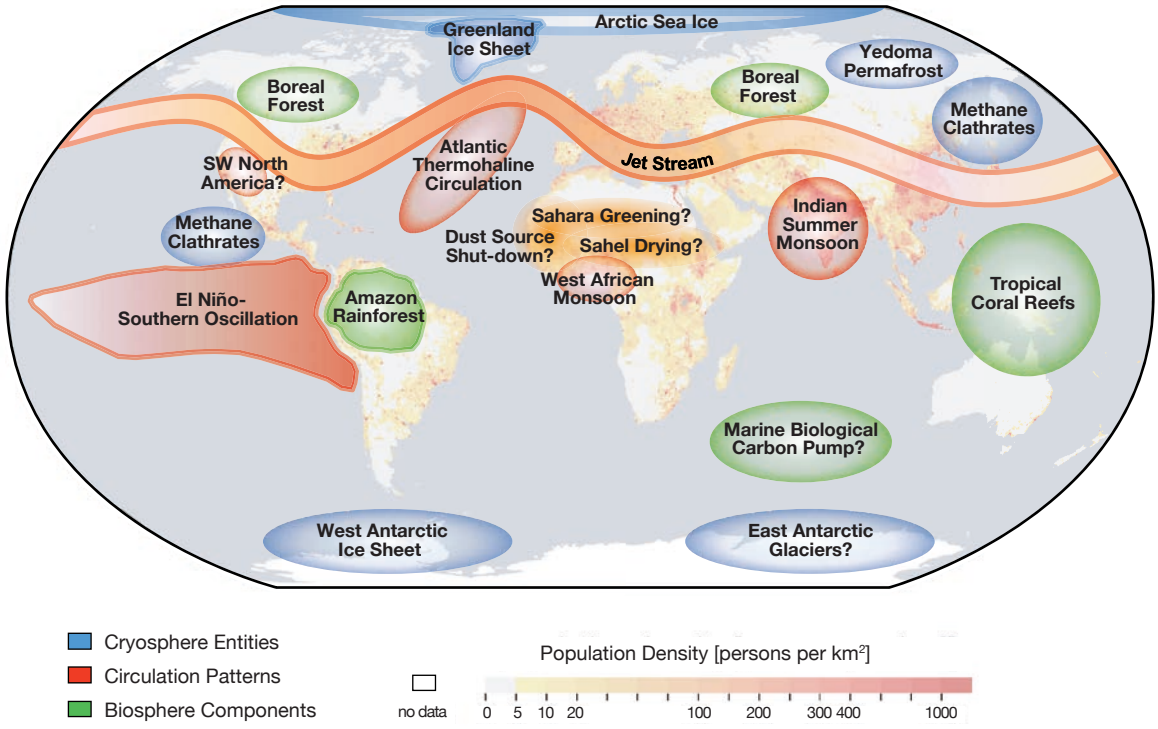


Figure 1.5-4
Potential instabilities (tipping elements) in the climate system and population density. The subsystems shown could exhibit non-linear behaviour in response to anthropogenic climate changes, where a small perturbation near a threshold leads to qualitative changes in the future development of the system. Question marks indicate systems whose status as tipping elements is particularly uncertain.
Source: Schellnhuber, pers. comm., based on Lenton et al., 2008

acidification by about 170% relative to pre-industrial levels by the end of this century (Ciais et al., 2013). In some areas of the world's oceans (especially in the Arctic and the Antarctic) there would already be an undersaturation of calcium carbonate (calcite, aragonite) within a few decades in surface waters.

1.6 Observed impacts of climate change

Climate change is not only expected to have an impact on natural and human systems in the future; in fact impacts can already be observed today on all continents and across the oceans (Cramer et al., 2014). In particular, warming, shifts in precipitation patterns and ocean acidification are having impacts that are already measurable today. The Fifth IPCC Assessment Report shows very clearly that climate change is an increasingly important factor in many natural and human systems, although it can be superposed by many other natural and societal factors impacting at the same time. Attributing these observed impacts to climate change is correspondingly difficult, but such attributions are increasingly being made, even when other factors like pollution or land-use change are exerting an influence at the same time.

Human systems

Knowledge on observed climate impacts on human systems has grown considerably since the time of the Fourth IPCC Assessment Report (IPCC, 2007b). In agriculture, climate-induced impacts have been proven on many agricultural products that are of great importance for food security and the world economy. For example, decreases in output have already been documented for wheat and maize – in many regions and in terms of the global total – while the negative effects on rice and soya are smaller. Extreme weather events such as heavy rainfall or heat waves are on the increase and can damage or destroy crop harvests. By contrast, the positive fertilizing effects of anthropogenically elevated CO_2 concentrations are having only little influence on trends in total agricultural production.

Measurable impacts of climate change on indigenous peoples can already be observed in several regions. This is the most visible in the Arctic, where climate change is having a very negative impact on livelihoods (e.g. with regard to hunting, food security, traditional migration routes and cultural values). The links between climate change and migration, security, poverty, living and working conditions and economic growth are increasingly becoming the subject of scientific studies. However, attributing the impacts to climate change as a factor is difficult to prove; there is therefore still a considerable need for research in relation to human systems.

Natural systems

Knowledge on the impacts of climate change on natural systems is much more extensive than in the case of human systems. Confidence regarding already observed consequences of climate change is high for the cryosphere (snow and ice on sea and land) and medium for the water cycle (Section 1.1). Precipitation patterns, the regional water balance and the availability of freshwater are already being affected by climate change on all continents and many islands. For example, in Europe and North America the number of extreme rainfall events has increased, with an increased risk of floods in the UK, while droughts have become more frequent and intense in other regions.

The climate impacts on ecosystems described by the IPCC (2007b) have been confirmed and the knowledge base broadened. The development of species in the course of the year, as well as their productivity and distribution, are already being affected by climate change. For example, a shift in terrestrial populations towards the poles and up mountains can be observed in many regions, and this is happening two to three times faster than had been expected. Such shifts can cause cascading effects, e.g. in marine ecosystems, which can ripple through the entire food chain to fish and ultimately, via fisheries, to humans. The rule here is that the further the studied climate impact is from the cause (climate change) along the chain of cause-and-effect relationships, the more difficult it is to prove the causal link.

Considerable climate impacts have been observed in Arctic ecosystems, as well as in many freshwater and coastal ecosystems. In the oceans the physical (e.g. warming) and chemical (primarily acidification) properties have changed markedly as a result of anthropogenic climate change (Section 1.1). Regionally, considerable climate damage has already been observed in coral reefs, where climate change has triggered an irreversible loss of biodiversity.

Global synopsis

The regional range of already observable climate impacts is growing compared to the Fourth IPCC Assessment Report (IPCC, 2007b). For the first time, in its Fifth Assessment Report, IPCC (Cramer et al., 2014) has compiled the many case studies on observed climate impacts in a world map showing the intensity of the effect and the respective confidence level (Figure 1.6-1). In this map the climate impacts are allocated to three areas: physical systems (freshwater and droughts, cryosphere, and coasts), biological systems (terrestrial and marine ecosystems; wildfires), and human and managed systems (food systems; livelihoods, health, economics). The figure shows that there is evidence of climatic effects in all three areas all over the world. In Australasia, Asia and Europe a large number of observed impacts attributed to climate change have already been found in several areas, and there is not a single major region where no serious climate impacts have occurred.

The Arctic is particularly affected by climate change: many case studies of serious climate impacts from all three areas have been described with a medium to high confidence level. Overall, regime shifts, i.e. large-scale and profound changes in the biophysical conditions, are in progress in the Arctic region, and this is having cascading effects on the ecosystems and livelihoods of the population living there. The rapid retreat of the Arctic ice cover has passed a tipping point which is causing considerable changes in the Arctic marine ecosystems, with negative consequences for the populations of mammals that live there (e.g. seals and polar bears).

Conclusions

The IPCC's synopsis of the scientific state of knowledge on observed climate impacts (Cramer et al., 2014) is not only of great scientific value, it is also of considerable importance for improving the quality of advice that can be given to policy-makers. The effects that are already occurring today can give political decision-makers an indication of how the world will change if climate change intensifies. If rising sea levels, an increase in droughts or melting glaciers can already be observed in a region today, then this is an indication that these effects might intensify in the future. On a case-by-case basis, however, confidence of these statements tends to be quite low, since, in the complex climate system, progressive warming can by no means always be expected to cause a linear increase in regional effects. Moreover, not only can the already observed impacts intensify, but new impacts can also be expected to be added if warming continues.

Almost all individual studies have a clear regional focus, but more and more examples of similar and interacting impacts in different regions are becoming known. Furthermore, looking at the impacts together across the regions makes it increasingly possible to recognize patterns, so that, seen overall, the synopsis of case studies submitted by the IPCC (Cramer et al., 2014) offers a valuable basis for further climate-risk analyses. Four of the five reasons for concern relating to global climate change described in various IPCC reports (Section 1.7) have been confirmed and substantiated by studies of the observed impacts of climate change.

The regional quality of studies of climate impacts varies considerably; for example the data for Africa are not yet good enough in many sub-regions to be able to derive well-documented case studies. The WBGU therefore recommends the continuous and systematic collection and evaluation of new case studies in the future.

1.7 The future impacts of global climate change on humanity's natural life-support systems

The IPCC's Fifth Assessment Report impressively confirms that unabated climate change endangers humankind's natural life-support systems. The report confirms earlier projections on the impacts of climate change, fur-

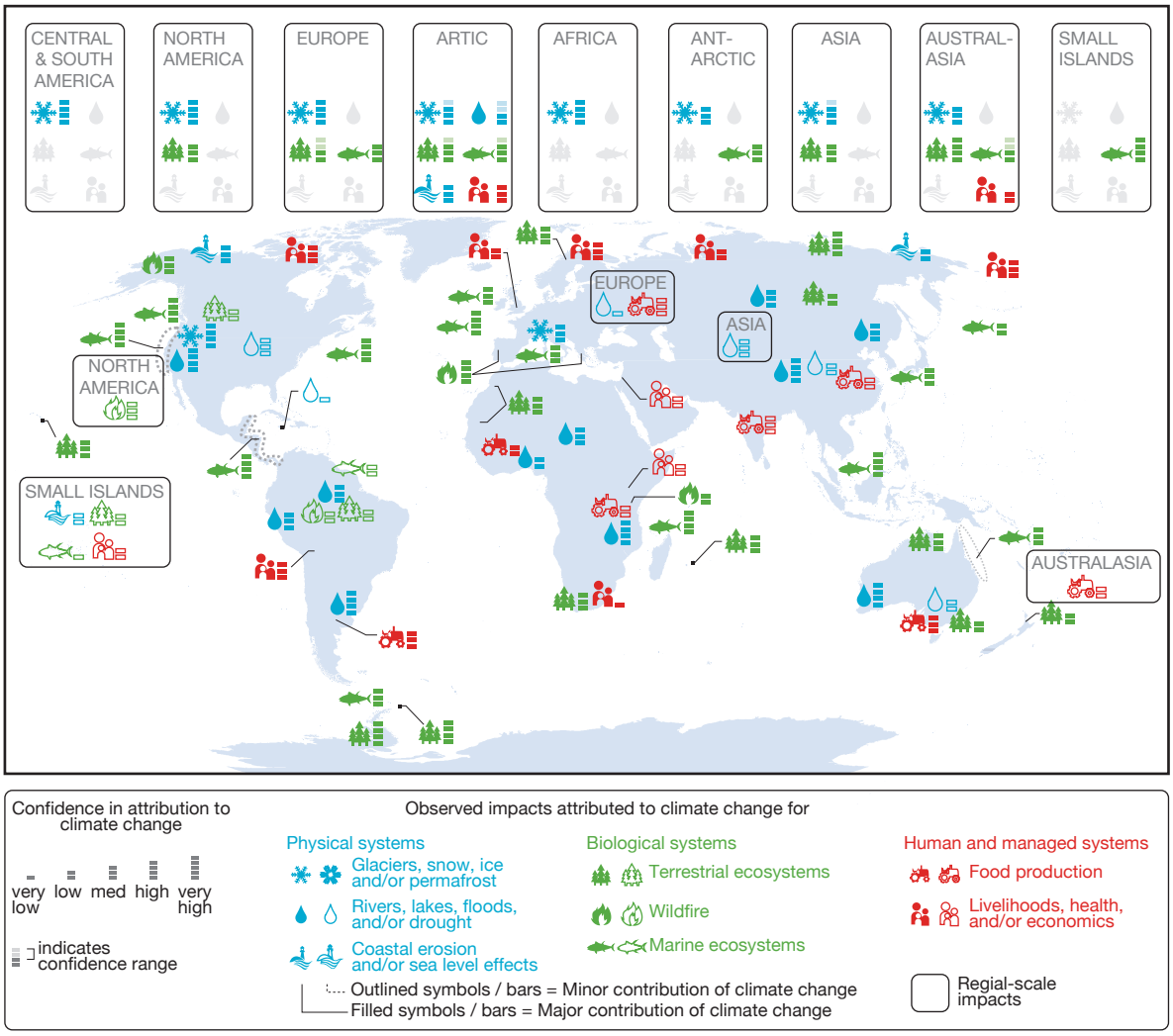


Figure 1.6–1
Observed climate-change impacts: Global patterns.
Source: Cramer et al., 2014

ther substantiates their justification, updates estimates, and looks into new problem constellations not previously covered, such as the security risks of climate change. This Assessment Report demonstrates how humanity's natural life-support systems will be changed if the business-as-usual attitude to greenhouse gas emissions continues. In view of the huge damage that is already being caused by extreme weather events such as floods, storms and drought today, the report also points out that the international community is not adequately prepared for the foreseeable challenges, emphasizing the need for transformative adaptation (as opposed to incremental adaptation); i.e. fundamental efforts to adapt. This might come too late for some parts of the natural environment: regime shifts have already begun in the Arctic and in tropical coral reefs (Section 1.7.3.8).

1.7.1 Dangerous anthropogenic interference with the climate system: Five reasons for concern

The report identifies five overarching, systemic reasons for concern that are especially relevant to dangerous anthropogenic interference with the climate system: (1) unique and threatened systems, (2) extreme weather events, (3) distribution of impacts, (4) global aggregate impacts and (5) large-scale singular events (IPCC, 2014c). These five reasons for concern illustrate the implications of climate warming and the adaptation limits of people, economies and ecosystems. It becomes clear in this context that negative effects of global climate change can already occur below the 2°C guard rail, and that beyond this threshold humanity as a whole must reckon with high risks. In order to understand where we stand today, it is important to know that the global mean temperature has risen by almost 0.9°C since the beginning of industrialization, so that there is only about 1.1°C to go before the 2°C guard rail is reached. Unless otherwise stated (e.g. in diagrams), all

figures on climate-change-related temperature changes given in the following relate to the period 1986-2005. 0.61 °C must be added to arrive at the figure relative to pre-industrial levels. The 2 °C climate guard rail relates to the pre-industrial period.

The assessment of the (cross-sector and cross-regional) risks of individual reasons for concern is based on an evaluation of the current state of research (literature review) and expert assessments. Evaluation of research literature since the Fourth IPCC Assessment Report (IPCC, 2007b) has essentially confirmed the assessment of these five reasons for concern (Figure 1.7-1); it has also led to an updating of previous assessments (Oppenheimer et al., 2014):

- Regarding unique and threatened systems, as well as large-scale singular events, the risks involved if warming exceeds 2 °C are now considered greater than was the case in the Fourth IPCC Assessment Report (now newly marked purple; Figure 1.7-1).
- Compared to the Fourth IPCC Assessment Report, the assessment of the risks from extreme weather events and the distribution of the effects are now confirmed at a higher confidence level.
- The assessment of the risks of global aggregate impacts and the confidence level formulated in the Fourth IPCC Assessment Report are confirmed.

Depending on the degree of warming, the following effects are expected on the individual risk areas if climate change continues unabated:

1. "Unique and threatened systems: Some unique and threatened systems, including ecosystems and cultures, are already at risk from climate change (high confidence). The number of such systems at risk of severe consequences is higher with additional warming of around 1 °C. Many species and systems with limited adaptive capacity are subject to very high risks with additional warming of 2 °C, particularly Arctic-sea-ice and coral-reef systems.
2. Extreme weather events: Climate-change-related risks from extreme events, such as heat waves, extreme precipitation, and coastal flooding, are already moderate (high confidence) and high with 1 °C additional warming (medium confidence). Risks associated with some types of extreme events (e.g., extreme heat) increase further at higher temperatures (high confidence).
3. Distribution of impacts: Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development. Risks are already moderate because of regionally differentiated climate-change impacts on crop production in particular (medium to high confidence). Based on projected decreases in regional crop yields and water availability, risks of unevenly distributed impacts are high for additional warming above 2 °C (medium confidence).
4. Global aggregate impacts: Risks of global aggregate impacts are moderate for additional warming between 1–2 °C, reflecting impacts to both Earth's biodiversity and the overall global economy (medium confidence). Extensive biodiversity loss with associated loss of ecosystem goods and services results in high risks around 3 °C additional warming (high confidence). Aggregate economic damages accelerate with increasing temperature (limited evidence, high agreement), but few quantitative estimates have been completed for additional warming around 3 °C or above.
5. Large-scale singular events: With increasing warming, some physical systems or ecosystems may be at risk of abrupt and irreversible changes. Risks associated with such tipping points become moderate between 0–1 °C additional warming, due to early warning signs that both warm-water coral reef and Arctic ecosystems are already experiencing irreversible regime shifts (medium confidence). Risks increase disproportionately as temperature increases between 1–2 °C additional warming and become high above 3 °C, due to the potential for a large and irreversible sea level rise from ice sheet loss. For sustained warming greater than some threshold, near-complete loss of the Greenland ice sheet would occur over a millennium or more, contributing up to 7 m of global mean sea level rise" (IPCC, 2014c: 12).

A World Bank report states that in a 4 °C warmer world (compared to the pre-industrial period), hitherto unknown heat waves and severe droughts must be expected in many regions (World Bank 2012a: xiii).

1.7.2 Key risks to the conservation of the natural life-support systems

The key risks posed by climate change for human living conditions include the potentially severe effects relating to a 'dangerous anthropogenic interference with the climate system' (Article 2 of the UNFCCC). Such key risks can involve far-reaching and irreversible consequences, a high probability of damage, or limited adaptation options (IPCC, 2014c: 13):

1. "Risk of death, injury, ill-health, or disrupted livelihoods in low-lying coastal zones and small island developing states and other small islands, due to storm surges, coastal flooding, and sea level rise.
2. Risk of severe ill-health and disrupted livelihoods for large urban populations due to inland flooding in some regions.
3. Systemic risks due to extreme weather events leading to breakdown of infrastructure networks and critical services such as electricity, water supply, and health and emergency services.
4. Risk of mortality and morbidity during periods of extreme heat, particularly for vulnerable urban populations and those working outdoors in urban or rural areas.
5. Risk of food insecurity and the breakdown of food systems linked to warming, drought, flooding, and

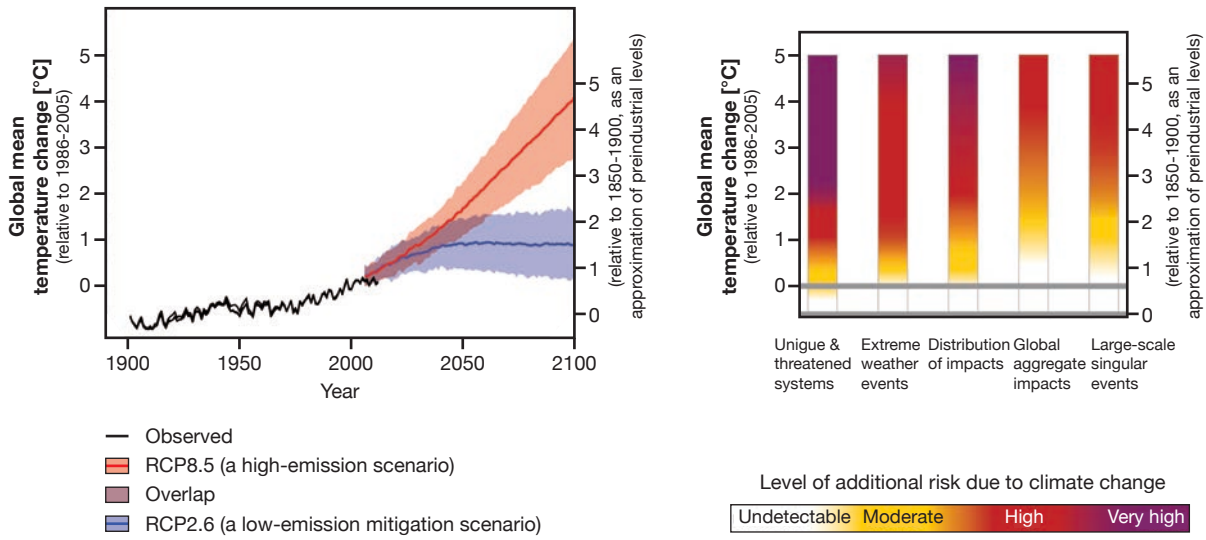


Figure 1.7-1
A global perspective on climate-related risks. Risks associated with reasons for concern are shown for increasing levels of climate change. The colour shading indicates the additional risk due to climate change when a temperature level is reached and then sustained or exceeded. Undetectable risk (white) indicates no associated impacts are detectable and attributable to climate change. Moderate risk (yellow) indicates that associated impacts are both detectable and attributable to climate change with at least medium confidence, also accounting for the other specific criteria for key risks. High risk (red) indicates severe and widespread impacts, also accounting for the other specific criteria for key risks. Purple shows that very high risk is indicated by all specific criteria for key risks.
Source: IPCC, 2014c

precipitation variability and extremes, particularly for poorer populations in urban and rural settings.

6. Risk of loss of rural livelihoods and income due to insufficient access to drinking and irrigation water and reduced agricultural productivity, particularly for farmers and pastoralists with minimal capital in semi-arid regions.
7. Risk of loss of marine and coastal ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for coastal livelihoods, especially for fishing communities in the tropics and the Arctic.
8. Risk of loss of terrestrial and inland water ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for livelihoods."

1.7.3 Key risks for sectors and regions: Examples

1.7.3.1 Food production and food security

The overwhelming majority of studies on the influence of global warming come to the conclusion that agricultural yields will be adversely affected, especially in the Tropics (IPCC, 2014c). If no adaptation measures are taken, temperature increases of 1 °C or more will already be enough to damage harvests of important food cereals (wheat, rice, maize) in the Tropics and in temperate latitudes, although yields in some regions will (temporarily) benefit from these higher temperatures. Overall, climate change can be expected to lead to a reduction in agricultural yields of between 0 and 2% per decade up to the end of the century and also cause greater yield variability. These decreases in yield are expected in a situation where the global demand for food will be increasing; the current assumption is that demand will rise by 14% per decade up to 2050.

If the rise in the global mean temperature exceeds 4 °C, then far-reaching negative effects on agriculture must be expected worldwide. Although there are still opportunities for adaptation if the climate warms by up to 2 °C (Figure 1.7-2), an increase in the global mean temperature of more than 4 °C can be expected to considerably widen the gap between the rising demand for food and food production in many regions; food insecurity will increase markedly despite adaptation measures.

1.7.3.2 Freshwater resources

A warmer world intensifies the global water cycle, so that overall precipitation increases; however, arid regions generally become drier, and wet regions generally wetter, and the risk of extreme precipitation also increases in arid regions (Jiménez Cisneros et al., 2014). This assessment, which was already made in previous IPCC reports, is also confirmed in the Fifth IPCC Assessment Report. The models show that this trend becomes clearly recognizable (statistically significant) when temperatures rise by more than 1.4 °C.

Climate change can alter the regional availability of freshwater resources to such an extent that it becomes difficult to meet the demand from households and irrigation agriculture in the same region, especially in arid, subtropical regions (Figure 1.7-3) and where there is increasing demand from population growth and

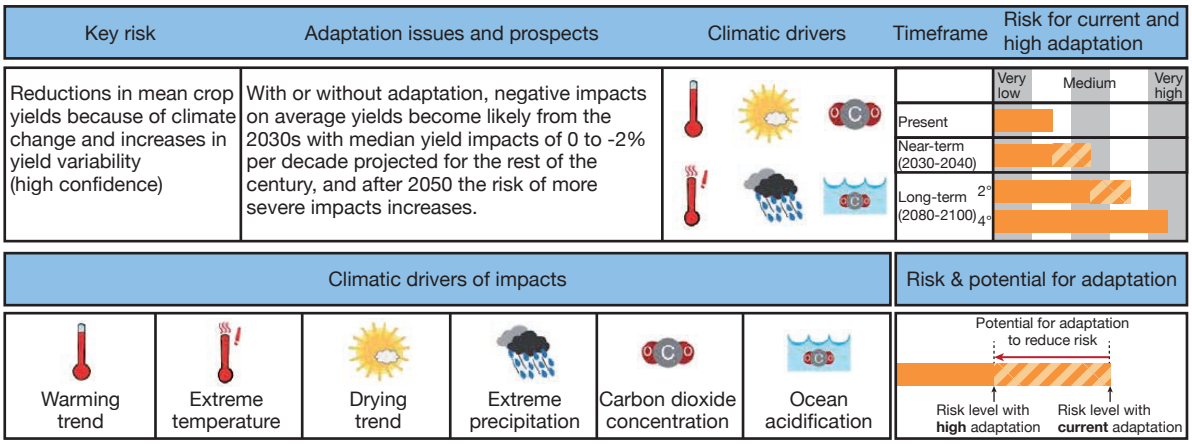


Figure 1.7-2
Climate-change-related key risks to food production and potential for adaptation.
Source: Porter et al., 2014

economic development (Jiménez Cisneros et al., 2014). Models evaluated by the IPCC show that, if climate change continues unabated, primarily the Mediterranean region and parts of southern Africa be affected by a decline in the natural water supply (Jiménez Cisneros et al., 2014). For South and Southeast Asia, the model results show a much greater degree of variability. According to the IPCC's model evaluation, up to a global mean temperature increase of about 1.4 °C, population development remains the dominant factor affecting water availability in a region; beyond this temperature threshold, the influence of climate change can regionally become the dominant factor. It is estimated that there is still adaptation potential both in a 2 °C world and in a 4 °C world (Figure 1.7-3).

Climate change will also increase the variability of surface-water availability as a result of higher precipitation variability and the reduction in the amount of water stored in ice and snow. The most obvious solution – tapping groundwater resources – will not be a sustainable solution if the amount of water abstracted is expected to exceed the natural groundwater renewal rate. Model calculations have shown that, depending on the scenario, between 24% (RCP2.6) and 38% (RCP8.5) of the population will suffer a more-than-10% decline in renewable groundwater resources in the period from 1980 to 2080 (Jiménez Cisneros et al., 2014).

1.7.3.3 Urban agglomerations

Climate change will have profound effects on a wide range of urban functions, infrastructures (e.g. cascade effects on water, energy, sanitation, transport and communications infrastructures) and services, and could further exacerbate existing problems. The potential effects of climate change in urban agglomerations will depend to a large extent on their location, resilience (e.g. of the infrastructure) to weather extremes, the fabric of the buildings, the population's vulnerability, coping capacity, etc. Large cities in low-lying coastal areas and river plains, many of which are located in Asia, are regarded as being particularly at risk in the next few decades (McGranaham et al., 2007; Revi et al., 2014). If temperatures rise by 3-4 °C (RCP8.5), a sea-level rise of 0.45-0.82 m (average 0.63 m) is to be expected by the end of the century.

Many climate-change-related key risks – and risks that are yet to emerge – are concentrated in urban areas. For example, the rapid urbanization in low- and middle-income countries is being accompanied by a fast growth of informal settlements that are often particularly exposed to risk with highly vulnerable populations (Revi et al., 2014). The projected increase in the number of droughts will have a particularly severe impact on the approx. 150 million urban dwellers, who are already suffering from severe water shortages. It is usually the inhabitants of informal settlements who have no reliable access to adequate water supplies, while at the same time having to pay the highest prices. A review of the scenarios shows that the number of people suffering from a severe shortage of water could increase to about a billion by 2050 (McDonald and Schrattenholzer, 2001; Revi et al., 2014). The over-exploitation of groundwater resources in densely populated coastal zones and rising sea levels have already led to salt-water intrusion into the groundwater in many places.

Since many urban areas are situated in low-lying coastal zones, there are particularly serious hazards because of a combination of sea-level rise, subsidence of the land masses (caused by the weight of buildings and groundwater depletion), storm events and flooding. By the end of this century, sea levels are expected to rise by 26-98 cm, tropical cyclones to intensify, and weather extremes in general to increase. Furthermore, several hundred million people are expected to be affected by flooding in coastal zones by the end of this century, especially in the South, Southeast and East Asia, if climate change continues unabated, current development pathways are continued, and no adaptation measures are taken (Field et al., 2014). At the same time, this region is currently experiencing the world's most intense urbanization.

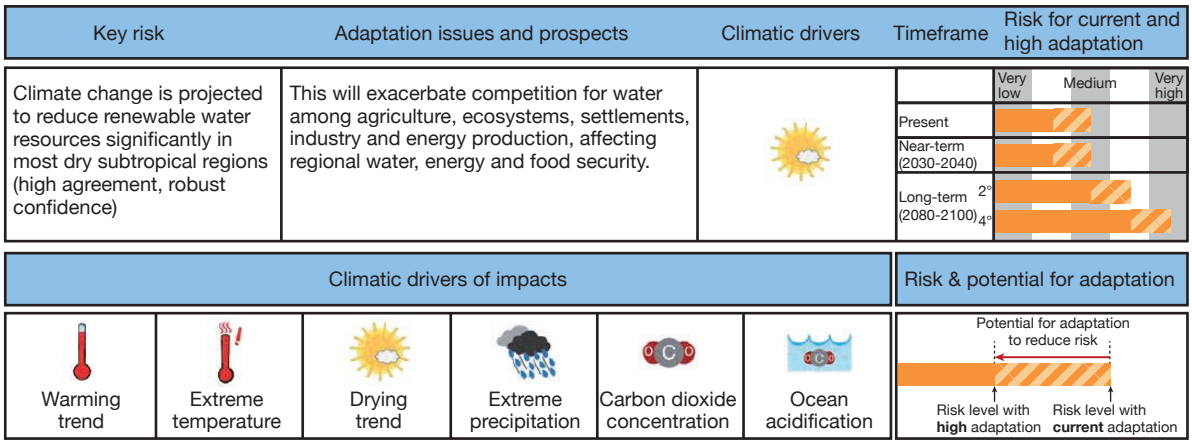


Figure 1.7-3
Climate-change-related scarcity of freshwater resources and risk-reduction potential.
Source: Jiménez Cisneros et al., 2014

It is estimated that a sea-level rise of only half a metre could already more than triple the number of people at risk and increase the amount of assets at risk more than tenfold in value terms – especially in port cities, which are important hubs for goods and where large industrial installations are located (Hanson et al., 2011; Revi et al., 2014). According to this study, the 20 most vulnerable cities (in terms of people and assets) are: Mumbai, Guangzhou, Shanghai, Miami, Ho Chi Minh City, Calcutta, New York, Osaka-Kobe, Alexandria, Tokyo, Tianjin, Bangkok, Dhaka and Hai Phong. Focusing only on assets as the criterion, cities like Miami, New York, Tokyo, New Orleans, Guangzhou, Shanghai and Tianjin are at the top of the risk list.

1.7.3.4 Human health

Global climate change can exacerbate existing health problems and generate additional hazards for human health (Smith et al., 2014a). This became clear during the extremely hot summer in Europe in 2003, when about 15,000 mainly old and sick people died in France alone (Smith et al., 2014a). The number of heat waves quadrupled in Europe between 1999 and 2008 as a result of climate change. Since many people all over the world work out in the open (e.g. in agriculture or construction), the number of heat strokes and cases of exhaustion caused by heat stress can be expected to increase, thus having an adverse effect on labour resources (Smith et al., 2014a).

The likelihood of injuries, an aggravation of existing diseases, the geographical distribution of disease carriers (e.g. malaria, dengue) and mortality risks (especially among the elderly, children, pregnant women and the sick) can be expected to rise in future due to increasing heat waves, floods, storm events, wildfires and a general warming of the climate. Although a reduction in cold-induced mortality can be expected, this positive trend will be more than offset overall by much greater negative effects on human health caused by global warming. Climate-change-related disruptions of food production are also likely to lead to an increased risk of malnutrition. A rise is also forecast in diseases (especially diarrhoea) transmitted by contaminated water or food.

Moreover, in many cases global warming improves living conditions for carriers of such infectious diseases as dengue fever, malaria and tick-borne encephalitis. On the other hand, if a certain temperature threshold is exceeded, this can inhibit the spread of these infectious diseases. For example, some malaria-transmitting mosquitoes cannot survive at temperatures above 40 °C (Smith et al., 2014a).

Dengue is the fastest spreading mosquito-borne viral disease; its global incidence has increased thirty-fold over the last 50 years, according to the WHO (Smith et al., 2014a). About 390 million cases of dengue fever are registered every year, about 96 million of which exhibit symptoms. Three-quarters of all cases occur in the Asia-Pacific area. The first case of dengue fever in Europe since 1920 was registered in Madeira (Portugal) in 2012. The carriers of Dengue (*Aedes aegypti* and *Ae. Albopictus*) are climate-sensitive.

According to the WHO, there were an estimated 216 million cases of malaria worldwide in 2010, mostly in Africa among children under the age of five. The number of deaths from malaria in 2010 was estimated at more than 1.2 million (Smith et al., 2014a). Since the incidence of malaria mosquitoes is also highly dependent on socio-economic factors, however, the generally improving climatic conditions for the spread of the disease have been more than offset by better controlling measures. There are no studies indicating a return of malaria to North America or Europe (Smith et al., 2014a).

Ticks are spreading north in Canada and Scandinavia, thus expanding the range of infectious diseases that are transmitted by them. However, the observed spread of tick-borne encephalitis and lyme borreliosis cannot be explained by climate change alone (Smith et al., 2014a). Socio-economic factors (leisure activities, agriculture) also seem to be playing a role here.

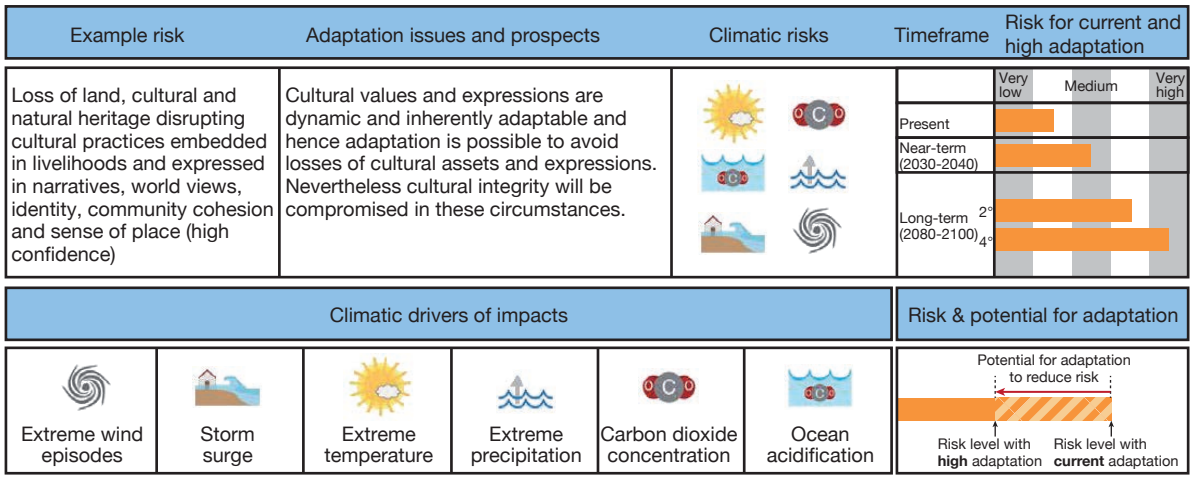


Figure 1.7-4
Loss of cultural heritage due to climate change. Since cultural heritage is deemed to be irretrievable, once lost, there is no scope for adaptation here.
Source: Adger et al., 2014

1.7.3.5 Loss of cultural heritage and cultural diversity

Unchecked climate change threatens the cultural heritage of humanity (Adger et al., 2014; Figure 1.7-4). A society's "cultural practices embedded in livelihoods and expressed in narratives, world-views, identity, community cohesion and sense of place" are key elements that determine how people perceive and deal with environmental change. They are correspondingly varied (Adger et al., 2014). The 400 million people attributed to indigenous communities have a particularly wide range of cultural diversity. At the same time they are particularly exposed to the risks of unmitigated climate change (combined with other influences of globalization). Examples include the Inuit people of the Arctic and the Sahel nomads (Adger et al., 2014). In addition, sea-level rise poses an existential threat to many UNESCO World Cultural Heritage sites, such as Venice or Hoi An (Vietnam). A recently published study shows that 136 of 700 UNESCO World Cultural Heritage sites will eventually be below sea level (Marzeion and Levermann, 2014). In addition there is the threat of losing unique cultural landscapes with a high symbolic value. In Europe, for example, these include the cork oak forests of Portugal, the Garrigue in the south of France, the Alpine meadow landscapes, the polder landscapes of Belgium and the Netherlands, the grouse moors in the UK, the Marchair in Scotland, the Irish peatlands, and the European wine-growing regions with their typical 'terroirs' linked to the soil and the immediate environs (Revi et al., 2014).

1.7.3.6 Climate change as a security risk

The IPCC's Fifth Assessment Report focuses for the first time on the security risks that can be associated with unabated climate change and draws attention to numerous new studies on these risks. In 2008, the WBGU – in its report 'Climate Change as a Security Risk' – showed that without resolute counteraction, climate change would overstretch many societies' adaptive capacities within the coming decades, which could result in destabilization and violence and considerably jeopardize national and international security (WBGU, 2008). On the other hand, climate change could also unite the international community, provided that countries recognize it as a common threat to humankind and act together. "If it fails to do so, climate change will draw ever-deeper lines of division and conflict in international relations, triggering numerous conflicts between and within countries over the distribution of resources, especially water and land, over the management of migration, or over compensation payments between the countries mainly responsible for climate change and those countries most affected by its destructive effects" (WBGU, 2008: 1). The global increase in temperatures can endanger the livelihoods of many people, especially in the developing regions, and thus increase vulnerability, particularly in weak and fragile states. Overall, the WBGU regards climate-induced wars between states as unlikely. However, it does expect climate change to aggravate national and international distributional conflicts and to intensify already hard-to-manage problems like failed states and a rising propensity to violence. This could lead to a proliferation of destabilization processes with diffuse conflict structures (WBGU, 2008: 1).

1.7.3.7 Migration

About 80% of migration worldwide currently takes place within countries; the dominant trend is rural-urban migration (Adger et al., 2014). As a rule, migration decisions are based on a large number of considerations, so that many authors currently regard it as problematic to speak of (pure) climate migrants. Nevertheless, available studies and scenarios indicate that the climate will play a much more important role in migration decisions in the future if climate change continues unabated

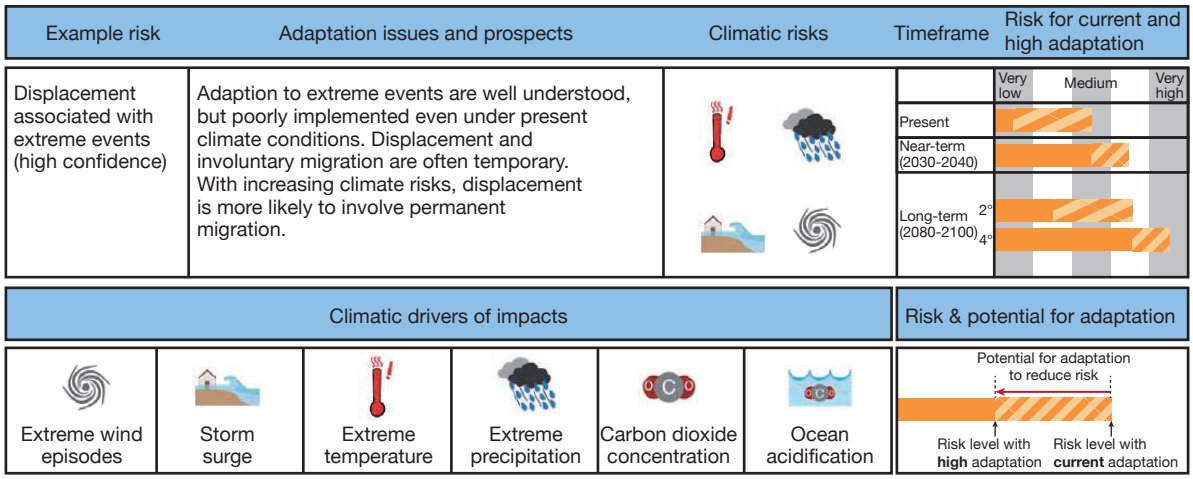


Figure 1.7-5
Loss of homes as a result of climate-change-related extreme events; potential risk mitigation through adaptation.
Source: Adger et al., 2014

(WBGU, 2008). According to the Internal Displacement Monitoring Centre, approximately 32.4 million people worldwide fled the effects of floods, storms and other environmental disasters in 2012. In 2012, 98% of these disasters were climate- and weather-related (IDMC and NCR, 2013:6). Environmental degradation, sea-level rise, coastal erosion and falling agricultural productivity will impact on migration movements worldwide, and existing migration trends, such as those from the country to urban areas, are expected to strengthen. In future, there will be coastal areas where people used to live that have been made uninhabitable by rising sea levels. A study (Curtis and Schneider, 2011; Adger et al., 2014) on four large coastal zones in the USA comes to the conclusion that around 12 million people will have permanently lost their homes by 2030. Another, global study (Nicholls et al., 2011; Adger et al., 2014) on the influence of sea-level rise on migration movements shows that, if sea levels rise by 50 cm and no adaptation measures are taken, there is a likelihood of over 66% that about 72 million people will lose their homes (involving an area loss of 0.877 million km^2). Assuming a sea-level rise of 2 metres, the number of people who would lose their homes – particularly in Asia – would rise to 187 million (area loss: 1.789 million km^2). If adaptation measures are taken in good time, this study concludes that a 50 cm sea-level rise will cause only a small number of migrants, whereas almost 500,000 people will be affected if sea levels rise by two metres. Such adaptation measures are 'very likely' (>90%) to be less expensive than the expected damage to unprotected urbanized coastal zones, especially in the large urban areas. The loss of homes as a result of extreme weather events is usually temporary, but in the event of unabated climate change a permanent loss of homes becomes more likely (Figure 1.7-5). If the global climate warms up by more than 2°C, this will markedly reduce the remaining scope for adaptation measures.

1.7.3.8 Ecosystems and biodiversity

The number of endangered ecosystems and the risks to biodiversity are growing with increasing climate warming (Field et al., 2014). Many species can only adapt to a limited extent to climate change and are therefore already exposed to very serious risks if temperatures rise by 2°C, especially in the Arctic and in coral reefs. Globally speaking, major risks from a considerable loss of biodiversity and ecosystem services are to be expected at about 3°C. Extreme weather events such as heat waves, droughts, floods or wildfires can cause great damage to ecosystems. As warming increases, tipping points in ecosystems can be crossed, leading to abrupt and far-reaching changes in the composition, structure and functioning of ecosystems (regime shifts). Initial signs of irreversible regime shifts can already be seen in coral reefs and in the Arctic; in the event of a temperature increase of 1–4°C, the risks of such developments are estimated to be high. In the future, large-scale and irreversible regime shifts are expected in the Arctic tundra and the forests of the Amazon region (RCP4.5, 6.0 and 8.5); this in turn can lead to higher emissions of greenhouse gases and thus intensify climate change.

In the second half of the 21st century, climate change will exert considerable pressure on *terrestrial and freshwater ecosystems*. Many species will be unable to adapt quickly enough to the changing climatic conditions, so that the risk of extinction will increase for a large proportion of the species. Tree and forest dieback must be expected over the coming decades in many regions if climate change continues. The probability of species extinctions increases with the intensity and speed of climate change, not least because climate change interacts with other anthropogenic drivers, such as habitat loss, over-exploitation, pollution and the introduction of invasive species.

Over the next few decades, climate change is expected to cause shifts in the populations of fish and invertebrates over large areas in *marine and coastal eco-*

systems. The higher latitudes will see an influx of species from the lower latitudes, and high local extinction rates are expected in the Tropics – coupled with a corresponding redistribution of catch potential for fishery and impacts on food security. The loss and global redistribution of biodiversity will threaten fishery productivity and other ecosystem services in regions sensitive to climate change. As in the case of terrestrial ecosystems, climate change also makes the management of marine ecosystems more difficult, because it interacts with other anthropogenic drivers such as overfishing. Ocean acidification, which is caused by anthropogenic CO_2 emissions, involves further risks for marine ecosystems, mainly in the polar ecosystems and in coral reefs.

The loss of biodiversity, ecosystems and the associated ecosystem services entails risks for humans (Field et al., 2014). The livelihoods of the fisheries-dependent coastal communities in the Tropics and the Arctic are particularly at risk. Local communities that are dependent on the services of terrestrial ecosystems will also be exposed to additional risks due to the impact of warming, precipitation patterns and extreme events on these ecosystems.

1.7.4 Regional challenges

As examples, the impacts of unmitigated climate change are outlined here with reference to three world regions. Europe has been selected to illustrate what consequences climate change might have even in a highly developed region; Africa and Asia were chosen to represent particularly hard-hit regions.

1.7.4.1 Europe

The key risks in Europe include, among other things (Kovats et al., 2014):

- *Economic losses:* The rise in sea levels and the increase in extreme precipitation events will markedly raise the flood risk in river and coastal zones in the second half of this century. The coastline of north-west Europe is the most vulnerable. Many European countries (the Netherlands, Germany, France, Belgium, Denmark, Spain and Italy) will have to reinforce their coastal protection measures. In some coastal zones a 'managed retreat' is likely (>66%) to be unavoidable. Substantial increases in flood damage are to be expected if no adaptation measures are taken. Timely adaptation can prevent most damage here. Restrictions on shipping traffic on major rivers (e.g. on the Rhine) are to be expected in the summer months. Hydroelectric power generation will probably (>66%) decline in all regions except in Scandinavia. A decline in tourism is expected in southern Europe from the second half of the century, and an increase in northern and continental Europe. Ski tourism will no longer be possible at lower altitudes in the long term.
- *Restrictions on natural water supply:* Climate change will markedly restrict the availability of surface and groundwater in several European regions, especially in southern Europe. The use of irrigation in agriculture will increase, but this will be limited by changes in the regional water balance, competing demand from other sectors, and excessively high costs.
- *Changing conditions for agriculture:* While cereal yields will improve in northern Europe (temporarily: a decline is also to be expected here if warming exceeds a certain level), they will fall in southern Europe. At the same time, the seasonal occurrence of pests and plant diseases will continue for longer in northern Europe.
- *Increased health risks:* Heat-related deaths and health problems are likely (>66%) to increase, especially in southern Europe. Despite more favourable climatic conditions in Europe for the spread of tropical diseases such as malaria, this has not happened because people carrying malaria (travellers) are quickly identified and treated. However, in central and eastern Europe there has been a marked increase in tick-borne encephalitis since the 1970s, although this cannot be explained by climate change alone (Smith et al., 2014).
- *Change in biodiversity:* It is very likely (>90%) that there will be changes in natural habitats, in particular a reduction in the size of Alpine flora habitats; this will involve the extinction of local species and continent-wide shifts in species distribution. Shifts in, or losses of wetlands in coastal zones are also considered likely. Finally, a growing proliferation of non-European invasive species is also to be expected.

Certain regions of Europe will be particularly hard hit by the climatic consequences described, especially coastal regions and the Mediterranean area. Virtually all analyses indicate that, unless climate warming is sufficiently restricted, the Mediterranean region will become a European flashpoint of climate-change impact, suffering multiple stresses and systemic failures (Kovats et al., 2014).

1.7.4.2 Africa and Asia

Africa

The key risks in Africa include, among other things, the following (Niang et al., 2014):

- *Natural water supply:* Rising temperatures and changes in precipitation will come on top of the existing pressures on freshwater resources caused by over-exploitation, degradation and rising demand. A decline in precipitation is likely (>66%) in Northern Africa and the south-western parts of Africa (under the A1B and A2 scenarios). The future development of precipitation in sub-Saharan Africa is uncertain overall (due to a lack of data).
- *Food security:* Climate change will have a significant negative impact on food security in Africa (food pro-

duction, access to food, food utilization and security of supply; Niang et al., 2014). Rising temperatures and changes in rainfall regimes are very likely (>90%) to cause a reduction in yields of food cereals and thus have an adverse effect on food security. There is new evidence that high value perennial crops (e.g. cocoa, coffee, tea) might be negatively affected.

- *Health risks:* Due to changing climatic parameters such as temperature variability, mean temperature and precipitation, changes are expected in the incidence and geographical range of diseases that are transmitted by vectors. For example, there is growing evidence to suggest that malaria is spreading in the East African highlands. Furthermore, climate change can exacerbate health risks caused by drinking-water pollution (e.g. due to a high microbial load) or malnutrition (e.g. due to crop failures).

Asia

The key risks for Asia include, among other things (Hijioka et al., 2014):

- *Food security:* The impact of climate change on food production and food security in Asia will vary from region to region, but overall the impact on food production is expected to be negative. Most models come to the conclusion that higher temperatures lead to shorter growing periods and thus above all to losses in rice production. In some regions climate warming has already reached the limits of heat stress that rice can withstand. In the Indo-Gangetic Plains, South Asia's granary, heat stress could cause harvest losses of approx. 50% (if CO_2 levels double) in the areas used for growing high-yielding wheat, the core regions of the 'Green Revolution'. Fertile agricultural land, especially rice-growing areas in coastal plains (e.g. in the Mekong Delta, the granary of south Vietnam), will be lost in many parts of Asia as a result of rising sea levels.
- *Natural water supply:* At present, no well-founded estimates can be made on the development of precipitation at the sub-regional level. Water scarcity is expected to become a major challenge in Asia because of population growth and rising per-capita consumption.
- *Extreme weather events:* Extreme weather events will have a growing, regionally varying, negative influence on health, security and local living conditions (livelihood, poverty; Field et al., 2014). Most at risk will be the population living in low-lying coastal zones; about half of Asia's population lives in such regions (Hijioka et al., 2014). Globally, 90% of the people that are exposed to tropical cyclones live in Asia.
- *Health:* More frequent and more intensive heat waves will increase mortality, especially among people who are already in poor health. Rising water and air temperatures will favour the transmission of infectious diseases like cholera, the occurrence of schistosomiasis (bilharzia), and in general the incidence of diarrhoeal diseases among children in rural and urban areas. The incidence of Japanese encephalitis, e.g. in the Himalayas, and malaria in India and Nepal has been associated with rainfall. A higher incidence of malaria is therefore also likely in urban areas due to direct (changes in land use) and indirect effects (rising temperatures, growing demand for water storage) (Bush et al., 2011). Rising temperatures are also expected to lead to a higher incidence of dengue fever (Banu et al., 2011). In addition, the distribution areas of diseases spread by vectors will probably shift (Hijioka et al., 2014). Negative health consequences are also expected due to the likely increase in flooding events (McMichael et al., 2012).

1.8 Limiting anthropogenic climate change

The analyses of the Fifth IPCC Assessment Report show that compliance with the 2 °C guard rail is possible via different development pathways. The sectors that need to decarbonize can be clearly named, and technical solutions for avoiding emissions are largely known. The discussion on these possibilities often focuses on 'supply-side' decarbonization options, while a transformation of final energy use also promises a lot of mitigation potential, although this often involves a change in lifestyles. However, there are few indications that the turnaround this would require is likely, so that more and more speculative measures to avoid the rise in temperature are being discussed: e.g. negative emissions or solar-radiation management (Section 1.8.3).

1.8.1 Transformation pathways to ensure compliance with the 2 °C guard rail

Stabilizing greenhouse gas concentrations in the atmosphere requires a transformation towards a low-carbon society and involves issues ranging from how we generate and use energy to how we farm the land (Clarke et al., 2014). The Fifth IPCC Assessment Report gives an overview of technological development pathways that could make it possible to restrict climate change. The core message is still that a stabilization of atmospheric greenhouse gas concentrations within a range of 430 to 530 ppm CO_2eq, which is compatible with the 2 °C guard rail, can still be reached via different development pathways reflecting a range of different technological, socio-economic and institutional assumptions. However, at the same time these scenarios show that low-emission energy technologies would have to approximately quadruple their share of primary energy generation by 2050 compared to 2010, and greenhouse gas emissions worldwide would have to peak by 2020 if possible, but certainly by the third decade of this century, in order to stabilize greenhouse gas concentrations within the range of 430 to

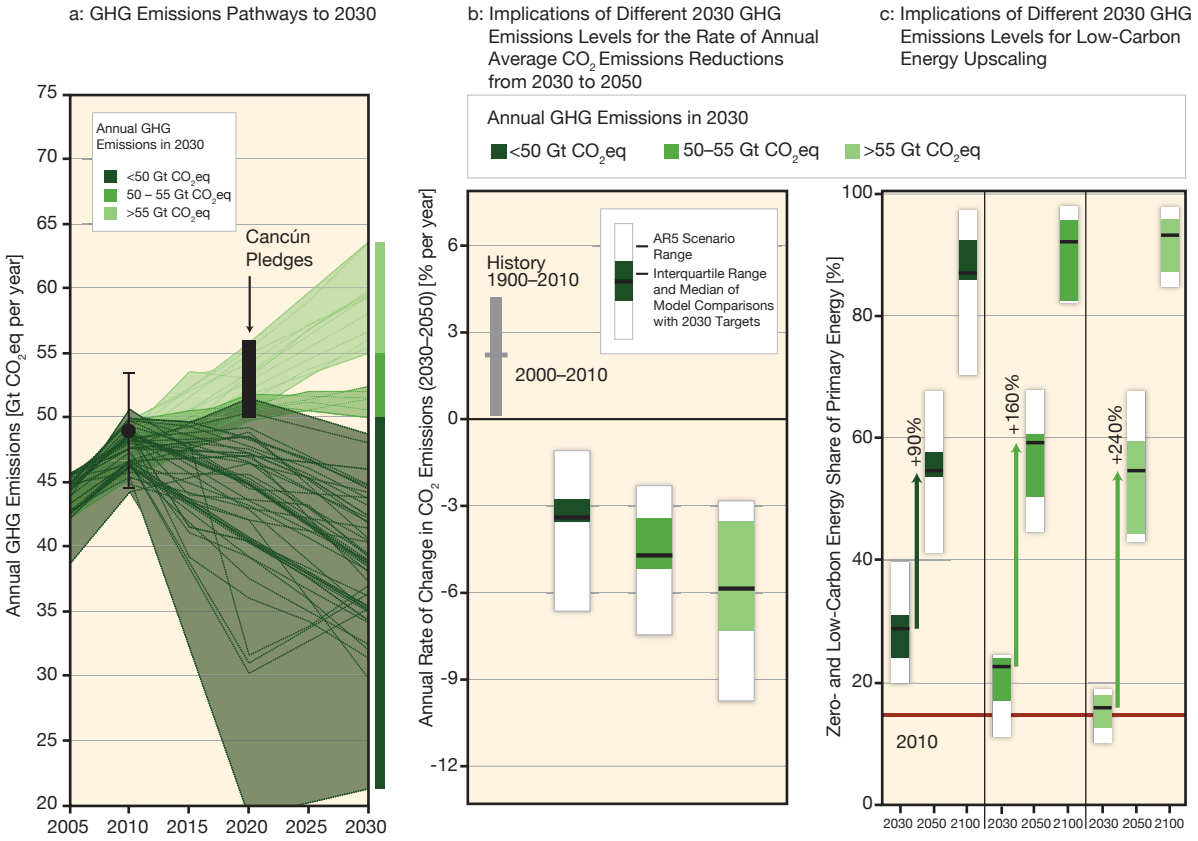


Figure 1.8-1
The implications of different 2030 greenhouse gas (GHG) emissions levels for the rate of subsequent emissions reductions up to the year 2050 in mitigation scenarios that reach concentrations of 430–530 ppm CO_2eq by 2100 (i.e. in which anthropogenic warming can be limited to 2 °C). The left panel (a) shows the pathways of GHG emissions up to 2030, the middle panel (b) the corresponding average annual emissions-reduction rates for the period from 2030 to 2050. The scenarios are grouped according to different shades of green, reflecting different emissions levels in 2030. The right panel (c) shows the magnitude of zero- and low-carbon energy-supply up-scaling from 2030 to 2050 subject to different 2030 emissions levels. Those scenarios in which there has not been a trend reversal in emissions by 2030 require much higher emissions-reduction rates in the years after 2030 and an extremely fast expansion of low-emission technologies. By contrast, the scenario group coloured dark-green – in which emissions peak much earlier and whose emissions are below 55 Gt CO_2eq in 2030 – requires lower reduction rates and a less aggressive growth of low-emission technologies.
Source: IPCC, 2014d

530 ppm CO_2eq (Figure 1.8-1). Globally speaking, there are currently no signs of such a development, although renewable energies are expanding with increasing speed. Scenarios in which such an expansion is not reached only achieve a corresponding stabilization by introducing technologies for generating net negative emissions on quite a large scale. This restricts flexibility with regard to the technologies used. In addition, the availability of technologies for generating negative emissions is highly uncertain (Section 1.8.3). Cost-effective scenarios are characterized by greenhouse gas emissions between 30 and 50 Gt CO_2eq in 2030, because in scenarios with higher emission levels a greater percentage of the emissions-intensive infrastructure can no longer be used in subsequent years if climate stabilization is to be achieved.

A change of direction is therefore needed in all sectors contributing to greenhouse gas emissions. The technologies for this are available and can be developed at an acceptable cost. The decisive factor now will be to ensure the necessary dynamics among the actors in order to direct resources in the appropriate direction.

1.8.2 Fields of action and sectors for climate protection

1.8.2.1 Energy

The energy-supply sector is the biggest emitter of greenhouse gases today. In order to stabilize the concentrations of CO_2 in the atmosphere, it is necessary to completely eliminate the release of CO_2 from the use of fossil fuels (Clarke et al., 2014).

Transforming the global energy systems is a key element of climate protection, yet this transformation is making only slow progress. Renewable energies accounted for 8% of primary-energy generation in 2010 excluding traditional bioenergy use, and 16% including it. Nuclear energy's share was 6%. Considering only the commercial energy system (i.e. not taking privately collected fuels into account), the share of fossil fuels fell only slightly from 88% to 86% between 1990 and 2010.

In addition to the transformation of the energy systems, further key elements of mitigation are improving efficiency, particularly in final energy use, and reducing the demand for energy. The more efficient the energy system, and the lower the demand for energy, the more flexibility there is in the choice of power-generation technologies.

1.8.2.2 Transport

The transport sector has a key role to play in the decarbonization of final energy use. This sector is currently responsible for about 27% of final energy use and directly for the emission of almost 7 Gt CO_2 (Sims et al., 2014). Both passenger and freight traffic are expected to rise worldwide in the future, so that annual CO_2 emissions in this sector could double to about 13 Gt CO_2 by 2050 if no further mitigation measures are taken. The introduction of low-carbon technologies is much more difficult in the transport sector because of the low energy density of low-emission fuels; however, mitigation measures must also be taken in the transport sector if efforts in other sectors not to be completely thwarted. Efficiency improvements in drive technologies in particular could lead (in 2030) to savings in the demand for final energy of 30-50% per annum compared to today; integrated spatial planning, forward-looking transport policies and more compact urban landscapes supporting mobility on foot or by bicycle can also make a contribution here. Furthermore, other important measures include redesigning urban spaces from a low-carbon perspective and investing in new infrastructure such as high-speed rail systems to at least partially substitute the demand for flights. According to estimates made by the IPCC, CO_2 emissions in the transport sector could be reduced by 20-50% compared to the baseline scenario by 2050.

1.8.2.3 Buildings

Buildings are currently responsible for about a third of global final energy consumption; annual emissions amount to just under 9 Gt CO_2. According to the IPCC (Lucon et al., 2014), it is assumed for the baseline case that the demand for energy in this sector will double by the middle of the century and that emissions will increase by 50-150%. The increase in the demand for energy is primarily due to the global increase in prosperity, to urbanization, lifestyle changes, improved supplies of modern energy services and the rising per-capita living space. With this momentum is linked to the risk of path dependencies from the long life of newly created building infrastructure. It is therefore important to make full use of existing constructional and technical solutions according to low-energy specifications for new and existing buildings to significantly reduce heating and cooling needs in the buildings sector. Options for avoiding greenhouse gas emissions can lead to negative costs, since their lifespan often exceeds the period of amortization (e.g. in the case of building insulation).

1.8.2.4 Industry

The industrial sector currently accounts for almost 30% of global final energy demand, as well as 13 Gt CO_2 of direct and indirect greenhouse gas emissions (Fischedick et al., 2014). Under the baseline scenario a further increase in emissions of 50-150% is expected by 2050, unless the introduction of efficiency measures is significantly accelerated. However, the industrial sector also has a number of short- and long-term mitigation options at its disposal. For example, energy intensity in the industrial sector could be reduced by 25% simply by using state-of-the-art methods everywhere. And further reductions in greenhouse gas emissions could be generated relatively easily using systemic approaches like recycling or improved material-flow planning. However, long-term structural changes are also necessary in addition to these improvements in efficiency if emissions are to be reduced further. These include, inter alia, providing process energy with electricity generated using low-carbon methods, radical product substitutions – for example by using alternatives to cement – or carbon capture and storage (CCS) technologies to avoid process emissions.

1.8.2.5 Agriculture, forestry and other land use

The land-use sector currently generates about one-quarter of global greenhouse gas emissions (Smith et al., 2014b). The main drivers are emissions from deforestation and agricultural emissions from land management and fertilization. Unlike the sectors examined above, the land-use sector is characterized by decreasing global annual average CO_2 emissions, primarily as a result of reforestation and a decline in deforestation. This shows the potential for establishing land use as a CO_2 sink. The most cost-effective measures to reduce emissions in the land-use sector are reforestation, management of forest resources, prevention of deforestation, sustainable management of agricultural and pasture land, and restoration of organic soils. In addition, considerable but difficult-to-quantify emissions reductions can also be achieved using demand-side measures. One example is reducing the amount of food that is thrown away during the production process or at the end-user level; another is reducing consumption of animal-derived foodstuffs.

1.8.2.6 Human settlements, infrastructure and spatial planning

Urban areas are responsible for 70% of global energy use and global energy-related CO_2 emissions. The urban population is expected to double by 2050 (IPCC, 2014d). The next two decades are therefore a decisive opportunity for climate protection, since the majority of urban infrastructures are just being built. Should the global population grow to about 9 billion by 2050, the production of infrastructure materials alone could cause about

470 Gt of CO_2 emissions (Seto et al., 2014).

Since infrastructure and urban development are interdependent and determine the patterns of land use, mobility, housing and behaviour, climate protection can be boosted primarily by mixing residential and working areas, improving public transport, and implementing demand-management measures. The biggest share of future urban growth is expected in small to medium-sized towns and cities in developing countries. Whether the instruments of low-carbon urban spatial planning can be successfully used will depend to a large extent on the cities' financial possibilities, their governance capabilities, and the extent to which they adopt knowledge and technology.

Thousands of cities have developed climate-protection programmes (Section 4.3.6). For lack of data it is difficult to say whether these have been successful up to now. A considerable proportion of the climate-protection programmes are currently focusing on energy efficiency and the deployment of technology, and less on spatial planning, changing behaviour and cross-sectoral approaches aimed at avoiding urban sprawl and high-traffic development.

1.8.3 Large-scale technical intervention

At first sight, the most important statement by Working Group III in the Fifth IPCC Assessment Report is the same as in the previous Fourth IPCC Assessment Report: the 2 °C guard rail can still be met via a variety of development pathways. However, a closer look reveals that many of the assessment models that calculate the transformation pathways can only reach solutions for 2 °C-compatible pathways by allowing 'negative emissions' or even the manipulation of the Earth's radiation balance, which makes it more and more likely that this option will be needed. In the WBGU's view, such a conclusion implies that too little attention is being paid to two arguments:

First, most of the scenarios presented and evaluated in the IPCC report are not 'transformative scenarios' in the strict sense of the word. The assessment models are designed to show a large number of possible areas of long-term development compared to a baseline that extrapolates existing policies. Climate policy is then usually implemented in the form of CO_2 prices or other restrictions (in practice, however, a large number of instruments are often implemented), leading to a gradual tapping of CO_2-mitigation potential. In these modelling studies, investment decisions are usually made according to cost-minimization criteria (Section 1.2.2), which tends to favour existing infrastructures and in this way contributes to a certain degree of inertia in the system. In reality, change does not always take place gradually, but often in a disruptive way. This can be illustrated by the expansion of photovoltaics, which took place much faster than would have been possible according to cost-minimization criteria. Integrated assessment models correspond to the scientific state of the art when it comes to assessing climate-protection measures; they aim to present a large number of areas of development, but not necessarily the speed of change in the sense of a holistic transformation. Research is therefore needed to improve the representation of complementary instruments of energy and climate policy for creating transformative scenarios in which an accelerated substitution and diffusion of technologies is possible (Section 5.2.3). This suggests that structural breaks can greatly speed up the expansion of low-emission technologies and thus reduce the need for large-scale interventions.

Secondly, although large-scale technical interventions have the potential in principle to mitigate warming, other unacceptable risks of climate change, especially the acidification of the oceans (WBGU, 2014), are left out. This is evident in the case of technologies to manipulate the Earth's radiation balance, since these exert no influence on the core of the problem, the increase in CO_2 concentration in the atmosphere. By contrast, the active removal of CO_2 reduces the concentration of CO_2 in the atmosphere; at best, however, this can only slow acidification down by reducing the rate at which CO_2 enters the ocean from the atmosphere. An extreme reduction in the atmospheric CO_2 concentration would be necessary to remove the CO_2 from the ocean, and this is almost impossible to model plausibly. And even that cannot reverse the acidification that has already taken place, since large quantities of CO_2 have already reached, and will continue to reach, the deeper layers of the ocean; it cannot be removed on human time scales (Mathesius et al., in preparation). It therefore follows that this measure should only be used as an accompanying measure: it cannot reverse the mistake of not reducing emissions.

1.8.3.1 Active removal of CO_2

The active reduction of the atmospheric concentration of CO_2 by generating net 'negative emissions' is only possible to a limited extent. For example, the technical capture of CO_2 from the atmosphere is not economically feasible at present (Socolow et al., 2011). A much-discussed option for 'negative emissions' is combining bioenergy with CO_2 capture and storage (BECCS). The plants absorb the CO_2 from the atmosphere by photosynthesis, and after the biomass has been converted into thermal energy, the CO_2 is not returned to the atmosphere, but captured and stored. Overall, therefore, CO_2 is withdrawn from the atmosphere in this way. Apart from the availability of secure storage facilities for CO_2, one important limiting factor for such negative emissions is the amount of sustainably produced biomass that is available. The WBGU has estimated that a maximum of 1.8–3.7 Gt CO_2 per year could be made available for sequestration from sustainable biomass (WBGU, 2010a).

Another option for reducing the CO_2 content of the atmosphere is afforestation, as long it can be ensured that the timber is protected from decomposition. Also

in question would be the cultivation of algae in the ocean (WBGU, 2013). The CO_2 would then be stored either by sinking the algae in the deep sea – although this would involve unknown risks – or by fermentation and transfer to CO_2 repositories. Less well-known and little-researched options include the use of biochar and 'artificial trees' (Milne and Field, 2012). Biochar is made by slowly heating agricultural residues in a low-oxygen environment. The biochar can then be added to the soil, causing an increase in production under certain circumstances. In the case of 'artificial trees', the CO_2 is captured by coating a supporting material, which is exposed to the wind, with sodium carbonate; this reacts with CO_2 to form sodium bicarbonate. The advantage here is that the CO_2 can be easily released.

1.8.3.2 Manipulation of the Earth's radiation balance

Processes for manipulating the radiation balance aim to reduce incoming solar radiation, for example by introducing aerosols into the upper atmosphere, or by means of other large-scale technical installations that reflect some of the radiation. What all the processes have in common is that they can have side-effects on the climate and ecosystems, since they represent targeted interventions in a non-linear, coupled system. Furthermore, they are not suitable for restoring a climate that corresponds to a state with a lower greenhouse concentration. Even if the temperature can be reduced as desired, other climatic parameters such as precipitation patterns might be greatly changed (IPCC, 2013b). Moreover, these methods do not affect the forms of CO_2-induced damage that are independent of temperature, such as ocean acidification. Because some of the processes are technically relatively easy to implement, there is a risk of unilateral action being taken, with consequences for the entire international community. There is no sufficient basis in international law for regulating a large-scale application of such processes. In view of the given uncertainties, the WBGU advises against the use of processes to manipulate the radiation balance. The impacts of these processes on the climate system should first be subjected to more thorough research.

1.9 Overall conditions needed for the transformation towards a low-carbon society

1.9.1 Emission trends and their drivers

Despite all the efforts that have been made to date to combat climate change, global greenhouse gas emissions have continued to grow over the past few years. Between 2000 and 2010 the growth rate was 2.2% per year, compared to average increases in the three previous decades of only 1.3% per year (Section 1.4; Figure 1.4-3).

Figure 1.9-1 gives a breakdown of trends in greenhouse gas emissions according to different country groupings which correspond to the World Bank's classification of countries in four income groups: (1) low-income, (2) lower-middle-income, (3) upper-middle-income and (4) high-income countries. However, this classification does not take into account the considerable income disparities within the countries. These differences also have a considerable impact on per-capita emissions, which vary greatly both between the countries in the same income group and within these countries themselves (Figure 1.9-1c).

A considerable proportion of the absolute increases in global emissions over the past few years has been in upper-middle-income countries, where economic and infrastructure development has been strong. A sectoral breakdown of the emissions shows that these countries are essentially following the development paradigm of the industrialized countries (David et al., 2014). However, this should not obscure the fact that it is still the countries with high incomes that generate the highest per-capita emissions. Overall, per-capita emissions in the industrialized countries have changed little over the past few years. They are about five times higher than those of the poorest countries, which have also hardly changed. In-between lie the per-capita emissions of the upper-middle-income countries, which have risen greatly over the last few years (Figure 1.9-1).

The main driver of the increases in global emissions over the last few years has been the economic development of a growing world population. Unlike the years between 1970 and 2000, when there was a steady decarbonization of energy production, the carbon intensity of the energy sector (i.e. emissions from the generation of a certain amount of energy) has increased in the last ten years. This is because the use of coal in power generation has been rising again (David et al., 2014).

At present just 20 countries are responsible for a total of 75% of global emissions. This clearly shows that the decisions made by a small number of countries about their future development pathways have a considerable impact on global climate protection. However, these countries cannot halt climate change completely on their own, since anthropogenic climate change can only be stopped if fossil CO_2 emissions fall to zero in all countries (Section 1.4).

1.9.2 Climate protection requires new investment patterns

The transformation towards a low-carbon economy requires fundamental changes in investment patterns (WBGU, 2012). The IPCC's scenario calculations suggest that annual investment in conventional, fossil-fuel-based electricity generation would have to fall by US$30 billion (US$2–166 billion) over the next

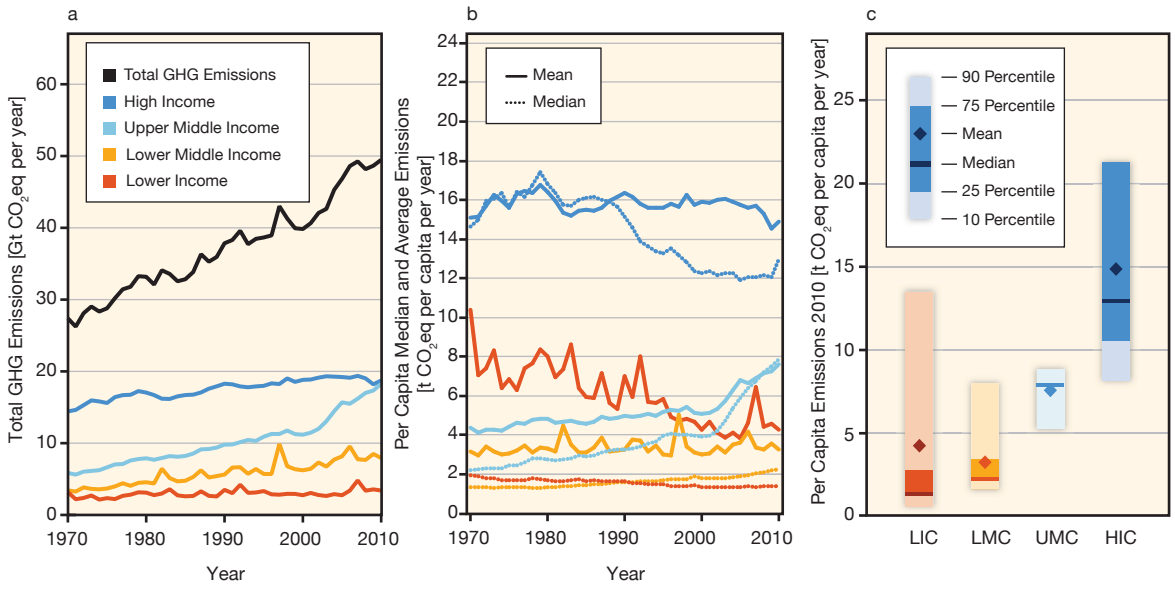


Figure 1.9-1
Trends in GHG emissions by country income groups. (a) Total annual GHG emissions from 1970 to 2010 (Gt CO_2eq/yr). (b) Trends in annual per-capita total and median GHG emissions from 1970 to 2010 (tCO_2eq/cap/yr). (c) Distribution of annual per-capita GHG emissions in 2010 of countries within each income group (tCO_2eq/cap/yr). Mean values show the GHG-emission levels weighed by population. Median values describe the GHG-emission levels per capita of the country at the 50th percentile of the distribution within each income group. Emissions are converted into CO_2 equivalents based on global warming potentials with a 100-year time horizon (GWP100) from the Second IPCC Assessment Report. Assignment of countries to income groups is based on the World Bank classification.
Source: Edenhofer et al., 2014

twenty years, while annual investment in low-emission power generation would have to increase in parallel to US$150 billion (US$30–360 billion). Annual global investment in energy currently amounts to about US$1,200 billion (IPCC, 2014d).

The International Energy Agency warns: "The date at which the existing energy infrastructure will lock in all the CO_2 emissions from the energy sector provided for in a global CO_2 emissions budget consistent with a 2 °C trajectory, leaving no provision for emissions from new carbon-emitting infrastructure to meet growing demand, is close" (IEA, 2013a: 44ff.). It therefore recommends already restricting the use and construction of inefficient coal-fired power plants in the period up until 2020.

In addition to changing investment in energy-generation sectors, the IPCC's 2 °C-compatible scenarios show a rise in annual investments in energy efficiency in the fields of transport, buildings and industry amounting to US$336 billion (US$1–641 billion) (IPCC, 2014d).

As the WBGU has stated elsewhere (WBGU, 2012), although a transformation of the energy systems towards sustainability involves additional investment in the short and medium term, it offers the economy as a whole considerable long-term cost reductions and additional societal benefits compared to maintaining the current structure of energy systems (IEA, 2010; WWF et al., 2011; GEA, 2012; Section 1.9.3).

Studies suggest that globally cost-effective pathways ensuring compliance with the 2 °C guard rail will require a large proportion of investments to be made in non-OECD countries this century (Edenhofer et al., 2014). In this context, effort-sharing systems can help clarify discrepancies between the distribution of costs based on mitigation potential and a sharing of responsibility based on ethical principles (Chapter 2). They can also help offset these differences by means of international financial transfers (medium confidence level). According to studies, financial transfers aiming to offset these asymmetries could reach the order of a hundred billion US dollars a year by the middle of the century (IPCC, 2014d).

1.9.3 Mitigation measures and their co-benefits

The IPCC names the following policy instruments for mitigation:

- economic incentives, such as taxes, tradable allowances, penalties or subsidies;
- direct regulatory measures, such as technological or performance standards;
- information programmes, such as labelling or energy audits;
- public procurement, e.g. of new technologies or in state-owned companies; and
- voluntary actions initiated by governments, companies or NGOs.

The successful implementation of such policies depends in many ways on individual and institutional modes of behaviour. Social norms, decision-making rules, behavioural biases and institutional processes also influence the activities that are to be addressed by climate policy (Edenhofer et al., 2014).

Since the Fourth IPCC Assessment Report, the focus has shifted to policies that pursue multiple objectives, boost co-benefits and minimize negative side-effects. The WBGU defines co-benefits as additional (positive) synergy effects which are not actually part of the objective but emerge when a political objective is achieved. Major co-benefits of climate-policy measures in the energy sector can, for example, be improvements in the local air quality or improved energy security. However, these effects are highly dependent on the circumstances, e.g. on whether or not measures to combat air pollution are already in place. These co-benefits can mean that an ambitious mitigation policy leads to considerable cost savings in the areas mentioned. The IPCC also mentions a number of co-benefits for other areas of mitigation; however, many of these are often difficult to quantify.

1.9.4
Change agents and alliances for climate protection

The Fifth IPCC Assessment Report comes to the conclusion that international cooperation for climate protection has become more institutionally diversified over the last ten years. Although the UNFCCC is still the central forum for climate negotiations, it has been joined by many other institutions at the global, regional, national and local level, as well as by public-private institutions and transnational networks (Stavins et al., 2014).

The number of national mitigation policies and strategies has also increased. In 2012, 67% of global greenhouse gas emissions were already covered by national legislations, compared to only 45% in 2007. However, up to now this has not led to substantial deviations in global emissions from the trend of the past (Edenhofer et al., 2014). In addition, the goals for the period up to 2020 that have been submitted by countries up to now ('Cancún pledges'; Figure 1.8-1) are not consistent with cost-effective mitigation pathways that offer a 50% probability of compliance with the 2 °C guard rail.

There is a huge gap between the potential for climate protection on the one hand, and the resources that are available, or are being mobilized, for its implementation on the other. The regions with the greatest potential for avoiding emissions-intensive development pathways and for directly pursuing a low-carbon pathway are the poorest developing regions; here, few path dependencies have developed to date because a modern energy infrastructure has yet to be built up, and in many cases urbanization processes are yet to develop. At the same time, financially, technologically and institutionally these regions are the most poorly equipped to follow a low-carbon development pathway. Emerging economies are already more locked into emissions-intensive pathways, while the rapid development of their energy systems and cities offers considerable potential for implementing climate protection. However, their financial and technological possibilities are also limited. Industrialized countries have the strongest path dependencies, but at the same time they are the best equipped to change their orientation in the direction of a low-carbon development.

Climate change is therefore a problem that can only be tackled with the help of global cooperation – for two reasons: first, it is a global commons problem in which free access leads to overexploitation; second, emissions, mitigation options, capacities and resources, and the degrees to which people are affected are all unequally distributed, so that cooperation is necessary. Organizing such global cooperation in a just and equitable manner is the subject of the following Chapter 2.

1.10
Core messages

- Climate change and human influence on the climate system are indisputable.
- Climate projections based on present emission rates point to a temperature increase of 4 °C (compared to the pre-industrial level).
- The 2 °C guard rail is becoming more important than ever in order to prevent great damage.
- Compliance with this guard rail requires a zero-emissions target: CO_2 emissions from fossil fuels should be cut to zero by 2070 at the latest.
- The longer action is delayed, the more expensive compliance with the 2 °C guard rail will become and the riskier the necessary technologies will be.
- Climate protection is an investment in the future, but it is affordable and can reduce costs in the long term.
- The transformation towards a low-carbon society offers considerable co-benefits.

Challenges for equitable climate protection

2

The goal that the international community has set itself with the United Nations Framework Convention on Climate Change (UNFCCC) seems clearly defined: to stabilize atmospheric greenhouse gas concentrations at a level that prevents dangerous anthropogenic interference with the climate system (Article 2 of the UNFCCC). Science can help specify and implement this goal by providing research findings on the interrelations and causes of climate change, by drafting scenarios and deducing scientifically founded recommendations. However, the decision on which level is to be sought and how a stabilization is to be achieved must be negotiated at the political and societal level and translated into practical actions.

2.1 Compliance with the 2 °C guard rail as a key target of international climate policy

At the 2010 UN Climate Conference in Cancún, the international community set itself the target of limiting human-induced global warming to less than 2 °C (Chapter 3). This target has been a subject of political discussion since the mid-1990s (WBGU, 1995, 1997).

The Fifth IPCC Assessment Report (IPCC, 2013a, 2014a, b; Chapter 1) underlines the appropriateness of this target by showing more clearly than in previous reports the serious risks to be expected as a result of climate change if global warming exceeds 2 °C. If the 2 °C guard rail is breached, this can endanger the natural life-support systems of millions of people, for example if food production is threatened by weather extremes, or the natural water supply declines in arid regions (Section 1.7). The WBGU therefore believes it is essential to gear global climate-protection efforts to compliance with the 2 °C guard rail, and at present it still seems possible to prevent warming from exceeding 2 °C.

The 2 °C guard rail has an important political and informational function, because it already enjoys a consensus in the international community and because targeted changes in actions are primarily made when they are focused on a target. Setting targets is effective when the targets are ambitious and simultaneously seem achievable in the given circumstances and with the available options (Locke and Latham, 1990), whereas targets that are not ambitious enough trigger little in the way of change (Becker, 1978). Another function of targets is that it is possible to continuously monitor the effectiveness of the measures that are taken to achieve them and to reveal the inappropriateness of unambitious measures. Once ambitious goals like the 2 °C guard rail have become established, they are supported and defended against dismantling (Jordan et al., 2013).

However, with every year that anthropogenic CO_2 emissions continue to rise, humanity becomes less likely to be able to prevent warming from exceeding 2 °C. If the required fundamental change in policies is not made in time, at least in the major industrial countries and emerging economies, then a point will be reached at which a future breaching of this barrier can no longer be prevented.

But even then, the WBGU's view is that it would make sense to maintain the guard rail as an orientation guide: the guard rail primarily represents an upper damage threshold upon which politically agreement has been reached. As with other norms set by the international community – such as the United Nations Charter of Human Rights – the guard rail would not become obsolete because nations fail to comply with it. Ambitious normative targets can therefore be regarded as a fundamental condition for the success of environmental and climate policy.

However, the identification of shared, normative targets initially only opens the negotiation process and defines the overall room for manoeuvre. The question then is what requirements have to be met for the guard rail to be complied with (Section 2.2). The subsequent question of implementation and, in particular, how responsibilities are to be distributed, focuses attention on perceptions of equity and processes of negotiating equity; these are covered in Section 2.3.

2.2 Prerequisites for compliance with the 2 °C guard rail

Continuing anthropogenic climate change can only be prevented if net emissions of CO_2 are reduced to zero worldwide (Section 1.4). However, the change in the climate that has already been caused by the CO_2 already emitted by then will remain irreversible for centuries: the surface temperatures will remain approximately

constant at elevated levels for many centuries, even after CO_2 emissions have stopped completely (IPCC, 2013a). If the 2 °C guard rail is not to be exceeded, there only remains a limited budget of still-sustainable global CO_2 emissions from fossil fuels (Section 1.8). Other greenhouse gases also contribute to climate change, and their emissions should be reduced; however, it will not be possible to limit anthropogenic climate change without a cessation of CO_2 emissions.

In the IPCC's new climate scenarios (Section 1.5) enabling compliance with the 2 °C guard rail, CO_2 emissions from fossil fuels are at or below zero in the second half of the 21st century (Figure 2.2-1). The sooner the CO_2 emissions are lowered, the less 'negative emissions' will be necessary, i.e. the active absorption and storage of CO_2 from the atmosphere, a process that has not yet been commercially tested (Section 1.8.3). The WBGU therefore recommends establishing the target of completely stopping global CO_2 emissions from fossil energy sources by 2070 at the latest in order to have a realistic chance of limiting global warming to 2 °C (Section 1.10). This requires reducing fossil CO_2 emissions to zero in every country, every region and every sector by 2070 at the latest.

2.3 Responsibility for compliance with the 2 °C guard rail

Reducing CO_2 emissions from fossil fuels to zero by the year 2070 at the latest is a key task for the present human generation in the context of inter- and intragenerational equity. The core issue is to avert irreversible damage for future generations and not to shift the responsibility for climate protection – and for dealing with the consequences of climate change – to the future generations. If action is delayed today, not only the costs of effective climate protection, but also the risks posed by climate change will rise sharply in the future. The affected future generations are not abstract groups of people. Rather, they are the children who have already been born in our time – who will spend the second half of this century either benefiting from an ambitious present-day climate policy or having to live with the negative consequences if it fails. According to Jonas' universally recognized imperative of responsibility (1979), future generations should not be confronted with worse, but if possible with better, living conditions than the present generations. In the spirit of this responsibility for the future, it is necessary to begin now with the transformation to a low-carbon society and economy (WBGU, 2011). In the WBGU's view, it is part of the common responsibility of all parties to the climate negotiations that every state creates the overall legal and political conditions for national climate-friendly development and for phasing out the use of emissions-intensive fossil energy sources. In particular, all states should ensure that no investment is made in long-lasting, emissions-intensive infrastructure.

However, this principle of being responsible for the future transformation into a decarbonized economy and society can be understood in different ways by the countries involved. There are various concepts (effort-sharing systems) in literature on how the task of global climate protection might best be spread over the shoulders of the states. The Fifth IPCC Assessment Report (Clarke et al., 2014) provides an overview of this along the lines of the categorizations presented by Höhne et al. (2013). The equity principles included there are as follows:

1. *Historical responsibility*: This can be a country's cumulative emissions, for example. Reference points often proposed include the beginning of industrialization and the year 1990; here it is assumed that the people were aware of the problem of climate change. Other reference years are also proposed and discussed.
2. *Capability:* Capability usually relates to the ability to pay and is represented, for example, by the gross domestic product GDP or the human development index (HDI). Other approaches relate capability to the concept of 'basic needs' or the right to development. The argument is that states with a lower capability may first meet their 'basic needs' before being obliged to take action to protect the climate.
3. *Equality:* Equality emphasizes that all human beings have an equal right to development and is usually translated into an equal allocation of emission rights. These equal rights can relate either to a certain point in time or to an average over a fixed period of time.
4. *Cost-effectiveness:* Cost-effectiveness is not so much an equity principle as one of burden-sharing. According to this principle, countries with high emission-reduction potential must implement more ambitious reductions than those with low mitigation potential. Mitigation potential is often defined using marginal abatement costs, i.e. the costs of additional reductions beyond a certain baseline. These cannot always be unequivocally determined, however.

Scientific observations of the climate negotiations have shown that the parties involved refer to different equity principles and often prefer those that involve the least operational effort and the lowest emission targets for themselves (Lange et al., 2010). However, since the various circulating principles can be connected with very different responsibilities and types of operationalization, a strict insistence on the most self-serving principle can block urgently needed agreements on practical steps toward implementation. In the WBGU's view, the diversity of different equity principles and effort-sharing approaches that exist side-by-side also have an ambivalent effect on the negotiation process. On the one hand, they create room for manoeuvre and flexibility within the discussions, which can be important for motivating countries to take part in the process at all. At the same time, however, the diversity increases complexity in an already highly complex situation. Accordingly, the

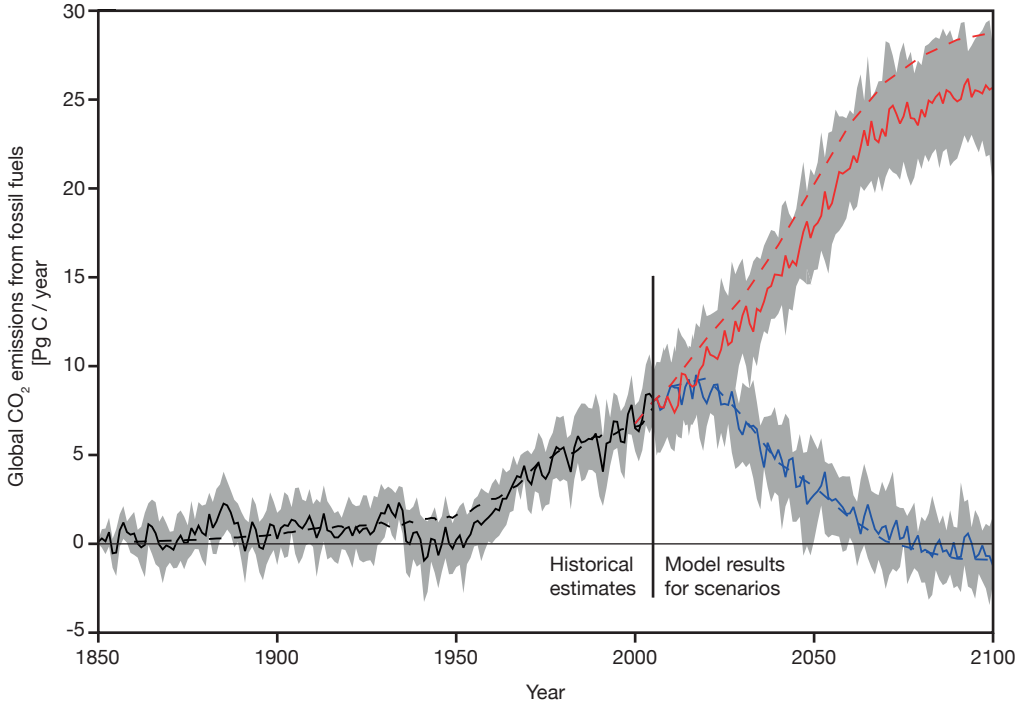


Figure 2.2-1
Global CO_2 emissions from fossil fuels according to historical estimates and for different future scenarios (1 Pg of C corresponds to 3.67 Gt of CO_2). The dashed lines show the historical estimates and model results of integrated assessment models; the solid lines show the results of a model comparison of more complex Earth-system models with the related standard deviations (grey-shaded area). The upper, red line shows emission paths that will lead to global warming of well over 4 °C compared to the pre-industrial level by 2100; the lower, blue line shows emission paths that are compatible with the 2 °C guard rail. The 2 °C-compatible paths show average emissions for 2050 that are 50 % below those of 1990. The cumulative global CO_2 emissions from fossil fuels between 2012 and 2100 for this scenario average about 990 Gt of CO_2.
Source: modified on the basis of Stocker et al., 2013

supposed room for manoeuvre simultaneously creates a 'lock-in situation'.

The WBGU therefore regards consultations and agreements on fundamental equity principles as a key precondition for the operationalization of climate targets. The WBGU proposes using the budget approach (WBGU, 2009; Box 2.3-1) and the equity principles enshrined therein for guidance. The budget approach is based on a clear and transparent system of distribution justice in which every human being is assigned equal emission rights (equality principle). At the same time, in line with the 2 °C guard rail, a ceiling is fixed on emissions (precautionary principle), resulting in different responsibilities in view of historical and current emissions (polluter pays principle). The WBGU proposes integrating these principles into the agreements on climate targets and using them as a basis for assessments of the suitability of targets and transfer payments. In the WBGU's view, the budget approach can thus serve as an orientation aid for equitable climate protection. However, the function of the budget approach shifts in the light of the WBGU's recommendation to reach the zero fossil CO_2 emissions target worldwide by 2070 at the latest. Pursuing the zero-emissions target, the priorities will gradually shift from the distribution of emission rights to a fair distribution of the costs of climate change, i.e. the costs of mitigation, technology transfer, adaptation and dealing with loss and damage caused by consequences of climate change (Chapter 3).

Under the UNFCCC, the states agreed to protect the climate system "on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities" (Article 3 (1) of the UNFCCC). In the WBGU's view, the zero-emissions target is linked to two new meanings, or extended perspectives, of the 'common responsibilities', i.e. responsibilities that are shared by all. These relate first to the climate negotiations in the narrower sense of the word and require all participating states to take responsible and committed decarbonization action in their own countries. Second, an extended interpretation of 'common responsibility' is also connected with opening the arena of climate protection to all social actors, who should contribute to decarbonization and to both local and global climate protection according to their capabilities.

2.3.1 The zero-emissions target as a common responsibility of all states

The WBGU regards it as the common responsibility of all states to come to an agreement on reducing global CO_2 emissions from fossil fuels to zero by the year 2070 at the latest. Ideally, this should be agreed multilaterally (Chapter 3) and would reflect developments

Box 2.3-1

Equity principles and the WBGU budget approach

Proceeding from the realization that the extent of global climate change is largely determined by cumulative CO_2 emissions, the WBGU began its 2009 report on climate policy (WBGU, 2009) with a concept for a global climate treaty. According to this 'budget approach', the first step would be to decide on a global emissions budget; in order to achieve a two-thirds probability of complying with the 2 °C guard rail, this would be approximately 750 Gt of CO_2 from fossil sources for the period from 2010 to 2050. This global budget would be distributed among all countries based on their share of the world's population. The approach further states that all countries should undertake to submit internationally and objectively verifiable decarbonization road maps which are oriented not only towards the national CO_2 budgets, but also towards the country's actual emissions-reduction potential. Any exceeding and undercutting of the allocated budgets would be offset by international emissions trading, in which transfers between high-emission and low-emission countries would be expected. In addition, the WBGU's approach requires the states to make payments for adaptation measures to the countries affected as compensation for their historical emissions before the beginning of the budget period (WBGU, 2009).

The WBGU's budget approach is based on the precautionary principle, the equality principle and the polluter pays principle.

The points of departure are the *responsibility for future generations* and the *precautionary principle*. This principle calls for timely action to prevent irreversible damage for future generations. As described above, this is taken up in the operationalization of the 2 °C guard rail by laying down a global emissions budget. This limited budget requires that the policies not only of the industrialized countries, but also of the emerging economies and developing countries aim for a low-carbon future. A 'catch-up' development based primarily on fossil fuels would be tantamount to gambling with much of humanity's natural life-support systems.

The *equality principle* postulates that every individual has an identical right to the use of the global common goods. Although it has not yet been enshrined in law, it is recognized by many states. This principle suggests basing the distribution of national emissions budgets on per-capita emissions, i.e. all states are allocated a national budget from the global budget in accordance with their share of the world's population. This limited budget should not, however, be understood as an individually enforceable right to a particular per-capita budget. It represents a special challenge for the industrialized countries, since their per-capita emissions will have to fall particularly sharply.

Finally, the *polluter pays principle* implies special obligations for industrialized countries due to their high cumulative emissions in the past and their expected over-exploitation of the budget – obligations not only to reduce emissions, but also to provide compensate to those countries that do not use their full budget in the spirit of common responsibility. But equally it is a great challenge for the emerging markets, whose current and cumulative emissions are rising sharply at present. From the point of view of intragenerational equity, high-emission countries also have a special obligation to support countries and regions that are currently particularly threatened by the consequences of climate change.

The impression from the current status of multilateral processes in climate negotiations is that there is insufficient support for a practical operationalization of the budget approach as suggested by the WBGU, i.e. a per-capita distribution of the budget among the states. However, the WBGU continues to regard the normative principles of the budget approach – i.e. the precautionary principle, the principle of equality and polluter pays principle – as an important orientation framework, e.g. with regard to the responsibility to support adaptation measures (Chapter 3).

in recent international environmental law, where there is a process towards a symmetry of legal obligations for all participating countries (e.g. Minamata Convention; French and Rajamani, 2013). This responsibility, which is primarily based on the precautionary principle – i.e. the shared concern to prevent irreversible damage for future generations in the spirit of intergenerational equity – is a special challenge especially for emerging economies and (above all) developing countries; after all, up to now they have perhaps been reluctant to accept responsibility for global climate protection. Yet it also requires decisive action from them. They must reinterpret their 'right to catch up in their development' against the background of a global decarbonization strategy and join the industrialized countries in pursuing sustainable/zero-emission development paths.

Following the principle of common but differentiated responsibilities and countries' different capabilities, as mentioned in Article 3 (1) of the UNFCCC, this shared responsibility of all states cannot, however, mean that the financial burden of the transformation must borne by every country in the same way. In the WBGU's view, here, too, the WBGU's budget approach and its underlying principles can provide clear orientation. According to the equality and polluter pays principles, countries with currently and/or historically high per-capita emissions in particular have a responsibility not only to proceed quickly with their own decarbonization, but also to support other countries financially, technologically, and through knowledge transfer and capacity building in their transformation towards a low-carbon society. This responsibility is also increasingly relevant to the emerging economies, which are pursuing an emissions-intensive development path and whose absolute and per-capita emissions are rising sharply (Section 1.9.1). For the emerging markets this means a change both in their self-image and in their role in climate negotiations. As co-polluters they are confronted not only with the call to transform their own development path, but increasingly also to take on more responsibility for global climate protection.

The operationalization of the high-emission countries' responsibility to provide financial, technological and capacity-building support should, in the WBGU's view, represent a key point in the debate on equity in relation to climate protection.

An interim appraisal of multilateral processes under the UNFCCC shows that there has not yet been a breakthrough in international climate protection with the international community agreeing ambitious decarbonization

Box 2.3-2

CO_2 budget – where does Germany stand?

In its report entitled 'Solving the climate dilemma: The budget approach', the WBGU (2009) proposed agreeing a global emissions budget for the period up to 2050 and distributing this budget among the countries of the world on a per-capita basis. Two possible options are explained in the following and compared with the possible development of emissions in Germany.

The 'future responsibility' option favoured by the WBGU lays down a global budget of 750 billion tonnes of CO_2 for the period from 2010 to 2050; if no more than this amount is emitted, there is a two-thirds probability of limiting anthropogenic global warming to 2 °C. This budget is then distributed among the individual states according to their share of the world's population in 2010. In line with its estimated 1.2% of the world population, Germany's budget would amount to 9 billion tonnes of CO_2 for the period from 2010 to 2050 (WBGU, 2009).

In the WBGU's second option, called 'historical responsibility', the budget to be distributed begins in 1990. It is based on a global emissions budget of 1,100 billion tonnes of CO_2 for the period from 1990 to 2050; this would limit warming to 2 °C with a probability of 75%. In line with its 1.5% share of the global population in 1990, under this option Germany would be entitled to a total budget of 17 billion tonnes of CO_2 for the 1990 to 2050 period. This budget was already exhausted in 2009 (WBGU, 2009).

The German Federal Government is seeking a reduction in greenhouse gas emissions of 40% by 2020 and 80–95% in 2050 compared to 1990. In 2010, on behalf of the German Federal Ministry of Economics and Technology and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, energy scenarios were developed to implement these targets; they were complemented by further scenarios in 2011 after the decision had been taken to phase-out nuclear power (Schlesinger et al., 2010, 2011).

The WBGU bases its exemplary estimate of Germany's cumulative CO_2 emissions up to 2050, as outlined in Figure 2.3-1, on a scenario incorporating both the nuclear-energy phase-out and ambitious CO_2 emissions reductions from the study by Schlesinger et al. (2011). The scenario contains emissions figures for the years 2015, 2020, 2025 and 2030, which were connected linearly in the figure. Since the scenario ends in 2030, a further linear reduction in emissions was assumed for the period between 2030 and 2050 in which emissions in 2050 are 87% lower than those of 1990. In this scenario, Germany's cumulative CO_2 emissions – corresponding to the total area beneath the curve in Figure 2.3-1 – come to 34 billion tonnes of CO_2 for the period from 1990 to 2050. Of this, 17 billion tonnes of CO_2 relate to the period from 1990 to 2009, and a further 17 billion tonnes of CO_2 to the period from 2010 to 2050.

As already mentioned, Germany already exhausted its budget under the 'historical responsibility' option in 2009. Under the 'future responsibility' option, Germany would be entitled to a budget of 9 billion tonnes of CO_2 between 2010 and 2050; in the scenario outlined this would be exceeded in the course of 2024 (Figure 2.3-1).

This calculation shows that, if Germany maintains its current objectives, it will overdraw its carbon account in both responsibility scenarios. Germany would therefore have to make technology and financial transfers to support other countries in their efforts to reduce emissions, or promote adaptation measures and make compensatory payments to cover loss and damage.

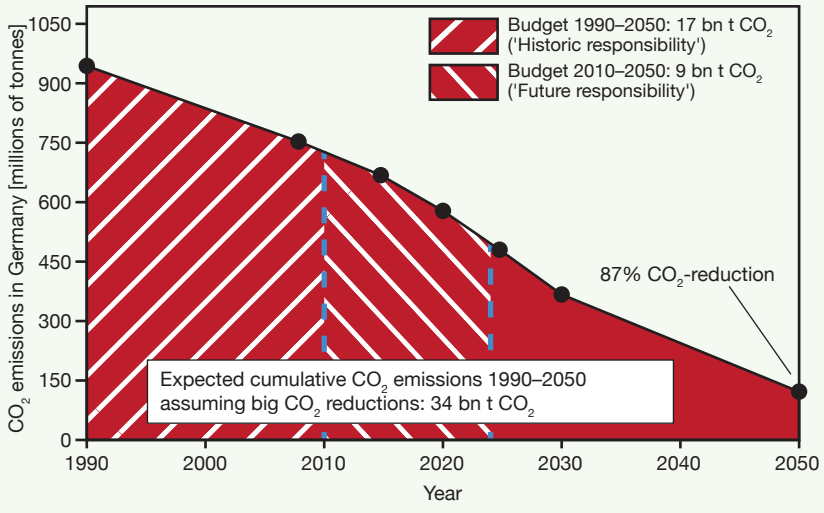


Figure 2.3-1
Sketch of the possible development of Germany's CO_2 emissions if the government's current mitigation targets are implemented as well as emissions permitted according to the WBGU's budget approach. In the case of the 'historical responsibility' option, which divides a global budget among all states as from 1990, Germany's budget has already been exhausted since 2009. In the case of the 'future responsibility' option, which divides a global budget as from 2010, Germany will exceed its budget in the course of 2024 if it follows the development of emission as outlined.
Source: WBGU using data from Schlesinger et al., 2011

targets and an equitable distribution of costs. It remains to be seen whether the positive signals recently coming from the USA and China in the field of climate protection are an indication that a trend reversal – and a new, ambitious agreement – can be reached in 2015 in Paris. The WBGU still believes the activities within the framework of the UNFCCC are important and will make concrete proposals for developing them further in the course of this report (Chapter 3). Additional, possibly decisive impulses for global climate protection are expected from other arenas – where there are initiatives that are raising expectations and intensifying pressure for multilateral negotiations and designing their own solutions for climate protection (Chapter 4).

2.3.2 The zero-emissions target as a common responsibility shared by all social actors

In the WBGU's view, the zero-emissions target raises the prospect of further extending the common responsibility for climate protection, bringing on board all relevant actors – whether they be states, municipalities, companies or individual citizens – and motivating them to focus their actions on the zero-emissions target. This seems an especially good idea because the impression is that the current multilateral processes and the countries that are particularly influential in these processes – like the USA, China and Europe – still seem to be blocked by short-term economic and geopolitical interests and perceptions. In the global civil society (churches, associations, citizens' initiatives), as well as increasingly at the level of cities and in more and more companies, there is a growing unease about these blockades, and efforts to influence climate policy are on the increase (Section 4.1).

At the same time these groups of actors are highly willing to take on individual and collective responsibility for the causes and the prevention of climate change. At the national and international level, important moral authorities like churches, foundations and trade unions regularly send ideas and proposals, both individually and in alliances, to climate policy-makers in order to raise expectations and build pressure to take action (e.g. EKD, 2013a; ITUC, 2010; Verolme et al., 2013). The tenor of these different publications is similar: they call for a commitment that is more serious and more oriented towards active climate protection, that is based on accepting and taking on a high level of responsibility – and on a sensitive approach to equity issues. The respective protagonists also see that they themselves have a responsibility to work on climate protection, both at the international level and locally in their own spheres of action (e.g. the German Protestant Church's Climate Report: EKD, 2011). These initiatives are explicitly or implicitly guided by the norms of the precautionary, equality and polluter pays principles. They gear their own actions towards the categorical imperative and no longer want to be co-responsible for further delays in mitigation and any breaching of the 2 °C guard rail. Examples include the wide range of new initiatives that have emerged in great density over the last few years in local authorities, businesses and civil society, and reveal ways to overcome blockades in climate protection. They include 'Sustainable Energy for All', 'Decarbonization 2050', 'Climate-Neutral Church' and the networks and self-commitments of cities and companies.

2.3.3 A new responsibility architecture for climate protection: The interplay between the world citizen movement and multilateralism

If the multilateral process stagnates as the best way of solving a global 'commons' problem, this certainly does not mean that climate policy in the sense of a global assumption of responsibility for climate protection has failed. On the basis of the above-proposed expanded definition of 'common responsibility' and the zero-emissions target, the global society and all social actors are also under an obligation – independently of multilateral or international cooperation. Initiatives with promising transformative potential are introduced in Chapter 4, together with information on how their influence for global climate protection can be strengthened.

However, the objective here is not to delegate responsibility for global climate protection from the political to another societal level. It is rather to connect the initiatives of different social actors and constellations of actors with the multilateral negotiations in a newly forming responsibility architecture. As explained in greater detail in Sections 4.6 and 6, the growing assumption of responsibility by global civil society can achieve a more horizontal distribution of responsibility, powerfully complementing the vertical delegation of responsibility to climate diplomacy. The different initiatives can reinforce each other and extend their effect to different actor levels. The world citizen movement that is emerging from this (Appiah, 2006; Beck, 2009; Benhabib, 2006) sends impulses to state actors of international climate diplomacy. It can vitalize the negotiations by extending the horizon of values and revealing exemplary low-carbon practices and development paths. Interaction between the world citizen movement and multilateral climate diplomacy can also be strengthened by offering promising initiatives optimal conditions for diffusion and networking, and by enabling them to participate in the global climate-policy arena.

2.4 Core messages

- The 2 °C guard rail and the resultant focus on the zero-emissions target for every country, every region and every sector of society should be maintained as the political goal and normative orientation in the climate negotiations and laid down in a binding form.
- Regardless of a global agreement, it is the responsibility of all countries to initiate and implement a transition to a CO_2-emissions-free economy, in order to preserve options for action and development opportunities for future generations.
- Given their large contribution to the causes of climate change, the high-emission countries have a responsibility to support the low-emission countries in their transformation.

- For the further climate negotiations it is useful to agree on basic equity principles (such as the precautionary principle, the principle of equality and the polluter pays principle) and to relate to them when evaluating the objectives of the individual countries.
- The prospect that CO_2 emissions must be cut to zero by 2070 at the latest offers actors at all levels and in all areas of society a clear orientation for their actions and a basis on which they can assume their share of the responsibility for achieving the zero-emissions target.

Proposal for a Paris Climate Protocol in 2015

3

The negotiations on international climate policy under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC) are currently essentially based on (1) a mandate to enhance pre-2020 mitigation ambition, and (2) a mandate to negotiate a climate agreement applicable to all parties to come into effect from 2020 (Durban Mandate, Box 3-1). The basis for international climate policy is a consensus that global warming should to be kept below 2 °C.

For the period up until 2020 there is a patchwork of binding and non-binding agreements. A small group of countries, including the EU member states, have agreed to a second commitment period under the Kyoto Protocol (2012-2020) and to binding quantitative mitigation targets. In addition, all countries were called upon to disclose their emissions-reduction plans and targets for the period from 2012 to 2020. These are not, however, binding obligations, but part of a 'pledge-and-review process' in which the states first pledge climate-protection targets which they believe can realistically be reached. Although compliance is reviewed, no sanctions are imposed if the targets are not reached. About 60 countries have made such commitments to reduce their emissions. However, taken together, the targets submitted by the states to date are far from sufficient to ensure an ambitious and effective climate policy that guarantees compliance with the 2 °C guard rail (UNEP, 2013a). All states are currently being called upon to declare more ambitious mitigation targets for the period up to 2020.

For the period after 2020, the mandate agreed in Durban states that a new binding agreement is to be negotiated by 2015 and applicable to all parties to the UNFCCC (Box 3-1).

The WBGU recommends shaping the Paris agreement in the form of a protocol pursuant to Article 17 of the UNFCCC (Figure 3-1). A protocol agreed in consensus on this basis is legally binding. COP decisions with soft-law character should flesh out and, if necessary, supplement the protocol. This approach has also been customary in UNFCCC processes before and has proved to be successful. For example, the Kyoto Protocol was fleshed out by the COP decisions of the Marrakesh Accords (WBGU, 2003).

The WBGU is convinced that an international solution incorporating all 196 parties to the UNFCCC (as of July 2014) is essential to address the global problem of climate change. Political conflicts of interest between developing and industrialized countries, as well as among the industrialized countries themselves, are currently blocking progress under the auspices of the UNFCCC. Despite its vagueness, the Durban Mandate, nevertheless offers a new opportunity to agree effective universal measures to combat continuing global climate change in conjunction with other intergovernmental and civil-society processes. In the following sections the WBGU submits recommendations on how the planned Paris Climate Agreement can be designed in a way that it achieves as big an impact as possible and offers a realistic chance of political feasibility.

The following assessment, and the recommendations deduced from it, are based on an analysis of a wide range of scientific and policy proposals and drafts on the goals and content of a Paris agreement. A selection of important proposals on the planned Paris Climate Agreement is shown in Table 3-1 for comparison; this list does not claim to be exhaustive (Box 3-2). The WBGU does not subscribe fully to any of the proposals; rather, in the light of the debate on the planned Paris Climate Agreement and the demands of political feasibility, it develops a proposal of its own for a protocol that is compatible with WBGU's previous approaches in the context of the 2 °C guard rail. (1) The proceduralization of the 2 °C guard rail is a key element of the proposal: the idea is to put global civil society in a position – by means of information, participation and 'access to justice' (cf. Aarhus Convention; Box 3.2-1) – to measure, assess and monitor the climate-protection efforts of the parties in relation to the global, long-term goal (Section 3.3.1.2); the WBGU's budget approach (WBGU, 2009) should serve as orientation. (2) In addition to this democratization of the international climate regime, the WBGU proposes to use the Protocol to promote ambitious players in climate protection – e.g. city networks and alliances of countries engaged in energy transformation – and in this way initiate a change in the culture of multilateral climate protection, so that it takes its orientation not from the sluggish players, but from the ambitious ones. (3) In addition, an ambitious pledge-and-review process should be enshrined as a legally binding element, and (4) the industrialized countries should honour their pledges to mobilize US$100 billion every year from 2020 to support mitigation and adaptation in developing countries.

Box 3-1

The Durban-Mandate

The Durban Mandate (UNFCCC, 2011) does not clearly specify what legal form, targets and instruments the new binding agreement should have. This has been the subject of intense discussions ever since. There is agreement that the Conference of the Parties (COP) should adopt the new treaty in 2015 in Paris, that it should apply to all UNFCCC parties from 2020, and that its level of ambition should be higher than in the past. In principle the Durban Mandate also offers the option of agreeing a completely new treaty that could replace the UNFCCC. Such an option is currently only being discussed on the fringes, since the states are continuing to search for solutions under the auspices of the UNFCCC. In the WBGU's view, this is to be welcomed, because developing and agreeing an entirely new agreement would considerably delay effective greenhouse gas reductions. The UNFCCC already has almost universal participation among the countries of the world (with 196 parties), which should certainly not be put at risk. An attempt to replace the UNFCCC would further exacerbate the already fragmented nature of international climate-protection law, and hinder and delay ambitious solutions.

There is an intense discussion on whether the COP in Paris should simply take one or several 'COP decisions', which are not legally binding under international law (soft law). Although soft law is an important supplement to legally binding law in the context of international environmental conventions (see French and Rajamani, 2013, on the role of soft law in international environmental law), a restriction to soft law would not be in line with the Durban Mandate, which aims at a result with legal force. Total renunciation of a legally binding set of rules should therefore be rejected.

3.1 Guiding principle: Proceduralization of the 2 °C guard rail

The negotiations on a post-Kyoto climate agreement are in deadlock because the parties cannot agree on new, internationally binding reduction targets.

In the WBGU's view, therefore, it is a good idea to place the emphasis in a new climate agreement in 2015 on making commitments that relate to climate-protection targets and decarbonization roadmaps voluntary and flexible for the parties. In order to persuade as many countries as possible to sign up to a new climate agreement in Paris, the states themselves should be responsible for defining the size and modalities of their individual contributions to mitigation, adaptation and to dealing with loss and damage. Such a flexible and voluntary approach based on self-commitments opens up creative scope for the parties. However, it will only contribute to climate protection if (1) the states are obliged to submit mitigation targets and decarbonization roadmaps, and (2) these can be inspected, assessed and monitored not only by the United Nations, but also by global civil society.

This requires accompanying rules on procedure that guarantee the linking of assessments and decisions to current knowledge in climate science, and ensure transparency, participation and monitoring. To this extent, the WBGU pursues an approach that may be called the proceduralization of the 2 °C guard rail, since no compulsory and material reduction targets are agreed.

Rather, the extent and form of the individual nations' contributions to decarbonization are decided voluntarily by the parties themselves – without further rules under international law. However, they do have an obligation to develop climate-protection targets, e.g. up until 2030, and roadmaps for decarbonization up to 2070 at the latest. To this extent the WBGU's proposal for the Paris Climate Protocol is a 'hybrid approach' with both compulsory and voluntary elements.

Unlike the negotiation process on new global sustainable development goals (SDG process), for which the WBGU recommends the recognition of the 2 °C limit as an environment-related planetary guard rail to protect the Earth-system services (WBGU, 2014), the parties to the UNFCCC have already recognized the 2 °C guard rail on several occasions within the framework of the climate regime. Nevertheless, it is legally doubtful whether the guard rail is a target in the international climate regime that is recognized under customary international law and therefore marks the borderline of "dangerous anthropogenic interference with the climate system" within the meaning of Article 2 of the UNFCCC. In order to overcome this legal uncertainty, the WBGU recommends enshrining the 2 °C guard rail in a legally binding Paris Climate Protocol (WBGU, 2011, 2014). The *conditio sine qua non* for compliance with the 2 °C limit is the scientifically derivable, long-term objective of reducing CO_2 emissions from fossil fuels to zero worldwide in the second half of the century; the WBGU recommends striving to achieve this by 2070 at the latest (Section 1.4, Chapter 2). This global long-term objective should also be enshrined in a legally binding Paris Climate Protocol.

In view of the global rise in temperatures to date, the Paris Climate Protocol cannot, however, restrict itself to climate-protection measures; rather it must also include rules on adapting to climate change and on how to deal with loss and damage caused by climate change. The three areas – mitigation, adaptation and dealing with loss and damage – should be designed as an instrumental cascade. As before, measures based on the precautionary principle primarily target *mitigation*, i.e. preventing and avoiding "dangerous anthropogenic interference with the climate system" (Article 2 of the UNFCCC). At a second level, *adaptation measures* aim to alleviate and limit the effects of climate change that have already occurred or are expected, in order to reduce the hazards and risks. At a third level, finally, there is a need for measures to deal with the *loss and damage* that has already been – and will in future be – caused by climate change.

In the WBGU's view, the Paris Climate Protocol should have a 'General Part' containing legally binding overarching, procedural regulations for these three

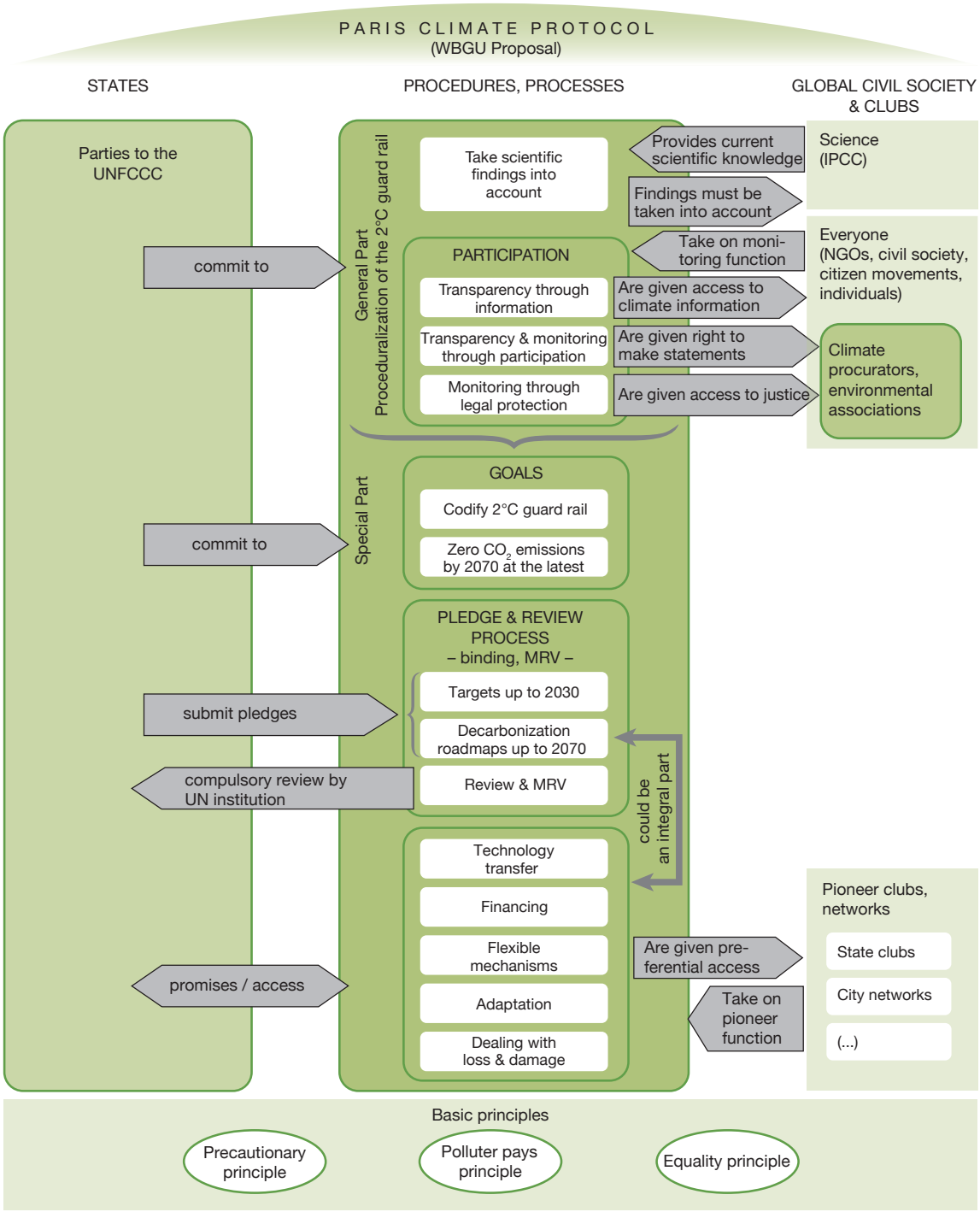


Figure 3-1
The WBGU's proposal for a Paris Climate Protocol. The principles are the precautionary principle, the polluter pays principle, and the equality principle. The parties to the UNFCCC commit to two compulsory parts of the Paris Protocol. The General Part of the Paris Protocol would oblige the parties to consider scientific expertise in all decision making and to guarantee participation rights, thus promoting transparency and monitoring by global civil society. These stipulations would apply to all areas and mechanisms of the Special Part. In the Special Part of the Protocol, the 2 °C guard rail and, as its concretization, the goal of zero CO_2 emissions by 2070 at the latest, would be enshrined as a compulsory, integral part of the treaty. The WBGU recommends a pledge-and-review process to ensure compliance with these obligations. The pledges would be (1) voluntary self-commitments in the form of a specific emissions-reduction targets up to 2030, and (2) decarbonization roadmaps up to the year 2070. The pledges would be subject to a binding review. Compliance with the fixed targets would be monitored by regular measurement, reporting and validation (MRV). The Special Part of the Protocol should contain rules on technology transfer, financing, flexible mechanisms, adaptation and dealing with loss and damage. Pioneer clubs and networks that are particularly engaged in the field of climate protection could be given preferential access to funding and technology transfer.
Source: WBGU

Table 3-1
Assessments of proposals on the planned Paris Climate Agreement. See Box 3-2 for information on sources.
Source: WBGU, 2014

	Mitigation	Measurement, reporting and verification (MRV)	Adaptation	Loss and damage	Financing, capacity building and technology transfer	Market mechanisms	Legal form
Haites et al. (2013)	› Pledge-and-review process › Phase-out of GHGs by 2050 › Ambition level rises automatically every 4 years › States not split into groups in the sense of the annex system › New way of registering measures by non-state actors	› Annual lists and semi-annual reports for all parties › Review by experts	› More financial and institutional resources required › UN panel should develop proposals for 2015	› More financial and institutional resources required › UN panel should develop proposals for 2015	› Financing according to the UN 'scale of assessment' › Technology transfer: use existing UNFCCC bodies; simplify and promote dissemination › Capacity building: no new rules required	› New body for market mechanisms which also takes on CDM and JI functions	› Content-related rules initially decisive; it could be a mixture of different instruments
Kreft and Bals (2013)	› Pledge-and-review process › Range of commitments › Commitments dependent on development status	› Uniform standards and verifiable procedure › Further develop International Consultations & Analysis (ICA) & International Assessment & Review (IAR)	› Continuation of the 'adaptation framework' developed in Cancún › States could set themselves an adaptation target	› International 'insurance solution' similar to the African Risk Capacity on drought risks › Compensation mechanism under the UNFCCC	› The existing funds must be replenished › The Standing Committee on Finance should review the financing mechanism every four years	› Market mechanism in which only states that commit to comply with the 2°C target are allowed to take part	› Legally binding part is short and concise › Supplemented by COP decisions
EU Submission to the ADP (2013)	› Pledge-and-review process: regular assessment including ambition raising › Reduction commitments for all, taking 'common but differentiated responsibilities' into account › Compliance with the 2°C target	› System for monitoring commitments required › Experience from Kyoto: ICA & IAR	› Support for ongoing adaptation efforts › Mitigation and adaptation are linked	› Initiate work programme	› Mobilization of further financial resources required › EU wants to pay a fair share of the promised $100 billion per year up to 2020	› Market mechanisms important instruments for promoting cost-effectiveness	› Legally binding and ambitious commitments for all states in the form of a Protocol
Edenhofer et al. (2013)	› Pledge-and-review process with scientific review & incentives to raise ambition › Gradual, continuous increase in ambition must be possible	› Transparent MRV system required	› Further research and analysis required › Role of private investment should be looked at		› Innovations and transfer of mitigation technologies must be financed	› Allow, interlink, and possibly coordinate bottom-up market mechanisms in the context of the UNFCCC	› Hybrid legal form with legally binding and non-binding elements › Flexibility of the agreement
Sterk et al. (2013a, b)	› Agreement with flexible design › Various forms of commitment › Regular review of ambition level (at intervals of max. five years) › Development of ZEDS (zero-emissions development strategies) in all states	› Uniform system similar to rules of the Kyoto Protocol	› Financing must also focus on adaptation	› Financing must also focus on loss and damage	› The Paris agreement should contain financing commitments that are based on scientific estimates of developing countries' needs › Ideally the climate regime should finance itself by 'emissions pricing'	› Criticism of emissions trading and Kyoto Protocol ('basket approach') › No emissions trading by governments	

Morgan et al. (2013)	› Ambitious reduction targets to be reached by 2015 › Presentation of very specific options with different ambition levels	› Description of four possibilities with different ambition levels					
WWF (2013)	Two options: 1. Developed countries raise reduction and financing targets; trusting in this, developing countries increase targets 2. All states determine new ambitious targets jointly or individually › Development of zero-carbon action plans (ZCAPs) and low-carbon action plans (LCAPs)	› System on MRV developed in Durban, e.g. continue using ICA and IAR	› Further action should relate to the IPCC report › Financial funds must be increased	› Development of principles, functions and institutional components of an International Mechanism on Loss and Damage	› Developing countries need confidence created by the developed countries' financial pledges › Reveal concrete steps to increase ambition	› Carbon pricing of bunker oil as an additional possibility (with a discount system for developing countries)	
Vieweg et al. (2013)	› Pledge-and-review process › Periodic review every 2 years › Targets of the EU 20-20-20 kind › Differentiated commitments › Clubs within and outside UNFCCC as an interim step towards broader, more ambitious participation		› Proposal relates mainly to mitigation commitments	› Proposal relates mainly to mitigation commitments	› Market mechanisms with supporting function for capacity building and technology transfer	› Despite several criticisms, market mechanisms offer flexibility with respect to reaching reduction targets	
Zhang and Shi (2013)	› Larger global emissions budget than if 2 °C is complied with › Pledges by the individual states (binding: low ambition) and green growth clubs (voluntary: high ambition) › 'Emissions account' in the sense of an income and expenditure system						
Ngwadla et al. (2013)	› Criticism of pledge-and-review: failure to increase the ambition level using the Copenhagen Accords › Clear commitments for Annex-I and developed states		› Clear financing commitments for developed countries		› Clear financing commitments for developed countries		› Analysis results: Protocol is recommended by many

Box 3-2

Selected proposals on the planned Paris climate agreement – Sources

- Edenhofer, O., Flachsland, C., Stavins, R. and Stowe, R. C. (2013): Identifying Options for a New International Climate Regime Arising from the Durban Platform for Enhanced Action. Policy Brief. Cambridge, MA: The Harvard Project on Climate Agreements, The Mercator Research Institute on Global Commons and Climate Change.
- EU Submission to the ADP (2013): Submission by Lithuania and the European Commission on behalf of the European Union and its Member States, 16. September 2013. New York: United Nations Framework Convention on Climate Change (UNFCCC).
- Haites, E., Yamin, F. and Höhne, N. (2013): Possible Elements of a 2015 Legal Agreement on Climate Change. Working Paper 16. Paris: Institute for Sustainable Development and International Relations (IDDRI).
- Kreft, S. and Bals, C. (2013): Warschau, Lima, Paris – Im Dreisprung zum Klimaabkommen. Ausblick auf den Klimagipfel COP 19 in Warschau. Hintergrundpapier. Bonn: Germanwatch.
- Morgan, J., Tirpak, D., Levin, K. and Dagnet, Y. (2013): A Pathway to a Climate Change Agreement in 2015: Options for Setting and Reviewing GHG Emission Reduction Offers. Working Paper. Washington, DC: World Resources Institute (WRI).
- Ngwadla, X., Abeysinghe, A. C. and Freitas, A. (2013): The 2015 Climate Agreement: Lessons from the Bali Road Map. Oxford: European Capacity Building Initiative (ECBI).
- Sterk, W., Beuermann, C., Luhmann, H., Mersmann, F., Thomas, S. and Wehnert, T. (2013a): Input to the European Commission Stakeholder Consultation on the 2015 International Climate Change Agreement: Shaping international climate policy beyond 2020. Website: http://epub.wupperinst.org/frontdoor/index/index/docId/4927 (viewed 30. June 2014). Wuppertal: Wuppertal Institute.
- Sterk, W., Beuermann, C., Dienst, C., Hillebrandt, K., Hermwille, L., Lechtenböhmer, S., Luhmann, H., Mersmann, F., Samadi, S., Thomas, S. and Wehnert, T. (2013b): Submission to the Ad Hoc Working Group on the Durban Platform for Enhanced Action, Workstream 1: The 2015 Agreement. Website: http://wupperinst.org/uploads/tx_wupperinst/ADP-WS1-Submission-Wuppertal-Institute.pdf (viewed 30. June 2014). Wuppertal: Wuppertal Institute.
- Vieweg, M., Sterk, W., Hagemann, M., Fekete, H., Duscha, V., Cames, M., Höhne, N., Hare, B., Rocha, M. and Schmole, H. (2013): Squaring the Circle of Mitigation Adequacy and Equity: Options and Perspectives. Draft for Public Comment. Köln, Wuppertal, Berlin, Karlsruhe: Ecofys, Wuppertal Institute, Fraunhofer Institute for Systems and Innovation Research, Climate Analytics, Institute for Applied Ecology.
- WWF (2013): Consultation Submission. The 2015 International Climate Change Agreement: Shaping International Climate Policy Beyond 2020. Brussels: WWF European Policy Office.
- Zhang, Y. and Shi, H.-l. (2013): From burden-sharing to opportunity-sharing: unlocking the deadlock of climate change negotiation. Climate Policy 14 (1), 63–81.

areas on incorporating scientific expertise, on the transparency of assessment, decision-making and monitoring procedures, and on participation and opportunities for access to justice (Section 3.2). The 'Special Part' of the Paris Climate Protocol should include legally binding special instruments on the three areas: mitigation (2 °C guard rail, global long-term goal, pledge-and-review process), adaptation (development of existing mechanisms), and dealing with loss and damage (Warsaw Mechanism; Section 3.3.3). The Special Part should also contain regulations on the instruments of the flexible mechanisms, technology transfer and financing.

As already mentioned, the Paris Protocol should be characterized by a hybrid approach that is based on a combination of compulsory and voluntary elements (Edenhofer et al., 2013). Since internationally binding commitments on emission reductions for all countries in the sense of a 'top-down approach' negotiated under the UNFCCC are still widely regarded as politically unrealistic, it should be possible – in the context of a pledge-and-review process (Section 3.3.1.3) – for the parties to freely choose targets in a 'bottom-up approach' that are consistent with national policy (pledges). One important compulsory element would be a commitment by the countries to set themselves national climate-protection targets, submit them in the context of the UNFCCC, and implement them nationally by e. g. 2030. Emissions-reduction targets are particularly relevant in this context. All the relevant framework conditions relating to the targets should be specified to make each target internationally comparable; this would make it possible to conduct a scientific review to determine whether the globally aggregated targets are in line with the 2 °C guard rail. The targets should be submitted in the context of national strategic decarbonization roadmaps which explain how the global, long-term goal of avoiding all CO_2 emissions by 2070 at the latest is to be achieved in the respective national context (WBGU, 2009, 2014). The submission of the decarbonization roadmaps should also be a binding obligation.

The target should be followed up by a review by a body of the United Nations to determine, inter alia, whether the submitted national targets, taken together, are sufficient to move towards a global emissions pathway that allows compliance with the 2 °C guard rail. This review should also be part of the binding Protocol, as should agreements on the measurement, reporting and verification (MRV) of all agreed measures, which should be repeated regularly.

Initially this approach primarily aims at offering a compromise that is acceptable to all countries. The ambitions should be gradually raised in the repeated pledge-and-review process, interacting with the national climate policies of the parties.

Figure 3-1 shows the WBGU's proposal for a Paris Climate Protocol. It demonstrates how the proceduralization of the 2 °C guard rail in the Paris Climate Protocol can forge a link between state multilateralism and other actors such as environmental organizations.

Box 3.2-1

The Aarhus Convention

The Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention), which was adopted in the Danish city of Aarhus on 25 June 1998, was developed by United Nations Economic Commission for Europe (UNECE) and entered into force in 2001. It has 47 parties including the EU (date: July 2014). The Aarhus Convention is not limited to member states of the UNECE region; any member of the United Nations can accede to the Convention, after approval by the Meeting of the Parties (see Article 19 of the Aarhus Convention). The objective of the Convention is to mobilize civil society, i.e. individuals and non-governmental organizations, to engage in environmental protection, and to improve the enforcement of environmental law in the member states (Erbguth and Schlacke, 2014). The Convention codifies a novel legal development in international environmental law by committing the member states to grant individuals and associations rights to information, participation and access to judicial or non-judicial control procedures. The Convention therefore not only contains guidelines for states, it also imposes obligations on the parties vis-à-vis their citizens (Schlacke, 2008). The Aarhus Convention's aim is to make decision-making in environmental matters more transparent, to improve its quality by getting civil society involved, and to monitor public authorities' enforcement of environmental law (Schlacke et al., 2010). Another purpose of the Convention is to support democratic and constitutional development by the parties, thus following the guiding principle of the plural legitimation of public decisions (Schlacke et al., 2010; on the further development of environmental law: Falke, 2004).

As far as the Paris Climate Protocol is concerned, the WBGU's view is that the regulations of the Aarhus Convention should not be directly transferred to the parties to the UNFCCC. However, the three-pillar model of the Aarhus Convention – (1) access to environmental information for all, (2) public participation in environmental decision-making, and (3) access to the courts – should be integrated into the administrative, decision-making and monitoring procedures of the UNFCCC and the Paris Protocol in order to mobilize global civil society, support climate-protecting measures and to promote and monitor compliance with climate-protection commitments of the parties and the United Nations.

3.2 Paris Climate Protocol: General Part

The WBGU recommends creating a General Part of the Paris Climate Protocol for the three areas of mitigation, adaptation and dealing with loss and damage. The Protocol would stipulate overarching and binding regulations on the following points:

- Procedural incorporation of scientific expertise (IPCC) into assessment, decision-making and monitoring procedures,
- Improved transparency, in particular by providing access to information for all, creating an obligation to publish documents, and giving 'climate procurators' the right to make statements (participation) and take legal action (environmental organizations acting on behalf of others under a 'procuratory legal status', they could also be referred to as 'climate stewards'); these 'climate procurators' are associations or NGOs that must demonstrate their interest in climate protection and be recognized – for example by the contracting states.

The General Part of the Paris Climate Protocol should thus consist primarily of legally binding procedural rules aimed at contributing to the democratization and greater effectiveness of the Protocol; they are explained in detail in the following.

3.2.1 Incorporating scientific expertise on a legally binding basis

Measures on mitigation, adaptation and dealing with loss and damage should be based on scientific evidence (Kreft and Bals, 2013) and continuously updated to keep in line with the current state of science. The work of the Intergovernmental Panel on Climate Change (IPCC), which regularly assesses global knowledge on climate change (Chapter 1), is of great importance here. The IPCC conducts a globally unique process of reviewing and scientifically assessing climate change. In the WBGU's view, the current state of the science on climate change, which is determined at regular intervals by the IPCC in its Assessment Reports and Special Reports (see Chapter 1 for an analysis of the current Fifth IPCC Assessment Report), should form the basis for measures and instruments in the fields of mitigation, adaptation and dealing with loss and damage.

Up to now, scientific findings on the development of climate change have been taken into account and included in the UNFCCC system via the Subsidiary Body for Scientific and Technological Advice (SBSTA). According to Article 9 (2) of the UNFCCC, the SBSTA should operate by "drawing upon existing competent international bodies". A direct reference to the IPCC was deliberately omitted to avoid the risk of political influence being exerted on the IPCC (Bodansky, 1993:535). The first COP defined the remit of the SBSTA (UNFCCC, 1995), which is to refer to competent bodies, including the IPCC. The UNFCCC thus neither contains an obligation to take account of the current state of climate science in its decision-making procedures, nor does it precisely regulate how the current state of climate science is to be incorporated into decision-making processes.

The COP decisions at Cancún provide for the "review [of] the adequacy of the long-term global goal", which is explicitly supposed to take the IPCC into account (UNFCCC, 2010: Article V.). This review of the 2 °C guard rail is to be completed by 2015. In this respect, at present the IPCC's findings are *de facto* being included in the decisions.

In addition to this, the WBGU recommends making

Box 3.2-2

Climate-related lawsuits

National courts in particular are increasingly being confronted with 'climate-related lawsuits', i.e. court actions brought by individuals who blame climate change for damage they have incurred. Furthermore, some states that are particularly affected by climate change, or most probably will be in the future, are considering taking other states that are among the main emitters of greenhouse gases (GHGs) to an international or even national court.

Individual lawsuits before national courts

Examples in the USA include Native Village of Kivalina v. ExxonMobil, Connecticut v. American Electric Power Company, and Comer v. Murphy Oil.

In the first case, an action brought by the inhabitants of the village of Kivalina in Alaska against the oil and gas company ExxonMobil was rejected by a US district court (as the court of first instance) on the grounds that climate change was non-justiciable, being a political rather than a legal issue (political question doctrine) (US District Court for ND California, Oakland Division, C 08-1138 SBA, 30.9.2009; Erling, 2010). The petitioners were also defeated before the court of appeal (US Court of Appeals for the Ninth Circuit, 09-17490, 21.9.2012; Frank, 2013).

In the case of Comer v. Murphy Oil, in which victims of Hurricane Katrina sued several utility companies, the competent court first determined the admissibility of the case. Particularly noteworthy in this case was the argument that the power utilities – by delivering or burning coal, thus causing emissions – had contributed to climate change and had ultimately been the trigger for the hurricane and the resulting damage (Erling 2010). However, the action was finally dismissed after further appeals (US Court of Appeals for the Fifth Circuit, 12-60291, 14.5.2013).

In the case of Connecticut v. American Electric Power Company, in which several American states sued the biggest emitters of GHG in the USA, the US Supreme Court, as the final instance, refused in its verdict to impose limits on GHG emissions on the defendants, stating that this fell under the jurisdiction of the Environmental Protection Agency (EPA; US Supreme Court, 10-174, 20.6.2011).

Lawsuits brought by countries before the International Court of Justice

As early as the beginning of the millennium, the island nation of Tuvalu, which is especially under threat from climate change, considered taking the main emitters of CO_2, i.e. the USA and Australia, to the International Court of Justice (ICJ) and, perhaps, to the national courts for their contribution to climate change. However, this project was never carried out (Ralston et al., 2004).

The neighbouring nation of Palau is now pursuing a campaign in cooperation with other states with the aim of clarifying issues under international law relating to liability for climate change. They are seeking an ICJ Advisory Opinion to draw attention to the international-law aspects of climate change. The first step is only to ask the ICJ what obligations states have under valid international law in relation to climate change (Yale Center for Environmental Law and Policy, 2012:8). According to Article 38 (1) of the ICJ Statute, the sources of international law include, inter alia international treaty law (sub-paragraph a.) and customary international law (sub-paragraph b.).

International treaty law and climate change

According to Article 2 of the UNFCCC, the parties' objective is to prevent dangerous anthropogenic interference with the climate system. It can certainly be argued that this is not only a political statement, but a contractual obligation (Yale Center for Environmental Law and Policy, 2012:20; Voigt, 2008). Similarly, the commitment of developed countries and Annex I states to reduce emissions under Article 4 (2) of the UNFCCC can also be interpreted as binding (Yale Center for Environmental Law and Policy, 2012:21; Voigt, 2008). In order to meet their obligations under the UNFCCC, the parties ought, for example, to regularly adapt their efforts to reduce GHG emissions to the current state of science, in order to prevent a dangerous anthropogenic interference with the climate system (Yale Center for Environmental Law and Policy, 2012:21). Further obligations under international law can be deduced, for example from the Kyoto Protocol or the UN Convention on the Law of the Sea (Yale Center for Environmental Law and Policy, 2012:22ff.) Even if these contractual obligations are considered too unspecific, state obligations can be deduced from customary international law.

Customary international law and climate change

In customary international law, one issue that is of particular importance for the problem of climate change is the concept of accountability for cross-border environmental pollution, or 'transboundary harm'. The Trail-Smelter Award (1941) laid down principles for the prohibition of significant cross-border damage, and has since become accepted as part of customary international law (von Arnauld, 2012:347). According to this, states may not use their territory, or allow it to be used, in a way that leads to significant environmental damage on the territory of other states. In order for a country to be deemed liable as a result of harmful use, e.g. the emission of greenhouse gases, facts must exist that prove liability, i.e. damage must have been done on the territory of another country caused by human acts on the territory of the other country; the damage must be significant and the breach of the duty of care must be the cause of the damage (Erbguth and Schlacke, 2014:169). There are indications that significant damage is being (or will be) done as a result of climate change – caused by GHG emissions – and its impacts, such as sea-level rise; this has been sufficiently proven by scientific studies, including the IPCC report (Frank, 2014). The difficulty lies in the fact that the damage that is possibly attributable to climate change has been caused by cumulative effect, and the causal contribution of a single country is probably virtually impossible to determine. Deliberations on how this problem of causality and attribution might be overcome are based on the International Law Commission (ILC) Draft Articles on Prevention of Transboundary Harm from Hazardous Activities, and the Draft Articles on Responsibility of States for Internationally Wrongful Acts (Frank, 2014). As a subsidiary body of the UN General Assembly, the ILC's task is to record and further develop existing customary international law.

If it is assumed that liability can be established by invoking the ILC Draft Articles, the legal consequence of the above mentioned claim relating to cross-border damage would be that the state whose territory is the source of the damage would have to refrain from, or stop, the harmful use, and would be liable for damages according to the principles of responsibility under international law. Furthermore, in a different case the ICJ found that the states also have a primary duty to prevent damage (von Arnauld, 2012:347, 'duty to active preventive intervention').

Finally, the question remains as to whether states can claim damages if they themselves have contributed to climate change. According to Article 39 of the ILC Responsibility Draft, when calculating the size of the claim for compensation, account must be taken of the contribution to the damage made by the state that is suing for damages (Frank, 2014). It remains to be seen how a minimal contribution to climate change – as is the case with small island states – would be taken into account in this calculation.

Preventive and possibly greater (compensation) obligations

of states can be deduced from (customary) international law. However, numerous legal issues are yet to be clarified with regard to the enforcement of these obligations by legal actions brought by individual citizens or affected states by means of a claim. Particularly problematic are the attribution of causal contributions to climate damage, the burden of proof and the forfeiture of claims. Initiatives like those of the island nation of Palau or the appointment of the ILC Special Rapporteur on the protection of the atmosphere (ILC, 2014) are welcome in the sense of a further development of the enforcement of international law.

Role of individuals and non-governmental organizations in the global arena

In addition to the need to clarify the outstanding questions of international law, national and global environmental organizations, as parts of global civil society, should be entrusted (as 'climate advocates') with the (judicial or extra-judicial) enforcement of obligations under international climate law. For example, environmental organizations could be assigned national rights to bring legal actions through which they could assert compensation claims for individual citizens, either in or out of court, in the sense of representative actions. On the other hand, these environmental organizations could also be entrusted with this task internationally (e.g. within the framework of the Paris Protocol). Such a recognition of the international legal personality of organizations would be justified because of their channelling function.

it legally binding for the parties to consider the current state of climate science as made available by the IPCC in all three areas (mitigation, adaptation, dealing with loss and damage) in accordance with the precautionary approach, and to incorporate this commitment in the decision-making process.

3.2.2 Ensuring maximum transparency through information

Transparency plays a role in several proposals on the Paris Climate Agreement (e.g. Edenhofer et al., 2013), although the details vary. Building on the Aarhus Convention, which came into force in 2001 (Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters; Box 3.2-1), the WBGU defines transparency as providing access to climate information for all, and obliging authorities, other public offices in the parties' sphere of influence, and international organizations to publish documents. The purpose of providing access to climate information is to enable global civil society to monitor parties and UNFCCC bodies and to promote not only the democratization of – and participation in – the decision-making procedures, but also acceptance of the decisions. In order to achieve these aims, a high degree of transparency should be ensured in the sense of giving the general public (e.g. citizens and environmental organizations, clubs of pioneers) free access to all relevant data and actively publishing all data by the parties to the proceedings.

3.2.3 Promoting acceptance and monitoring through participation

It is important for the monitoring and acceptance of measures and decisions that associations and NGOs that are engaged in climate protection ('climate procurators'), can prove the fact and have perhaps been recognized by the parties, are given the right to participate in decision-making processes. Also building on the Aarhus Convention, these procurators should be given the right to issue statements that must then be taken into account in UNFCCC evaluation and decision-making processes. Currently, Article 7 (6) of the UNFCCC allows observers to participate in Conferences of the parties only if there is no objection by at least one-third of the parties to the observers' accreditation. Observer status can be granted to the United Nations, its specialized agencies, and non-governmental organizations, although the latter are not necessarily all 'climate procurators' in the sense discussed above. Up to now, the observers recognized by the UNFCCC *de facto* have the right to speak and to make submissions, which are published by the secretariat. However, they do not have the right to issue statements, and there is no binding obligation to take these into account. The WBGU recommends giving the above-mentioned associations and NGOs that act as climate procurators precisely these rights. For example, the parties should commit themselves on a legally-binding basis to deal with the submissions of recognized climate procurators in order to improve acceptance and monitoring. The main criterion in the selection of associations and NGOs to take on the steward function should be that their purpose is to protect the climate and/or the environment. Rules and criteria for accreditation as a climate procurator could be developed as soft law under the Paris Protocol. Recognition could be given by the parties as they implement the requirements of the Protocol. A similar legal position could also be granted to clubs of pioneers (Box 3.3-2) which consist not only of states, but also work with the participation of civil-society actors.

3.2.4 Improving compliance by creating rights of action

Furthermore, the task of monitoring compliance with the regulations of the Paris Climate Protocol should certainly not be left to the parties alone. Supervision of how parties meet their obligations could equally be transferred to the climate procurators, who would be selected according to the above criteria. Clubs of pio-

neers with the participation of civil-society actors could also be considered for selection. Such a form of monitoring could be carried out before international courts or extra-judicially; however, this aspect requires more discussion and a further development of international legal remedies.

In this way, the third pillar of the Aarhus Convention, which provides for such judicial or extra-judicial monitoring by selected environmental organizations, would also be transferred (Article 9 of the AC). Without legal remedies there would be a risk that the first and second pillar would peter out with no effect, and other climate commitments would not be monitored.

In this way a form of monitoring would be created which could at least result in the parties complying with commitments they have entered into. When it comes to claims between parties – or claims by individuals against parties or corporations – when damage that has been (partly) caused by climate change has already occurred, most questions are still open or have only been partially answered (Box 3.2-2).

3.3 Paris Climate Protocol: Special Part

The Special Part of the Paris Climate Protocol, as proposed by the WBGU, contains legally binding and specific regulations and measures for the three main areas: mitigation, adaptation, and dealing with loss and damage. Mainly thanks to the hybrid approach, i.e. the combination of self-committing and compulsory elements, these are well-suited for giving the parties enough leeway for a future-oriented, non-static and flexible management.

3.3.1 Mitigation

As already indicated, it is a *conditio sine qua non* for mitigation that the international community commits itself, in the context of the global climate regime, to comply with the 2 °C guard rail, to formulate a global, long-term goal on emissions reduction, and to implement both. To achieve this, in view of the current negotiation situation, the pledge-and-review process should be developed and firmly installed as a key mechanism of mitigation. Furthermore, the WBGU advocates the continuation and enhancement of flexible mechanisms. Technology transfer, too, needs to be expanded and fleshed out.

3.3.1.1 Establish the 2 °C guard rail as a legally binding standard

The 2 °C guard rail marks the level of global mean surface temperature rise compared to the pre-industrial level that must not be exceeded if intolerable environmental damage is to be avoided (WBGU, 1995: 107f.; 2014). Neither the UNFCCC text nor the Kyoto Protocol lay down the 2 °C guard rail.

The 2 °C guard rail could specify the UNFCCC's foremost goal, as laid down in Article 2 – to prevent dangerous anthropogenic interference with the climate system – and thus be given binding character. In the UNFCCC, "dangerous anthropogenic interference with the climate system" is neither defined nor specified in terms of a threshold that must not be exceeded (Schlacke, 2014a). In principle, in the case of an international agreement like the UNFCCC, this process of concretization is in the hands of the parties. However, up to now the parties have not stipulated such a specification by creating a binding legal rule, i.e. an amendment to the Convention within the meaning of Article 15 of the UNFCCC or a protocol pursuant to Article 17.

The 2 °C guard rail was included for the first time in the Copenhagen Accord of 2009 and was part of the Cancún Agreements of 2010 (UNFCCC, 2010), the Durban Outcome of 2011 (UNFCCC, 2011), the Doha Climate Gateway of 2012 (UNFCCC, 2012) and the Warsaw Outcome of 2013 (UNFCCC, 2013a). The Copenhagen Accord of 2009 did not reach a consensus among all parties. The other four acknowledgements of the 2 °C guard rail by the parties were laid down as soft law in the form of COP decisions.

The naming of the 2 °C guard rail in 2010–2013 in the form of COP decisions agreed by consensus could represent a "practice in the application of the treaty" by the parties – pursuant to Article 31 (3) (b) of the Vienna Convention on the Law of Treaties (VCLT) – interpreting Article 2 of the UNFCCC. Article 31 of the VCLT, as a regulation under customary international law, applies to the UNFCCC (ICJ, 1999: para. 18; Dörr and Schmalenbach, 2012: 523). There is disagreement as to whether the above-mentioned four acknowledgements of the 2 °C guard rail justifying 'practice' are in themselves sufficient to make it legally binding. In order to dispel legal doubts that might prevent or at least inhibit the operationalization of the 2 °C guard rail, the WBGU recommends enshrining the guard rail as legally binding in the Paris Climate Protocol.

3.3.1.2 Stipulate a legally binding global, long-term goal

To ensure compliance with the 2 °C guard rail, the WBGU regards it as essential to codify an agreement on the global, long-term goal of reducing CO_2 emissions from fossil fuels to zero worldwide by 2070 at the latest. This goal is a scientifically deducible consequence of the 2 °C guard rail (Section 1.4) and should be enshrined in a legally binding form in the Paris Protocol. The reason for this is that, in the IPCC's climate scenarios that allow compliance with the 2 °C guard rail, CO_2 emissions from fossil fuels are at or below zero in the second half of the 21st century (Section 1.8; Chapter 2). The sooner the CO_2 emissions are reduced, the smaller will be the need for net 'negative emissions', i.e. the active capture and

storage of CO_2 from the atmosphere, a process that has not yet been commercially tested. The WBGU therefore recommends not only reducing the CO_2 emissions from fossil fuels to zero worldwide by 2070 at the latest (WBGU, 2014), but also enshrining this rationale as a global, long-term goal in the Paris Climate Protocol.

3.3.1.3 CO_2-reduction commitments by parties and verification procedures (pledge-and-review process)

In addition to the binding incorporation of the 2 °C guard rail, it is necessary – as has often been proposed (e.g. Haites et al., 2013; Kreft and Bals 2013; Edenhofer et al., 2013) – to operationalize this guard rail, i.e. to break it down into commitments by individual nations to reduce greenhouse gas emissions. With its budget approach, the WBGU has shown a meaningful and fair way of operationalizing the 2 °C guard rail (WBGU, 2009). The WBGU continues to see this proposal as an effective solution in the fight against climate change (Chapter 2). However, the prevailing political negotiating situation suggests that a consensus on the budget approach is impossible; the same applies at present to the agreement of legally binding reduction targets for all parties in the sense of a 'top-down approach'. The WBGU therefore considers it imperative to present proposals which, though still ambitious, seem politically feasible.

To this extent, the pledge-and-review process initiated at the COP in Copenhagen should be continued, extended and standardized to bolster the acceptance of and compliance with this procedure by the parties. The first condition for an ambitious pledge-and-review process is the acceptance of scientific findings that show what demands must be made on the development of emissions if the 2 °C guard rail is not to be breached. As already explained (Section 1.2), CO_2 emissions from fossil fuels should be reduced to zero worldwide by 2070 at the latest (WBGU, 2014).

First step: Pledge

The first step in the pledge-and-review process (Haites et al., 2013; Edenhofer et al., 2013; Zhang and Shi, 2014) is that the parties formulate offers which, in the WBGU's opinion, should contain (1) self-selected targets to combat climate change, and (2) self-created decarbonization roadmaps up to the year 2070 at the latest. This procedure will still rely on each Party setting its own targets, but these should not relate to GHG reduction alone; they could also cover the expansion of renewable energies or improving the energy efficiency of buildings (Sterk et al., 2013a, b). Decarbonization roadmaps should contain information on how the respective country intends to reach the zero target in 2070, indicating intermediate objectives (milestones), gearing its efforts to national emissions-reduction potential, and stating what conditions still need to be met, such as financial or technology transfers (WBGU 2009:3). Pledges can vary in terms of their timescale, i.e. they can also include intermediate targets for certain periods; this ensures that different individual national situations are taken into consideration. The contracting parties should be required by the Protocol to submit pledges; only the contents of the pledges should be left to the countries themselves.

In this way the parties formulate national mitigation schemes and decarbonization roadmaps showing the climate targets of the individual states in stages up to the year 2070.

Second step: Review in two phases

The second step is then the review of the national pledges in two phases.

- In the first phase, the individual countries' national climate targets are checked on the basis of the scientific state of knowledge (especially the IPCC reports) to determine whether their sum total is compatible with the 2 °C guard rail. The decarbonization roadmaps must also be checked during this phase to determine whether they are plausible with respect to the zero target for the year 2070. Moreover, when examining these two elements together, the national targets chosen must be consistent with the decarbonization roadmaps. The decisive issue is that the review process must be geared towards the 2 °C guard rail, and the climate targets and decarbonization roadmaps must be plausible in terms of compliance with the guard rail.
- The second phase of the review checks whether the emissions-reducing potential of each country (a) is sufficiently exploited (WBGU, 2009) and (b) corresponds to a decarbonization pathway that is compatible with compliance with the 2 °C guard rail.
- The final question to be asked is whether the package of mitigation targets and decarbonization roadmaps, which can also contain supplementary commitments on financial and technology transfers, leads to the country contributing a fair share to global mitigation (Box 3.3-1).

Once the pledges have been defined, it is necessary to begin the continuous process of reviewing whether the targets and intermediate targets that have been laid down are being complied with or have been implemented. This should be carried out using the measurement, reporting and verification (MRV) procedure (Section 3.3.1.4).

Box 3.3-1 explains how the WBGU's budget approach can be used to judge the appropriateness of national reduction targets up to 2030 with regard to compliance with the 2 °C guard rail. An analogous analysis of other target years would also be possible. 2030 is under discussion as the target year for mitigation efforts by the parties under the Paris agreement. Among others it is used by the EU when calculating its reduction target, and is regarded as a meaningful target year by the WBGU.

The commitments offered should be reviewed by a new body yet to be created within the UNFCCC institutional structure – in the best-case scenario involving the participation of UNEP – which has an obligation to incorporate the scientific state of knowledge and research findings.

Box 3.3-1

What emission reductions will be necessary up to 2030 to comply with the 2°C guard rail?

The Fifth IPCC Assessment Report makes it clear that, as from 2011, a total of only about 1,000 Gt CO_2 may be emitted from anthropogenic sources if global warming is to be kept below 2°C with a probability of two-thirds (IPCC, 2013b). In previous reports, the WBGU has submitted figures a for a global budget that are methodologically different (WBGU, 2009, 2011). WBGU estimates based on the work of Meinshausen et al. (2009), Friedlingstein et al. (2010) and others showed a budget of 750 Gt CO_2 from fossil sources for the 2011-2050 period, which must not be exceeded if global warming is to be kept below 2°C with a probability of two-thirds (WBGU, 2011). The budget given by the WBGU relates to a limited period (2011-2050) and does not include the CO_2 emissions from land-use change; it therefore does not contradict the figure cited by the IPCC, but is compatible with it.

Distributing this global budget among countries according to their share of the world's population, as the WBGU proposed in 2009, makes it possible to deduce national budgets (WBGU, 2009). However, in the absence of a global regime with a top-down approach under which these budgets can be laid down and traded between the states, striking a balance between the emissions budgets allocated in this way and the individual countries' actual emissions-reduction potential is difficult, as is the timing of its use. It is therefore also not possible to unequivocally deduce specific national emissions-reduction targets up to 2030 from the global budget alone; for this reason, other results on transformative scenarios are used in the following.

Analyses conducted by the IPCC's Working Group III (IPCC, 2014d) show that global emissions of all gases should be lower than 50 Gt CO_2eq in 2030 to ensure that the rate of emissions reduction that then becomes necessary is not too high. Analyses by UNEP (2013a) cite a figure of 35 Gt CO_2eq (range: 32–42 Gt CO_2eq) for this. In 2011 the WBGU already suggested one possible way to deduce national emissions targets from these globally possible emissions for 2030 – for the existing pledge-and-review system (WBGU, 2011). Building on the WBGU's budget approach, the globally possible emissions for 2030 could also be divided up among countries according to their respective share of the world population. Based on global emissions of 35 Gt CO_2eq and using the EU's population figures for 2010, this leads, for example, to total emissions of 2.5 Gt CO_2eq for the EU in 2030, which corresponds to a 50% reduction compared to 1990. The emissions level for the USA would be 1.6 Gt CO_2eq (equivalent to a reduction of about 70% compared to 1990); for China it would be 7 Gt CO_2eq (which is about twice the figures for 1990). The targets derived in this way should be used to give some orientation in calculating fair contributions to mitigation by individual countries. However, it can be anticipated that in some industrialized countries the reduction targets derived in this way can only be reached at high costs, while in several developing countries emissions-reduction potential might go unused. With a view to the total costs of transformation, it would therefore be sensible to take a more flexible approach to reaching targets in this context. If the derived targets are seen as the overall responsibility that a state should assume for global mitigation, then this can be made up of a slightly lower reduction target within the country itself plus supplementary commitments to make financial and technology transfers towards additional reductions in another country (WBGU, 2011). However, this requires that the actual reductions in emissions in the country receiving the transfers turns out to be higher than its reduction target as calculated according to the system outlined above. Such a balance can also be created via flexible mechanisms (Section 3.3.4). Ultimately, the objective must be to ensure that a transformation towards an economy with no CO_2 emissions from fossil fuels is initiated in all countries (Chapter 2).

Höhne et al. (2013) have summarized and evaluated allocations of global emissions that are compatible with the 2°C guard rail according to different concepts of fairness. Table 3.3-1 shows the range of reduction targets that result for different groups of countries up to 2030. The targets recommended by the WBGU are within the range of the figures in this table.

Table 3.3-1
Reduction targets for individual groups of countries for 2030 compared to 2010 and 1990 (Kyoto reference year) deduced from different effort-sharing systems. OECD 1990 comprises North America (USA, Canada), Western Europe, Japan, Australia and New Zealand; EIT refers to the economies in transition (e.g. Eastern Europe and the Russian Federation); ASIA comprises South Asia (including India, Bangladesh and Pakistan), East Asia (including China, Korea, Mongolia), Southeast Asia and the Pacific; MAF comprises the Middle East, North Africa and sub-Saharan Africa; LAM covers Latin America and the Caribbean.
Source: Höhne et al., 2013

	Deduced reduction targets (2030 compared to 2010)	Deduced reduction targets (2030 compared to 1990)
OECD 1990	–37% to –75%	–33% to –74%
EIT	–28% to –53%	–52% to –69%
ASIA	+7% to –33%	+100% to +25%
MAF	+24% to –7%	+159% to +95%
LAM	–15% to –49%	–3% to –41%

The results of this review should be published (transparency requirement; Section 3.2.2). If the above-mentioned requirements are not met, the individual parties' commitments should be renegotiated. Pressure to raise ambition levels could be generated by the 'blaming and shaming' of states by civil society or other countries. Furthermore, incentives to raise the national ambition level could be offered (e.g. technology transfer, financial support).

The Paris Protocol should furthermore create incentive systems for climate clubs such as city networks that have already embarked on a more effective decarboniza-

Box 3.3-2

Strengthen climate clubs in the international climate regime

Climate clubs should be supported by the UNFCCC as pioneers for mitigation. By strengthening clubs, the UNFCCC's parties should promote a change in the culture of multilateral mitigation, so that it takes its orientation not from the sluggish players, but from the ambitious ones. A more flexible, modular form of multilateralism incorporating different speeds could dynamize the UN negotiations (Section 4.2).

Climate clubs are alliances of actors (e.g. countries, cities or civil-society actors) that set themselves ambitious and innovative targets in the fields of mitigation, adaptation or dealing with climate-related loss and damage, which go beyond the general ambition level in the UNFCCC context (Section 4.2). In principle, according to its own text, the UNFCCC is open for complementary measures (Weischer and Morgan, 2013: 12). For example, Article 3 (3) of the UNFCCC states: "Efforts to address climate change may be carried out cooperatively by interested parties." Thus far, however, there is not a formalized procedure for inclusion of obligations which go beyond what is required by the UNFCCC.

The WBGU recommends that ambitious climate clubs should become better integrated, stronger and more visible in the UNFCCC process. For example, they should be supported with financial resources, but also with advice and mechanisms for mutual learning in the context of the UNFCCC. Developing countries and emerging economies that are members of ambitious climate clubs could receive preferential financial support for mitigation or adaptation measures. Similarly, OECD countries could be given financial incentives to pursue ambitious club targets. For example, a proportion of the Green Climate Fund could be reserved to support clubs and their pioneering activities. All members of ambitious climate clubs could then apply for such funds.

Furthermore, the WBGU also sees opportunities for civil-society actors that join together to form clubs or pioneer alliances – with or without the participation of states – to make use of the proposed rights to information and participation and rights of action. They can support or monitor the mitigation efforts of the UNFCCC member states if they act as 'climate procurators'.

Weischer et al. (2012) propose going further in the Paris Climate Agreement: establishing a system by means of a COP decision to enable reports from pioneering alliances to be sent to the UNFCCC in a fixed format to raise their profile. The parties could also enable the clubs to enter into certain commitments, and for the UNFCCC to review compliance. Another possibility might be for a small group of states to raise the ambition level of their commitments and then bring this higher ambition back into the UNFCCC process. 'Bringing back' could mean on the one hand that the ambition level in the UNFCCC is already raised by the fact that a climate club's more ambitious efforts offer economic club benefits (Section 4.2). On the other hand, it might be conceivable for the club states to put their commitments under the control of the UNFCCC (Weischer et al., 2012).

tion pathway. Box 3.3-2 presents some visions on this.

The WBGU does not recommend automatic rises in the ambition level according to a certain annual rhythm (Haites et al., 2013), since this would only set an incentive for a starting point that fixed a very low ambition level.

3.3.1.4 Clear structure and legally binding basis for reporting

A decisive factor for achieving and monitoring targets in the field of mitigation (2 °C guard rail, long-term goal) is the establishment of a system for the measurement, reporting and verification (MRV) of commitments, i.e. above all the pledges, of the parties (Section 3.3.1.3). The more precise and refined the standards for this are, the better will be the chances of success, e.g. for emissions reductions by the parties.

In particular, the WBGU believes that plausible and detailed standards should be agreed for reporting. The reporting requirements could comprise four successive levels of information provision in which Level 4 would be the most ambitious form of reporting (Morgan et al., 2013):

- *Level 1* contains simple reporting commitments such as the type of target and the period in which it is to be reached (corresponds approximately to the reporting obligations under the Kyoto Protocol).
- *Level 2* adds emissions projections and costs.
- *Level 3* also includes methods and calculation standards.
- *Level 4* involves an additional description of the steps the parties intend to take to reach their targets.

Similar standards should also be developed in the areas of measurement and verification. Above all, this procedure should not be limited to achieving GHG-reduction targets, but also be applied to adaptation and compensation measures.

3.3.2 Adaptation: Continue and strengthen existing measures

Adaptation measures are necessary in addition to mitigation measures, even when the 2 °C guard rail is observed (see Chapter 1).

The wording of the UNFCCC contains far-reaching regulations on adapting to climate change. Article 4 (1) (b) of the UNFCCC formulates the obligation that all states, "taking into account their common but differentiated responsibilities," shall "formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures [...] to facilitate adequate adaptation to climate change". Article 4 (1) (e) determines cooperation between the parties "in preparing for adaptation to the impacts of climate change". Article 4 (4) commits the developed states to "assist the developing country parties that are particularly vulnerable to the adverse effects of climate change". Article 4 (8) refers in this context to technology transfer and the generation of funds.

Box 3.3-3

Responsibility for climate migrants – a thought experiment

Present situation

Current estimates of climate-change-induced migration put the number of people who will be forced to temporarily or permanently leave their homes, either within their country or across national borders, as a result of climate change at between 150 million and 300 million in the period up to 2050 (BAMF, 2012; Biermann and Boas, 2010; Stern, 2006). The International Organization for Migration's most cited estimate is 200 million climate migrants (environmentally displaced persons) (IOM, 2009; Myers, 2005). This figure also includes people who have to leave their homes temporarily and should be seen as a rough estimate. The deviations between the estimates can be traced to a number of uncertainties. One is the multi-causality of migratory movements (WBGU, 2008). Qualitative studies cannot always determine why a person decides to leave his/her home. For example, economic reasons are often given by those affected as the main reason for migration, and this can in turn be partially due to climate-change-induced crop failures. Furthermore, there is no adequate data on current population figures in many at-risk regions with a highly vulnerable population. Ultimately it is almost impossible to determine to what extent the frequency or intensity of natural disasters that trigger migratory movements is caused or intensified by climate change, or whether it can be attributed to natural weather phenomena. Despite all the uncertainty, however, there is no doubt that climate change is one cause of growing migratory movements, and that they will increase in scale in the future.

The problem of responsibility for climate-induced migration

Up until 2014, people affected by climate change have had no legal entitlement to compensation or asylum, and so far all lawsuits on such issues have been rejected – e.g. the action brought in November 2013 by an man from Kiribati before the New Zealand High Court in Auckland (High Court Auckland, CIV-2013-404-3528 [2013] NZHC 3125, 26.11.2013). In 2014 the New Zealand immigration tribunal discussed the danger from climate-change-induced environmental damage as the justification of a humanitarian emergency in two judgements on the right of abode of a family from the island state of Tuvalu. The court refused to classify the affected family members as 'refugees' within the meaning of the international law (Immigration and Protection Tribunal New Zealand, [2014] NZIPT 800517-520, 4.6.2014). In this individual case, the tribunal granted the family right of abode on humanitarian grounds; they were allowed to remain in New Zealand due to strong their family ties (Immigration and Protection Tribunal New Zealand, [2014] NZIPT 501370-371, 4.6.2014). This decision, which does not set a precedent, shows once again that there is still no international consensus, let alone a legal basis under international treaties, for a classification or legal definition of migrants as 'environmentally displaced persons' or 'climate refugees'. In this respect the WBGU uses the term 'climate migrant' because the terms 'environmental' or 'climate refugee' are highly controversial in literature, and the term 'migrant' has a much broader meaning than the legal term 'refugee' (WBGU, 2008: 129). However, there is a broad consensus, especially in scientific literature, that the international community must address this problem; in this context a separate legal regime for environmental or climate 'refugees' is frequently proposed (WBGU, 2008).

The hardest hit sections of the population, and therefore potential climate migrants, are to be found in developing countries and emerging economies, which have contributed little or nothing to climate change, i.e. to greenhouse gas emissions. If responsibility were to be attributed according to the polluter pays principle (Chapter 2), countries that contributed most to the damage caused by anthropogenic climate change would thus have to compensate people for the climate-change-related loss of their livelihoods and homes.

A closer look at responsibility for climate-induced migration: A WBGU thought experiment

Based on the above-quoted estimate of 200 million climate migrants by 2050, different degrees of nation-state responsibility for climate-induced migration could be derived from the application of the polluter pays principle. For Germany the calculation would be as follows. Based on the WBGU's budget approach, which covers the period from 1990 to 2009 under the section 'historical responsibility' (WBGU, 2009: 25), Germany's share of cumulative emissions from 1990 to 2009 would be 1.54% of the possible total emissions allowed under the 2 °C guard rail (75% probability of compliance with the 2 °C guard rail). Calculating for the period from 1990 to 2050, the result is a share of about 3% of the possible total budget according to the Federal Government's targets (40% CO_2 emissions reduction up to 2020 and 80% to 95% CO_2 emissions reduction up to 2050 compared to 2009; Box 2.3-2). Relating this share of emissions generated to the damage (in this case the potential loss of livelihoods for about 200 million people), Germany could have a responsibility vis-à-vis 6 million migrants according to this scenario. If the total number of climate migrants changes up to 2050, there will also be a change in the number of people for whom responsibility could be assumed in this thought experiment, e.g. by making compensation payments or providing more development aid for disaster-control systems and resilience-strengthening measures. Germany's overall share of cumulative historical emissions from 1850 to 2008 was about 7% (WRI, 2008), which would correspond to a responsibility for just under 14 million people. If Germany were to reduce its relative share in the years up to 2050 by making bigger reductions in emissions than is provided for in today's emissions scenarios, the historical responsibility would fall. The calculation examples according to the polluter pays principle show that Germany's responsibility is small in relative terms, but large in absolute terms.

Since most migrants only move temporarily within their own country's borders or migrate to neighbouring countries, Germany will not have to expect a massive influx of climate immigrants. As a thought experiment, the above calculation makes Germany's responsibility for the humanitarian consequences of climate change clear, and shows in addition how important it is from the perspective of the nation state to pursue a policy of emissions reduction in order to reduce one's percentage share of total emissions.

Outlook: Rising temperatures and migration

Seen over the period up to the fourth decade of this century, the different emissions scenarios do not make a great deal of difference to the development of the temperature. Thereafter, however, the impact of the decisions that are taken is clearly reflected in the global mean temperature. The present mitigation strategies will therefore have only a limited effect up until the middle of the century because of the inertia of the Earth system; they will, however, be crucial for subsequent developments. This also applies to the numbers of potential climate migrants. Consequently, up to 2050, adaptation measures will have the biggest influence on the number of climate migrants; however, beyond a certain rise in temperature such measures can no longer limit the loss of human livelihoods (Adger et al., 2013). For example, the Fifth IPCC Assessment Report shows that the risks of displacement by extreme weather incidents can be greatly reduced by adaptation measures in a 2 °C scenario for the period from 2080 to 2100; by contrast, adaptation measures only achieve a minimal reduction in these risks in a 4 °C scenario (Adger et al., 2013). If humanity continues following the present emissions pathway, the climate-induced migration figures could reach a dimension that destabilizes societal systems by 2100. This in turn could lead to, or at least intensify, national and even cross-border conflicts (WBGU, 2008).

Structures for adaptation measures have thus already been created under the UNFCCC. These have been fleshed out over the years by COP decisions, although these are not legally binding.

The Work Programme for Least Developed Countries (LDCs) was adopted by the COP in Marrakesh in 2001. It aims to support LDCs with capacity building, e.g. with drawing up National Adaptation Programmes of Action (NAPAs). LDCs can use NAPAs to identify and report their needs for adaptation measures (UNFCCC, 2001). They are supported in this by the LDC Expert Group. The measures under the LDC Work Programme are ongoing. In May 2013, 49 LDCs had drawn up NAPAs and submitted them to the UNFCCC Secretariat (Adaptation Committee, 2013).

In Nairobi in 2006, the contracting parties decided to commission the Subsidiary Body for Scientific and Technological Advice (SBSTA) to conduct a programme to review consequences, vulnerability and adaptation in the context of climate change. The programme aims to improve the understanding and assessment of these problems. Building on this, decisions are to be taken to launch adaptation measures. These activities, too, are being continued. The programme plays an important role in the exchange of information between different stakeholders and for spreading information and knowledge on adaptation (Adaptation Committee, 2013).

In addition, the Cancún Adaptation Framework was adopted by the COP in 2010. It promotes action aimed at reducing vulnerability and strengthening resilience in developing countries that are particularly vulnerable to the effects of climate change. LDCs in particular are to be supported in preparing and implementing national adaptation plans (NAPs).

In addition, the Cancún Adaptation Framework set up the Adaptation Committee (AC) to promote the implementation of adaptation measures (UNFCCC, 2010). The AC started work in September 2012. The first Adaptation Forum was held in Warsaw in 2013.

The existing measures for adapting to climate change that have been launched and initiated in the context of the UNFCCC include some good elements. The WBGU recommends continuing and permanently strengthening them. This will require the provision of sufficient financial resources by the international community (Haites et al., 2013; Section 3.3.6). Furthermore, it must be possible to pass on adaptation technologies (Section 3.3.5).

Unlike mitigation targets, and especially reduction targets, adaptation targets cannot be laid down globally. They must be fixed and implemented locally, since they strengthen local resilience and offset loss and damage. One case of adaptation that has local causes and consequences, but global dimensions, is migration that is triggered by the impacts of climate change (Box 3.3-3). It is evident that islands and coastal zones are exposed to great risks when sea levels rise and must be abandoned by the people who live there where there is periodic or permanent flooding. Migratory movements can also be triggered by droughts caused by climate change. However, up to now it has not been possible to determine unequivocally to what extent historical and current migratory and refugee movements are due to climate-related or environmental damage; this is controversial because, among other things, it cannot be assumed that climate change is the single cause of any migration. In addition to ecologically motivated migratory movements, there are also other causes such as ethnic and religious tensions, civil wars, poverty, or lack of economic prospects; these can in turn be exacerbated by climatic impacts.

The international community and national governments will have to be prepared for local, internal and cross-border migratory movements induced by climate change, to which they will have to react – and for which they must to some extent take responsibility (Box 3.3-3).

3.3.3 Loss and damage: Extend the Warsaw Mechanism

In 2013 the UNFCCC began to deal with the losses and damages caused by climate change by creating the Warsaw Mechanism. More than two decades after its adoption, it is thus devoting itself for the first time to the hitherto neglected consequences of climate change. The purpose of the Warsaw Mechanism is to

1. improve knowledge and understanding of risk-management approaches in relation to loss and damage (e.g. uncovering gaps in knowledge, data collection, best practices),
2. strengthen dialogue, coordination, coherence and synergies between relevant stakeholders (inside and outside the UNFCCC),
3. promote action and support in relation to funding, technology and capacity building (technical support and advice, information and recommendations for the COPs).

Under the Cancún Adaptation Framework the Warsaw Mechanism is equipped with an executive committee that is accountable to the COP. The committee reports once a year to the COP via the Subsidiary Body of Scientific Technological Advice (SBSTA) and the Subsidiary Body of Implementation (SBI). Until an appointments procedure has been introduced, it consists of two delegates from different UNFCCC bodies whose selection aims to reflect a balance between developed and developing countries.

The Warsaw Mechanism is supposed to become integrated into the UNFCCC process and its institutions and to complement them – this applies equally to processes outside the UNFCCC relating to loss and damage. The Warsaw Mechanism is to undergo a review at the 22nd COP in 2016 (UNFCCC, 2013b). The Warsaw Mechanism is only to be part of the Cancún Adaptation Framework for a limited period of time (Kreft et al., 2013).

The creation of the mechanism sends out a positive signal. Up to now, the Warsaw Mechanism has been geared to research and consulting; this is appropri-

ate, but it needs to be extended and specified in more detail, especially with a view to the financing of loss compensation and the technology transfer this requires (Section 3.3.5, 3.3.6). Since climate-related damage is caused by cumulative effect, the model of an insurance pool for covering damage caused by climate change seems a good idea. One example of such a model is the African Risk Capacity, an insurance pool that covers African states against drought risks (Kreft and Bals, 2013). If damage were to occur, the states concerned would be financially covered without their having to name a specific party or parties as the agents that caused the damage (insurance solution). The WBGU believes the process initiated in Warsaw should urgently be speeded up and intensified in this direction.

3.3.4 Flexible mechanisms

One major challenge for effective climate policy is that it has long been characterized by a short-sighted 'efficiency paradigm'. For example, under ideal conditions certain governance designs, like emissions trading (Box 3.3-4), are economically superior to other political and societal approaches to economic management. They promise to reach given environmental targets (such as compliance with certain emission caps) with minimal economic costs.

Yet the actual political experience of the past 20 years shows that comprehensive and effective emissions-trading regimes have rarely been successfully introduced under real political conditions. Primarily due to their inadequate or non-binding emission caps, little in the way of emission reductions has been achieved to date through emissions-trading schemes (Edenhofer et al., 2014; EU ETS: Box 3.3-4).

From an economic perspective, this is assessed as a non-market failure or government failure. What is meant by this term is that politicians have failed to create the necessary framework conditions for successful implementation. This diagnosis illustrates an important aspect of the use of market-based policy instruments; however, it falls short of the mark from the perspective of interdisciplinary transformation research. Complex transformation processes cannot be based solely on economic mechanisms, which only work in an ideal model world. They do not help to effectively control environmental challenges – on the contrary. What is needed, therefore, is an enlightened and interdisciplinary form of governance research that develops recommendations under framework conditions that can actually be created (Section 5.2). After all, in the sense of interdisciplinary research the non-market failure comprises not only the failure of specific politicians or governments, but also political and social mechanisms like the resistance of affected stakeholders, diverging political interests or social distribution of power, with which all policy-making is confronted and which must be taken into account in transformation research.

In view of the epic environmental challenges facing the world at the beginning of the 21st century, there must be a primacy of ecological target achievement (effectiveness) and not a primacy of cost efficiency. Strategies that are often termed second best solutions by economists are frequently 'first best' from the point of view of effectiveness strategies, since they are politically easier to enforce and therefore more successful at supporting the transformation towards a low-carbon society. One example is the feed-in tariff for renewable energies, which is well-established in many countries in the meantime and has made an essential contribution to the success of renewable energy in Germany.

Provocative as it may sound to economists: humanity will probably only be able to save the world in an inefficient way. The present special report is therefore also a plea for a more developed form of economics that incorporates the overall political and societal conditions more intensively into the interdisciplinary discussion. This does not mean that market mechanisms that are geared towards cost-efficiency no longer have any relevance for climate protection, but they must not be allowed to dominate politics and lead to exclusively economics-based advice being given to politicians.

Against this background, the WBGU discusses in this Section the conditions under which, in future, flexible mechanisms can be used to achieve cost-efficiency in climate policy, and recommends the further development of the European Emissions Trading System. At the same time, market-based policy instruments can be used in the context of state pioneering alliances, in order, in a similar way as in the EU, to reach climate targets.

3.3.4.1 The flexible mechanisms under the Kyoto Protocol

In the context of emissions reductions by committing parties, three flexible mechanisms were established under the Kyoto Protocol. These flexible mechanisms allow the states to meet a proportion of their emissions-reduction commitments abroad, making cost-efficient emissions reduction possible. First, industrialized countries can trade emissions allowances among themselves. Every country receives an allocation of emissions according to its reduction target which can be divided up into tradable emission allowances (assigned amount units, AAUs). If a country reduces its emissions by more than its AAUs, it can sell the excess emission allowances to the highest bidder. The buyer countries can offset these emission allowances from their commitments. After the end of the respective commitment period (first commitment period from 2008 to 2012, second period from 2013 to 2020), the states must submit an internationally recognized emission allowance for every tonne of CO_2 they have emitted. Second, there are two project-based mechanisms, Joint Implementation (JI) and the Clean Development Mechanism (CDM). The aim of the project-based mechanisms was to encourage additional investment in low-carbon tech-

Box 3.3-4

EU ETS: Problem areas and design options

Countries use economic policy instruments, inter alia, to meet their emissions-reduction targets. The European Emissions Trading Scheme (EU ETS) is a market instrument based on quantity control. Its aim is to help achieve the EU's self-imposed climate targets, as well as the commitments undertaken by the EU under the Kyoto Protocol, as cost-efficiently as possible.

At present, the effectiveness of the instrument is being criticized, since there is a surplus of more than 1.5 billion emissions allowances in the second trading period as a result of the low level of demand; this has led to a collapse in the price of emissions allowances to €3 to €4 per tonne of CO_2.

The low price level, combined with the uncertainty about how the price will develop in the future, does not offer investors the necessary incentives to invest in low-carbon technologies. Yet precisely such investment is needed in order to reach European and global climate targets, avoid undesirable lock-in effects, and limit transformation costs (e.g. the subsequent non-use of CO_2-intensive infrastructure).

The main reasons for the surplus of emissions allowances are the recent economic crisis in the EU and the very large supply of cheap certified emission reduction credits from CDM projects. The EU has responded to the latter issue by limiting the quota for emission allowances from flexible mechanisms in the third trading period.

The weakness of the EU ETS in its current form is the inability of the cap (and thus prices) to adjust to these exogenous shocks. The WBGU therefore recommends the establishment of a price floor of about €12 to €15 per tonne of CO_2, which could then rise over time. This will increase the security of investments in mitigation options.

It would also be a good idea to adjust the cap flexibly to external developments, for example in the form of a 'rolling cap' which can be re-adjusted every five years, or by linking the cap to the development of relevant exogenous parameters such as economic development. The possibility of subsequent re-adjustment should furthermore already be institutionally laid down when the cap is fixed in the future.

In addition, care should be taken to ensure that short- to medium-term caps are consistent with long-term climate goals. In the following, the cap is approximately determined for the year 2030. According to Kriegler et al. (2014), the EU's reduction target for 2030 should be at least 40% compared to 1990, in order to remain on the trajectory of the EU Low Carbon Roadmap for 2050 at acceptable costs. The emissions level for 2030 to which the EU would still be entitled in 2030 – in line with the 2 °C guard rail and taking into account the fairness criteria laid down in the budget approach (WBGU, 2009) – can be derived in simplified terms as follows (Box 3.3-1).

According to the UN Gap Report (UNEP, 2013a), a global budget of 35 $GtCO_2eq$ would still be acceptable in 2030 to comply with the 2 °C guard rail. If this budget is adjusted to the EU population's share of the world's population in 2010 (7.2%), the resultant budget for the EU for 2030 is 2.52 $GtCO_2eq$. This corresponds to a reduction in annual emissions of more than 50% compared to the figure for 1990, when emissions totalled 5.37 $GtCO_2eq$. This can be interpreted as a moral obligation, in addition to achieving a reduction of at least 40% within the EU, to provide additional financial support for further reductions outside the EU, in order to reach a 50% EU reduction target in the spirit of effort-sharing.

The reduction target of (at least) 40% for 2030 must then be divided up into an EU ETS target and a target for the non-ETS sectors. Analyses conducted by the European Commission (2014) show that the ETS sector should be weighted more heavily in order to reach the 40% target cost-effectively. The European Commission's proposal calls for a 43% target for the ETS and a 30% target for the non-ETS sector. In order to reach the 43% target in 2030, it will be necessary to raise the linear reduction factor (which quantifies the annual reduction rate of the cap relative to the reference period) to -2.2% from 2021.

nologies in emerging economies and developing countries. JI facilitates projects between countries with emission-reduction commitments: the investing country can offset the emissions reduction with Emission Reduction Units. CDM facilitates projects between states with emission-reduction commitments and signatory states of the Kyoto Protocol with no emission-reduction commitments, primarily emerging economies and developing countries. The investing countries can offset the Certified Emission Reductions. The Kyoto Protocol requires 'additionality' for the JI and CDM projects. This means that a JI or CDM project must generate additional emissions reductions from sources – or a reduction in emissions via sinks – which would not have been made without the project. A registration authority has been created for these flexible mechanisms which registers all the projects, emission allowances and transactions, so that the activities are verifiable.

An intermediate appraisal of the project-based mechanisms to date paints a mixed picture. On the positive side, specifically the CDM has made a major contribution to creating an awareness of the possibilities of emissions reduction and generating corresponding capacity in emerging economies and developing countries (Kreibich and Fechtner, 2013). Current developments like the creation of a Chinese emissions-trading scheme would have been unlikely to happen in this way without the pioneering work done by the CDM.

However, the above-defined additionality of the emissions reductions achieved under CDM and JI is often doubtful; even in principle any solution can only be an approximation. The reduction in emissions achieved is calculated by contrasting the actual project with a scenario (baseline) representing the fictitious future development had the project not been implemented. Since this is a hypothetical question, windfall gains can never be completely excluded. In practice, various studies have called into question the additionality of up to half of the CDM projects (Haya, 2009; Schneider, 2009; Spalding-Fecher et al., 2012).

Moreover, the project-specific approach generates considerable uncertainty which greatly weakens the mechanisms' incentive effect. Project managers cannot be sure beforehand whether their project will be approved at all, whether the projected emissions reduction really will be reached as expected, and what price will be received for the emission allowances. Another issue is the price of emission allowances, which historically is usually relatively low. As a result, the mechanisms are seldom the crucial factor that determine

investment decisions. Project developers say themselves that, on the contrary, the emission allowances are usually more like the 'cherry on the cake' (Haya, 2009).

Another criticism is the highly uneven geographical and sectoral distribution of CDM projects. About half of all projects take place in China and a further quarter in India, while poorer countries, especially sub-Saharan Africa, are hardly represented at all in the CDM. Similarly, important sectors like transport or energy end-use efficiency have hardly been addressed by the CDM up to now. This allocation, too, is a result of the instrument's design. In line with the goal of mobilizing emissions reductions as cost-efficiently as possible, the CDM concentrates on relatively advanced countries with a low investment risk, as well as on cost-efficient types of projects with low complexity (Byrne et al., 2011).

In addition, the interventions of CDM and JI usually only have a selective impact because of their project-based character; they are unlikely to cover entire regions, which would really be necessary in the fight against climate change.

Considerable efforts have been made in the past few years to resolve these weaknesses. Efforts to achieve a greater degree of objectivity and a broader range focus on the standardization of baselines and programmatic approaches (Kreibich and Fechtner, 2013). However, there are fears that the efforts to reform the CDM might become to nothing if carbon markets collapse.

3.3.4.2 Future use of flexible mechanisms

The WBGU advocates the inclusion of two key elements in the 2015 Paris Climate Protocol: (1) the complete elimination of CO_2 emissions by 2070 at the latest as the target for all countries, and (2) an international pledge-and-review process. It can be assumed that a meaningful use of flexible mechanisms – building on those of the Kyoto Protocol – is also conceivable as part of a voluntary pledge-and-review process. It is also important for effective climate protection that national economies are not financially overstrained and that short- to medium-term flexibility is used to reduce the global abatement costs.

Under the pledge-and-review process, all parties stipulate their own national targets for avoiding CO_2 emissions. At the same time, all states are to develop decarbonization roadmaps in which they explain how they intend to meet their targets. With respect to flexible mechanisms, the WBGU recommends carrying out most emissions reductions within the respective country; only a small proportion can be achieved abroad.

The WBGU has repeatedly pointed out that the transformation of fossil energy systems must begin immediately in order to avoid dangerous climate change (WBGU, 2011, 2012, 2013). Should states carry out most of their emissions reductions abroad, the transformation of the national systems will be delayed, and there will be an increased risk of creating lock-in effects that will make a complete phasing out of CO_2 emissions more difficult.

The use of flexible mechanisms should only be allowed if ambitious pledges are made. In this case, they can make a useful contribution to ensuring that the national economies are not financially overstrained and to supporting developing countries. If the pledges are not very ambitious, the costs involved in target achievement will probably be comparatively low. A reduction in emissions abroad would probably not lead to substantial cost savings, but it certainly would delay the transformation to a low-carbon economy.

The incentive to set ambitious emissions-reduction targets in a pledge-and-review process could increase the opportunities to use flexible mechanisms. The WBGU therefore recommends linking the entitlement to use flexible measures to sufficiently ambitious targets. If a pledge exceeds a certain level, a certain percentage could be carried out abroad.

If it is assumed that all countries develop a decarbonization roadmap, developing countries could mention in their plans what kind of support they need for their transformation to a sustainable society (WBGU, 2009). In this case, the WBGU recommends using flexible mechanisms along the lines of Joint Implementation. All participating countries set themselves reduction targets, and industrialized countries and emerging economies, if their own targets are ambitious, would have an incentive to meet some of their own commitments by investing in developing countries, in order to generate flexibility in emissions reductions for themselves (WBGU, 2009). It is important in this context to avoid double counting.

If all states gear their efforts to the goal of reducing global CO_2 emissions to zero by 2070, such flexible mechanisms can offer all states cost flexibility in preventing emissions, albeit only in the short to medium term. A global zero target implies that all states must cut back their CO_2 emissions to zero. Since the aim is to achieve this by 2070 at the latest, according to the WBGU's budget approach (WBGU, 2009) this implies that, although the timing of mitigation can vary in different countries, the industrialized countries should make a start in the course of this decade (WBGU, 2009, 2011). Industrialized countries and emerging economies with ambitious targets could thus initiate a cost-efficient climate policy via Joint Implementation in the short term; however, in the medium to long term it must effectively happen in their own country.

3.3.5 A transformation fund for a low-carbon economy

Under Article 4 (5) of the UNFCCC and Article 10 of the Kyoto Protocol, Annex I countries have an obligation to transfer technology. Measures have been developed to meet this obligation; they include the Technology Transfer Framework, several programmes financed by the Global Environment Facility (GEF) – e.g. Concentrating Solar Power in Egypt, Mexico, Morocco and

Namibia – and technology-transfer mechanisms such as the Clean Development Mechanism (CDM) (Chuffart, 2013). However, as early as 2009 the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) found many barriers to technology transfer that is oriented towards the needs of the emerging economies and particularly those of the developing countries. These include information deficits on technologies, economic problems in the developing countries and emerging economies, in some cases a lack of access to capital markets, institutional and regulatory deficits, a lack of technical and social infrastructure, and the definition of intellectual property rights (Chuffart, 2013; Mersmann and Hermwille, 2014). Intellectual property rights can hinder the diffusion of low-carbon technologies in two ways. A lack of intellectual property rights can lead to lower direct investment. At the same time, patented technologies are more expensive to buy, so that many developing countries avoid them and choose low-cost, established, high-emission technologies (Chuffart, 2013). Other studies also show that there has been little or no effective technology transfer to date under the UNFCCC beyond isolated programmes and individual demonstration projects (Ockwell et al., 2010; Hedger, 2012). In 2010 the Cancún Agreement established the Technology Mechanism, which goes beyond simple technology transfer and supports developing countries in research, development, application and diffusion in the field of low-carbon technologies in line with their national needs (Blanco et al., 2012; Mersmann and Hermwille, 2014). This Technology Mechanism consists of the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN). According to the Technology Needs Assessments (TNA) carried out by the TEC to date, it is clear that the biggest technological needs for developing countries and emerging economies lie in avoiding GHG emissions in the energy sector (TEC, 2013).

Conceptually the UNFCCC's new Technology Mechanism goes one step further than the previous technology transfer by including diffusion efforts, the permanent application of technologies, and in particular the country-specific strengthening of research and development capacities – a prerequisite for a general improvement in the countries' innovation and technological expertise. This broader understanding of technology and innovation is in line with the WBGU's approach to use international cooperation to encourage a global transformation towards a low-carbon society (WBGU, 2011). In addition to disseminating existing knowledge of low-carbon technologies, developing countries and emerging economies also need support for their economic development, support for innovation potential, and the creation of suitable framework conditions for innovators who, as change agents, could play a key role in the transformation to a low-carbon society (Chapter 4; WBGU, 2011). In addition, the WBGU sees a need to support transformative regulatory policies in the developing countries and emerging economies in the context of the UNFCCC's Technology Mechanism. The networks that have already been initiated and individual joint learning schemes in the context of the CTCN are not enough for this purpose. In the WBGU's view, that the Technology Mechanism should contribute to the transformation towards decarbonization by comprehensive and country-specific cooperation packages, and to the support of mitigation pioneers: it should be equipped with adequate financial resources for this purpose.

The WBGU believes that compliance with the 2°C guard rail and the global zero target for CO_2 emissions (Sections 3.3.1.1, 3.3.1.2) can only be achieved with a transformation of the global energy systems and an extensive decarbonization of the economies (WBGU, 2009, 2011, 2014). In Section 1.9.1, it was shown that the emissions trend of the last few years was the result of economic growth in developing countries and emerging economies that were following the fossil-based development pathway of the industrialized countries. The rising emissions can only be stopped if all countries formulate and implement decarbonization roadmaps with corresponding intermediate targets for their sustainable economic development (Section 3.3.1; WBGU, 2009, 2011, 2014). In these decarbonization roadmaps the individual countries not only describe their strategies, but also formulate their respective needs for assistance – to enable them to achieve an endogenous low-carbon development in the transformation fields of energy, land use and urban development. The decarbonization roadmaps can be used to identify ambitious countries that should then be given particular support as climate pioneers (WBGU, 2011).

A global transformation to sustainable energy and economic systems is a societal challenge requiring considerable investment. For example, high up-front investments are necessary for improved energy efficiency and the conversion to renewable energies; at the same time, however, these investments can trigger new stimuli for the economy and lead to national cost savings and additional societal benefits in the medium to long term. The high levels of up-front investment in renewable-energy technologies and energy efficiency can be offset by savings in the costs of fossil fuels required by conventional technologies; this is very attractive for energy-importing countries (WBGU, 2011, 2012). The following picture emerges in the energy sector: GEA (2012) estimates current global investment in the energy sector at approx. US$1,300 billion per year. This corresponds to about 2% of the global gross domestic product (GDP) (WBGU, 2012:8). However, this percentage of investment varies considerably from one country to another. In developing countries, the energy sector's annual share of investment averages 3.5% of GDP, compared to only 1.3% of GDP on average in industrialized countries (GEA, 2012: 1253). Approx. US$50 billion per year is currently being spent globally on (public and private) research and development in the energy sector as a whole, half of which is invested in fossil and nuclear energy (WBGU, 2012:8; GEA, 2012). The IPCC's

scenarios for a decarbonized energy supply show that, in future, annual investment in climate-friendly power generation would have to rise to about US$150 billion and annual investment in energy efficiency in the fields of transport, buildings and industry to US$336 billion (Section 1.9.2). The WBGU, too, has estimated the amount of global investment needed to build up a sustainable energy sector (WBGU, 2011, 2012): overall investment in the energy sector will need to double between now and 2030, and triple by 2050. GEA (2012) estimates the future additional investment required in the energy sector at between 1.8 and 2.3 % of the global GDP per year (GEA, 2012: 1255). A large proportion of this investment must take place in non-OECD countries (Section 1.9; WBGU, 2011, 2012; GEA, 2012).

The involvement of both private- and public-sector agents will be needed to finance these investments. If public funds are targeted to support private investment, they can have a considerable leverage effect on private capital. For instance, the IFC Partial Credit Guarantee for Energy Efficiency has achieved a high leverage ratio of 15:1, i.e. a million of public funds was able to mobilize 15 million in private capital. In other cases the leverage ratio was only 8:1 or 4:1. The leverage ratio increases at the rate at which public funds reduce the risk for private investors (Neuhoff et al, 2010; WBGU, 2012: 12).

In the following, the WBGU outlines a transformation fund under the auspices of the UNFCCC for the decarbonization of the world economy. This proposed transformation fund should make a significant financial contribution and, using public funds, minimize risks for private investors in the respective developing countries, thus promoting the momentum for transformation.

3.3.5.1 Proposal for a transformation fund

Up to now, private investors have been rather reluctant to invest in the energy-system transformation, the development of climate-friendly energy systems, or the decarbonization of other sectors of the economy. The transformation fund aims to help minimize transformation barriers – such as inadequate political objectives; subsidies for fossil and nuclear energies; unfavourable risk-return ratios; inadequately developed markets and administrative structures in many developing countries and emerging economies; and high transaction costs due to fragmented international financing mechanisms. At the same time, the transformation fund should offer preferential support for pioneers from developing countries and emerging economies that unite to form climate clubs or join existing climate clubs with OECD countries (Box 3.3-2, Section 4.2). The WBGU recommends implementing the following points when designing the fund:

1. *Sufficient volume of funding:* The WBGU assumes that about half of the public funds of the Green Climate Fund (Section 3.3.6) are invested in mitigation. A large proportion of this money for the decarbonization of the economies should flow into the transformation fund. These public funds can be used to reduce the private economic and technological risks of climate-friendly innovations in developing countries and emerging economies, e.g. with loan guarantees, so that significant amounts of private capital, too, can be mobilized for climate-friendly investments via leverage effects. This could improve the risk-return ratio for potential investors. One possibility would be to introduce insurance solutions for technological and project risks like the ones that already exist in industrialized countries. Another possibility is to provide financial support for public measures to reduce economic risks, e.g. by means of subsidies, feed-in tariffs, low-interest loans, loan guarantees, or public risk capital. Innovations can also be made more competitive by measures like market-launch programmes or market regulation. The German Renewable Sources Energy Act (EEG) is an example of such measures. It is important that such policy instruments are subject to a gradual degression over time and are eventually phased out to avoid permanent subsidies like the ones that have been – and still are – practised in the fossil and nuclear-energy fields. In cases where low-carbon key technologies are protected by intellectual property rights, the fund could buy patents or licences from private companies and grant sub-licences, or broker licence agreements between companies as an intermediary. The Medicines Patent Pool (MPP) launched in 2010 could be a model for this task. Another possibility is joint research and innovation cooperation between industrialized and developing countries, as well as other public and private stakeholders, in order to develop joint patents and intellectual property rights and to design the technologies to be integrated in such a way that they can fit into the respective national innovation system (WBGU, 2009; Blanco et al., 2012; Chuffart, 2013).
2. *Country-specific solutions:* The current economic development of emerging economies and developing countries is the result of public and entrepreneurial activities, as well as foreign direct investment. As part of a decarbonization roadmap, each country should present a low-carbon development strategy, part of which should be an innovation strategy. The WBGU recommends that the developing countries and emerging economies should document their need not only for funding or support with capacity building, but also for climate-friendly technologies. It is crucial here that a country's technological capabilities are taken into account. New knowledge about technologies – whether imported via international technology transfer or developed in the respective country with the help of innovation promotion – does not automatically enable either the production or the diffusion of low-carbon technologies. For production to be possible, companies would already have to be present in the respective country that have the technological ability to understand and apply the new knowledge and adapt it to the

local situation. Only if new knowledge can be linked with national innovation systems and is compatible with the respective country's capabilities can decarbonization efforts be sustainably promoted (WBGU, 2011). The fund should therefore promote country-specific research, technology and innovation policies and help reduce the risks of climate-friendly investments; it could also function as a facilitator in order to bring suitable partner countries, companies and research-and-development institutions together to form transformation alliances.

3. *Ensure the diffusion and long-term application of climate-friendly innovations – promote low-carbon transformation reforms:* The fund should ensure that not only measures for innovations in energy systems, urban areas and land-use systems in the respective country are promoted, but that their diffusion and long-term application is also ensured. The diffusion and application of climate-friendly innovations requires public support, due to the hitherto higher costs and the demands on systems integration. Examples include the decentralized supply of electricity from renewable energies in rural areas, the broad use of solar energy for water pumps in irrigation agriculture, and low-emissions public transport in the cities. For this purpose, the respective countries could explain in their decarbonization roadmaps what measures they intend to take to promote their energy and economic sectors. If they need additional funding and capacity development to do this, collaborations with the relevant institutions would have to be integrated into the planning.
4. *Promotion of climate pioneers and ambitious climate clubs:* In order to drive the global transformation process, about a fifth of the transformation fund's total financial volume should be used to promote pioneer countries of climate protection and ambitious climate clubs. Such privileged promotion accelerates the dynamics of the global transformation, and successful examples of a rapid low-carbon conversion are created, providing orientation which other countries can follow.

3.3.6 Financing

The Fifth IPCC Assessment Report reiterated the urgency of increasing investment in both mitigation and adaptation (Gupta et al., 2014). At the same time, the current international financial architecture for private and public investment in mitigation and adaptation is very complex (Figure 3.3-1).

At COP 15 in Copenhagen in 2009, the industrialized countries promised to mobilize climate finance to support mitigation and adaptation to climate change in developing countries: US$30 billion for the period from 2010 to 2012 and US$100 billion per year from 2020. This promise was repeated in the following years in the official COP decisions (e.g. UNFCCC, 2010).

According to UNFCCC agreements, a significant proportion of this climate finance is to be channelled into the newly developed Green Climate Fund (GCF). In addition, there are other multilateral funds mandated by the UNFCCC, for example the Special Climate Change Fund (SCCF), the Least Developed Countries Fund (LDCF) and the Adaptation Fund (AF).

The Green Climate Fund was adopted at COP 16 in Cancún in 2010 (UNFCCC, 2010). It is intended to finance measures in developing countries and emerging economies aimed at reducing emissions and adapting to climate change. The Fund will then manage a considerable proportion of these funds. It has been accepting payments since May 2014. Instead of only supporting individual projects, the Green Climate Fund has a more ambitious approach: to contribute to a major transformation – for example by promoting renewable energy laws in individual countries or supporting long-term, national plans in poorer countries to adapt to climate change. Germany has already paid almost €17 million into the Fund (German Climate Finance, 2014b) and pledged €750 million over the next nine years.

The Special Climate Change Fund (SCCF) is administered by the Global Environment Facility (GEF), which promotes the implementation of the Rio Conventions, including the UNFCCC, in developing countries. The SCCF supports developing countries that are members of the UNFCCC in their measures to adapt to climate change, as well as in technology transfer and capacity building. The SCCF is intended to be a catalyst for generating additional bi- and multilateral resources (German Climate Finance, 2014d). Germany has pledged a total of €60 million to date for the SCCF (German Climate Finance, 2014d).

The Least Developed Countries Fund (LDCF) is also managed by the GEF. This fund is intended to help the 48 least developed countries cope with adjustment costs (German Climate Finance, 2014c). Up to now Germany has pledged €115 million for the LDCF (German Climate Finance, 2014c).

The Adaptation Fund (AF) was adopted under the Kyoto Protocol in 2001 and began its work in 2008. It finances specific adaptation projects in developing countries that are signatories to the Kyoto Protocol; with resources from the trade in Certified Emissions Reductions (CERs) and voluntary donations it gives these countries direct access to finance without the detour via multilateral institutions (German Climate Finance, 2014a). Because of the sharp fall in prices for CERs under the Kyoto Protocol, the AF sought to raise US$100 million from donor states in 2013 – and achieved this goal at the COP 19 in Warsaw (German Climate Finance, 2014a).

There are other multilateral funds in addition to the UNFCCC funds and the UNFCCC-mandated funds, for example EU funds and bilateral funds like the German-funded International Climate Initiative or the British International Climate Fund, which can also be used to reach UNFCCC goals. In addition to the provision

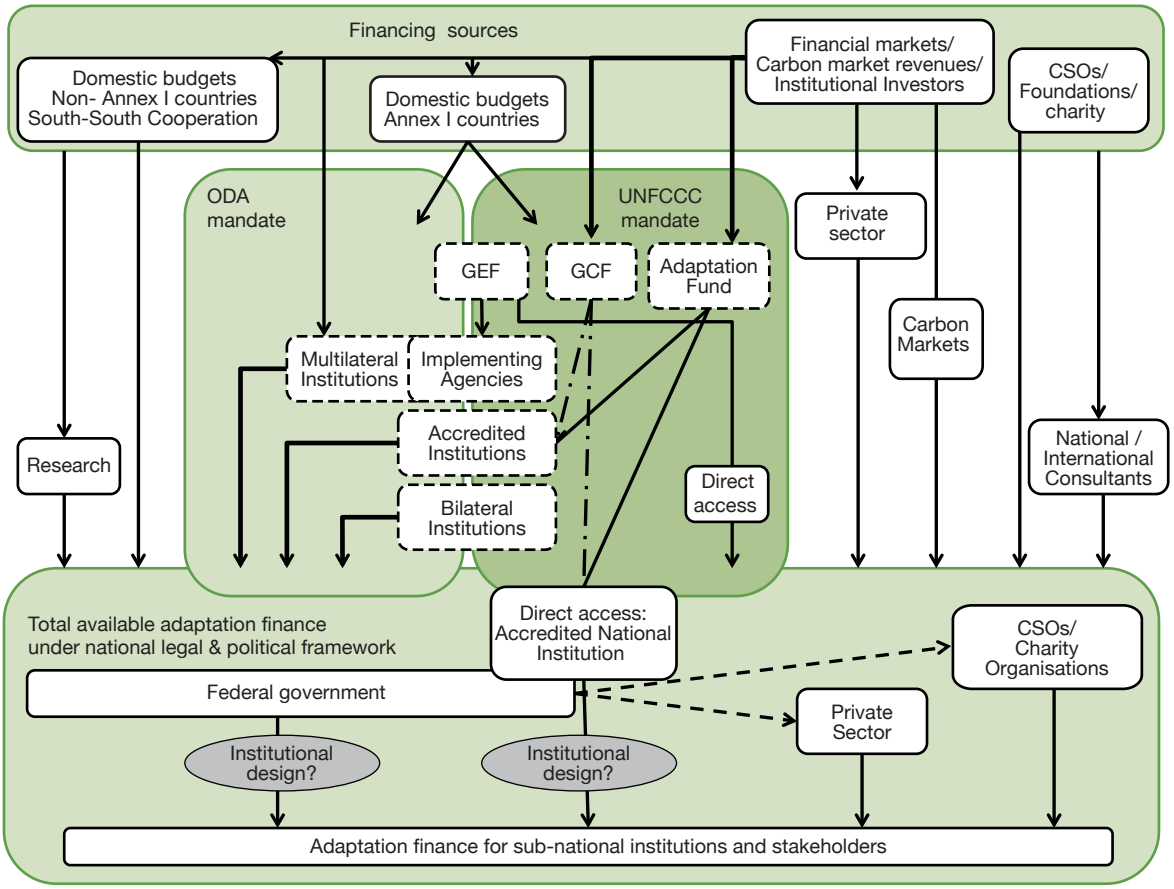


Figure 3.3-1
International financial architecture for investment in mitigation and adaptation.
Source: Horstmann and Schulz-Heiss, 2014

of climate finance by institutions of the international climate regime and official development assistance, funds can also come from the private sector or national and international civil society organizations.

The following five challenges should be addressed in order to reach the targets for climate finance that have already been agreed – to mobilize US$100 billion every year as from 2020 – and to adequately meet the additional financing needs for mitigation and adaptation.

1. *Mobilization of funds:* The promised funds for mitigation and adaptation should be paid. It is essential for a functioning effective fund that criteria are defined and selected for the financial contributions of the states. One suggestion is to base the level of financial contributions to be paid by the UN Member States on the UN scale of assessments (Haites et al., 2013:). The WBGU's suggestion is to gear the individual countries' financial contributions to the polluter pays principle and to historical responsibility for emissions – this also takes into account the principle of common but differentiated responsibilities (WBGU, 2009; Chapter 2). In addition to the nation-state contributions, the private sector plays a key role in the provision of the promised and additionally needed funds for mitigation and adaptation. The closer the year 2020 approaches, the more attention is being paid to this private-sector contribution in the international climate debate. Several developing countries fear that the focus on the private sector could delay and reduce the flow of what are already limited public funds (Pauw and Dzebo, 2014). However, the mobilization of private funds is of great importance for global adaptation and mitigation initiatives – also beyond the promised annual sum of US$100 billion (Romani and Stern, 2011; WBGU, 2012).
2. *Allocation of the funds:* The allocation of the funds for climate finance raises important questions. As regards the funds for adaptation, a method needs be found to prioritize the countries – and specifically the population groups – that are most vulnerable to the consequences of climate change and how such a vulnerability approach can be implemented. In this context the corresponding institutional solution at the national level is also an important challenge (Horstmann and Schulz-Heiss, 2014). It should be clarified here whether and how the money arrives at the local level and how the local population can be involved. The WBGU recommends continuing support for measures like the Federal Government's GCF Readiness Programme, which prepares selected countries to use money from the Green Climate Fund (GCF). With regard to the allocation of the financial resources for mitigation, the WBGU suggests reserv-

ing a certain proportion of the funds that are available for this (e.g. 20%) for particularly ambitious initiatives and pioneer clubs, in order to boost the momentum of the global transformation. Internationally visible decarbonization lighthouses can be created in this way.

3. *Definition of climate finance:* There should be an agreement on a precise and clear definition of climate finance, especially with respect to adaptation measures. The funds for mitigation and adaptation should be 'new and additional' to official development assistance. A consensus should be sought on defining this concept, since different states currently use different definitions of these terms (Brown et al., 2010). The definition of 'private climate finance' and its assignment must also be clarified. For example, if several private-sector agents are involved in a relevant investment, this investment should not be assigned and counted several times.
4. *Balance between mitigation and adaptation:* An appropriate balance needs to be found between the provision of financial resources for mitigation on the one hand and for adaptation on the other. Although the Copenhagen Accord and the Cancún Agreement call for such a balance, up to now less than half of the public funds have been made available for adaptation. The WBGU welcomes the fact that the Green Climate Fund is seeking a 50/50 balance and recommends making a distinction between the two aims of mitigation and adaptation for two reasons: *First*, the rapidly rising investment in renewable energy and energy efficiency in recent years illustrates the fact that the financing of mitigation can be a business model for the private sector, whereas it is not easy to find promising business models for the financing of adaptation (Pauw and Pegels, 2013; Surminski, 2013). *Second*, most public climate finance for mitigation measures flows into emerging economies, where mitigation is relatively inexpensive. As often as not, little or nothing gets through to the least developed countries, small island developing states and countries in sub-Saharan Africa, which have the most urgent need for adaptation financing; they lack not only adequate resources of their own, but also the political and economic resources to solicit private and institutional investors (Lindenberg and Pauw, 2013; WBGU, 2012).
5. *Transparency:* The WBGU calls for climate finance to be organized in a transparent way. Developing countries contribute to mitigation with national climate strategies and receive support from the industrialized countries in the form of funding, technology transfer and capacity building. Like the mitigation activities themselves, this support should be measurable, reportable and verifiable (MRV). Work should be continued on an MRV system for developing countries' mitigation efforts and the support provided by the industrialized countries; the essential basic principle of climate finance must be transparency.

The German Federal Government has repeatedly announced its desire to make a fair contribution to climate finance. The WBGU welcomes this promise. Indeed, German funds provided for climate finance have increased markedly in the last few years. However, commitments for bilateral climate projects will be considerably lower in 2014 than they were in 2013. If the Federal Government is to honour its pledges, however, the German contribution should not be falling, but moderately rising.

Chancellor Angela Merkel's recent promise that Germany would pay €750 million into the new Green Climate Fund over the next nine years means that the Federal Government is contributing to a successful launch of the Fund. An initial payment of €20 million is planned for 2015. The German Government's pledge has now also put pressure on other countries. In addition to Germany, France, the UK, Norway, Sweden, Japan and the USA have publicly announced that they will be making pledges. Some emerging economies, including Mexico and South Korea, are also planning to make pledges of their own. No further pledges have yet been made apart from the Chancellor's. If the pledges requested by the developing countries totalling US$15 billion are received by the end of 2014, this could improve the mutual trust between industrialized countries, emerging economies and developing countries and have a positive impact on the UN negotiations for a global agreement in Paris in 2015.

The WBGU recommends making more effective use of the diversity of available public instruments – such as grants, loans, credit lines, guarantees, bonds, structured funds and technical support (WBGU, 2012) – to mobilize private capital for climate finance. The UNFCCC's Green Climate Fund should consider extending its range of instruments and also using the whole range of possible instruments to mobilize private capital in addition to concessional loans and grants.

Private-sector involvement in climate finance should be stimulated by effective public funds and political measures in industrialized and developing countries. As the WBGU has already emphasized, there are a number of important starting points available here (WBGU, 2012). These include more suitable legal and institutional framework conditions, better risk-minimization strategies and efforts to close information gaps, especially a uniform definition of 'climate finance' and 'private', as well as reliable data for measuring private climate investment. International institutions of development and climate finance should strengthen the links between policies on energy, climate and development in terms of both content and finance. Corresponding institutions should be strengthened and equipped with sufficient funding. When mobilizing private funds, clear social and ecological standards and safeguards, as well as compulsory control and accounting.

3.4 Core messages

- *Interaction between all relevant actors:* An international solution to the global problem of climate change is indispensable. The level of decarbonization required to reach the zero target by the year 2070 at the latest can only be achieved through the interaction of state, intergovernmental and civil-society processes and actors.
- *Legally binding protocol:* The planned Paris Climate Agreement should be designed in such a way that it includes as many of these processes as possible and promotes ambitious actors. The WBGU recommends a legally binding protocol to the UNFCCC and complementary COP decisions.
- *Integrating the 2 °C guard rail and the zero-emissions goal:* The Protocol should follow a hybrid approach based on a combination of compulsory and voluntary elements. The WBGU recommends integrating the 2 °C guard rail into the Paris Protocol in a legally binding form. To concretize the guard rail, it should be agreed as a legally binding global, long-term goal that CO_2 emissions from fossil fuels must be reduced to zero worldwide by 2070 at the latest.
- *The proceduralization of the 2 °C guard rail:* The WBGU recommends proceduralizing the 2 °C guard rail. This would be characterized by the obligatory consultation of scientific expertise (IPCC) in decision-making processes of the UNFCCC and the Paris Protocol, ensuring maximum transparency by guaranteeing access to information for all, and by giving participation rights and rights of action to climate procurators (i.e. associations and non-governmental organizations that can prove an interest in climate protection); this would promote acceptance and the monitoring of how well countries comply with their commitments, thus supporting a kind of democratization of the climate regime.
- *Install a hybrid approach in the pledge-and-review process*: The WBGU recommends an ambitious pledge-and-review process which differs from the previous pledge-and-review process primarily in its hybrid (compulsory/voluntary) approach.
- *Pledges:* Every party to the Paris Protocol would be obliged to set self-selected targets, e.g. up to 2030, and to submit decarbonization roadmaps (pledges). These should not relate solely to greenhouse gas reduction, but could also cover, say, the expansion of renewable energy or improving the energy efficiency of buildings. The decarbonization roadmaps explain how the respective country intends to reach the goal of zero emissions by the year 2070 at the latest. These plans can also include intermediate targets (milestones).
- *Review:* Submission of the pledges should be followed by a legally binding review process to determine whether all the submitted targets, taken together, are sufficient to constitute a global emissions pathway allowing compliance with the 2 °C guardrail. Similarly, the review should also deal with the plausibility and implementation of the individual national contributions. After the review, any deficits in the pledges determined in the review should be renegotiated between the states. The ambition levels can be gradually raised in the course of the repeated pledge-and-review process in interaction with the contracting states' national climate policies.
- *Measurement, reporting and verification:* Measurement, reporting and verification (MRV) is a key mechanism for ensuring the implementation of the targets and the decarbonization roadmaps by the contracting states. The WBGU recommends that the German Federal Government advocates the development of an MRV system for the Paris Protocol.
- *Adaptation and dealing with loss and damage:* Adaptation and dealing with loss and damage must be moved higher up the agenda. The Warsaw Mechanism should be extended.
- *Flexible mechanisms:* The WBGU believes that a meaningful use of flexible mechanisms – in a similar way to the Kyoto Protocol – can also be implemented as part of the pledge-and-review process recommended by the WBGU, provided that the reduction targets submitted are ambitious enough. It is also important for effective climate protection that national economies are not financially overstrained and that short- to medium-term flexibility is used to reduce the global mitigation costs. At the same time, the possibility of using flexible mechanisms increases the incentive to make ambitious pledges.
- *Transformation funds:* The WBGU recommends developing a transformation fund for the global decarbonization of the economy. *First,* by providing sufficient financing, the fund should mobilize the necessary private investment in the transformation of the energy systems and other areas of the economy, minimize the economic and technological risks of innovations, and ensure access to low-carbon technologies. *Second*, the fund should act as an intermediary between national and international actors and support country-specific solutions according to the national decarbonization roadmaps. *Third*, it should enable the diffusion and permanent application of low-carbon innovations. *Fourth*, the WBGU recommends providing preferential support in particular to ambitious climate clubs or pioneer alliances in developing countries and emerging economies.
- *Financing:* The industrialized countries should honour their financial pledges to mobilize US$100 billion every year from 2020 to support mitigation and adaptation in developing countries. The German Federal Government should set an example in this field by making a financial contribution of its own; this could serve as a blueprint for other industrialized countries. Transformative criteria for the allocation of the funds must be developed at the international level.

Narratives and laboratories for active climate protection

4

The great risks of climate change have been further corroborated by the IPCC and climate science (Chapter 1). Yet up to now the international climate negotiations have still not made a breakthrough, nor are there any indications of imminent ambitious agreements on mitigation at the global level (Chapter 3). Against this background, the WBGU looks in this Chapter at other possible ways of moving the mitigation of climate change forward – modular multilateralism, and narratives and laboratories for the transformation to sustainability. The WBGU also considers the possibilities of their interactions and mutual reinforcement, which might bring fresh momentum to the multilateral negotiations. There are many examples, from the local to the global level, of promising citizens' initiatives, social movements, enterprises and clubs that are taking on responsibility for climate protection, raising awareness and mobilizing people for political action. In this Chapter the WBGU shows some selected, striking examples illustrating the broad spectrum of instruments being used to actively try forms of mitigation. The interactions and synergies of the many initiatives are of great importance for their broad-based impact.

4.1
Vitalizing international negotiations

In view of the current status of climate diplomacy, the kind of agreement that can be expected in Paris will probably not be sufficiently ambitious to ensure adequate mitigation (Chapter 3). Unless there is a decisive change of direction, the world is moving towards a level of global warming that could exceed 4 °C by the end of this century – as scientific evidence can now prove in greater detail and with more certainty than ever before (Chapter 1). Nevertheless, the WBGU regards international mitigation within the framework of the United Nations as indispensable and recommends an ambitious, legally binding Paris Climate Protocol (Section 3.1), because the UNFCCC still offers a suitable framework for negotiations on universal challenges concerning all countries.

The question is: how can the deficits of climate protection on the global level be compensated and global climate policy be revived? The WBGU is convinced that pioneering countries and civil society can be a major driving force for both. In the run-up to the Paris Conference of the Parties to the UNFCCC in 2015 (COP 21), demonstrations of considerable size are taking place in many parts of the world. They are being organized by environmental, development and climate-protection groups with the support of religious communities and trade unions, which have been advocating more active mitigation for a long time.

The following overview shows that there are many and varied forms of unconventional social practices, which, once they start relating with each other, can act as catalysts for a more active climate policy and give added momentum to governments that are interested in as ambitious an outcome of the negotiations in Paris as possible. Accordingly, the German Environment Minister Hendricks recently set out the foundations of a successful climate policy: "Implementation will involve an enormous effort from all of us. That is why I would also like to encourage all of Germany's states, local authorities and societal groups to join in" (BMUB 2014). In this sense, productive government action can be driven forward and made possible by decisive action on the part of civil society in its many different forms. For although global climate policy has lost so much momentum since 2009, and disappointment and disaffection have spread among climate activists, at the same time efforts in civil society have increased and taken on a more concrete form. The following synopsis of these efforts to support and strengthen climate-policy governance may also contribute to giving the diverse initiatives, which often seem isolated and weak to the actors involved, a feeling of collective self-efficacy (Zaccaro et al., 1995): "It's up to us – together we can move something" (Bandura, 1997; Bandura and Locke, 2003).

Societal initiatives in the overall context

To begin with, these diverse initiatives are classified as part of an overall context. What can be observed is a potential or current interaction within a triangle made up of (1) civil society (including economic actors), (2) political institutions in the multi-level system from the local to the supranational level, and (3) pioneer countries in the multilateral negotiation system of the United Nations. The dynamic force field in this triangle has been formed in recent years by civil-society initiatives and new social movements. It is known from social-science research into societal movements that they work in an

area that has been neglected by the established political forces, a so-called 'enjeu' (Alain Touraine), a challenge where much is at stake (Touraine, 1993). In this case it is the lack of protection for the global commons – like the atmosphere – which can trigger dangerous climate change.

Social movements (like those in the 19th century on social injustice and political inequality) develop alternative narratives and open up horizons of expectation; they thus highlight and demonstrate political/moral dissent on prevailing conditions and opinions. Beyond this normative level, social movements can mobilize resources which they use in a historically favourable situation as a window of opportunity (Appiah, 2011). Despite this informality, even minority currents can intervene in the political and societal realm by linking ideas and ideals, practices and actions. In relation to climate policy and other international agendas of environmental protection and sustainability, it is significant that such social movements have recently also been networking and bringing themselves into position transnationally in the course of economic and cultural globalization. International non-governmental organizations can operate as lawyers or stewards of global commons, and in the policy cycle they have also gained in importance at the international level. In this way they have become transnational actors (examples: WWF, Germanwatch, Greenpeace) that have taken on a mobilizing role, specifically in climate policy. There have been similar developments involving think tanks and scientific advisory bodies (e.g. Ecofys, World Resources Institute, Woods Hole Research Center; Thinktankmap, 2014).

Similarly alternative pioneering practices can be observed among nation states. By setting up the 'Renewables Club' in 2013, Germany's Federal Government gained the support of several countries that will be decisive for the success of mitigation to pursue new approaches of intensified cooperation. Such ambitious clubs of different actors (e.g. the C40 Cities Climate Leadership Group) can have a catalytic, transformative effect by encouraging other players either to follow their example and replicate the club approach, or to join an existing club.

Historical experience shows that such currents and movements can ease situations that have been deadlocked for a long time and create scope for action. Decisive success factors are what might at first sight seem surprising links between local and wider individual initiatives, or alliances across sectors and national frontiers, which open up action parameters beyond the 'usual suspects', i.e. the well-known stakeholders, and allow 'contentious politics' in a comprehensive sense (Tilly and Tarrow, 2006). By way of contrast to classic stakeholders, such initiatives should be seen as 'stewards' that are concerned primarily with the matter in hand, regardless of the extent to which they are affected themselves. A closer look at climate-policy actors reveals that they are found in different societal subsystems (politics, business, culture, knowledge) and use all media of political interaction: power and influence, money, discourse, law. Such a parallel change happening at different, often unrelated societal levels indicates a profound transformation (Osterhammel, 2009). The initiatives described in more detail in the following can be systematically classified into subsystems (Figure 4.1-1). The strength of the initiatives probably lies in the fact that they are often present in several subsystems in parallel or end up moving 'in step'.

When the individual initiatives are located and assigned to the societal subsystems, political clubs, driven by nation states, can be termed an element of *modular multilateralism*. The latter arose following a multipolar reorganization of the international community, distinct from the classical multilateralism of the UN's negotiation system. Ideally, regional and sectoral forms of cooperation develop where global cooperation does not materialize. In the context of the UNFCCC, state clubs can generate 'tipping points' if their members strive (nationally) for significantly more ambitious goals than could be achieved in the UN process, enabling them to act – as a club – more ambitiously in the UN negotiations. Modular multilateralism is being backed up and motivated by a *normative and cognitive paradigm change*. This is initiated and sustained by stimuli from, for example, religious communities, but also from science that has a transdisciplinary orientation and systematically incorporates the local knowledge of non-scientists. This improves the prospects of a *re-embedding of the markets* (Polanyi, 1944) which favours and sustains low-carbon individual investment and consumer decisions and analogous decisions by institutional actors, such as businesses and public administrations.

All of this is happening at the same time as numerous individual and collective initiatives are declaring themselves responsible for the change and are able to redefine responsibility for the future.

The WBGU would like to demonstrate that the performance and legitimacy of international climate protection depends to a substantial extent on such initiatives and their interactions. It can be taken as given that a broad normative consensus exists for global mitigation and related orders of preference for sustainable development, which are gaining ground not only in developed economies, but also in emerging economies – or have at least influenced strategic groups in the societies concerned.

The change in values is in full swing

There are many indications – e.g. the results of the World Values Survey (WVS) that has been carried out worldwide since 1981 – which suggest that value systems that assign a key priority to the protection of the natural environment are growing among large sections of the world population, that they are spreading globally and thus creating a basis for the transformation in the knowledge system and the cultural system (WVS, 2014). For example, the WVS's current sixth 'wave of enquiry' also shows that the majority of respondents in almost

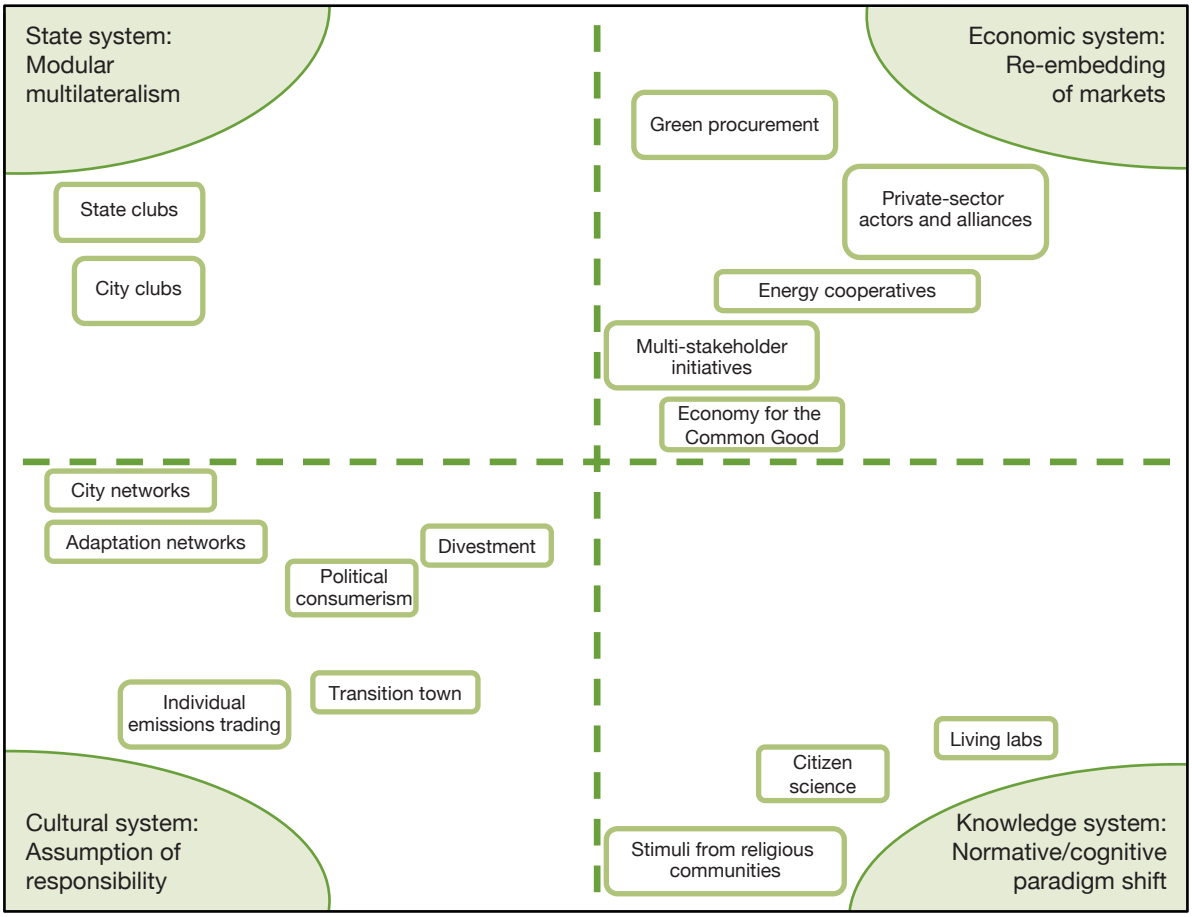


Figure 4.1-1
Societal subsystems in which climate-policy players act, and changes inspired by initiatives.
Source: WBGU

all participating countries regard environmental protection as important to them personally and, as a development goal, of similar importance as education and the improvement of infrastructures. In the meantime, citizens in 30 of the 53 participating countries assign a higher priority to the protection of the environment than to economic growth (WVS, 2014). The growing concern for the environment and the spread of environment-related values is seen as an expression of a change in values towards post-material ideas and self-development (Inglehart, 2008), which are to be found primarily in more prosperous, democratically organized countries, but are also spreading increasingly in emerging economies. Other international studies also show a lot of similarity across countries and cultures when it comes to attitudes to the hazardousness – as well as the causes and consequences – of climate change and related concerns (BBC, 2007; Brechin and Bhandarai, 2011). Furthermore, surveys focusing explicitly on attitudes and assessments of international climate policy show that citizens in the nations involved in the negotiations take their own responsibility for mitigation much more seriously – and are more agreed among themselves – than their government representatives. While the latter tend to focus on national self-interest in climate negotiations (Long et al., 2010), citizens consider principles of justice and responsibility to be more important than pursuing one's own interests (Kals et al., 2005; Schleich et al., 2014).

Similar developments can also be observed among international actors. For example, the heads of international organizations like the World Bank and the OECD have declared their support for the 'decarbonization' of energy supplies and the protection of resources. World Bank President Jim Yong Kim stated: "A 4 degree warmer world can, and must be, avoided – we need to hold warming below 2 degrees" (World Bank, 2012b); and OECD Secretary General Angel Gurría declared: "I am making a strong call for governments to put us on a pathway to achieve zero net emissions from the combustion of fossil fuels in the second half of this century" (OECD, 2014). This commitment is also reflected on a broad front in national and local mitigation plans, in self-commitments and investment decisions by companies, and in a lot of scientific research. The examples all show that a normative discourse in favour of climate protection and sustainability has taken hold and that it has moved from the realm of ideas, visions and desires to concrete forms of social practice.

How change can take place

The political-strategic question now is how opinion-poll majorities and individual declarations of intent can be turned into effective collective action, and how climate

policy can be (re-)politicized. In other words, how can a global line of division and conflict develop that reaches the UN system via the above-mentioned influence of global civil society and avant-garde countries and cities?

The topic of climate protection is regarded as a 'wicked problem', i.e. seemingly insurmountable at the national and local level because it is so long-term, complex, etc.; that is why it is rarely an important issue in national and regional elections, but usually hits the headlines via unconventional political participation. This begins with petitions (e.g. the Memorandum of the Nobel Cause Symposium 2014, PIK 2014), fund-raising activities and the like. It then develops into demonstrations on the street calling for mitigation and a transformation of energy policy (e.g. the 'Mother Earth Day to May Day' on 1 May 2014; Global Climate Convergence, 2014) or the decentralized demonstrations in Germany under the motto 'Don't Let the Energy Transformation Capsize!' on 10 May 2014, organized by the Climate Alliance Germany (2014). Then come city networks (C 40), boycotts, 'divestment' campaigns and environmental law suits – in which environmental organizations can act on behalf of others under a 'procuratory legal status' (Section 3.2.4; Schlacke, 2014B; Ekardt, 2014).

What is important now is how the different actors involved interact. Of course, this is not being directed by a fixed choreography or by 'stage directions', but unfolds polyphonically as a unifying basic narrative: decarbonization and the transformation towards sustainability. It is not least the media effect of such 'glocal' individual actions that creates a feeling of collective self-efficacy, which actually comes together in laboratories on decarbonized production methods and lifestyles, in science, in businesses and in civil society – for example in cooperatives and class actions.

According to Ostrom, four factors favour responsible action in societal dilemma situations, of which climate change is one (Ostrom, 2009: 12f.; Poteete et al, 2010):

1. A basic awareness of the problem (of climate change), its causes, the need for change and personal responsibility among as many participants as possible.
2. A high degree of reliability of information about the problem and continuous dissemination of this information.
3. Information that other participants are also seeking change and that efforts are being monitored.
4. Communication between the participants or subsets of the participants.

Under these conditions, small, autocatalytic foci of mitigation can kindle a large-scale transformation dynamic. The effectiveness of isolated foci must be supported by institutional and procedural advances in climate negotiations at the local, national and global level, since, for example, political consumerism and divestment approaches are subject to the cycles of social movements and the latter's potential can dwindle as a result of disaffection and disappointment (Hirschman, 1970, 1982).

In the following, exemplary action practices are presented that offer medium to high potential both for decarbonization (which represents a reliable planning factor for all actors (Chapter 2) and for the transformation towards a low-carbon society. From the perspective of social practices and initiatives they illustrate the stimuli that are at the disposal of the negotiators in the UNFCCC process. The selected initiatives range from the level of multilateral actors (clubs of nation states, city networks), via the meso level of social movements, to possibilities of collective actions by smaller communities and individuals. The transformative potential of the initiatives and their interaction is analysed in four categories (Table 4.6-1).

The *first* is the *ambition level* chosen by the actors themselves: what and how much do the participants want to change with the alternative action practices? Is it a question of creating 'islands' or alternatives to the mainstream within the field of application, or is an alternative regime (of supply systems, financial systems, forms of social life) being sought? What counts in this context is not the specific, alternative action practice itself, but the vision or alternative to the mainstream which is developed by the actors and the extent to which this comprises a transformation of society.

Second, the *scalability* of the initiative is of decisive importance: how great is the extent of individual and collective mobilization? How far can the alternative action practice diffuse within societal levels, spatial borders and beyond? Can all people, regardless of their resources (financial, cognitive, social) and cultural background, take part, or is the alternative mainly suitable for certain social and cultural milieus?

Permanence is the *third* category and it points to the future: are the alternative structures in question organized formally (like associations, cooperatives) or informally (like temporary actors' networks, internet platforms and forums)? Can they link up with existing structures (e.g. company law, institutions), or are they more 'isolated'? It is important in this context to distinguish between whether the activities of the initiative are the objective and are to be implemented permanently (e.g. organizing energy supplies cooperatively based on renewable energies), or whether they are a means to an end that is not intended to be permanent, but will become obsolete once the aim has been reached (e.g. political consumerism or divestment is not the aim, but a way of changing supply systems or financial systems; once the systems have changed, the means are no longer necessary).

Fourth, every initiative must be judged according to its *feasibility*. Feasibility needs to be understood in two ways. As Type 1 with regard to the alternative practices as such: are these easy to implement? For example, can participants get started (e.g. with de-investing) as soon as the necessary personal resources are available? Or is some form of preparation or activation of collective resources necessary first, e.g. to set up an energy cooperative or a producer/consumer cooperative (developing a business plan, establishing contacts, finding fellow-campaigners, etc.)? As Type 2 with regard to the

ambition or the goal: how different from the existing regime is the alternative (see ambition level)? To what extent must established routines and systems change in how many areas of society for the alternative to become mainstream?

Only very limited assessments on this are currently possible for some of the examples listed below. Furthermore, it is the cumulative impact of networked initiatives that is crucially important, i.e. the way in which they mutually influence and reinforce each other in the subsystems of politics, business, culture and knowledge. At best, they create an impression of self-efficacy among the participants, and support and legitimacy among the institutional actors whose aims are geared to sustainable progress. Demonstration and imitation effects arise, followed by power shifts; in this way, narratives and sustainability laboratories become effective; in this way they shape the routines and habitus of broad sections of the population; and in this way, as global action models, they become culturally acceptable to a majority and possibly hegemonic.

4.2 Modular multilateralism

Definition

The UNFCCC should be complemented by a flexible form of modular multilateralism in order to dynamize the UN negotiations. Clubs are a promising format for such an approach. Clubs are voluntary associations in which (1) membership is linked to meeting specific criteria, and (2) only members have access to the respective club goods. Club goods are advantages of the club which offer an incentive to join the club (Buchanan, 1965). Club members can be individuals (e.g. in sports clubs), states (e.g. the EU), cities (e.g. C40), or totally different types of actors.

Examples

There are already a wide range of club-like groupings outside the UNFCCC. However, existing groupings usually only aim for incremental changes. Although they make important contributions to mitigation as dialogue forums or initiatives geared towards implementation and capacity-building, they only strive for small advances (Figure 4.2-1).

In order to generate fresh momentum for the cause of climate protection, what is needed instead of the existing groupings are ambitious clubs that actually contribute towards triggering fundamental change (Box 4.2-1). To date, no club exists that generates transformative change.

Transformative potential

Clubs whose members have come together as climate pioneers to pursue an ambitious climate policy can contribute to accelerating the transformation towards a low-carbon, sustainable society. Even if such clubs cannot stop climate change alone, they can develop a transformative effect as catalysts, for example by presenting a successful example; innovative approaches that have been successfully tested in the club can be replicated in other contexts.

Ambitious clubs can act as role models and encourage other actors by demonstrating what is possible. The club approach is scalable: clubs can grow by accepting new members until they make themselves superfluous, i.e. when all UN states have become members of the club and a global climate agreement is in place. The initially exclusive logic of the clubs can thus develop an inclusive dynamic in the long term.

Clubs can generate climate-policy 'tipping points' in the UN process, not by replacing the UN process, but by complementing and supporting it. The global problem of climate change can ultimately only be solved by a multilaterally agreed global response. Clubs, however, can boost momentum at the UN if their members pursue much more ambitious national targets than would be possible in the climate negotiations, and at the same time take a more ambitious stance as a club in the multilateral process.

Clubs can develop transformative potential through a variety of advantages:

- *Speed:* As early as 1965, Mancur Olson argued that smaller groups reach a consensus faster because there is more social pressure between the members than in larger groups (Olson, 1965). Club advantages that exclusively benefit members also generate greater incentives for an agreement than in the large group of UNFCCC states, where the goal is the provision of a global public good.
- *Ambition level:* Smaller groups could reach agreements that are more precisely tailored, but more profound – i.e. more ambitious – than would be possible as the lowest common denominator of all the UNFCCC members (Aldy et al., 2003; Biermann et al., 2009). Moreover, clubs are in a better position to experiment with innovative approaches.
- *Participation and fairness:* Clubs could offer more scope for new actors. These can include, for example, cities, companies, or less influential actors that would be dominated by the more powerful negotiating parties in the context of a larger group (Biermann et al., 2009).
- *Enforcement mechanisms:* Clubs are better at avoiding free-riders because of their positive incentives (the clubs advantages) and sanctions (such as the threat of exclusion), and are therefore more effective at enforcing their goals than initiatives and institutions without enforcement mechanisms.

In the WBGU's view, clubs with a transformative effect must contain the following elements:

1. *Ambitious vision:* The members of the transformation club should share an ambitious vision.
2. *Clear criteria for membership:* The club members must meet measurable criteria which are in line with the

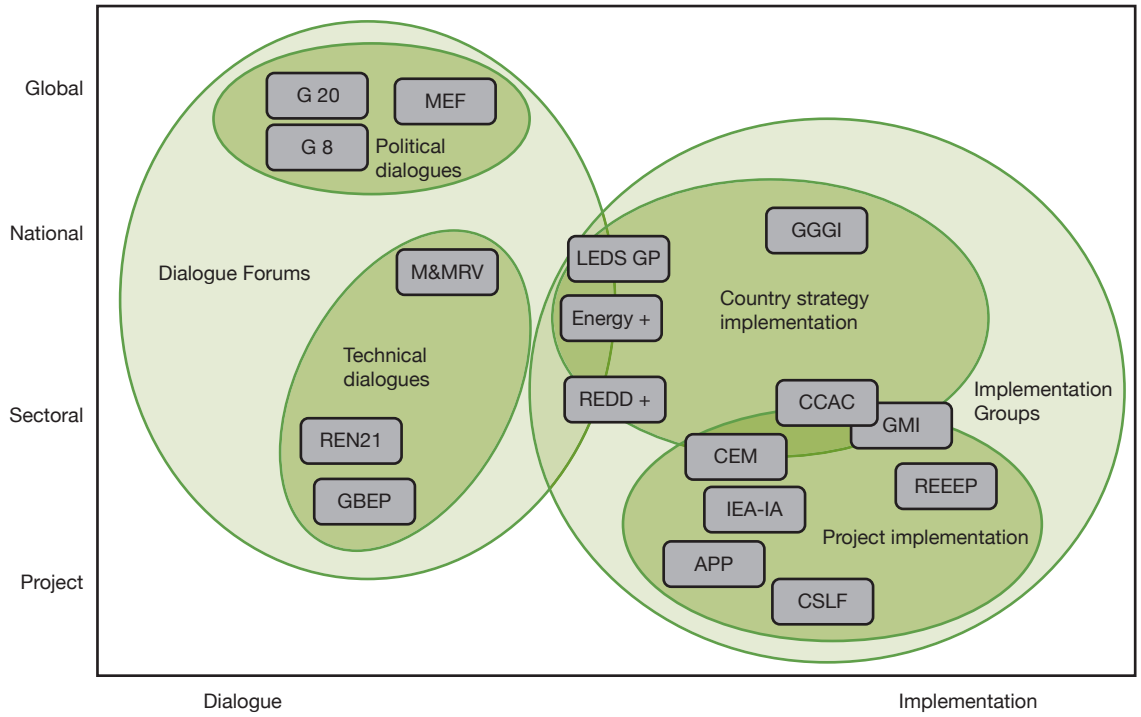


Figure 4.2-1
The landscape of clubs involved in mitigation: the seventeen groupings shown contribute to mitigation as dialogue forums or implementation groups, but lack transformative character. APP: Asia-Pacific Partnership on Clean Development and Climate; CCAC: Climate and Clean Air Coalition; CEM: Clean Energy Ministerial; CSLF: Carbon Sequestration Leadership Forum; Energy+: International Energy and Climate Initiative; G8: Group of 8; G20: Group of 20; GBEP: Global Bioenergy Partnership; GGGI: Global Green Growth Institute; GMI: Global Methane Initiative; IEA-IA: IEA Multilateral Technology Initiatives (Implementing Agreements); MEF: Major Economies Forum on Energy and Climate; LEDS GP: LEDS Global Partnership; M&MRV: International Partnership on Mitigation and Measurement, Reporting and Verification; REDD+: Reduced Emissions from Deforestation; REEP: Renewable Energy and Energy Efficiency Partnership; REN21: Renewable Energy Network for the 21st Century.
Source: Weischer et al., 2012, modified

club's ambitious vision.

3. *Significant advantages for members:* The club should offer members significant advantages which exclusively benefit the members, so that they have strong incentives to meet the ambitious membership criteria.
4. *Openness for new members*: The club should be open for new members that meet the membership criteria – as well as for new types of members, such as cities or companies.

Examples of clubs that bring together different actors are presented in the following: state clubs (Section 4.2.1) and city clubs (Section 4.2.2).

4.2.1 State clubs

Definition

A promising starting point for modular multilateralism is the formation of transformative clubs whose members are nation states. Germany and the EU should promote the creation of such state clubs which commit themselves to ambitious mitigation targets and policy for an energy-system transformation. Clubs can set themselves ambitious and innovative targets in the fields of mitigation, adaptation or coping with loss and damage, which go beyond the ambition level that can be achieved in the UNFCCC context and can help breathe new life into the UN negotiations (Box 3.3-2). Alternatively, or in addition, clubs can set themselves ambitious goals for expanding the use of renewable energies or for improved energy efficiency.

Example

The 'Renewables Club' (*Club der Energiewendestaaten*), which was launched by Germany's then Federal Environment Minister Altmaier in 2013, could become a transformative club and give the UN negotiations a boost. China, Denmark, France, the UK, India, Morocco, South Africa, Tonga and the United Arab Emirates are members of the club. The Federal Government has thus succeeded in gaining support for the club from several countries that will be decisive for the success of mitigation. The other member states of the Renewables Club have high expectations of enhanced cooperation within the framework of the club. If only for reasons of credibility vis-à-vis important international partners, Germany should take a lead in the expansion and development of the club.

Box 4.2-1

Examples of associations with club character

At present there are no clubs with transformative character in the climate policy field. The creation of such a club would thus be a social innovation. Outside of climate policy there are communities, clubs and club-like initiatives that can inspire the creation of clubs:

Regional organizations like ASEAN, Mercosur and the EU can serve as such models. The European Coal and Steel Community (ECSC) was an European trade association and a precursor of the EU. The ECSC gave all member states access to coal and steel without having to pay duty. The EU is a community with club character that has grown to 28 members in the meantime and is offering more and more club goods, including, for example, participation in the European internal market, the right to use European regional and structural funding, and the existence of a common foreign and security policy.

The Association of Southeast Asian Nations, or ASEAN, is based in Jakarta. Its aims are to improve economic, political and social cooperation, but also cooperation on security, cultural and environmental issues. In 2009 the heads of state and government of the ASEAN members decided to form a common economic area based on the European model.

Another example can be found in the field of global health policy. The Advance Market Commitment (AMC) offers incentives for the commercial development and rapid introduction of new vaccines: donors issue a legally binding guarantee that, if a vaccine against a certain disease is developed in the future, they will pay the developing countries' costs of purchasing the vaccine. The idea is thus that the vaccine will ultimately benefit not only investors in research and development, but also others. In this context, the club good is the payment of the research and development costs. Although the logic is slightly different than in the case of the proposed transformation clubs, AMCs could nevertheless provide ideas that could be taken up in mitigation, for example if they were set up to promote innovative low-carbon technologies.

Transformative potential

State clubs can be ambitious if they pursue a challenging vision. The club idea is scalable: if other countries meet the respective criteria for accession, they can join and the club's transformation potential grows with the number of new members. However, in order to be able to have a transformative effect and boost the multilateral UN process, the Renewables Club must be more than a talking shop without commitments. The Federal Government should propose a concept to its partners. Looking at the elements mentioned above, the following ideas should be considered for the transformative Renewables Club.

1. *A common vision:* The common vision of the club members could be to create by 2050 an energy system that is based as completely as possible on renewable energies and ensures competitive, affordable and predictable energy costs. This vision should be the point of departure for specific targets. The club members could agree to double renewable energy's share of their joint energy mix by 2025. That would be compatible with the target pursued by the UN's 'Sustainable Energy for All' initiative – to double the share of renewable energy in the global energy mix by 2030 (SE4All, 2014). As pioneers, the club members would reach this target five years earlier. To manage this, each member would set itself clearly defined, individual targets. In addition, the club could support transformative strategies for renewable energy in other parts of the world. Since the club unites pioneers, it is in a unique position to use its expertise to support such strategies, for example in small island developing states, sub-Saharan Africa, North Africa or Latin America.
2. *Membership criteria:* The criteria for membership could be a share of at least 40% for renewable energy by 2030, or at least 10 GW of renewable energy capacity, plus a target of adding at least 3 GW of renewable energy a year (interesting for China, for example), or a certain amount of annual investment in the expansion of renewable energies (potentially interesting for the Emirates), or as a percentage of gross domestic product (Weischer and Morgan, 2013). The membership structure of the Renewables Club should be reconsidered. For example, Latin America is currently not represented in the club, which was founded in 2013, although there are promising candidates there, for example Mexico. The club could also offer companies a chance to be recognized as official partners. The condition might be a commitment by the company to procure a certain proportion of the energy it consumes from renewable sources.
3. *Advantages for club members:* Club benefits can have either a softer character – like joint initiatives for mutual learning – or consist of 'harder incentives' – such as trade advantages through protection against so-called climate tariffs. Harder incentives for transformation clubs in the context of trade policy, especially the taxation of commercial transactions with non-members, involve the risk of side-effects like trade disputes. However, since softer incentives might ultimately be too weak to build up successful transformation clubs quickly, harder incentives should at least be considered. The portfolio of club advantages should in any case be designed in such a way that all members can reap substantial benefits from the club.

Mutual learning

The club members could benefit by mutual learning. For example, they could exchange their experience with relevant policies and corresponding best practices; they could set up a peer-review process where members report at regular intervals on the current status of relevant technologies, policies and investments and then receive feedback for future steps; they could launch advanced-training measures for engineers and decision-makers from the

member states at their best universities and institutes; they could set up dialogue forums where they discuss what forms and amounts of support for renewable energies are most effective and acceptable (Weischer and Morgan, 2013).

Joint research and development

The club members could generate additional advantages for themselves by conducting joint research projects and implementing demonstration projects – and subsequently jointly apply for and use the corresponding patents (patent pools).

Cooperation on standards

The club members could create further benefits by harmonizing or mutually recognizing their existing standards or by cooperating within the club on the development of new standards for future technologies – e.g. in the context of e-mobility or power-to-gas technologies – in order to create new markets in this way.

Better access to finance

The club should set up financing mechanisms for poorer member states, for example to support feed-in tariffs for renewable energy in developing countries (WFC, 2009; Deutsche Bank Climate Change Advisors, 2010; WBGU, 2011; Weischer and Morgan, 2013). Such a measure would also be in the interests of Germany, other OECD countries and emerging economies, especially China, since the expansion of the markets for low-carbon technologies and renewable energy is also in their interests.

Linking emissions-trading systems

Clubs could also generate advantages for their members by linking their emissions-trading schemes (WBGU, 2010b, 2011). The EU should play an important role in this context, but must first overcome the current shortcomings of the European Emissions Trading Scheme (EU ETS) (Box 3.3-4). Apart from the EU, countries like Japan, Canada (Western Climate Initiative), New Zealand and the USA (Regional Greenhouse Gas Initiative) also offer promising points of contact. The extension of emissions trading would enhance the market liquidity of all the companies involved and open up new mitigation potential (WBGU, 2010b).

Reducing trade barriers for climate-friendly goods and services

Furthermore, the club members could create club advantages by mutually lowering their trade barriers for goods and services that are highly relevant for the development of renewable energies. In this way, they would reduce the prices of these goods and services. Such a Sustainable Energy Trade Agreement (SETA) could be formed as a plurilateral agreement either within or outside the framework of the WTO (ICTSD, 2011).

Taxation of commercial transactions with non-members

If climate clubs do not provide attractive club goods for members, there is no incentive for a country to join, since membership would not involve any additional benefits, but perhaps short-term costs.

One approach to circumvent this dilemma is suggested by William Nordhaus (2013). He proposes creating advantages for the club members by taxing commercial transactions with non-members, without excluding them in principle from joining the club in the future. This leads to the establishment of a free-trade zone that is exclusively available to the club members. However, such a tax would violate Article I:1 (principle of most-favoured-nation treatment) of the General Agreement on Tariffs and Trade (GATT). It is questionable whether this violation of world trade law can be justified for reasons of climate protection. A justification for discrimination against identical products could possibly be based on Article XX (g) of GATT (general exceptions; measures for the conservation of exhaustible natural resources) or on Article XXIV:5 of GATT (territorial application; free-trade area or customs union). Up to now, there has been no judgement by an arbitration court to clarify whether climate policy can be regarded as a measure to protect exhaustible resources (WBGU, 2011). Ultimately, the question as to the WTO-compatibility of such a tax on commercial transactions with non-members must be decided on a case-by-case basis and is at least doubtful. In principle, therefore, the idea of a Sustainable Energy Trade Agreement, which could resolve such conflicts, should be supported.

4.2.2 City club: The example of the C40 Cities Climate Leadership Group

In addition to the pioneering role being played by individual cities in climate protection, cities are also among the best networked actors in international climate policy. Networks of cities are seen as a link between local pioneer cities and the global governance level (Gordon, 2013). As a special case, the C40 Cities Climate Leadership Group has gained considerably in importance and since 2011 has attempted to overcome the weaknesses of city networks (Section 4.3.6) by carrying out a number of reforms (C40 & Arup, 2014). For example, the self-commitments on the part of the member cities have been extended and formalized, thus raising the barriers to entry. In addition, the C40 group has entered into partnerships, for example with the World Bank. Self-commitments and partnerships are regarded as ways of increasing C40's authority and legitimacy. Furthermore, internal agreements on meeting standards and reaching targets have been tightened up by making compliance a condition for such club goods as access to external funding or expert knowledge (Gordon, 2013:294).

As a result, the C40 group can be regarded as quite an

exclusive club of like-minded actors, although Gordon (2013:301) questions this on the basis that club goods are available to all interested cities. The C40 group is currently made up of 63 major cities worldwide, including Johannesburg, Rio de Janeiro, Jakarta, Tokyo, Los Angeles and London. Germany is represented by Heidelberg and Berlin. The members have committed themselves to reducing greenhouse gas emissions and undertake to publish a report on their CO_2 emissions once a year to ensure performance measurement and comparability. C40 stresses that this enables the cities to call each other to account (C40 & Arup, 2014). Results are currently only measured in terms of the increase in the number of mitigation and adaptation measures. C40 cities are regarded as having a high ambition level (Barber, 2013). C40 underlines the member cities' potential for reducing CO_2 emissions – also in the context of reaching national reduction targets. As a result, the members together can reduce future greenhouse gas emissions by up to 1.3 billion tonnes by 2030 (C40, 2012).

Moreover, the C40 group makes good use of the media to position cities as a driving force in global climate-change mitigation. The focus here is on the exchange of experience and direct support for implementation. Thanks to its stronger club character, C40 generates advantages such as faster enforcement and more ambitious targets. The cities can build up a lot of pressure via shared partial interests. At the same time, the disadvantages of city clubs are a lack of transparency, a lack of representation and the exclusion of rural areas and small to medium-sized cities. Mayors play a prominent role within C40. The former mayor of New York and ex-C40 Chair Michael Bloomberg has been appointed UN Special Envoy. This influential advisory role has now given him an opportunity to raise awareness for the theme of 'Cities and Climate Change'.

Although city clubs represent an innovation in governance as an intermediary between the local level and international politics, their possibilities are limited in terms of the scalability of measures. Up to now, a number of pilot projects and individual measures exist which have not yet had a particularly broad impact. Moreover, there is a lack of monitoring when it comes to the implementation of agreements. Inadequate scalability and impact measurement of agreed measures make it difficult to build up legitimacy for inclusion in the international climate-policy processes (Gordon, 2013:297). Another critical point is the fact that as a club of metropolises increases its decision-making power, megacities and global cities, which have their own interests, also find themselves playing an advocacy role for small to medium-sized cities.

Overall, city-network clubs like the C40 group should not be regarded as the only new actors for international climate policy, but rather part of the interaction between different levels (Aust, 2013; Gordon, 2013). The decision-making structures in international climate policy are shaped by the complex relationship structures and dynamics that are typical of a multi-level system. In this context, city clubs are one of many actors operating at different levels with different degrees of decision-making power at their disposal (Betsill and Bulkeley, 2006).

Overall there are indications that clubs of large cities like C40 are becoming effective with respect to climate-change-related adaptation and action needs. The WBGU plans to examine the importance of networks of major cities more intensely in its next flagship report because of their highly rated transformation potential.

4.3 Individual and collective responsibility

4.3.1 Political consumerism: Boycotts and buycotts

The term 'political consumerism' refers to consumer actions in which the consumer does not base a purchase decision solely on product characteristics like price, quality or distinction gain, but also takes into account aspects like the production conditions or the manufacturer's other economic activities. The purpose of this decision is not only to satisfy consumer needs, but also to send a political signal relating to certain business and manufacturing practices (Micheletti, 2003). The most prominent forms of political consumerism are the boycott, i.e. deliberately avoiding certain products or manufacturers, and the buycott, a targeted decision in favour of a certain product or producer.

The boycott continues a long tradition of specifically avoiding certain products or producers in order to exert an influence on, say, the environmentally harmful behaviour of producers (as in the case of the boycott of Shell gas stations in protest against the disposal of the Brent Star in 1995) or on discriminatory political systems (e.g. the boycott of goods from South Africa at the time of the Apartheid regime). A buycott is a more recent form of political consumerism in which people either buy from a specific provider or purchase a specific product to express support or to reward certain production practices. Boycotts in particular can also be used for stigmatizing or discriminatory purposes (Beck, 1997; Holzer, 2007). However, the current discourse on political consumerism relates primarily to consumer actions where the underlying values target issues such as climate change or sustainability in general, but also social justice and health (Balsiger, 2013). Against the background of the debate on sustainable consumption and the responsibility of consumers for sustainable development highlighted in the Rio Declaration of 1992 (UNCED, 1992), political consumerism is therefore also of great relevance for climate policy.

Examples of political consumerism are many and varied, since all routine consumer decisions can in principle be 'politicized' and understood or used as a signal to suppliers and manufacturers. However, such signals have the biggest impact when the views behind them

are expressed in public. Boycott or buycott activities that are clustered into campaigns attract an especially high level of public attention. Networks and organizations like 'Behind The Label' or the 'Clean Clothes Campaign', for example, draw attention to the political situation or labour conditions in countries where clothing is produced. By calling for a targeted boycott they want to exert media and economic pressure on companies to change their practices (e.g. rates of pay, workers' rights, cooperation with authoritarian regimes) (Baringhorst, 2006; Micheletti and Stolle, 2005).

Among buycott campaigns, so-called Carrotmobs in particular have attracted a lot of media attention. Carrotmobs encourage as many consumers as possible to shop in a selected store over a specific period. The shop's owners commit themselves in advance to invest a certain proportion of the revenue generated during the action, for example in making their store more energy-efficient. The main issue for Carrotmobs is, therefore, not to choose a specific, more sustainable product, but to reward and support a supplier with a purchase. Since the first action of this kind in 2008 in San Francisco, it has been imitated many times around the world; in the meantime Carrotmobs are even being politically promoted (e.g. the German Federal Environment Ministry's support for the creation of a 'Carrotmob Academy') or institutionally integrated (e.g. as an environmental education project in schools).

A large number of empirical studies suggest that political consumerism has become a relevant form of political expression for a growing number of consumers in several countries (Copeland, 2013; Micheletti et al., 2012; Sassatelli and Davolio, 2010). The current sixth 'wave of enquiry' of the World Values Survey (2010-2014) shows that, on average, more than half of the respondents worldwide have taken part in a boycott at least once in the last two years (WVS, 2014). Compared to the data from previous waves of polls (e.g. Stolle et al., 2005) and other forms of political participation (demonstrations, petitions, strikes), this way of expressing opinions has grown the most since the 1990s. Similarly, buycotts enjoy considerable popularity – in some cases even more than boycotts – in many countries (e.g. Balsiger, 2013: 14). It should be noted, however, that a more profound and permanent change in people's actions can fail for lack of opportunities or be blocked by regular habits and the rationalities of everyday life (Klöckner and Verplanken, 2012).

The transformative potential of political consumerism does not lie primarily in consumers buycotting or boycotting for political or ethical reasons, but in the underlying narrative. This speaks of competent, mature and committed consumers who, in their everyday behaviour, individually and collectively exert an influence on business and manufacturing practices seeking change based on ethical and sustainability criteria. This is connected with the idea of expanding the possibilities of political participation: after all, everyone can consume politically at any time. Political consumerism thus has a medium ambition level for the transformation towards a climate-neutral society.

The simplest forms of political consumerism – like being persuaded by a campaign not to purchase a product or offer for political reasons – require little preparation and are easy for individuals to carry out if the corresponding opportunities and action options exist. The willingness to change behaviour can be strengthened if the gain in quality (of life) is emphasized (Eberle et al., 2004), the imparting of knowledge is combined with the revelation of practical action alternatives and feedback on the effectiveness of the action (Abrahamse and Matthies, 2013), and if the social relevance of the action is made clear (Aronson and O'Leary, 1983; BMU and UBA, 2013). Political consumerism is also an option for organizations, such as schools, businesses, institutions and even government ministries in the field of public procurement with their high volumes of investment, for example by awarding contracts according to sustainability criteria or gearing procurement measures to these criteria (Section 4.5.2). The potential for scalability, i.e. the extension of political consumerism to other groups of actors and other areas of society, is therefore high. However, as in the field of procurement, a large number of conditions have to be met, especially if entrenched institutional practices need to be changed. At the same time, extending measures to the public sector or companies of key importance to a given system can achieve a special degree of influence as well as spillover effects. Long-term visions, like those of a consumer democracy or a sustainable economy, will require numerous and wide-ranging changes. They include a considerable willingness to change, great commitment among the actors concerned and a comprehensive change of economic practices and consumer styles.

Critics regard political consumerism as an inappropriate politicization of everyday life that above all distracts politicians from the real tasks of societal transformation and political responsibility for it (Grunwald, 2010; Geden, 2008). Another criticism of the consumer-empowerment model is that many consumers are influenced unconsciously in their purchasing decisions, or are simply overburdened by the lack of sufficient information or the routinization of everyday actions (Scientific Advisory Board on Consumer and Food Policies at the Federal Ministry of Food, Agriculture and Consumer Protection, 2010). Furthermore, there can be conflicts of goals between 'fair' and 'green' consumption, as well as contrary side-effects: for example the frequent purchase of climate-damaging products at Carrotmob actions.

Nevertheless, the WBGU believes political consumerism is important and has expandable transformative potential. In a first step, political consumerism contributes to a public discussion on the moral and political side of consumption and helps reveal new opportunities for action in the form of alternative consumption patterns both for individuals and for organizations.

However, political consumerism, or boycott and buycott actions, should rather be seen as a way to reach spe-

cific objectives – e.g. changes in manufacturing practices. Behind such forms of action, the focus should be on the vision of a transformation towards sustainable patterns of production and consumption, and on the call to open up political and economic systems to more consumer participation.

The political process seems to be so intertwined with the dynamics of the consumer society that the road to a climate-neutral society is no longer conceivable without a politically supported 'consumer citizen'. At the same time, the state alone is hardly likely to be able to restructure purchasing decisions comprehensively, nor should the transformative effect of the 'consumer citizen' be overestimated. Rather, the potential of a 'consumer democracy' in which a 'consumer citizen' makes politically motivated purchasing decisions lies in the fact that the public negotiation of consumption, and its politicization in democratic areas for experimentation, ultimately demands a political response in order to transform the comprehensive form of (welfare) state (Lamla, 2013).

4.3.2 Individual emissions trading: Example of the CO_2 credit card

In individual emissions trading, emissions generated by private consumption are priced and emission rights traded between consumers. Calculating one's own ecological footprint is already a well-established concept. There are internet portals for the purpose where individual consumption can be estimated for many areas of life. But how does one deal with a CO_2 footprint that is too high? The concept of emissions trading for private households could offer action possibilities and create an awareness of one's own CO_2 consumption compared to that of other people.

Several years ago at the Tyndall Centre in the UK, the idea of emissions-trading rights for private households and a CO_2 credit card was born (Starkey and Anderson, 2005): individuals have a specific CO_2 budget, and if they exceed their credit limit they must cover their need for emissions by trading. The free monthly credit balance could be based on emissions-reduction targets or a global budget approach and be reduced accordingly every year (Starkey and Anderson, 2005). Pricing must be appropriate, since trading does not function if prices are too low or too many emissions are freely available or can be consumed for free. A pricing structure based on real CO_2 prices which, for example, internalizes external costs such as damage to the environment or to human health, would also raise awareness in the population of the effects of CO_2 emissions.

The direct consumption of raw materials has been discussed as a basis for calculation in the context of a CO_2 credit card (Starkey and Anderson, 2005; Aachener Stiftung Kathy Beys, 2008). For example, the CO_2 credit card would be used in the purchase of crude oil, gas and electricity from fossil fuels. In Germany, too, a proposal for individually tradable emission quotas and a CO_2 card has been presented by the Aachen-based Kathy Beys Foundation (Aachener Stiftung Kathy Beys, 2008). The basis would be a national CO_2-reduction plan in which an individual CO_2 credit balance is fixed for every citizen. CO_2 units would be charged for every purchase of fuels and energy sources. Purchases of other products, foodstuffs and services would not be paid for with CO_2 units; producers and suppliers would pay for these and in turn have to buy CO_2 units on the market (Aachener Stiftung Kathy Beys, 2008). In this way high emissions would be reflected in the price. In Germany, transport and private households are indirectly registered with a national emissions target in the National Allocation Plan 2008-2012. But under greenhouse gas emissions trading law, they do not take part directly in the emissions trading scheme. However, individual emissions trading could be integrated into, or linked to, the European Emissions Trading Scheme.

In general, there is a need to inform consumers on the CO_2 emissions of products, be it by settling accounts with a CO_2 credit card, charging a correspondingly higher price, or labelling the respective product. Because of the lack of such information, it is currently difficult for consumers to decide which products generate a lot of CO_2 emissions and which are more climate-compatible. However, this provision of data must be based on standardized calculations and independent validation, which in turn takes a lot of effort to implement. The concept of the CO_2 credit card depends on sound indexing. In the example given by the Aachen Foundation, this only happens when fuels are purchased for production. However, when parts or even the entire product is imported, international emissions would have to be determined.

The CO_2 credit card, perhaps supplemented by emissions-related product labelling, would give consumers a better basis for decision-making and enable them to avoid products that cause a high level of CO_2 emissions. Subsequently, this could also put pressure on companies to consider more climate-compatible practices.

At the same time, an instrument like the CO_2 credit card requires a considerable willingness on the part of the population to concern themselves with self-caused emissions and, where appropriate, also to pay for them. The distribution and scalability of an individualized emissions trading system also depends to a large extent on its degree of institutionalization.

The idea of individual emissions trading is a convincing one: the nationwide introduction of a CO_2 credit card would set the tone for the future and generate fresh impetus in many areas of transformation. For example, a positive correlation with boycott movements can be expected. Furthermore, there would be strong incentives for people to question their own consumption and make it more sustainable within the existing system. This, in turn, would have the potential to change the current system from the inside.

4.3.3 Transition town movement

Definition

The transition town movement, which is international in the meantime, is an interesting form of local, yet globally networked active citizenship. It includes features of social and environmental movements, business interest in the public good, openness for local political processes and an affinity with a 'deep ecology' ethic (Arne Naess, Joanna Macy). In both urban and rural regions this leads to transformation efforts with different priorities and potentials.

The movement originated in 2005 from local ecological energy and investment projects in Kinsale, Ireland (Hopkins, 2005), and Totnes, southern England. The basic idea of a transition initiative is to increase local resilience and adaptability vis-à-vis the predicted negative effects of climate change and dwindling resource availability – primarily of the key raw material for industrial societies: oil – and in this way to locally initiate comprehensive societal change (Hopkins, 2008). The movement and projects are based on the three ethical principles also used in permaculture, which are usually only passed on orally: "care for the people, care for the Earth, fair share." Resilience is to be made possible in a process-oriented way by means of bottom-up, broad-based, undogmatic and inclusive citizen involvement, the development of one's own visions to prepare for the local future, community-generating social practices, energy cooperatives (Section 4.5.3), more regional self-sufficiency in food, and social activities oriented towards the public good and a strengthening of crafts and culture. Satisfaction with life and the perceived capacity to act are supposed to be enhanced, and any feelings of impotence counteracted, by local practical action (Wessling, 2011).

Dissemination and examples

From the beginning, the movement comprehensively integrated and communicated information and knowledge. In this way it soon generated various instructions manuals (Brangwyn and Hopkins, 2008), books (e.g. Hopkins, 2008, 2011, 2013; Chamberlin, 2009; Pinkerton and Hopkins, 2009; North, 2010; Bird 2010), films, and its own extensive homepage. In addition, especially a self-developed seminar with handouts for multipliers who wish to start their own local transition initiatives represents one of the key elements of dissemination. According to the international Transition Network (UK), which was founded in 2007, requests were received for such seminars from more than 25 countries up to 2013. It says there are now over 1,100 registered initiatives in 43 countries worldwide (Transition Network, 2014).

The highest density of initiatives is in the UK, where many projects have been initiated in the last few years, e.g. energy cooperatives, local currencies, neighbourhood energy-saving clubs, urban garden projects – plus the creation and networking of numerous community-run enterprises for the 'common good' (Hopkins, 2011).

The approach has not only taken root in 'western' countries. In 2010 committed local residents founded the Brasilândia 'transition favela' in São Paulo and made good use of the process-oriented transition approach to tackle their own issues such as violence, social justice, local food supplies and education. In the meantime many projects are now being offered and run on a community basis, such as numerous swap shops, a cooperative bakery, upcycling (trash-processing) companies, a social film workshop for producing their own media programmes, and numerous educational projects specifically for the illiterate (Hopkins, 2013:113).

In many places, such initiatives are quickly supported by local administrations or companies or get directly involved in local politics themselves. One particular example here is the small town of Monteveglio in Italy, where a number of transition activists contested the local elections in 2009, were immediately elected to the local council, and declared that the administration would now cooperate with citizen initiatives as official policy.

Transformative potential

The potential of the local initiatives, which vary greatly in size, lies in their diversity and high level of adaptation to the local context, combined with the empowering feeling of belonging to a global movement. Innovative and professional participatory and project formats enable small-scale alternatives and experimentation opportunities to develop locally, as positive visions take practical shape. In this way, the transformation to a low-resource, self-sufficient, climate-neutral future that is worth living in can be imagined and experienced in a hands-on way and becomes established, both culturally and in practice. Precisely these factors represent a necessity on the road to greater sustainability that is otherwise often overlooked (Welzer, 2013). The many examples of possible change continuously lead to highly effective narratives of change, which in turn have a positive effect on people's individual and collective perceptions of their ability to act.

However, a broad international study that accompanied the projects also showed that local factors – whether encouraging or inhibiting – are more important for the internal and external success of transition initiatives than is often thought (Feola and Nunes, 2013). This is why the transition movement – in addition to a largely self-organizing local structure – is pursuing a strategy of supra-regional and international networking and experience exchange (e.g. conferences) on the basis of its international network and national nodes. In 2013 a European network of local civil-society bottom-up actors for climate protection was founded in Brussels with strong participation from the transition movement (O'Hara, 2013). At the German-language level, the national transition network maintains an online exchange platform for sharing ideas, organizes annual

conferences, offers seminars and keeps in contact with the international movement.

Furthermore, because the transition approach is so dynamic, scientific interest in the movement – internal and external – has risen sharply in recent years. For example, numerous international studies have already been written on transition towns, and the Transition Research Network, which was founded in the UK, designs and initiates additional transdisciplinary research projects for the scientific monitoring of transformation processes and methods.

Doubts have been expressed about the movement's assumption that professional participatory formats and projects can be implemented locally anywhere without difficulty. Successful projects in particular (e.g. Nexthamburg; Petrin, 2012) show that success requires a high degree of professional project management and conflict-resolution strategies – an experience also shared by many less visible or disbanding transition initiatives. Furthermore, depending on the respective characteristics there is a limit to how far the local populace will identify with local transition projects and opinions, despite their claims of inclusiveness. At the regional or national level, too, perceptions vary on the extent to which the movement is a networking point and integrating force for existing initiatives. In Germany, compared to major national environmental and social associations, it remains a niche phenomenon to date and lives very much in the form of non-formalized projects and as a cultural impulse. It remains to be seen whether the projects and experimentation spaces that have already emerged will correspondingly develop a more universal transformation potential.

4.3.4 Divestment

Divestment movements in the field of fossil fuels make use of the global consensus that the current path of exponentially growing CO_2 emissions is not sustainable. While there is often no agreement on how emissions should be reduced in the future, there is at least a consensus that they do need to be reduced. It therefore makes sense to stop acting contrary to this view and to stop investing in emissions-intensive companies.

Definition

Divestment is the sale of holdings in companies – shares, private equity or corporate bonds – for political or ethical reasons. The divestment movements against the extraction of fossil fuels demand the withdrawal of investment in fossil fuels and, where possible, its reinvestment in sustainable industries. Divestment aims to exclude investment and lending to companies whose business fields include the extraction, processing and distribution of fossil fuels (called 'fossil-fuel companies' in the following).

Apart from the normative rationality, economic risks also represent substantial grounds for large-scale divestment. One risk for investors here is that the 'carbon bubble' might burst. The maximum budget that can be derived from the 2 °C guard rail is 750 billion tonnes of CO_2; this is the amount that may still be emitted while ensuring – with a probability of two-thirds – that the guard rail is not breached (WBGU, 2009). However, if the confirmed fossil-fuel reserves that are already owned by public and private enterprises were to be used in full, this would release at least 2,795 billion tonnes of CO_2 into the atmosphere (Carbon Tracker Initiative, 2012). This figure is several times higher if owned difficult-to-extract or suspected fossil energy reserves are added. And exploration continues: in 2012 the 200 largest fossil-fuel companies invested US$674 billion in the exploration of new reserves (Carbon Tracker Initiative and Grantham Research Institute, 2013). The world market prices for fossil fuels are calculated on the basis of these existing reserves. However, if the goal is to avoid breaching the 2 °C guard rail, then 80% of already confirmed deposits of fossil fuels will have to stay in the ground, making them therefore worthless for companies. The calculation is simple: if demand is reduced by a legally binding 2 °C guard rail, the shares of these companies will lose value.

Divestment as a societal movement can thus help persuade investors to consider the risks of a carbon bubble. If key investors increasingly sell shares in fuel companies, this can be an indicator of the future composition of the energy market. Very different actors can make a relevant contribution in divestment campaigns (Figure 4.3-1):

- *Private individuals:* Personal equity portfolios can be evaluated in terms of carbon-intensive investments ('negative screens'). This practice already exists for tobacco or arms trading ('sinful stocks').
- *Universities:* Universities can play a special role in social movements as a source of innovation. In addition, from the perspective of intergenerational equity, students can be expected to be particularly committed.
- *Religious communities:* Investments of churches and other religious communities could be withdrawn from fossil-fuel companies based on an attitude of wanting to protect the integrity of creation (Section 4.4.2).
- *Cities and communities:* In order to counter the risks of a carbon bubble, pension funds and other investment portfolios can divest shares and other forms of capital investment in fossil-fuel companies. Communities that are already beginning to be affected by the negative externalities of climate change, e.g. increased flooding, could be pioneers in this context.
- *Foundations and non-profit organizations:* Philanthropic organizations that want to improve the living conditions of specific groups have an interest in ethical investments.
- *Commercial banks:* The influence of major banks on capital flows can hardly be overestimated. If lending to fossil-fuel companies stops, the effect on these

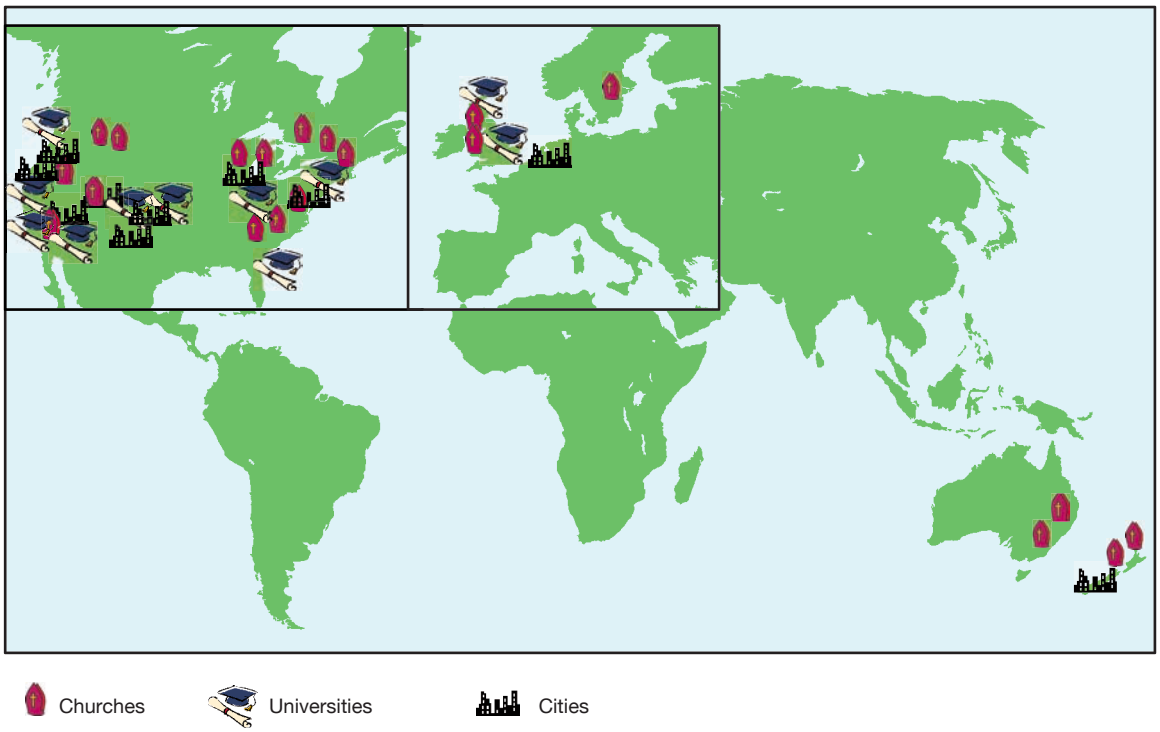


Figure 4.3-1
Global divestment movements: selection of announced or implemented self-commitments to date to divest from the 200 largest fossil-fuel companies (as of July 2014).
Source: WBGU, based on data from Fossil Free (2014a)

companies' liquidity will be considerable.

- *Development banks:* The influence of development banks is also very large. For example, if the KfW were to follow the announcements of the World Bank and stop issuing loans for coal-fired power plants, this would lead to changes in the development pathways and, in the long term, in the energy market.

The range of possible actors shows that the divestment movement can be encouraged not only by groups or individuals in society, but also at the institutional level. This inclusiveness also constitutes part of this movement's transformative potential; individual people can decide against rules that appear to be set in stone and promote the transformation to a low-carbon society by participating in a global divestment movement.

Examples

In the USA there have been divestment movements targeting, for example, the tobacco industry, the arms industry, and against the apartheid system in South Africa. The divestment movement against investment in fossil fuels has already developed a dynamic of its own. For example, a growing student movement has formed in the USA which is putting pressure on the universities to withdraw their capital from fossil-fuel companies. Several universities, including Stanford, have announced divestment measures. The administration of Harvard University has also come under pressure from continuing student protests to divest its 'carbon investments' (totalling about US$33 billion; Goldenberg, 2014). In Berkeley and at other campuses of the University of California a majority of students have voted against investing in the shares of fossil-fuel companies. 64 professors and scholars, as well as over 800 students, alumni and employees of the University of Oxford have also signed a petition and an open letter calling on the university council to show leadership and responsibility in the societal discourse on climate change by divesting from fossil fuels (Oxford Academics for Fossil Fuel Divestment, 2014).

Similarly, several US cities, including San Francisco and Seattle, have announced their intention to divest (Greene and Kammen, 2014). In Norway an evaluation is currently ongoing to decide whether the investments of the Government Pension Fund (€800 billion), also referred to as the state oil fund, should be withdrawn from fossil-fuel companies. The largest holdings include BP and Royal Dutch Shell. Furthermore, Pope Francis has received an open letter from various Christian groups appealing to the Catholic Church to stop investing its money in the fossil-fuel sector (Readfearn, 2014). The World Council of Churches, with a membership of 345 Christian churches in 140 countries, has announced that it will no longer be investing in fossil-fuel companies (WCC, 2014). Through the internet, too, a 'multiplier effect' has already developed in the divestment movement (Fossil Free, 2014a). The platform for divestment movements, gofossilfree.org, coherently summarizes the moral basis for divestment: "It's wrong to profit from wrecking the planet" (Fossil Free, 2014).

Transformative potential

The impact of divestment does not lie primarily in any immediate financial impact on the companies. Assuming constant consumption of fossil fuels, the withdrawal of small capital investments is initially relatively insignificant from a financial point of view. This is because other, neutral investors who are not environmentally conscious quickly buy up the shares, which have, perhaps, also fallen in price (Ansar et al., 2013). A financial effect therefore only occurs if the divestment has a disruptive impact on capital flows, i.e. the cash outflows as a result of divestment are larger than the cash inflows from other investors. Nevertheless, divestment and other social movements have a great inherent strength: they can set new moral standards. If the global discourse on divestment leads to a tipping point, so that many investors consider it no longer acceptable in general to invest in fossil-fuel companies for ethical reasons, then this would have a considerable impact on these companies and the energy market as a whole. Furthermore, divestment can increase the political pressure to call into question, and ultimately reduce, the current subsidies for fossil-fuel companies. In 2012, $544 billion was spent in subsidies for fossil energy (IEA, 2013b). This sum rises to as much as US$1,900 billion if appropriate taxes for fossil fuels are taken as the yardstick, including consumption taxes and the negative externalities of consumption (e.g. health damage, environmental pollution, impact on the climate) (IMF, 2013). In 2011 only a total of 8% of the global subsidies reached the poorest 20% of the population (IEA, 2011). The abolition of these subsidies could lead to a 13% reduction in CO_2 emissions (IMF, 2013). Even a partial diversion of these subsidies to the promotion of innovation in sustainable technologies would have a considerable transformative impact on the energy market.

Social movements generate an awareness for problems by incorporating different actors. This also applies to the divestment campaign: it reveals that churches, universities and other institutions with responsibility for the public have invested large sums in the shares of fossil-fuel companies. The public was not aware of this fact before. If cities like Berlin decided to divest, at least in individual sectors (the decision could be brought about by a referendum, for example), this would send out a strong signal. Individual major corporations or universities could also take on such a role-model function. For Germany this means that the withdrawal of public money from fossil-fuel companies should become part of the *Energiewende* (energy-system transformation).

The divestment movement is developing parallel to the stagnating international climate negotiations. This can be relevant, particularly in countries where the negotiation process is dominated by groups with a large self-interest in fossil fuels. Social movements like divestment can cause cracks to form in a static system. They create room for transformation.

4.3.5 Adaptation networks

In adaptation networks, actors facing similar climate-change-related challenges can share information and, in addition, develop a common agenda for political objectives.

Since climate change has different effects worldwide, adaptation strategies must, on the one hand, be developed and implemented in a regionally specific way. Adaptation networks can therefore open up opportunities for cooperation and reduce transaction costs within the network especially for regions with similar geographical conditions. On the other hand, regions are connected with each other, e.g. by global trade flows. If there is damage in one place, e.g. caused by extreme weather events, this can have a disruptive effect on the value chain. Hence, regional approaches alone are insufficient. Global databases can be used, for example, to identify places that are particularly relevant for adaptation and transnational adaptation risks, in order to strengthen resilience at the global level.

Local examples

In addition to informal networks, formalized adaptation networks already exist. One example is the 'Klimzug-Initiative' ('sustainable approach to climate change in regions'; Klimzug, 2013), which is funded by the German Federal Ministry of Education and Research (BMBF). Here, adaptation strategies have been developed over the last five years based on seven different regions in Germany. They focus on issues such as coastal protection and flood control, health and agriculture. In the field of health, for example, studies have been conducted in the North Hessian region by Fulda University of Applied Sciences to determine whether mosquitoes and ticks are becoming (or can be expected to become) more widespread as a result of climate change, leading to a higher health risk (Klimzug Nordhessen, 2012). Special aspects of the study included the spread of diseases such as Lyme disease and tick-borne encephalitis. Another focus was to find out whether there were any Asian tiger mosquitoes in the region, which can be a carrier for various pathogens such as malaria and dengue fever.

Regional examples

UNEP also funds an adaptation network, the Asia and the Pacific Adaptation Network, with the aim of promoting regional adaptation to climate change through knowledge transfer and capacity building (UNEP, 2012a). In this network another aim is to create a communication platform for the management of cross-border ecosystems like the Himalaya region and various river deltas. The loss of land as a result of sea-level rise is particularly relevant for the small island states; here, migration offers the final adaptation option (Box 3.3-3). For the network of small island developing states, therefore, the community purchase of land can be an adapta-

tion strategy, as can intensive participation in the international negotiations on dealing with loss and damage (Section 3.3.3), in which adaptation measures based on compensation payments are under discussion.

Global examples

Adaptation is not only in the national or local interest, it can also attain global significance. For example, the floods in Thailand in 2011 (Kraas, 2012) caused a more than 30% fall in the global production of hard disks in the fourth quarter of the year (Coughlin and Grochowski, 2012). To date, however, there is no adequate data basis for estimating the knock-on effects of damage caused by failures in the value chain after extreme weather events (Levermann, 2014). There is no information on this in the Fifth IPCC Assessment Report either.

The citizen science project *zeean* collects data on the global flow of goods on its online platform *www.zeean.net*. This makes it possible to demonstrate what can happen if production suddenly stops in a region (Levermann, 2014). Effects of the first and second order can be shown. For example, exports from the Philippines fell after typhoon Haiyan, and this is estimated to have had a direct effect on up to 6% of US production (Levermann, 2014). As a further result, this could mean that the value chains of 21% of American production was affected by the supply shortage (Levermann, 2014). This does not only cause economic losses. For example, if the production of pharmaceuticals or medical devices is directly or indirectly affected, it can lead to difficulties in maintaining supplies to hospitals and thus in the care of patients.

Anyone can take part in entering trade data on the zeean platform. Using a similar principle to that of Wikipedia, validity is checked by the scientific community, as well as by zeean's operators (Levermann, 2014). It is hoped that broad participation will lead to ever more accurate flows of goods being mapped. This concentration of data aims to make it possible to identify vulnerable regions which are key nodes in trade flows. More effective disaster control systems or alternative trade routes can then be developed for these regions. The aim is thus to also strengthen global resilience by means of targeted adaptation. The project shows that, in a globalized world, climate change can also have hitherto unknown effects on temperate zones – indirect, but nevertheless significant effects.

Transformative potential

Adaptation networks are still in their formation phase. As the difficulties of adapting to climate change increase, however, regions, institutions, individual initiatives and smaller networks can increasingly be expected to join together in a formalized way to test mechanisms and share experience. These networks could also become the basis for unexpected partnerships which could gain in importance as actors in development debates. Online platforms like *weadapt.org* of the Stockholm Environment Institute (weADAPT, 2013, 2014), or *adaptation-learning.net* (ALM, 2014), which is funded by UNDP, are growing steadily and making knowledge transfer possible across borders, even without formal meetings.

4.3.6 City networks

In view of the weakness of international climate policy, the local level in general and cities in particular are becoming increasingly important in climate protection (UN Habitat, 2011; Gordon, 2013; Monaghan et al., 2013; Heinrichs et al., 2011; C40 and Arup, 2014). On the one hand, cities are important as contributors to the causes of climate change; on the other, they are especially affected by it and vulnerable because of their often exposed locations and great concentrations of people. At the same time, being the level that is closest to individual citizens, they can be part of a broader movement, influence the opinion-forming process, and take mitigation and adaptation measures. The Fifth IPCC Assessment Report refers to studies which show that the ICLEI Cities for Climate Protection Initiative has not only influenced political decisions, but also helped the exchange of knowledge and experience (Revi et al., 2014).

Cities set up networks in the climate field primarily to act together effectively and constructively in climate protection (Lee, 2011; Barber, 2013). City networks vary in terms of membership numbers and reach. They range from national networks such as the Swiss KlimaBündnis-Städte (Climate Alliance of Cities) with 21 member cities; to regional networks like the Asian Cities Climate Change Resilience Network with 10 members; the Climate Alliance of European Cities with Indigenous Rainforest Peoples with 1,600 member cities; to global networks like the ICLEI – Local Governments for Sustainability, the United Cities and Local Government (UCLG), and the Cities Climate Leadership Group (C40) (ACCCRN, 2014; Climate Alliance, 2014; KBSS, 2014). C40 is in this context classified as a club because of its more exclusive character (Section 4.2.2).

In general, a regional openness can be observed among city networks; cities from industrialized, emerging and developing countries are all represented. Moreover, many networks include such actors as non-governmental organizations and research institutes as associated partners (Insar Consult, 2013: 15).

Transformative potential

The potential of city networks lies in the fact that they are able to work together better than nation states, because they build relationships at the personal level, have local legitimation and are more solution-oriented, so that they collaborate more effectively (Barber, 2013). However, their inclusion in global climate governance upgrades the status of the municipal level, and this raises medium-term questions of transparency, distribution equity and inclusion/exclusion. It is emerging among existing city networks that not only the hin-

terland of the cities, but also smaller and medium-sized towns are being insufficiently represented (Insar Consult, 2013:24), although they are experiencing the biggest influx in some regions.

When cities act independently, there is a risk that they will not do enough for mitigation unless they become integrated into global processes of climate policy. This can perhaps be offset in a network if it sets itself challenging targets. In order to take on targets, some cities must first be empowered to participate in networks. Furthermore, the voluntary nature of the targets and agreements taken on always involves an uncertainty factor, and key aspects of climate governance can only be resolved in cooperation with the national and multilateral levels.

City networks usually assume several functions in the areas of interest representation, implementation and knowledge transfer. When it comes to the representation of interests, networks present cities' emissions-reduction potential and adaptive capacity to ensure that they are heard as actors in international climate policy. Furthermore, city networks can function as intermediaries at the international level to promote the implementation of a mitigation agenda at the local level – if necessary even without the involvement of the respective national level. For example, the Global Initiative for Resource Efficient Cities (GI-REC), launched in 2012 by UNEP during the Rio+20 summit, invites cities with more than 500,000 inhabitants to take part in the initiative and thus, among other things, gain access to technical expertise (UNEP, 2012b).

Nevertheless, there are legal issues that must be clarified in the context of their new role as representatives of interests in global governance. Neither cities nor city networks have international legal personality. Even if cities in Germany can refer to the fact that mitigation is a matter for the local community in the context of their municipal self-government, the situation for cities in other contexts can be different (Aust, 2013).

In addition, the member cities set themselves voluntary and ambitious targets at the implementation level – e.g. in the reduction of greenhouse gas (GHG) emissions. They thus also have interesting mitigation potential at their disposal, but they cannot exert any influence over emissions for which they are not responsible.

Although much attention is paid to the role of city networks in the multilateral climate regime and to their ability to act to implement the agreements reached there, first and foremost city networks offer an important space for the exchange of experience and knowledge on innovative policies and best practices (Lee, 2011; Liefferink et al., 2013). This takes place via peer-to-peer exchanges of experience, town-twinning, mentoring, organizing expert opinions, and various exchange formats such as best-practice databases. The following example illustrates how city networks perform these functions:

ICLEI Local Governments for Sustainability is an example of a broad, inclusive alliance with about 1,000 members of different sizes and types (cities, local governments, districts, local-government associations and comparable bodies) that promote local measures to achieve global sustainability. ICLEI sees itself as a driving force in enabling local governments to connect with global policy processes and multilateral environmental agreements. In addition, the member cities set themselves voluntary targets to reduce greenhouse gas emissions. ICLEI is not only the access point of the UNFCCC for local governments and urban authorities, it also supports the Local Government Climate Roadmap, a process aimed at the awareness, participation and empowerment of local governments in global climate policy (ICLEI, 2014b). Because of its heterogeneous composition and large membership, however, ICLEI requires long decision-making and implementation processes.

Some activities explicitly relate to the exchange of experience at the expert level, e.g. the tutorials conducted between the Climate and Development Knowledge Network (CDKN) and ICLEI (Anton et al., 2014). One should also mention the initiative of the German Society for International Cooperation (GIZ), the Service Agency Communities in One World, and the German Cities Council to build up an international city platform for sustainable development, in order to initiate learning processes between urban actors and in this way help spread local solutions (Connective Cities, 2014). Another innovative example is the initiative of the Mistra Urban Futures programme, which networks science and local-government practice in selected cities (Mistra Urban Futures, 2014).

Cross-network processes

In addition to individual networks, there are also a number of cross-network processes aiming to give greater weight to the role of local authorities in the fight against climate change. One example in the field of joint declarations is the already mentioned Local Government Climate Roadmap. This is an ICLEI project which is carried out in cooperation with the largest international local-government associations and their networks (including UCLG, C40, Metropolis). Up to 2015 the focus is on involving local government in the agenda-setting process and the implementation of mitigation measures using partnerships at all levels. Moreover, a financial mechanism to promote ambitious local mitigation measures is to be established in the context of the UNFCCC, and global, national and regional initiatives harmonized (ICLEI, 2014b).

Other cross-network initiatives focus on ways to reduce greenhouse gas emissions, e.g. the carbonn Cities Climate Registry (cCCR) – the most important global platform for reports on local mitigation measures (ICLEI, 2014a; cCCR, 2014) – and the Global Protocol on Community-scale GHG Emissions (GPC), which aims to identify greenhouse gas emission sources and reduce such sources in cities (GHG, 2014).

4.4 Normative and cognitive paradigm shift

4.4.1 From living labs to citizen science – on the underestimated potential of transformative science

Definition

In the discussion on climate change, the role of science is generally seen to be in the fields of monitoring and forecasting. Climate science, for example, describes the ecological changes and consequences of climate change; economic and social-science studies on climate change describe possible mitigation and adaptation strategies and their economic and social consequences.

Yet science itself can become a key catalyst for societal transformation. The WBGU has coined the term 'transformative research' (2011), which can be seen in the wider context of 'transformative science' (Schneidewind and Singer-Brodowski, 2013). What is meant here is a form of science that not only observes transformation processes in society, but itself initiates, catalyses and accompanies them. Transformative science is borne by the realization that, without targeted interventions, an understanding of complex socio-technical transformation processes cannot grasp the causal relationships that exist between transformation dynamics with sufficient depth or speed (Morton and Williams, 2010). 'Real-life experiments' and 'living labs' (Gross et al., 2005; Schneidewind and Scheck, 2012; Nevens et al., 2013) are therefore an important starting point for transformative science in order to drive transformation processes forward in a scientifically initiated way and at the same time to gain a better knowledge of precisely these transformation processes. A living lab is defined here as a societal context in which researchers carry out interventions in the sense of 'real-life experiments' in order to learn about social dynamics and processes. The idea of the living laboratory transfers the scientific concept of the 'laboratory' into the analysis of societal and political processes. It is a continuation of the 'experimental turn' in the social and economic sciences. There are close connections with concepts of field and action research.

In this way, transformative science creates 'socially robust knowledge' (Nowotny et al., 2011), i.e. knowledge that is not exclusively scientifically relevant, but also provides direct action orientation for the actors concerned.

Living labs can be urban neighbourhoods or entire cities, regions (e.g. rural regions, biosphere reserves, national parks), projects on conversion areas or university campuses; they can also be industries and value chains or a regional mobility system (for an overview see Expertengruppe Wissenschaft für Nachhaltigkeit (Expert Group on Science for Sustainability), 2013). The decisive point is the science-led intervention in the societal context.

In living labs, science itself becomes a transformation actor. This has a wide variety of methodological and ethical consequences (Gross et al., 2005; Schneidewind and Singer-Brodowski, 2013). At the same time, considerable intellectual capital is mobilized for specific transformation processes on sustainability in that researchers, but also students, become the drivers of transformation processes as action researchers.

Potential for transformation

The transformative potential is further strengthened if the borderlines of institutionalized science are crossed and the latter is reinforced by 'citizen science', i.e. scientific processes in which the citizens are involved as co-researchers (Finke 2014; Wechsler, 2014). For example, today many ideas on alternative prosperity models and lifestyles, especially in the urban context, are derived from citizen-science projects. When individual universities, a central location of institutionalized science, become 'citizen universities' (Schneidewind, 2013a), change processes within scientific institutions unite with broad-based citizen science to form a particularly powerful form of transformative science which can bolster the effect of the laboratories outlined in Sections 4.3, 4.4 and 4.5.

4.4.2 Stimuli from religious communities

"If we destroy creation, creation will destroy us". This was the conclusion drawn by Pope Francis in May 2014 from scientific evidence on global environmental change after a five-day workshop entitled 'Sustainable Humanity, Sustainable Nature: Our Responsibility at the Pontifical Academy of Sciences' (Vatican Radio, 2014). This raises the question as to what contribution religious communities can make to the protection of the Earth system.

Definitions

In early 2014 the Vatican announced that an encyclical would be published on the subject of 'Human Ecology'. Encyclicals are circulars issued by the Roman Catholic Pope commenting on current issues; they are regarded as guides or exhortations to the religious community. The environmental encyclical aims to critically question the relationship between humankind and nature, especially with a view to the global asymmetries between the so-called throwaway society and those sections of the population who are living in absolute poverty (ORF, 2014).

Examples

Christiana Figueres, Executive Secretary of the UNFCCC, reinforced the Pope's statements in a speech at St. Paul's

Cathedral in London and emphasized ethical obligations toward future generations. Beforehand, in an article in the British daily newspaper The Guardian, she had called on the world's religious leaders to take a stand and get involved in climate protection. Responsibilities derived from the Christian doctrine, such as feeding the poor, were being made more difficult by climate change, she wrote (Figueres, 2014).

The German Protestant Church (Evangelische Kirche in Deutschland, EKD) has also concerned itself with the topic of religiously motivated environmental protection. For example, an appeal by the chair of the EKD Council, Bishop Wolfgang Huber – 'It is not too late for a response to climate change' – was published in 2007 (Huber, 2007), and a memorandum entitled 'Turning back to life – sustainable development in the context of climate change' came out in 2008 (EKD, 2008). Similarly, the main theme of the Protestant Synod was 'Changing Climate – Changing Waters – Changing Lives' in 2008 and 'World Food Security and Sustainable Agriculture' in 2014 (EKD, 2014). Small real-life experiment projects have also been forming in the parishes; for example, parishioners in Lübeck gave up plastic for Lent in 2014 (Nordkirche, 2014).

Furthermore, a number of Christian congregations in the USA and the UK have joined the divestment movement and committed themselves to withdrawing emissions-intensive bonds from their investment portfolios (Section 4.3.4; Fossil Free, 2014a). Particularly when religious communities advocate environmental protection and emissions reduction, these divestment measures demonstrate the community's independent sense of responsibility. In its guide for ethically sustainable investments, the EKD, too, states: "An investment in raw materials is often problematic from an ethically sustainable perspective" (EKD, 2013b:18). Even so, raw materials, CO_2 intensity or environmental damage caused by companies have not been criteria for exclusion from church portfolios up to now. To date, only companies manufacturing the following products have been outlawed: armaments, alcoholic spirits, tobacco, gambling, genetically modified seeds, products that violate human dignity by degrading representation, or products that are manufactured "with the support or toleration of inhuman working conditions and child labour (…) including in the supply chain" (EKD, 2013b:12). However, the purchase of government bonds from the countries that have not yet ratified the Kyoto Protocol or the Biodiversity Convention is sometimes outlawed. Furthermore, there are positive criteria for investments that are made according to Christian values in line with principles of "social compatibility, ecology and generational equity" (EKD, 2013b:14).

The projects of the Islamic Foundation for Ecology and Environmental Science (IFEES) also deal with alternatives to the status quo. The organization stages workshops and courses to close knowledge gaps in society, and encourages the Muslim world community to engage actively against the destruction of the environment. It uses as its foundation verses from the Qur'an relating to the integrity of creation and the consequences of environmental damage. The organization has published the 'Muslim Green Guide to Reducing Climate Change' on the subject (IFEES, 2013). Another project is the ecologically sustainable design of mosques.

There are also movements in Buddhist communities that are concerned with the environment. Activities often focus on the protection of biodiversity, for example trees. The 'ordination' of trees, like in Thailand, and the related wrapping of orange robes around their trunks aims to prevent them from being felled and thus to counter deforestation in general, and "symbolically to remind people that nature should be treated as equal with humans, deserving of respect and vital for human as well as all life" (Darlington, 1998:8). In the publication entitled 'A Buddhist Response to the Climate Emergency', acknowledged Buddhist teachers from different movements, such as the Dalai Lama, Thích Nhât Hanh and the Karmapa, comment on climate change: "If we continue abusing Earth this way, there is no doubt that our civilization will be destroyed. (…) The Buddha attained individual awakening. Now we need a collective enlightenment to stop this course of destruction." (Thích Nhât Hanh in: Stanley et al., 2009:3).

The diversity of the religious communities' commitment can also be seen in the internet. The online platform *ourvoices.net* is an inter-religious portal where a petition can be signed for more climate protection and for the success of the Paris Climate Conference; joint prayers are also said for its success (Ourvoices, 2014). The World Bank report 'Faith in Conservation – New Approaches to Religion and the Environment' offers an overview of the nexus of environment and religion revealing the principles of environmental protection in the different theologies (Palmer and Finlay, 2002).

In September 2014 an inter-religious summit on the subject of climate change will take place immediately prior to the UN climate summit in New York. 30 religious leaders intend to jointly generate some fresh impetus for the UN summit.

The World Council of Churches called for a 'Pilgrimage of Justice and Peace' in 2013; against this background several church groups are considering an ecumenical pilgrimage to the UN climate negotiations in Paris in 2015.

Transformative potential

Seen from a historical perspective, religious networks are effective multipliers and can thus contribute to raising awareness for global environmental problems among the population. In addition, the 'integrity of creation' – in the sense of an appeal not to destroy humanity's divinely created natural life-support systems – is an element in the teachings of many religions and can thus represent a unifying element. Religious leaders in general are seen as role models in many cultures and can influence agendas in the communities. Through their actions, new standards can develop in a religious com-

munity which can then potentially also have an impact on other areas of civil society. However, this is highly dependent on how receptive the religious community is, as well as on the degree to which the respective values are internalized. However, religious communities have the potential to be an important interface between knowledge and action; they can influence the structure of values in a society.

4.5 The re-embedding of markets

4.5.1 Multi-stakeholder initiatives

Multi-stakeholder initiatives are voluntary associations of different actors (such as private companies, non-governmental organizations, scientists and other civil-society actors) which aim to find joint solutions to complex problems (Gabler Wirtschaftslexikon, 2014). This Section focuses on the kind of multi-stakeholder initiatives that support or implement large-scale innovative and transformative low-carbon energy-supply projects. They have the potential to generate fresh impetus for ambitious mitigation and to have an impact in this field.

Example: Desertec

Desertec is a prominent example that continues to impress through its vision. The basic idea is the central, low-carbon generation of electricity using renewable energies in arid regions and deserts. The power generated is intended both for use in the country concerned and for export to other countries using low-loss high-voltage direct-current transmission (HVDC). At the same time, development impacts would be triggered by the creation of local jobs, investment in infrastructure, and access to low-carbon energy services. One possibility might also be to couple the low-carbon power generation with seawater desalination, which would have additional impacts on development. The required multilateral cooperation could help stabilize international relations (Desertec Foundation, 2014).

The Desertec idea was given practical consideration for the first time in a collaboration between different countries bordering on the northern and southern shores of the Mediterranean. The project's original objective was to generate electricity cost-efficiently from solar energy for the EU-MENA (Europe, Middle East and North Africa) region. In addition, it was to secure approx. 15% of Europe's electricity needs by 2050 and provide balance energy to offset the fluctuating electricity output from other renewable energy sources. The basic idea is transferable to other sunny (desert) regions of the world. Power generation using solar and wind energy is planned in the Gobi desert under the name Gobitec Initiative. This electricity would be used both in Mongolia and, via a transmission network more than 4,000 km long, in eastern China, Japan and South Korea, and support environment-friendly development in Mongolia (Gobitec, 2014).

The Desertec concept was developed by a multi-stakeholder network consisting of scientists, economists and political decision-makers. This led to the creation of the Desertec Foundation in 2009 (Desertec Foundation, 2014). Also in 2009, the industrial consortium Desertec Industrial Initiative (Dii GmbH) was founded, among other things to promote the construction of solar thermal and photovoltaic plants in North Africa.

Later developments demonstrate the complexity of such projects. Only 30 of the original 50 members have remained. The Desertec Foundation also withdrew from the consortium in 2013 because of fundamental conflicts over strategy, the remit, communication methods and the management style within Dii (Desertec Foundation, 2013).

Apart from internal conflicts, criticism of the basic idea also increased. Among other aspects, critics focused on the high investment and transport costs, complex legal and international-law challenges, great uncertainties such as extreme weather and the risk of terrorist attacks, and competition with local power generation from renewable sources. Furthermore, studies have investigated possible negative socio-economic and socio-political effects of Desertec, especially on the most vulnerable sections of the regional population, and devised corresponding sustainability criteria and recommendations in order to avoid them (Schinke and Klawitter, 2011). However, from the WBGU's point of view, the development of Desertec must also be seen as a learning success. The industrial consortium is currently concentrating its activities on desert power generation in the EU-MENA region, especially in North Africa; some of the electricity will then perhaps be exported to Europe.

In this context, Dii sees its role as an implementation-oriented platform that makes desert power-generation projects possible by building up partnerships in the region. The Desertec Foundation, too, is currently concentrating on power generation and use in the countries of North Africa, but also in Chile.

Example: Renewables Grid Initiative

The Renewable Grid Initiative (RGI) was launched in 2009 by the Berlin-based think-do tank THEMA1. It is an example which shows that multi-stakeholder initiatives with a manageable number of heterogeneous actors can develop and become active relatively quickly. The RGI's aim is to support the development of Europe-wide networks for electricity from centralized and decentralized renewable energy sources while ensuring only a minimal negative impact on the environment (RGI, 2014).

RGI started as a consortium of the environmental organizations WWF International and Germanwatch and the transmission-network companies Vatten Europe Transmission, 50Hertz and the Dutch transmission system operator (TSO) TenneT. In the meantime, several

other European TSOs and environmental organizations have joined. In order to reach its objective, the RGI contributes to raising awareness on the development and expansion of cross-border, smart power grids. The measures used by the RGI include, among others, publishing studies and reports, organizing workshops with relevant stakeholders, initiating dialogues between network operators and environmental organizations, and participating in EU projects. A striking feature of the RGI is the cooperation between network operators and environmental organizations, which will hopefully avoid time-consuming conflicts between infrastructure development and environmental protection in the construction of power grids by developing joint strategies at an early stage.

Transformative potential

Multi-stakeholder initiatives can feed new ideas into public and political discourses and put them on the political agenda. Their influence is greater when a wide range of powerful stakeholders from different sectors are represented (Kemfert and Horne, 2013). Multi-stakeholder groups can also develop visionary projects and put them into practice.

Desertec and RGI are examples of visionary and differently designed multi-stakeholder alliances with the objective of a large-scale low-carbon energy supply. The initiatives outlined here are pioneers in overcoming barriers relating to, for example, political regulation, market conditions or socio-economic aspects in the respective regions. The two forms of multi-stakeholder groups described here, both Desertec and RGI, are significant in the context of the transformation to a low-carbon society. They can complement each other and each take on specific tasks.

The example of Desertec also shows that relevant societal and very powerful economic actors can develop a common vision which is of great importance for a future energy supply. The vision has not only stimulated broad-based discussions; the actors involved are also trying to implement it step by step.

In addition, the example of the RGI shows that different stakeholders with seemingly conflicting interests have shared concerns and can pursue common goals.

4.5.2 Sustainable public procurement

Definition

Sustainable or green public procurement is the purchase of products or services in the public sector according to ecologically sustainable guidelines. The aim is that these products should have a less negative impact on the environment in the course of their life cycle than products procured elsewhere. Green public procurement can relate to purchases of office supplies or official cars, but the concept can also be extended to projects such as the construction of schools or highways. Public procurement in Germany is subject to the German public procurement law, which is influenced inter alia by Directives of EU public procurement law. The Member States of the EU are obliged to implement Directives issued by the EU (2004/18/EU; 2004/17/EU) on public procurement in their national law that make it possible to incorporate environmental concerns into the public sector's procurement processes.

To date, political measures on sustainable or environment-friendly procurement have already been introduced or implemented in 43 countries. These include not only the Member States of the European Union and the USA, but also Brazil, Costa Rica, Ghana and South Korea (UNEP, 2013b). In civil society, too, there are numerous initiatives in support of sustainable procurement, e.g. Procura+ from ICLEI.

Examples

There are already many examples of ecological guidelines or energy-efficiency standards playing a major role in the award of public contracts. One is Barcelona's municipal waste-disposal and street-cleaning system (EU Commission, 2012), for which a new contract came into force in 2009. A requirements profile was formulated for the award of waste-disposal contracts which placed a strong emphasis on sustainability criteria. It included the procurement of more efficient vehicles, lower water consumption, more frequent waste disposal and waste containers that separate the different kinds of waste. In addition, the provider was to submit a plan for reducing energy consumption and minimize the use of resources in the procurement of working materials, such as staff uniforms. The process has been a success. 35% of the vehicles are now powered by biodiesel, 35% by gas, and 30% are electric or hybrids; this has greatly reduced emissions and noise pollution. Furthermore, groundwater is now used for street cleaning instead of drinking water, and more bio-waste is now collected by using separate waste bins.

Another example is the Central Project Management Agency in Lithuania (EU Commission, 2011), which is the central public procurement agency. By introducing sustainable office supplies on their online catalogue, the prices of sustainable products have been successfully reduced by offering volume discounts, which has helped them to become competitive. In addition, energy costs have been cut by using energy-efficient IT equipment.

Transformative potential

The total quantity of public procurement amounts to €1,000 billion per year worldwide (EU Commission, 2013). This large sum means that sustainable public procurement can make a significant contribution to the transformation towards a sustainable society. In addition to its regulatory responsibilities, the state can become a key transformation actor as a consumer and investor. This can be demonstrated, for example, by the potential emissions savings: if there was universal conver-

sion to green electricity in the European Union's public sector, 60 million tonnes of CO_2eq would be avoided, the equivalent of 18% of the EU's obligations under the Kyoto Protocol (RELIEF and ICLEI, 2002).

Companies whose production is ecologically sustainable will benefit from green procurement. This will enable them to invest more in research or in the promotion of product innovations, which could also become exports. Moreover, it creates incentives for other companies to operate in a sustainable manner.

Sustainable public procurement makes environmental protection a fully integrated variable in public purchasing. This also makes it possible for new norms and standards for sustainable products to develop in the long term. At the same time, the public sector is leading the way and setting an example. In many areas, such as improving the energy efficiency of buildings, sustainable public procurement reduces costs in the long term.

In addition to green public procurement, there are also efforts to make public procurement more innovation-oriented. This means more direct support for the development of new products and services for the public sector. The transformative potential could be strengthened by linking approaches to sustainable and innovation-oriented procurement. According to the OECD (2013), the USA, Japan, China and Germany are among the advanced countries in the field of sustainable public procurement. Other EU countries have also set themselves ambitious goals, e.g. France in the field of electromobility (PWC et al., 2009; Oekonews.at, 2014).

4.5.3 Energy cooperatives

Definition

Energy cooperatives are a form of business organization based on cooperative business operations conducted by their members; most pursue the aim of decentralized and ecological energy generation. Energy cooperatives have already made a major contribution to the transformation of energy systems in Germany. In 2012 private individuals accounted for 34.4% of installed renewable energy capacity (Agentur für Erneuerbare Energien et al., 2013); 25.2% was owned by individuals and 9.2% by citizen energy companies. Citizen energy companies are companies in which citizens own more than 50% of the shareholders' equity; this category also includes cooperatives. Another 11.6% are (supra-regional) citizen shareholdings. This means that the largest market shares in renewable energies in Germany are in the hands of the citizens.

By contrast, Germany's four biggest utilities E.ON AG, RWE AG, Vattenfall Europe AG and ENBW AG own only 5% of the installed renewable capacity, and all the other utilities put together own a total of 7.5% (Agentur für Erneuerbare Energien et al., 2013). Institutional and strategic investors own 41.5% of the shares in installed capacity (Agentur für Erneuerbare Energien et al., 2013). The number of energy cooperatives in Germany grew from 77 in 2005 to 754 in 2012 (Agentur für Erneuerbare Energien et al., 2013).

Every member of a cooperative has a share in the project and a vote, regardless of the amount of capital they have invested. Cooperatives often collaborate with local authorities in order to raise funds to realize a project. They are financed by equity and external finance, to which a cooperative is more likely to have access than private individuals (Holstenkamp and Ulbrich, 2010). The profits can be paid out to the members as dividends or used to finance further investments. However, cooperatives are usually communities of value, i.e. they do not work for profit, but see themselves as self-help organizations for their members. Energy cooperatives therefore invest in the respective region and strengthen the local economy.

Transformative potential

Energy cooperatives can turn passive consumers into producers of electricity and heat. What is more, the many new energy cooperatives have encouraged consumers to become more interested in finding out where their electricity is generated and how profits are used. In the cooperatives the pricing structures of the energy product are disclosed to the members, and decision-making processes are transparent and democratic. In addition, energy cooperatives can make an autonomous supply of energy possible for members and local governments which is independent of price changes in other markets. Even in regions that are dependent on deliveries of raw materials from other countries, or are already affected by conflicts involving them, individual groups or communities can make a change and open up opportunities for experimental sustainable solutions by forming a cooperative. The growing numbers of newly founded energy cooperatives are therefore movements with a high dissemination potential.

4.5.4 Private-sector actors and their alliances

Definition

Private-sector actors, such as companies, entrepreneurs or managers, have many and varied ways of contributing to climate protection and the transformation to a low-carbon society. They can do so primarily via the business model, i.e. the form of business organization, as well as via the products, the production process and the company organization. Further possibilities include engaging in business associations, societal engagement by the company, its owners or managers, and using their political influence (Caring for Climate et al., 2013). Private-sector actors can have a range of different functions in a process of transformation towards a low-carbon society. They generate innovations by investing in

research and development up to market maturity; in this way they contribute to knowledge generation and thus to a self-supporting process of change in the market. On the one hand, technological and social inventions are turned into innovations with the help of start-ups. New markets are opened up with these innovations, or competition is increased in established markets, thus promoting a structural change. On the other hand, established companies also develop inventions into innovations and integrate them into their products, product ranges or production processes. However, these product extensions often remain niche products within the established companies. Companies make financial and human resources available for their bridging function between research and application and also take on societal responsibility when they commit to sustainable development (WBGU, 2011).

Depending on the national climate policy and the degree to which they are affected by climate change, companies invest in the energy and resource efficiency of their own operations, get involved in spreading knowledge about climate change (e.g. insurance companies and parts of the financial industry), or actively support climate policy. Internationally, more and more companies are willing to become part of the Carbon Disclosure Project and to measure and disclose their CO_2 emissions (CDP, 2013).

Examples

Climate-friendly innovations in the fields of renewable energy technologies and energy efficiency have been introduced and diffused in recent years by business start-ups in production and services (WBGU, 2011; UBA and BMUB, 2014). Similarly, established companies in the chemical industry have introduced new insulating materials, construction firms have developed new materials and the automotive industry new mobility concepts and drive systems.

International private-sector agents not only from OECD countries are joining forces to form alliances, foundations or associations for their societal engagement and to promote climate policy (Caring for Climate et al., 2013). In Germany, companies from different industries and of different sizes and internationality levels are active in climate and environmental networks and alliances. Examples include Econsense (forum for sustainable development set up by German business in 2000), the German Association of Environmental Management (B.A.U.M.), which has been active for 30 years, and above all an association called Future set up especially for small and medium-sized businesses. A relatively new initiative called Stiftung 2°C (the 2°C Foundation) will be discussed in more detail in the following.

Stiftung 2°C, which was registered in 2011, is an initiative launched by German CEOs and senior executives in 2007. Its aim is to publicize, promote and link market-oriented contributions and examples of climate-friendly business and production methods oriented towards complying with the 2°C guard rail (Stiftung 2°C, 2013: 1f.). In addition to conducting business in a low-carbon manner, the foundation's members also want to act as dialogue partners and climate ambassadors at the international level (Stiftung 2°C, 2013: 7). Beyond the German context, Stiftung 2°C is also a member of the UK-based Corporate Leaders Network for Climate Action, which was founded in 2010 and is made up of similar platforms in eleven different countries and the EU. Here, too, the focus is on networking, cooperation and a common commitment to more ambitious climate policies. Also of great importance is the International Investors Group on Climate Change in which 80 members (banks, pension funds, insurance companies, institutional investors) from nine countries are currently active with managed financial assets of €7,500 billion (IIGCC, 2014).

Transformative potential

Since Stiftung 2°C, for example, is an alliance of CEOs, the range of strategic decisions taken by private-sector agents in favour of mitigation and sustainability must be regarded as large. In the same way, the support function in other companies or politics must be regarded as significant, due to the high profile, the weight carried by respected executives' opinions, and the high level of networking. However, up to now no studies have been submitted on the importance of the networking and foundation activities of private-sector agents for transformation processes within companies or in relation to (inter-)national climate policy. One striking fact is that, both internationally and nationally, only few companies from the energy- and emissions-intensive industries are involved in the existing networks, platforms and associations. Perhaps cognitive discrepancies and dissonance arise for private-sector agents if they mix private economic interests with common welfare interests (WBGU, 2011).

The development of innovations and the diffusion of technological and social innovation by private-sector agents has a high transformative potential, because the innovations can spread quickly via world trade, and the transformation process can be accelerated. It should be taken into account in this context that system innovations, like those necessary for energy systems, are not easily achieved. They require not only substantial innovations but also changes in the socio-technical systems in which innovations are embedded.

If the many mitigation activities of companies are to have an effect, they need a legally binding national climate, energy and economic policy. Both for corporate planning and for investment security, companies require stable overall conditions in the national economy and in the respective market (WBGU, 2012).

Seen from a critical perspective towards economic growth, it can be questioned whether a low-emissions economy is capable of achieving the required 80-95% reduction in emissions on the continuation of resource-intensive economic growth, i.e. whether it is possible to decouple resource consumption and emissions from economic growth (Jackson, 2009; Paech, 2012).

4.5.5 Economy for the Common Good

Description

The 'Economy for the Common Good' (*'Gemeinwohl-Ökonomie'*) is a social movement of small and medium-sized entrepreneurs, their supporters and a friends' association, which was founded in 2010. It arose from the conviction that there was a need for an alternative way of doing business, from a critique of capitalism and a 'vision of an economy for the common good' (Sikora and Hoffmann, 2001). Between 2008 and 2010, Austrian entrepreneurs and their supporters with links to Attac Austria and the publicist Christian Felber (2012, 2014) developed an alternative balance sheet for businesses: the common-good matrix with the two axes 'Value' and 'Interacting group' (Verein zur Förderung der Gemeinwohl-Ökonomie, 2013:19). The current version 4.1 comprises 17 indicators and seeks to measure corporate success in a new way: the extent to which it serves the common welfare (Verein zur Förderung der Gemeinwohl-Ökonomie, 2013:7). The manual contains a description of criteria, and a maximum attainable score, for each field of the matrix. In addition to the fields that are assessed positively, there are also negative criteria for each column, such as 'violation of ILO labour standards or human rights', 'violations of environmental regulations', or 'refusal to establish a works council', each of which costs negative points.

Dissemination

In 2013, nearly 150 companies took part by having common-good balance sheets independently drawn up and peer-evaluated. The movement's aim is a change in the law, so that companies that reach a certain number of common-good points are rewarded with tax cuts, relief from customs duty or low interest rates on loans (Verein zur Förderung der Gemeinwohl-Ökonomie, 2013:8f).

Transformative potential

Like the European Eco Management and Audit Scheme (EMAS), for example, the common-good matrix can be regarded as an extended example of 'new environmental policy instruments' (Jordan et al., 2003). The balance-sheet matrix, the comprehensive auditing and the inclusion of broad, sustainability-related criteria are thus potentially interesting instruments. It could be introduced gradually using different levels of obligation – from purely voluntary implementation, to official certification involving incentive-based rewards, to a legal obligation involving possible sanctions.

This initiative, which has received more media attention in the last few years, has been the subject of criticism from various quarters. From the entrepreneurial, market-economy perspective, the concept of the Economy for the Common Good and Felber's proposals have been criticized as naive, as operating with false business- and economic-accounting methods, or even as being authoritarian and dictatorial (Julius Raab Stiftung, 2012; Hörl, 2012; Die Junge Wirtschaft, 2013). Supporters of the 'Solidarity Economy', for their part, accuse the Economy for the Common Good of being a "ready-made, abstract, complicated and dry concept that is bureaucratic in character" (Exner, 2011). It seems necessary to conduct a more in-depth societal debate, to further develop the instrument and thus detach it from individuals like Christian Felber, and to conduct independent evaluations of existing pioneer companies.

Although it is currently not possible to quantify their transformative potential, niche developments like the 'Economy for the Common Good' are interesting fields of experimentation, and in some cases they might reach a broad impact in the mainstream, given certain windows of opportunity (Grin et al., 2010). For example, the above-mentioned private-sector alliances could take up the ideas on the common-welfare balance sheet.

4.6 The interaction

The question of how societal groups can be won for cooperation (Environment Minister Hendricks in BMUB, 2014) can be taken up constructively by an in-context analysis of the narratives and laboratories of transformation described here. The examples reveal a wide range of innovative action practices which, in the WBGU's view, have great potential for showing ways to a transformation into a climate-neutral future and for mobilizing a wide range of different actors for the cause of mitigation. They can develop a special stimulative character since, on the one hand, they often involve personal advantages (e.g. material advantages in the case of buycotts and energy cooperatives, social advantages in the case of the transition-town movement in the sense that social networks are developed or expanded); on the other hand, they can have a powerful effect on subjective self-efficacy because they give individuals who are willing to change direct and effective opportunities to act. They often have an innovative, proactive, even creative 'aura' – reinforced by media exposure – which can exert an additional attraction, as expressed especially in the club idea.

There are also promising activities in addition to the above-mentioned initiatives that have similar qualities and provide significant stimuli for mitigation. In particular, *simultaneous* activity by many initiatives, their indirect or direct *interaction*, and the resulting synergies, can generate an emergent societal dynamic (Figure 6-1).

Against this background, the interesting questions are how the innovative narratives and laboratories can have a joint impact, where they can mutually reinforce and complement each other, but also where they might contradict each other. In the following, therefore, the case examples described above are discussed comparatively with the help of the categories mentioned in Section 4.1 (ambition level, scalability, permanence and feasibility).

Table 4.6-1 shows a synopsis of the case examples.

- *Ambition level:* Although all the laboratories shown are distinguished by high ambitions on the part of the actors themselves, the comparative analysis shows that some initiatives have a medium or variable ambition level. For example, political consumerism aims to persuade companies to move more towards sustainability criteria and more transparent supply schemes which are more open to the participation of consumers. Divestment and transition-town initiatives, on the other hand, pursue higher ambitions, for example with the aim of transforming the established economic system in the direction of decarbonization.
- *Scalability:* When it comes to scalability it is important to note that the initiatives, when they interact, each have a different potential for diffusion within and between different levels and areas of society. Political consumerism is almost endlessly scalable, since every individual, every organization and every institution is consuming all the time in different areas of everyday life and virtually always has the opportunity to choose an alternative – even if that is a boycott. The barriers to entry are thus low and the possibilities many and varied. However, the low level of focus and the relatively small degree of commitment required from the participants involves the risk that political consumerism has little impact in terms of changing consumption patterns and production methods. Although divestment and energy cooperatives concentrate on a small number of areas (finance, energy supply), they can nevertheless develop a big impact because they can be extended to many actor groups within these areas. At the same time, however, initiatives that address the interests of certain actor groups very specifically are also important. For example, participants in state clubs or city networks can meet their political responsibilities through their activities.
- *Permanence*: In this respect the permanence of the initiatives also plays a role; here it is a question of making the structures lastingly available for alternative action practices. Practices such as divestment, individual emissions trading and political consumerism are not intended as long-lasting measures, but rather as a means of solving a problem. The practices become obsolete once the respective goals, e.g. a low-carbon economy and society, have been reached. Compared to energy cooperatives or the Economy for the Common Good, which themselves already represent a solution to the problem, practices like divestment are initially easier to implement for the parties involved. Divestment or buycotts offer immediately available alternative options for action and decision-making within existing structures, while cooperatives first have to be founded, and/or people must decide in favour of long-term participation. At this point, too, however, it is important to consider the initiatives as a whole: those that are easily implemented enable actors to start doing something immediately; however, alternative solutions are needed to arrive in a sustainable society.
- *Feasibility*: The issue here is other actors taking on alternative practices and achieving the desired ambition level against the background of existing regulatory systems (politics, culture, knowledge, economy). Overall, a mixture of different ambition levels is a positive thing, provided they point in a similar direction, since, with a view to feasibility, lower ambitions can often be achieved more quickly. They initially require fewer changes within the political, cultural, cognitive and economic systems, but they can already soften up possible obstacles to a transformation within those systems and thus prepare the way for initiatives with bigger ambitions for change.

Across the individual categories, it turns out that modular multilateralism is being backed up and motivated by a *normative and cognitive paradigm change*. This change is being initiated and sustained by stimuli from, for example, religious communities, but also from science that has a transdisciplinary orientation and systematically incorporates the local knowledge of non-scientists. This improves the prospects of a *re-embedding of markets* which favours and sustains low-carbon individual investor and consumer decisions and analogous decisions by institutional actors, such as businesses and public administrations. All this happens at the same time as an *individual and collective assumption of responsibility* by numerous (collective) initiatives which declare themselves responsible for change and are able to redefine responsibility for the future. The differences between the described and similarly positioned laboratories thus reveal great synergetic potential. In order to make optimum use of this, it is essential to bring the different narratives together to form an overall narrative whose common denominator is the vision of a climate-neutral, sustainable society comprising all the above-mentioned subsystems. The result may well be the horizontal dimension of a responsibility architecture (Chapter 6). At the same time, the power constellations in the societies shift towards climate compatibility as a result of the various activities of the climate pioneers.

The challenge for public-sector actors is, on the one hand, to strengthen their own climate-policy responsibilities (e.g. state clubs, procurement) and, on the other, to create a societal climate of responsibility for mitigation and an 'atmosphere for transformation' in which innovative laboratories can develop particularly well – without intervening too much in these places of experimentation.

Political leaders can take up these diverse initiatives. Furthermore, there are ways of facilitating the development of the laboratories through legislative, financial and other measures. This is where climate politicians should use their legislative competence to design and change overall legal frameworks in such a way that sustainability criteria and orientations become standard, and actors who follow this line in practice gain an advantage in terms of government funding, procurement, con-

Table 4.6-1
Comparative description of the laboratories on the basis of the following transformation characteristics: Ambition level (formulated by the actors themselves), scalability (possibility for diffusion within and between different levels and areas of society), permanence (making the structures lastingly available for alternative action practices), and feasibility (1. other actors taking on alternative practices; 2. achieving the ambition against the background of existing regulatory systems (politics, culture, knowledge, economy).
Source: WBGU

	Ambition level	Scalability	Permanence	Feasibility
System level: Modular multilateralism				
State clubs	Variable: depends on the shared vision of the respective club	Potential growth is possible until all states are included	Instrument to achieve goals and permanently establish ambitions	1. Renewables Club already provides a basis 2. Mobilization of political will is ambitious
City clubs	Variable: depends on the shared vision of the respective club	Diffusion focused primarily on large cities; worldwide diffusion possible in this field	Instrument for networking and achieving common goals	1. Orientation examples such as C40 exist 2. Simple and possible within existing structures where self-interest is high
System level: Individual and collective responsibility				
Political consumerism	Medium: the goal is to increase the influence of consumers in the long term; consumer offers should be based on sustainability criteria	All actors and organizations can make political consumer decisions in every field of consumption	Political consumerism aims to permanently change supply systems, making itself superfluous	1. Alternatives exist, but require knowledge and resources 2. Production methods and purchasing practices must change against the resistance of routines
Divestment	High: the goal is the decarbonization of the economy and society	Can be expanded to all investors	If there is widespread divestment from fossil fuels, this can permanently shape the energy system.	1. Individually easily to implement 2. On a large scale, resistance from fossil-fuel companies to be expected
City networks	Medium: primarily oriented towards exchanging experience	Diffusion is focused on cities; inclusion of all cities worldwide is possible	Will continue to exist until the stated goals are reached or new ones are formulated	1. Membership undemanding 2. Possible within existing political structures
Transition-town movement	High: minimizing dependence on fossil resources; more regionally based material and money cycles; improving quality of life	Approach taken up in many places, but large-scale diffusion is uncertain	Processes are geared towards local stabilization; big local differences	1. Possible in principle, since the scope of the remit is always self-chosen 2. Also varies, depending on the project size and the depth of intervention
Individual emissions trading	Variable, since the remit is always self-chosen. Also varies, depending on the project size and the depth of intervention	Can theoretically be introduced everywhere; practical implementation is unclear (at present)	Could help consumption patterns to become permanently geared to sustainability criteria	1. Problems with identifying GHG values 2. Resistance conceivable against interference in individual and organizational routines
Adaptation networks	Medium: networks are based on a voluntary exchange of information and agenda setting	Growing, can gain in importance if environmental damage increases	Depends on the adaptation requirements	1. Networking not demanding because of synergies of interest 2. Members of adaptation networks have been too weak up to now to enforce extensive ambitions

System level: Normative and cognitive paradigm shift				
Transformative science (living labs, citizen science)	High overall: paradigm shift in science and new societal role for science is sought	Diffusion across existing boundaries of science is possible	Completion of paradigm shift will lead to a permanent change in scientific practice	1. Partly demanding, since new skills and more resources are necessary; facilitated by orientation examples 2. Resistance in the science and political system is to be expected
Stimuli from religious communities	Variable: depending on self-set goals	Broad diffusion of standards and practices is possible depending on the topic and goal	Permanent change in religiously inspired social norms among believers and institutional practices in churches is possible	1. Depends on the content and the goal of the stimuli 2. Facilitated by community structures and use of existing networks
System level: Re-embedding of markets				
Energy cooperatives	Medium: own power supply, participation in electricity generation is sought	Diffusion is focused on the energy sector, where strong proliferation is possible	Long-term transformation of the energy market	1. Entering an existing energy cooperative is easy; creating a new one is demanding 2. Energy cooperatives already operate in the existing system
Green procurement	High: reorientation of public-sector consumption and investment	Diffusion focuses on procurement by the public sector; potentially, every public organization can become active	Institutionalization and role-model function can lead to a permanent change in the supply system	1. Alternatives exist in theory for virtually every act of procurement 2. Changes necessary in procurement legislation/laws
Alliances of private-sector actors	Variable: freely selectable changes in own organization (in some cases there is a focus on technical innovations)	Diffusion is focused on companies and their national and international networking	Alliances may be temporary until goals are met or overall conditions change	1. Introduction of innovations can be demanding; networking is easy, since private-sector actors are organized in many countries 2. Survival depends on overall conditions such as the distribution of subsidies
Economy for the Common Good	High: comprehensive reporting by all companies on economy, ecology and social issues; change in the tax system	Diffusion focuses on economic actors; widespread dissemination is possible, but implementation is unclear	Changes in the law must be regarded as very long-term goals; pioneering activities vary considerably	1. Pioneer companies can begin at any time 2. Implementation in all subsystems is extremely demanding
Multi-stakeholder initiatives	Variable: depends on the self-set goals of the actors	Expansion to many different actors and topics possible	Instrument to meet specific goals	1. Many orientation examples; high coordination costs in some cases 2. Simple where self-interest is high: possibility of conflicts caused by the heterogeneity of actors

tracts, permits, etc. The most important thing is to use societal movements, initiatives of the state clubs and transnational networks for mitigation as a legitimation basis for active mitigation policies at the supra- and international level – and as a mandate for negotiations at the Paris Climate Conference in 2015. Such an integration of civil society promotes sustainable development and means an increase in freedom and democracy.

4.7 Recommendations for action

In this report the WBGU outlines a dual strategy for global climate protection which focuses on the intense interaction between multilateralism and civil society. This Section presents a wide variety of opportunities for climate-friendly behaviour and engagement on the part of civil society.

The WBGU recommends that policy-makers should promote such initiatives, particularly in their mutual interaction. The WBGU also recommends designing or changing overall legal frameworks in such a way that sustainability criteria and orientations become standard, and actors who follow this line in practice gain an advantage in terms of government funding, procurement, contracts or permits (Section 4.6).

The challenge for policy-makers is to create a societal climate of responsibility for mitigation and an 'atmosphere for transformation' in which innovative laboratories can develop particularly well – without intervening too much in these places of experimentation, but at the same time defending them vehemently against attacks (Section 4.6).

The following sections offer exemplary recommendations for action of this kind which can be derived from the examples, narratives and laboratories dealt with in the section. The corresponding research recommendations are made in Chapter 5.

4.7.1 Modular multilateralism

Formation of a transformative state club

Clubs of nation states whose members have come together as climate pioneers to pursue an ambitious climate policy can accelerate the transformation towards a low-carbon, sustainable society (Section 4.2.1). Such clubs have a particularly strong impact if they commit to an ambitious mitigation or energy-transition policy and contribute to breathing new life into the UN negotiations.

Germany and the EU should advocate the formation of a state club that is committed to an ambitious energy-transition and mitigation policy ('transformative club'). Such a transformative club with an ambitious mandate can contribute significantly to catalysing fundamental change. No such climate club exists at present. The 'Renewables Club' (*Club der Energiewendestaaten*), which was launched by Germany's then Federal Environment Minister Altmaier in 2013 and currently exists only on paper, could offer a basis for such a transformative club and should therefore be ambitiously further developed. Suitable starting points in terms of content include in particular a common vision, ambitious membership criteria and the creation of club benefits – for example through mutual learning, joint research and development, cooperation on standards, better access to finance, links between emissions-trading systems or lower trade barriers for low-carbon goods and services.

The New York Climate Summit convened by UN Secretary-General Ban Ki-moon for September 2014 offers an opportunity to politically strengthen the Renewables Club and generate the motivation for more ambitious targets. At this and subsequent opportunities Germany could launch initiatives to further develop the Renewables Club into a club with a transformative goal that also offers a package of attractive club benefits.

Support for city clubs

The pioneering role of city clubs in the field of climate protection should be acknowledged and, where possible, strengthened and actively developed (Section 4.2.2). This should be reflected in international climate policy, for example by giving city clubs a political voice (e.g. a right to be consulted) in the context of the UNFCCC process (Section 3.2). This should not be misunderstood as giving them a representative function for the entire level of the city, but as an important corrective local viewpoint which would be introduced by an organized actor such as C40.

In addition, the engagement of city clubs in the implementation of mitigation objectives should be promoted. One possibility might be that city clubs also receive financial support from the state as a further incentive to implement and scale up local mitigation activities. This would be justified not least by the fact that the implementation of ambitious commitments by the member cities would also make it easier to meet national reduction targets.

4.7.2 Strengthen individual and collective responsibility

Improve conditions for political consumerism

In the promotion of political consumer actions (Section 4.3.1) – regardless of who promotes them – it should be taken into account that strategic decisions for more sustainable consumption options require knowledge, an ability to reflect, and the availability of resources (time, money) – and that such decisions can be blocked by familiar habits and everyday pragmatism. The WBGU therefore believes that the most suitable strategies for promoting political consumerism include

providing information (on the sustainability effects of products and the manufacturers' production practices) which stresses the ecological and social advantages of sustainable consumption and, not least, the co-benefits of a better quality of life. These strategies should be combined with efforts to show practical action alternatives and to provide feedback on the effectiveness of the action.

In addition, the social relevance of the action and the 'we-feeling' among the actors could be enhanced by portraying climate protection more as a common task of all societal actors and by reporting more intensively on the mitigation actions of other people.

Educational institutions have an important role to play in strengthening people's skills in political consumerism. Schools and other educational institutions could convey more knowledge about the way individual consumption is embedded in globally interlinked economic and production systems and how it relates to the guiding principle of sustainability. Suitable ways of doing this include existing offers such as 'globalized city tours'. Furthermore, project seminars could promote specific activities, as is already being practised in several schools in the context of Carrotmob education projects, for example (Section 4.3.1).

Concentrated initiatives like boycott or buycott actions can create practical action opportunities for consumers, and these opportunities are increasingly being taken up. Policy-makers should, for example, consider reducing bureaucratic hurdles to the approval of actions in public sphere, or providing financial and strategic resources for innovative projects in order to create further opportunities for action on mitigation.

Spreading practices of political consumerism should not, however, be a priority political objective, but be seen primarily as a way of supporting a transformation towards more sustainable societal practices in production and consumption. The measures to promote political consumerism should therefore be accompanied by strategies for increasing permeability or by opening up political and economic systems to the participation of consumers in the sense of 'consumer democracy'. These include expanding possibilities of direct participation in political decisions that are of direct relevance to consumers, developing products, and strengthening the influence of vulnerable sections of society with little 'buyer power'.

Support for local transformation initiatives

Locally active transformation projects (e.g. transition-town initiatives; Section 4.3.3) often require low-threshold sources of funding outside of complicated application systems. In such cases, local authorities can offer money for civic engagement in simple ways without long-winded and complex application processes. Equally important is the provision of land and premises for artistic, creative and craft activities, e.g. repair cafés or community gardens. Local authorities should become more sensitive and willing to support promising projects. Social innovations and urban experiments need a certain amount of 'advance trust' and also venture capital, but this can contribute to a lively transformation of a city. Furthermore, offers of dialogue, invitations and exchange platforms outside the usual planning processes between administrations and municipal politicians on the one hand, and transformative actors on the other, are of great value.

Divestment

Because of the risks involved in continuing investments in fossil fuels, the WBGU recommends a review of state investments with a view to their future profitability, as well as from the ethical standpoint (Section 4.3.4).

The WBGU recommends promoting the development and use of so-called 'negative screens' or exclusion criteria for shares in fossil-fuel companies, so that they can be avoided by retail investors if they wish. This has been a problem up to now because it is very difficult for retail investors to exclude individual shares when they buy conventional equity funds. Such an option already exists in some cases for shares in arms companies or firms that use child labour, which are often marked by negative screens and avoided by many funds.

Adaptation networks

Against the background of intense global networking, adaptation instruments should also be networked (Section 4.3.5). In future, adaptation should follow systemic approaches and not respond only to local challenges. To this end, the WBGU believes it is necessary to improve the integration of existing adaptation measures. This could be done by an increased promotion of both supra-regional databases on adaptation measures and formalized exchanges between the actors involved. It is important in this context to support exchanges between political decision-makers, such as members of parliament and mayors, and representatives of those directly affected.

Support of city networks

In the WBGU's view, city networks operating in the field of mitigation (Section 4.3.6) should be promoted by the Federal Government and other governments. The Federal Government should strengthen the engagement of cities and local governments in mitigation networks by emphasizing their contributions to achieving national mitigation targets. In addition, the Federal Government should financially support local governments that lack the corresponding funds, so that they can join networks and build capacity enabling them to be part of new governance arrangements. Furthermore, city networks could be supported in their efforts to play a contributory role in international climate negotiations. Inclusion in national dialogue formats would be a first step in this direction.

In these activities of the Federal Government, a greater formalization and institutionalization of city networks should be avoided, since this could restrict the

advantages of transnational cooperation. Cooperation between the city networks is characterized by flexibility and the possibility of personal talks on (rapid) solutions to similar problems.

The WBGU recommends strengthening the contribution of city networks to the exchange of ideas. In this context it is no longer just a matter of linking mayors, but of facilitating exchanges of experience at the level of experts.

At the implementation level, in the future it would be desirable to combine the mitigation and adaptation measures of cities and to introduce a system for monitoring effects and evaluating this implementation. Since this will increase the cities' need for funding, nation states should provide more financial support for their cities' networking activities. Furthermore, Germany's international climate financing, e.g. its contribution to the Green Climate Fund, could not only be distributed at the level of the federal states, but also be used to collectively reward urban mitigation pioneers. An initiative organized by the Service Agency Communities in One World (SKEW) and the Working Group on the Agenda 21 North Rhine-Westphalia (LAG21) deserves to be mentioned here; it promotes local climate partnerships between German cities and municipalities in developing countries and emerging economies, which jointly implement mitigation and adaptation measures. Such examples should serve as a stimulus for important synergies between local mitigation policy and development-policy engagement and should therefore be encouraged.

4.7.3 Re-embedding of markets

Multi-stakeholder initiatives: Create conditions for feeding-in power from Desertec projects

Many solutions that are generated by multi-stakeholder initiatives and can potentially have a very powerful effect, also on a large scale, are unsuccessful even though they encounter positive social feedback (Section 4.5.1). The reasons are that supported solutions do not fit into the established political and economic framework, that the initiatives themselves often encounter barriers, and that arising opportunities cannot be used. Policy-makers should take on the task of promoting innovations generated by such associations, if they assess them as being relevant. The promotion should target changing the respective framework conditions and the related undesirable lock-ins, blockades and institutional routines that stand in the way of the spread of innovations.

The following Section specifies the necessary conditions for the Desertec project. The WBGU has endorsed the consistent promotion of renewable energies and the development of a common European energy system (WBGU, 2011, 2012, 2013) – including the integration of North Africa (WBGU, 2004, 2011) – on numerous occasions. In order to further increase the share of electricity generated by renewable energies in Europe, it is necessary to build the corresponding infrastructure (e.g. cross-border power grids, storage capacity), and to continue state measures to promote renewable energy sources. In this context, the WBGU has recommended strengthening climate policy at the EU level, implementing the internal energy market, developing a Europe-wide, union-based energy strategy, and harmonizing the promotion systems. The integration of electricity from the deserts of North Africa requires the establishment of corresponding interfaces in the infrastructure and the creation of a legal and regulatory basis. The WBGU has also recommended examining the idea of integrating North Africa into a European system for promoting renewable energy sources.

At the same time, the conditions for the production and use of Desertec electricity must be created in countries with arid areas and deserts. This applies both to technological and infrastructural aspects and to the construction of appropriate technical and administrative capacity (Vidican et al., 2014). Once appropriate regions in North Africa and the Middle East have been selected, this could happen in the context of an international energy policy or specific partnerships between the EU and neighbouring countries. Development cooperation is extremely important here. The energy partnership with North Africa and the MENA region currently envisioned by the Federal Ministry for Economic Cooperation and Development would be a step in this direction.

The Renewables Club could also take up the Desertec vision and cooperate to create the required overall conditions and promote the build-up of infrastructure (e.g. high-voltage direct-current networks).

Support sustainable public procurement

The WBGU recommends examining which areas in the public sector are particularly suitable for green public procurement. In this context, the legal basis should be examined and, where necessary, extended, applying sustainability criteria. Furthermore, areas promising co-benefits, e.g. lower energy costs through sustainable procurement should be identified. Lastly, the WBGU advocates using public procurement specifically and increasingly to promote sustainability, environmental and climate goals (Section 4.5.2).

Energy cooperatives

The promotion of cooperatives for renewable energies (Section 4.5.3) should be taken up more as an instrument of development cooperation as synergies will arise. On the one hand, people participating in energy cooperatives take on responsibility (ownership); on the other, off-grid installations can lead to progress towards a sustainable and affordable power supply, particularly in rural areas.

Improve overall conditions for low-carbon innovations in the private sector

By creating frameworks and implementing policies in different political fields, the state can embed markets in a way that is in the common interest (Section 4.5.4). This includes both the legal design of new markets and the use of regulatory and market instruments in labour-market, environmental, energy and economic policy. Moreover, it can accelerate technological and social innovations in the private sector through its technology and innovation policy, thus promoting structural change towards an environmentally compatible economy (WBGU, 2011, 2012).

The WBGU suggests that chambers of craft and commerce, as well as business and industry associations, should concern themselves more intensively with innovative balance-sheet instruments that encourage strong, sustainable development – e.g. those proposed by the Economy for the Common Good – develop them further and look into their potential applications.

4.8 Core messages

- The existing form of multilateralism has reached its limits. The climate negotiations in Paris should support a paradigm shift on four levels: (1) a development towards a modular form of multilateralism, (2) a paradigm shift in the cultural system that re-organizes the assumption of responsibility in society, (3) a normative and cognitive paradigm shift, and (4) a paradigm shift in the economic system that re-embeds markets into society. These four paradigm shifts are currently being promoted by different actors, actor groups and arenas. Their interaction creates a new dynamic for complete decarbonization by 2070 at the latest.
- Mitigation is being tested using different instruments in diverse laboratories, which further strengthens their respective leverage effect.
- There are many examples on all levels (states, cities, social movements, the private sector and individuals form clubs, cooperatives and networks with transformative potential) with diverse instruments (club goods, self-commitment, exchange of experience, demonstration projects, competence building, capacity building, problem awareness).
- The interplay of all actors in an awareness of the actions of others strengthens the feeling of self-efficacy.
- States can promote this not only by providing financial incentives and enacting legal requirements, but also by supporting and creating experimentation spaces and living labs.
- Taken together, this puts the state actors in the international negotiation system under legitimation pressure, but it also gives them room for manoeuvre in the negotiation process.

Research recommendations 5

5.1 Transformation research and transformative research

As one of the greatest challenges facing humankind, climate change makes particular demands on the science and research system. The knowledge required in order to limit anthropogenic climate change ranges from the scientific principles of the Earth system to technical options available for avoiding climate change and its economic consequences, and new forms of climate governance. A large proportion of this knowledge has been compiled by the IPCC.

There are many unresolved research issues in each of these fields, and integrating the different areas of knowledge also poses challenges to the institutional further development of the science system. In its report 'World in Transition – Social Contract for Sustainability' (WBGU, 2011), the WBGU examined the requirements for such inter- and transdisciplinary research accompanying necessary transformation processes. Limiting climate change is one of the most important applications of this research. In addition to its observer role, science also has an important role to play in this context as a catalyst for a broadly based civil-society movement for mitigation, as examined in this report (Chapter 4).

The WBGU coined the terms 'transformation research' (Tr) and 'transformative research' (tR) in its report on the transformation to describe the special demands that the challenge of climate change will make on the science and research system (WBGU, 2011).

5.1.1 Transformation research

Transformation research (Tr) "focuses on the forthcoming task of shaping the transformation. Here, transitory processes are explored in order to come to conclusions on the factors and causal relations of transformation processes. Examples from history can serve as a basis for analysing observed transformative moments" (WBGU, 2011:23).

The design and further development of the planned Paris Climate Agreement (Chapter 3) and the development of new governance mechanisms for an effective bottom-up climate policy (Chapter 4) highly rely on such transformation research.

The climate challenge is proving to be a key debate for understanding complex global transformation processes. It is becoming clear in the discussion that successful changes can only be initiated with an interplay between moral, institutional, economic and technological processes, since conventional, purely disciplinary explanation patterns – like those of classical economics – are simply insufficient to overcome existing obstacles.

Ultimately, therefore, transformation research aims to increase 'transformative literacy', both in the science system and among transformation actors. Transformative literacy means the ability to understand information on societal change processes and to contribute one's own actions to these processes. Such skills have a technological, economic, institutional and cultural dimension (Schneidewind, 2013b). Transformation research stands for a new dimension of interdisciplinary interaction in the generation of knowledge. This form of interdisciplinarity – combining scientific and technical knowledge of the Earth system with economic, institutional, social-science and cultural-science aspects of the transformation – is only conducted at a few institutions in today's science system.

In its report on the transformation the WBGU therefore submitted proposals for a comprehensive institutional reform of Germany's science system (WBGU, 2011). These range from the establishment of a new field of studies, called 'transformation research', which "examines transformation processes and the social preconditions within the scope of planetary boundaries," to the establishment of a "German federal university with a research and education profile that focuses on the transformation towards sustainability. Research and teaching should be inter- and transdisciplinary." In the context of the present report, the WBGU confirms the relevance and topicality of the analysis and recommendations it made then.

5.1.2 Transformative research and the co-production of knowledge

Transformative research (tR) is defined by the WBGU as "research that actively advances the transformation.

Transformative research supports transformation processes with specific innovations in the relevant sectors. It encompasses, for example, consumer research, which is needed for the development of new business models such as the shared use of resource-intensive infrastructures, and research for technological innovations like efficiency technologies. Transformative research can have a wider transformative impact if, as of a certain development stage, development activities for low-carbon innovations are embedded into a systemic context, their impact on climate and sustainability is verified, and they reflect the conditions required for transformative impact."

Transformative research extends beyond interdisciplinary cooperation between scientific disciplines. It is 'transdisciplinary', i.e. a form of research which also incorporates explicit and implicit knowledge from transformation actors in addition to the knowledge gained from within the science system. This is of crucial importance, specifically for the concrete design of transformation processes. The 'co-production' (ICSU, 2013) of knowledge attains key importance in transformative research: scientists create knowledge together with practitioners in transformation processes in order to give concrete shape to such processes.

The 'world citizen movement' for a comprehensive transformation towards a low-carbon society described in this special report is highly dependent on the co-production of knowledge. Suitable strategies and forms of interaction between science and civil society will also emerge from scientifically accompanied experimentation in the coming years which support the outlined transformation process (WBGU, 2011). A form of transformative science that is embedded in this way will thus itself become a catalytic element of the civil-society movement outlined in the report.

In addition to the development of technological solutions, which is significant in transformative research, the co-design of research agendas and the co-production of social innovations becomes increasingly important for transformation processes, specifically in the context of climate change.

5.1.3 Institutional impetus

The implementation of transformative research also requires many institutional changes to be made in the science system. These are currently being intensively discussed under such keywords as 'transformative science' (Schneidewind and Singer-Brodowski, 2013), 'co-design' and 'co-production' (ICSU, 2013), and 'citizen science' (Finke, 2014).

In addition to the institutional proposals already discussed in the report 'Social Contract for Sustainability' (WBGU, 2011), new forms of research infrastructure also play an important role. In the present report they are discussed under the name of 'living labs' (Section 4.4.1). Transition towns, divestment campaigns or energy cooperatives are potential living labs, when the knowledge of different scientific disciplines can be successfully united with actors' specific knowledge of the target and the transformation – in order to stimulate and continually further develop specific transformation processes in the course of a reflective process.

With its proposed structuring of sustainability research along three integrated main lines – 'urban change', 'transformation of the energy system' and 'sustainable business' – the Federal Ministry of Education and Research (BMBF) is creating a suitable framework for integrated approaches to both transformation research and transformative research.

The following recommendations take up basic research issues relating to the substantive fields discussed in Chapter 1 (Box 5.2-1). They are complementary to the recommendations on the institutional further development of the science system and methodology.

In the WBGU's view, the climate system and the role of anthropogenic greenhouse gases have been sufficiently researched to justify immediate global action on mitigation. Further basic research on climate change is nevertheless essential in order, for example, to improve the predictive power of models, which ultimately reduces uncertainty and thus also makes it easier to design the transformation to a low-carbon society.

This Chapter does not examine in detail the necessary basic research on the climate system and climate change; rather, Box 5.1-1 refers in this context in an exemplary way to the corresponding research recommendations of the Fifth IPCC Assessment Report.

The following recommendations are meant primarily in the sense of transformative research; they aim to support the transformation to a low-carbon sustainable society. The selection follows the priorities and main messages of this Special Report.

5.2 Global governance for the transformation to a low-carbon society

In the following section, the WBGU makes research recommendations on the design and implementation of the planned Paris Climate Agreement. They begin with basic research on global governance with the aim of gaining information on the possibilities and limits of global governance's role in the transformation to a low-carbon, sustainable society. This is followed by research questions aimed at supporting the concrete design of the Paris Climate Agreement 2015. Also relevant to the agreement are studies on the integration of disciplinary knowledge, in order to discuss policy on the basis of integrated research and in this way to encourage knowledge-based political decisions. There are also research recommendations to assess selected large-scale technologies whose use is currently the subject of controversial discussion.

Box 5.1-1

Basic research on climate change

Excerpts from IPCC (2013a)

The most important current gaps and uncertainties in understanding the climate system, and in the ability of science to describe natural and anthropogenic influences and project them into the future, are discussed at the end of the Technical Summary of Working Group I to the Fifth IPCC Assessment Report (Stocker et al., 2013). The main gaps relate to observations, drivers of climate change, understanding the climate system and its recent changes, and projections of global and regional climate change. What the WBGU considers the most urgent points are mentioned in the following.

- *Observations:* There are considerable uncertainties in observations on clouds, particularly with regard to their global-scale variability and trends, and thus their impact on the radiation balance and the precipitation rate. Further data gaps relate to the long-term trends in the strength of tropical cyclones; circulation in the deep ocean and its temperature below 2,000 metres; the thickness of the sea ice, particularly in the Antarctic; and the mass balance of the mountain glaciers and the two ice sheets (Antarctic and Greenland).
- *Drivers of climate change:* The main uncertainties in this field relate to the interaction between aerosols and clouds and thus to the radiation balance. The cloud feedback is considered to be positive, but its quantification remains difficult. This also applies to the feedback between the climate and the carbon cycle.
- *Understanding of the climate system and its most recent changes:* The main gaps lie in the understanding of the processes relating to the water cycle, clouds and the mass balance of the ice sheets. Data is similarly incomplete on long-term changes in extreme events, including cyclones in the tropics and storm fronts in the mid-latitudes.
- *Projections of global and regional climate changes:* Projections of climatic variations using Earth-system models show uncertainties particularly in the simulation of the water cycle and the carbon cycle. But one of the biggest problems is the regionalization of climate projections. Only regional climate information is of any use for political and other decision-makers and as a source of information for citizens. To achieve such regionalization, it is not enough to refine the resolution of the models; rather, the parameterization of the processes that cannot be resolved should also be reviewed.

Suggestions from German science

The WBGU's discussion with German climate scientists in May 2014 led to the following main recommendations. Research is urgently necessary in the following fields: the maintenance and further development of the global and regional climate-observation systems for different time scales; a better understanding of the uncertainties in climate sensitivity and the trends in the extreme values; the optimization of the coupled Earth-system models and a focus on regional aspects of the simulated climate changes; as well as improvements in access to and the availability of climate data.

The exchange of data and access to data should be made easier. This applies to the preservation of historical data, the development of international databases, and access to the data of national authorities. There should be international agreements to ensure that data from publicly funded research are accessible to the public.

5.2.1 Issues of governance and justice

The increasing impact of human activities on the Earth system generates fundamental ethical and normative issues, as well as a need for theories on responsibility and justice. They concern the role of humanity in relation to the future of the Earth system, the conservation of global public and common goods such as the atmosphere, and global distribution equity (WBGU, 2013).

- *Climate justice:* Research on climate justice should be funded. This includes, in particular, the question of how the causes and consequences of climate change are to be judged from the point of view of justice – especially with a view to the relevant distribution of burdens between different countries and individuals – and what role is played in this context by such normative concepts as responsibility, human rights and equality.

Global problems like climate change can only be solved by global cooperation and global governance (WBGU, 2014). Interdisciplinary research on governance has the task of examining basic preconditions for global governance and its specific form.

- *Future governance:* Research should examine the role of global governance and global cooperation in historical processes of transformation and radical change, in order to use lessons from the past to help shape the future. There should also be research into whether, and in what form, global governance can support the design of future development pathways towards climate-friendliness and sustainability. At the same time there is a need for greater cooperation between global-governance research focusing mainly on the social sciences and jurisprudence on the one hand, and the natural and engineering sciences on the other, in order to develop corresponding governance patterns based on a better understanding of the interaction between ecological, socio-economic and technical systems (WBGU, 2011).
- *Principles of cooperation:* It remains the case that there is only limited knowledge on fundamental questions relating to human willingness to cooperate as a prerequisite for global governance. To date there is no answer to the question of whether there are natural limits to the human intra- and intersocietal or intra- and intercultural capability to cooperate, or whether the humans are capable of developing a global 'We' identity. This also involves the search for possible cognitive boundaries which perhaps overtax humans and human societies, and how these can be transcended. From a scientific point of view it is not clear whether human societies can deal with the huge complexity of a globalized world economy, and can organize stability, security, wealth and fairness in a closely linked global society within the boundaries of the Earth system (WBGU, 2011).

Box 5.2-1

Selected gaps in knowledge on climate change identified by the IPCC – impacts, adaptation and vulnerability

From the numerous gaps in knowledge identified by the IPCC on impacts, adaptation and vulnerability to climate changes, this Box highlights those considered by the WBGU to be particularly relevant in the context of this report (Working Group II; IPCC, 2014a; in the following, the chapters are cited under the name of the respective lead authors; Section 1.7). The selection criteria include: urgency; potential for damaging the environment and society; references to the transformation towards a low-carbon society and to the debate on planetary guard rails; and research topics dealing with action and solution options.

Food production
More attention should be paid to the qualitative and quantitative variability of crop yields due to climate change. There is a lack of studies on systemic and transformative adaptation options for agriculture (Porter et al., 2014). Research on the impact of climate change on food production should also cover other climate-change-relevant aspects such as the processing, distribution and consumption of food, as well as access to food.

Water resources
More knowledge is needed on the adaptation costs of climate-related changes in water resources, e.g. as a result of droughts or floods. There is also a need for better spatial resolution in regional climate models, since water management and adaptation measures are implemented at the level of water catchment areas. Hydrological models, or the land-surface components of climate models, should be coupled with data on water management. The effects of a combined use of surface and groundwater resources need to be better understood. There is a particular need for research in regions where the use of groundwater resources is expected to increase. There is a need for research on the impact of climate change on water quality and vulnerability, as well as on the possibilities of adaptation, especially in developing countries (Jimenez Cisneros et al., 2014).

Urban agglomerations
There is not enough understanding of the vulnerability of city-dwellers, urban companies and city centres to climate change and interdependencies between systems; the vulnerability of the existing building stock to climate change and corresponding adaptation options; or the adaptive capacity of cities, the related costs and the limits of adaptation (Revi et al., 2014).

Health
The link between climate change and health is one of the risks on which there has been little research. In general, there is a need for research on the extent and character of climate-change-induced health risks; on the effectiveness of health-protection measures; on the health effects of sectoral adaptation and mitigation measures; on the improvement of decision-making and monitoring systems; and on the financing needs of health measures. There is a great long-term need for research on the health effects if the global mean temperature rises by more than 4°C (Smith et al., 2014a).

Ecosystems and biodiversity
In order to coherently determine the effects of the climate on ecosystems and biodiversity, and the importance of these effects for society, research should be conducted above all on the following points (Scholes et al., 2014; Wong et al., 2014; Pörtner et al., 2014).

Comprehensive, long-term monitoring is a prerequisite of research into the impact of the climate on ecosystems and biological diversity. More attention should be paid to the effects both of the speed of climate change and of extreme weather events on organisms. This also applies to the interaction between different drivers of global change (e.g. CO_2 concentration and tropospheric ozone).

Knowledge is incomplete on the interactions between different species in relation to their phenology and migration speed. A better understanding of ecosystem structure and function should be promoted to improve the upscaling of physiological studies of individual species to the level of ecosystem dynamics.

In order to better understand the climate sensitivity of ecosystems, it is necessary to confront complexity in ecosystems; this relates in particular to tipping points and the feedback between climate change and ecosystems.

Models should better depict future interactions between natural and societal systems – and facilitate improved predictions on ecosystem responses and adaptability, including the evolutionary adaptation of species.

Economic assessment of the losses of ecosystem services and biodiversity due to climate change should be improved.

5.2.2 Design of the Paris Climate Protocol

The WBGU recommends a Paris Climate Protocol (Chapter 3) and shows possible interactions between state multilateralism and civil-society actors (Chapter 4). In particular, further research is required into possibilities of productive and constructive interaction between states, non-governmental organizations (NGOs) and other actors of global civil society such as city networks (Box 5.2-2).

How can it be ensured that the multilateral level does not inhibit, but encourages activities by other actors that are on a more effective decarbonization pathway? How can decarbonization on the above-mentioned actor levels be politically and legally linked? How can civil-society actors contribute to resolving blockades of multilateralism?

In addition to the recommendation that the 2°C guard rail and the zero target – i.e. the global, long-term goal of reducing CO_2 emissions from fossil fuels to zero by 2070 at the latest – be specified in the Paris Protocol in a legally binding form, it should be possible for all commitments undertaken by the parties to the UNFCCC within the pledge-and-review process to be monitored by global civil society (Section 3.1). Transparency of information, the right to access this information, the involvement of associations or NGOs, and the right of associations or NGOs (as 'climate procurators') to sue for compliance with the commitments established by the Convention – these would represent a novelty at the UNFCCC level. The assignment of these rights – which have only been tried out by the contracting parties to the Aarhus Convention up to now – to the UNFCCC level should be continuously scientifically analysed.

In the WBGU's view, the Paris Climate Protocol should

Box 5.2-2

Selected gaps in knowledge on governance research identified by the IPCC

From the numerous gaps in knowledge identified by the IPCC, this Box highlights those considered by the WBGU to be particularly relevant in the context of governance (Working Group III; IPCC, 2014b; in the following, the chapters are cited under the name of the respective lead authors). The selection criteria include: urgency; potential for damaging the environment and society; references to the transformation towards a low-carbon society and to the debate on planetary guard rails; and research topics dealing with action and solution options.

Perception, decisions, participation

- Studies on cross-cultural differences in the perception of climate change and response options (Kunreuther et al., 2014).
- Studies on the effectiveness of communication methods such as simulations, games and films for enhancing public awareness of climate change (Kunreuther et al., 2014).
- The further development of regulatory mitigation mechanisms (e.g. standards, emissions trading, taxes) would be improved by more ex-post evaluations of existing mechanisms, taking into account the effectiveness of different regulatory approaches, individually and combined (Kolstad et al., 2014).
- More studies are required on new intergovernmental and transnational arrangements, including 'hybrid' approaches with both voluntary and binding elements (Stavins et al., 2014).
- There is only an incomplete understanding of the possibilities for generating co-benefits in international cooperation on mitigation and which of these approaches are promising (Stavins et al., 2014).

cover the three areas of mitigation, adaptation and dealing with loss and damage (Section 3.1). Questions on the latter area in particular have only been covered at the UNFCCC since 2013 with the Warsaw Mechanism for Loss and Damage. This welcome step must be promoted by further research: how can a way be found to compensate victims of real damage caused by climate change, despite the difficulties of attributing the effects of climate change to individual actors? In addition, under the WBGU's proposal for the Paris Climate Protocol instruments on technology transfer, financing and flexible mechanisms are further developed and, in some cases, newly designed. In this context, too, research questions remain open; they are illustrated in the following.

- *Incorporating scientific expertise*. Mitigation, adaptation and compensation measures require continuous substantiation from scientific research. Scientific data and scientific expertise are of huge value for mitigation. In view of the fact that the IPCC is incorporated de facto, but not compulsorily, into the UNFCCC processes, there is a need to (further) develop a model on how these and other scientific data can be incorporated into international political and legislative processes.
- *Integrating pioneer alliances and clubs into multilateral mitigation processes:* In the WBGU's view, it is necessary for compliance with the 2 °C guard rail and helpful for the climate negotiations if clubs, alliances, networks and a wide range of other actors get involved in mitigation (Chapter 4). There is a need for research on the question of how these alliances should be politically and legally, formally or informally integrated into the Paris Climate Protocol, and what incentives might promote their formation. In this context, another important question is how a change of culture in multilateralism might be achieved, i.e. so that it no longer gears its actions towards the slowest actor, but strengthens and encourage pioneers.
- *Participation rights and rights of action for NGOs:* Participation rights and rights of action have been tried out by the member states of the Aarhus Convention up to now. The implementation of such rights at the level of the UNFCCC or other environmental conventions requires continuous analysis.
- *Loss and damage:* Questions on compensating loss and damage caused by climate change have been given a new forum under the umbrella of the UNFCCC by the Warsaw Mechanism. This mechanism is initially focusing on collecting knowledge, data and best-practice solutions and should be supported by further research in this field. The law on liability under international environmental law requires further development here, because the rules on proving that damage has been caused by a specific action may no longer be appropriate and up-to-date in times of climate change.
- *Flexible mechanisms in the Paris Climate Protocol*: In the context of its recommendation to reduce CO_2 emissions from fossil fuels to zero worldwide by 2070 at the latest by means of an international pledge-and-review process, the WBGU also advocates the use of flexible mechanisms. Research is needed on the specific design of one or more mechanisms and on strategies for their implementation. The emphasis should be on the effects of the voluntary nature of the pledges on the specific design. The experience gained with the Kyoto mechanisms have shown, inter alia, that in some cases the mechanisms do not adequately take distribution and external effects into consideration. There is a need for broad-based research on how flexible mechanisms, alongside efficiency criteria, can also take external and distributive effects or equity criteria into account in a practicable way.
- *Use of flexible mechanisms within climate clubs and pioneer alliances:* In addition to the use of flexible mechanisms within the framework of the pledge-and-review process, strategies and specific proposals should also be designed on a scientific basis on how various flexible mechanisms might be used in the context of clubs and pioneering alliances, e.g. in the

form of market-based policy instruments.

- *Technology transfer:* There are many studies dealing with the international transfer of low-carbon technologies. However, it is largely unclear what specific conditions individual countries need to meet for the further development and permanent application of individual low-carbon technologies. These include, for instance, the technological capabilities of firms, research institutions that work in a complementary way to the technologies, testing and certification facilities, further-training institutions for qualifying employees, especially engineers, and market-research companies. Against this background, the question also arises as to how technological skills, especially in developing countries, can be increased in order to be able to introduce at least selected parts of the value chain of low-carbon technologies there.
- *Finance:* There is a need for further research into how criteria can be generated for the distribution of funds for mitigation, adaptation to climate change, and loss and damage. Research is also required on the definition of 'climate finance' and 'private climate finance' in the context described in Section 3.3.6. The lack of recognized definitions leads to information gaps and differences in understanding by the actors. Moreover, additional research would be important on the role of the private sector in financing adaptation to climate change and on the question of how private-sector mitigation measures can be replicated and expanded.

5.2.3 Integrative approaches

The Fifth IPCC Assessment Report shows that knowledge about climate change and how to overcome it has already reached considerable dimensions. At the same time, however, in many aspects there has not yet been any integration of knowledge from different disciplines. Integration would be necessary, however, to make it easier to weigh up the respective advantages of different political alternatives. This is where science should take up integrative issues. A few exemplary suggestions are listed in the following:

- *Irreversibilities and time scales:* Theories of economics and social science frequently reach their limits when dealing with how to handle large-scale irreversibilities in the Earth system or global changes whose time frames and causalities reach intergenerational dimensions. Methods should therefore be developed, for example, on how the different time scales of natural-science and social-science perspectives can be bridged, in order to be able to develop action options for politics and society.
- *Transformative development pathways:* Integrated assessment models (IAMs) correspond to the scientific state of the art for assessing transformation pathways. Their main advantage is their ability to depict a large number of areas of development, but not necessarily the speed of change. Climate policy is usually shown in the form of CO_2 prices, which makes it possible to gradually incorporate CO_2-reduction potential based on cost minimization. This method tends to favour existing infrastructures and neglects the potential of disruptive change. There is therefore a need for research on a better depiction of complementary instruments of energy and climate policy in the creation of transformative scenarios in which accelerated technology substitution and diffusion can occur.
- *Clearly defined model regions:* One weakness of integrated assessment models is that model regions as used in different models are often not comparable. An important improvement would therefore be to develop clearly defined model regions on which all models can be based.
- *Costs and benefits of mitigation:* The mitigation scenarios described by the IPCC's Working Group III also mention the costs that are connected with mitigation. As a rule, however, they do not mention the costs that are avoided by reducing climate change. Differences in methodology between different costing methods make a simple cost-benefit analysis impossible, especially since many of the effects of climate change cannot be translated quantitatively into costs. There is therefore a need for research into how the benefits of mitigation can be taken into account in policy decisions.
- *Migration due to climate change:* It can be assumed that unabatedly progressing global climate change will become a relevant factor in migratory movements in the medium to long term. Research needs to be conducted, inter alia, on regional hot spots and vulnerabilities, as well as on the best ways to handle climate migration, e.g. in terms of international law and in humanitarian terms. Also needed is an improvement in the data situation and in scenario development on the kind of climate-change-related migratory movements to be expected in the future.

5.2.4 Research on low-carbon technology and large-scale technical interventions

Research into and the dissemination of low-carbon technologies should be given a high priority. Technologies for generating negative emissions in general, and solar radiation management (SRM) in particular, should at best be regarded as a last resort – as ways to avoid a further rise in global temperatures. In theory, they make it possible to change the permitted emissions budget that ensures compliance with the 2 °C guard rail. These technologies can theoretically 'buy' a certain amount of flexibility by temporarily overshooting the 2 °C trajectory, which is then offset by negative emissions or SRM. The risk assessment of these technologies is, however, only in its early stages, and it is completely unclear whether

a broad application will ever be possible.

- *Spread of innovative low-carbon technologies:* The diffusion of innovative technologies that will be needed in the future is still not fully understood. This applies, for example, to many of the technologies that are required for the decarbonization of the sectors listed in Section 1.8.2. Research in this area can show how niche markets can be developed for the required innovations, and from which of these markets the technologies can diffuse to large-scale application. For many technologies this also includes research into the potential for better modularization (e.g. electromobility), in order to achieve better economies of scale in production.
- *Active removal of CO_2:* The generation of 'negative emissions' is being regarded more and more as a necessary measure to ensure compliance with the 2 °C guard rail. The technology options are known in principle. Negative emissions can be achieved either by a combination of bioenergy and CO_2 capture and storage, or by creating 'additional' CO_2 sinks, for example in the form of reforestation or algae growth. Both forms of CO_2 storage interact with the Earth system in ways that are not yet fully understood. This relates in particular to interaction with the carbon cycle. Furthermore, a development pathway that is dependent on the comprehensive use of a technology option in the future also requires a sound risk assessment which also takes technical breakdowns into account.
- *Manipulation of the Earth's radiation balance:* In theory, SRM has the potential to counteract the rise in temperature caused by the increased concentration of CO_2 in the atmosphere (Section 1.8.3). Applications like stratospheric aerosol injection can be realized at relatively low cost and would have an immediate effect on temperature development. However, this method is expected to cause considerable side-effects, and there is a risk of triggering non-linear effects in the climate system. Furthermore, SRM would have to be maintained for thousands of years, since it only reduces the rise in temperature caused by the greenhouse effect, but not its cause. Ocean acidification cannot be averted by SRM – it would continue unchecked. If SRM were interrupted, surface temperatures would increase rapidly. There is a need for further research on the risks of these technologies, as well as on the possibilities of their legal integration and international regulation, including liability issues.

5.3 Selected laboratories for a transformation to a low-carbon society

The examples of transformation narratives and laboratories compiled in Chapter 4, which range from the individual actor to the level of the nation state, require further empirical and conceptual substantiation. The evaluation criteria for classifying these laboratories in the context of the transformation to a low-carbon society are the ambition level of the respective goal, scalability, permanence and feasibility.

It is difficult to gauge what specific effects – quantitative and qualitative – laboratories and narratives will have in the context of the transformation process. Knowledge is at best sketchy on exactly how they come into being and interact, whether and how they will be promoted and accelerated or expanded, and how they can best be understood and assessed in comparison with each other. Accompanying political and social-science research is required to find these things out. Research would also be useful to accompany new laboratories when they are initiated. A transdisciplinary research design offers a good opportunity for gaining empirical and theoretical knowledge on aspects of a transformation whose effects (and interactions) go beyond the customary system criteria and existing analytical patterns. Research is also needed to determine under what social and structural conditions alternative practices of engagement in organizational and individual routines become permanent. This is particularly important against the background that civil society's interest in engagement is increasing, yet people's willingness to engage in time-consuming activities over long periods of time is declining (BMFSJF, 2010 for figures from Germany). People are more likely to take part in short-term and one-off activities rather than fundamentally change their own behaviour (WVS, 2014; Stolle et al., 2005).

Furthermore, there is a lack of studies on how collective self-efficacy – i.e. the supra-individual conviction of a reference group's competence to act – can be promoted in the context of social innovations and movements in climate protection. In addition, international comparative studies are also needed that deal with the perception of individual action options in the mitigation field and with people's willingness to take on individual responsibility against the background of intra- and intergenerational justice. There is also a lack of studies on the interaction between (modular) multilateralism and societal initiatives and movements. Finally, further research is needed on governance, or 'soft control', e.g. through incentives, living labs and experimental democracy projects (Box 5.3-1).

The synopsis on the interaction between (modular) multilateralism and societal initiatives and movements (Section 4.6) needs to be extended, especially by adding examples from developing countries and emerging economies. In the analysis of clubs of states and in the field of global cooperation between transnational movements, the democracy/autocracy problem in particular should be examined more closely.

In order to strengthen the type of research outlined above, science policy has an obligation to improve the structural conditions for transformative science: by further developing research-programme policy and by offering structural incentives for transdisciplinary research and teaching at universities and other scientific

Box 5.3-1

Selected gaps in knowledge on political instruments identified by the IPCC

The report of Working Group III to the IPCC has identified political measures to mitigate climate change and research needs (IPCC, 2014b; in the following, the chapters are cited under the name of the respective lead authors). Some research recommendations which the WBGU considers especially relevant to transformation and actions are outlined in the following.

Values, lifestyle

- Studies on the importance of changes in values in the transformation process in comparison to the implementation of economic instruments. The different influence on behaviour and economic activities is difficult to gauge up to now (Fleurbaey et al., 2014).
- Little is known about the potential of frugality (lifestyle and consumption patterns involving less expenditure on goods and services) compared to ecologically conscious behaviour (lifestyle and consumption patterns involving less resource consumption and causing less environmental damage, but without necessarily reducing expenditure) (Fleurbaey et al., 2014).

Cooperation, initiatives

- Knowledge is incomplete on the quantitative influence of regional cooperation on the mitigation of anthropogenic climate change (Agrawala et al., 2014).
- Knowledge is incomplete on the factors that contribute to the success or failure of regional cooperation, especially in the case of regional disparities and a mismatch between capacity and potential (Agrawala et al., 2014).
- There is an insufficient understanding of the synergies and conflicts of aims between adaptation and mitigation measures (Agrawala et al., 2014).
- There is a need for research on cross-regional interaction between different instruments of climate policy. Regional policies interact with national and international policies, but it is not clear how these numerous initiatives support or contradict each other (Agrawala et al., 2014).

institutions. Living labs can also be seen as a new form of research infrastructure which should be promoted more intensely. The following Section gives research recommendations on several examples of living labs selected from Chapter 4.

5.3.1 Promotion of experiments and living labs

The WBGU recommends issuing tenders for programmes on experiments and living labs for a societal transformation towards sustainability with a focus on mitigation. They should be supported for a limited period both materially and politically, and at the same time be the subject of independent scientific monitoring and evaluation.

There is a lack of comparative studies on living labs and narratives and their interaction in the context of the transformation to a low-carbon, sustainable society. This requires corresponding accompanying research on existing living labs and on new living labs when they are initiated. This opens up opportunities to gain empirical and theoretical knowledge on all those aspects of a transformation whose 'self-invention' processes, effects, interactions and statements are outside customary system criteria and existing analytical patterns.

5.3.2 Political consumerism

There is a need for research into the dissemination and impact of political consumerism, such actions as boycotts or buycotts. Up to now, most available literature has been theoretical work on the cause and potential impact of political consumerism in which links are created between post-modernism, changing values and political consumerism. Any mention of empirical aspects often tends to be only anecdotal. Empirical references are often limited to the development of the markets (development of labels and standards and the demand for products marked accordingly) and to surveys on people's willingness to engage in political consumerism or related actions. There is a need for research into how one is related to the other, i.e. whether and why political consumerism leads to changes in business and production practices (Balsiger, 2013). Research on political consumerism should examine in particular the cultural and milieu specificity of the respective practices and their effect of changing everyday actions and general value orientations on the individual level, as well as the change in societal, political and economic structures. In this context the research also covers the direct and indirect ecological, economic and social sustainability effects of different forms of political consumerism. These are relevant, inter alia, to reveal conflicts of aims between the goals of fair or green consumerism and those of political and frugal consumption, and to identify practices that have a lot of sustainability potential.

In order to further develop the concept of consumer democracy and its chances of implementation, many studies will be needed on the individual and systemic prerequisites. These include questions about the possibilities of strengthening consumer skills and rights in different social milieus and about the legislative possibilities for improving participation in political and corporate decision-making processes.

5.3.3 Scientific accompanying of local transformation initiatives

The methods of transdisciplinary research are particularly suitable for examining local transformation initiatives such as transition towns. Research projects should be initiated in the context of – and actually accompanying – real-life experiments and living labs for a transformation to a low-carbon, sustainable society. The WBGU therefore recommends already focusing more on transdisciplinary projects and approaches (co-design and co-production) when issuing tenders.

In addition, further research should be conducted on the needs of local projects for material, societal or political support, on the possibility of scaling them up, and on their associated potential for transformative and mitigating effects.

5.3.4 City networks

There is a need for research into the functioning and effects of city networks in the field of international mitigation, especially on the importance of the exchange of experience between local authorities. City networks are still inadequately studied by research as new actors at the international level. In addition to evidence-based research on their impact on the implementation of measures, there is a need above all for research on the possibilities and limits of transferring policy innovations and cooperation between local authorities, as well as their role in global governance. Impact analyses are required, and efficient reporting tools must be developed, in order to make the emissions reductions promised by city networks more traceable and verifiable in the future.

5.3.5 Adaptation networks

In order to have recourse to experience of adaptation networks, the exchange of information should be supported by networking them. This requires the additional creation of databases and online platforms; it also involves the need to research how this can be done efficiently, effectively and permanently in the context of diverse structures, overall conditions and cultures.

5.3.6 Desertec

Desertec as well as the related activities of the Desertec Foundation and the companies involved are important multi-stakeholder initiatives. The WBGU recommends an independent, scientific evaluation of the Desertec process, more intense scientific monitoring of current developments, support for transfers to other regions, and in particular research on conditions for cooperation and opportunities for acceleration. Accompanying research by social science and cultural science should be stepped up, since the important factors in large-scale projects like Desertec are not only technical feasibility, but also (and especially) the overall political, social and cultural conditions in the different countries and regions.

5.3.7 Transformation requirements and barriers in the private sector

Balance-sheet instruments like the common-good matrix demand strict documentation of the social and ecological effects of economic processes. The transparency and evaluability of these effects should be significantly improved.

When industries and companies try to re-internalize social and ecological effects that are outsourced in existing globalized markets, the need for change often arises. The WBGU therefore proposes setting forth such needs for change in a scientific way and describing and quantifying disadvantages – such as possible competitive disadvantages caused by sustainable business practices in a purely business-oriented market model – using key economic indicators.

5.3.8 Development of tradable emissions allowances for private households

The concept of tradable emissions allowances for private households (personal carbon allowances) has been the subject of controversial discussions in several European countries for some time. The WBGU sees a need for further studies and research on how individuals with their CO_2 balance sheets can be integrated into emissions trading, and under what conditions this seems feasible on a larger scale. In addition, it would be a good idea to examine the feasibility of a model in which two countries, or two local authorities or cities, each of which has introduced a CO_2 credit card, are paired. The guiding principle here would be that if one actor overdraws its account, the CO_2 credit can be directly replenished from a partner community, on condition the latter has made corresponding emissions reductions.

5.3.9 Integration of sustainable and innovation-oriented procurement

Extensive research has been conducted both on sustainable and on innovation-oriented procurement. But as yet there are no analyses on the integration of the two bodies of knowledge or the development of political

strategies to encourage connecting innovation orientation with sustainability goals in public procurement.

5.4 Epilogue

In this report, the WBGU describes a dual strategy for international climate policy in which, on the one hand, the planned Paris agreement serves as a guide, and, on the other, a societal climate is promoted in which all actors worldwide can make their contributions to a low-carbon economy. This process can also be seen as a societal search process in which both the direction and the destination – i.e. the area of activity – are evident, but there are many different ways of getting there. Research is an essential element of this search process in which both basic research and applied research are indispensable.

Since civil society must (and wants to) be actively involved in shaping this transformation process, it must also participate in research through the development of the corresponding research agendas, especially in applied research – if the process is to succeed. This is more likely to succeed if institutional changes are made to the science system. In addition, there must be more openness to new methodologies, such as the co-design and co-production of knowledge, which lead to innovations for transformation processes. Further studies are also needed on the new methods themselves, their potential and their limitations. More space should also be given to areas for experimentation, and comprehensive accompanying research established on so-called living labs.

A whole series of examples of living labs have already been listed in this chapter; further examples should be added. Building on this, there is a need for further studies on the transformative potential, scalability and feasibility of these diverse ideas.

Overall, this would help gear research findings more towards the solution of societal problems and needs and in this way boost the perceived value of research as a key element of societal progress.

Synopsis

6

Global emissions continue to rise, while the climate negotiations stagnate. This gap shows the weakness of a 'vertical responsibility architecture', which imposes considerable burdens and risks on future generations. Both the international community and citizens must therefore take on more responsibility for the future. The dilemma of a vertical responsibility architecture, well known especially in multi-level systems, lies in the fact that responsibility is delegated 'upwards' to political agents 'from below', and that these agents choose a negotiating strategy that imposes as few changes as possible in their sphere of influence – in an effort to protect established interests and maintain their power base. Societies in turn excuse their passivity with the low ambition level and failure of multilateral negotiations. In global climate protection this has so far led to a 'vertical complicity of the present to the detriment of the future'.

The question is how can the best of intentions, which do exist in politics and society on the basis of expertise and insight, be translated into effective global action for climate protection? The significant examples of transformative narratives described in this report outline a complementary 'horizontal responsibility architecture' in the form of a world citizen movement for climate protection. Here, responsibility for the future is not delegated 'upwards'; rather, it is exercised autonomously by broad sections of society. Committed citizens become global procurators who seek to protect the climate by developing social innovation and creativity – as well as for their own gratification – apart from the fact that they, too, are personally affected. Their narratives and laboratories can sustainably change social norms and practices and are not confined to appeals to third parties. One example is Germany's energy-system transformation (*Energiewende*), which was initiated and promoted by individuals and cooperatives.

If the political players are responsive enough, the transformative impulses provided here can penetrate into the vertical architecture of international negotiations, in that the governments point to a mandate from the *more advanced* demands being made by the constituencies they represent. The multilateral negotiation system will then no longer focus on the lowest common denominator; rather, it will bring together ambitious proposals introduced by clubs of states and transnational climate-protection networks at the supranational and international level. An ambitious Paris Climate Protocol based on the WBGU's recommendations, that takes on board all actors working for effective and sustainable climate protection, can, in turn, generate positive feedback with civil society's creativity and accelerate the 'bottom-up' transformation.

In this differentiated responsibility architecture, which gives shape to a global social contract, the (national) state, in addition to its involvement in multilateral negotiations, retains the central responsibility to flesh out the legal framework to this purpose, elevate sustainability criteria to a standard, and reward advanced actors involved in promoting, procuring, assigning and approving projects. States can use legislative, financial and other instruments to help laboratories flourish.

Alongside the vertical and horizontal dimensions of the responsibility architecture, the WBGU emphasizes the (virtual) inclusion of future generations in the current negotiation and decision-making process – as a third, quasi diagonal dimension. The generation that is living today and holds responsible positions in politics, business and society must recognize that the actions it takes, or does not take, will play a decisive role in the future of human civilization. The goal of the complete decarbonization of the world economy by 2070 at the latest requires immediate action. The transformation of the world into a zero-carbon society must be completed in less than sixty years – i.e. in less than a human lifetime. With a view to the third and fourth decades of the 21st century, when the children and children's children of today's leaders and decision-makers will have grown up and will be taking on responsibility themselves, decisions must already have been made in 2015 to flesh out this Herculean task and translate it into dimensions that humans can grasp. This must be done in such a way that, on the one hand, future generations retain freedom options and, on the other, they can assert their own creativity and powers of innovation. The road maps of emission reductions (leading up to the target of zero in 2070) are embodied and illustrated in subsequent generations.

Dynamic interaction and feedback – between the UN level, the nation states and the wide range of procurators of protected global resources (such as the climate) in the world citizen movement – can spawn a global climate policy that is compatible with democracy and shows responsibility for the future, as put forward by

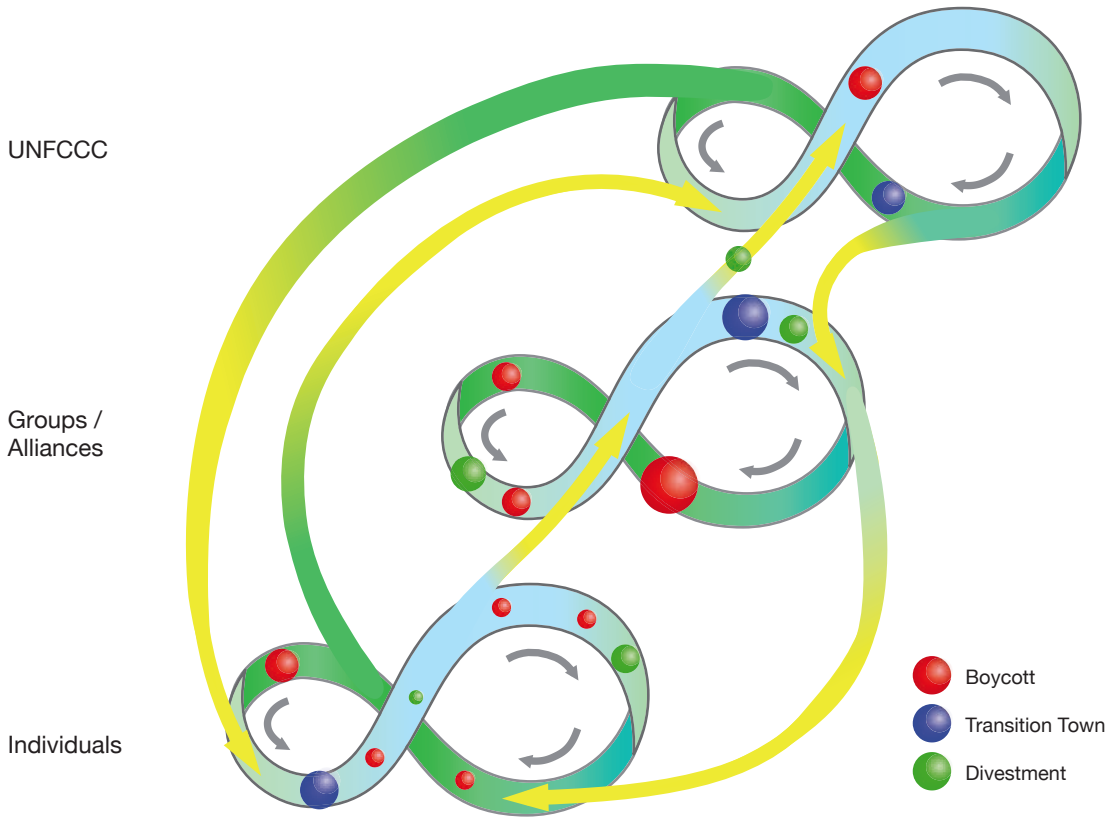


Figure 6-1
Dynamics of social movements in a multi-level space – a visualization. The transformative narratives and laboratories mentioned in this section do not develop in isolation from each other, but are characterized by dynamic polycentric processes. The diagram shows how individual phenomena mutually reinforce each other and in turn generate new dynamics and centres of transformation at different levels by way of spill-over effects. Three movements – divestment, transition towns and boycotts – are taken up as examples. Each is represented by a ball. The movements can pass through different actor levels in different countries, triggering or boosting new processes. As a result of a compression of social movements – the formation of a world-citizen movement by individuals and alliances – the balls are played into the field of the upper actor level of the UNFCCC. There they can open up scope for taking action and generate fresh ideas, and this can in turn have a favourable effect on other levels. This also illustrates another fundamental thought: an individual cannot exercise this influence, but it cannot come about without the individual's contribution in civil society either. In the same way, stagnating negotiating processes at the upper level cannot serve as a system confirmation or as an argumentation basis for restraint practised individually by private individuals, companies and countries.
Source: WBGU

the WBGU (2011) in its report 'A Social Contract for Sustainability' (Figure 6-1). In this context, the freedom of today's generation ends where the freedom of future generations begins.

References

7

Aachener Stiftung Kathy Beys (2008): Die CO_2-Card–Emissionsquoten als marktwirtschaftliches Instrument zum Klimaschutz. Zusammenfassung der Veranstaltung der Aachener Stiftung Kathy Beys am 27. Mai 2008 im ARTrium der Britischen Botschaft in Berlin. Website: http://www.co2card.de/fileadmin/content/Texte/zusammenfassung_globaldokument_final.pdf (viewed 2. Juni 2014). Aachen: Aachener Stiftung Kathy Beys.

Abrahamse, W. and Matthies, E. (2013): Informational strategies to promote pro-environmental behaviour: changing knowledge, awareness and attitudes. In: Steg, L., von den Berg, A. E. and De Groot, J. I. M. (eds.): Environmental Psychology: An Introduction. Chichester: Wiley-Blackwell, 224–242.

ACCCRN – Asian Cities Climate Change Resilience Network (2014): About ACCCRN. Website: http://www.acccrn.org/ (viewed 14. April 2014). New York: ACCCRN.

Adaptation Committee of the UNFCCC (2013): The State of Adaptation under the United Nations Framework Convention on Climate Change. 2013 Thematic Report. New York: United Nations Framework Convention on Climate Change (UNFCCC).

Adger, N., Barnett, J., Dabelko, G. D., Hovelsrud, G. K., Levy, M., Spring, U. O. and Vogel, C. (2014): Human security. Chapter 12. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-63.

Agentur für Erneuerbare Energien, Leuphana Universität Lüneburg and trend:research (2013): Definition und Marktanalyse von Bürgerenergie in Deutschland. Bremen: trend:research.

Agrawala, S., Klasen, S., Moreno, R. A., Barreto-Gomez, L., Cottier, T., Gámez-Vázquez, A. E., Guan, D., Gutierrez-Espeleta, E. E., Jiang, L., Kim, Y. G., Lewis, J., Messouli, M., Rauscher, M., Uddin, N. and Venables, A. (2014): Regional development and cooperation. Chapter 14. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–93.

Aldy, J. E., Barrett, S. and Stavins, R. N. (2003): Thirteen plus one: a comparison of global climate policy architectures. Climate Policy 3 (4), 373–397.

ALM – Adaptation Learning Mechanism (2014): Website. Website: http://www.adaptationlearning.net (viewed 14. July 2014). New York, UNDP.

Ansar, A., Caldecott, B. and Tilbury, J. (2013): Stranded Assets and the Fossil Fuel Divestment Campaign: What Does Divestment Mean for the Valuation of Fossil Fuel Assets? Oxford, New York: Smith School of Enterprise and the Environment.

Anton, B., Cambray, A., Dupar, M., Westerlind-Wigstroem, A. and Gogoi, E. (2014): Close to Home: Subnational Strategies for Climate Compatible Development. London: Climate and Development Knowledge Network (CDKN).

Appiah, K. A. (2006). Cosmopolitanism: Ethics in a World of Strangers. New York: W. W. Norton.

Appiah, K. A. (2011): Eine Frage der Ehre oder Wie es zu moralischen Umbrüchen kommt. Munich: Beck.

Aronson, E. and O'Leary, M. (1983): The relative effectiveness of models and prompts on energy conservation: A field experiment in a shower room. Journal of Environmental Systems 12, 219–224.

Aust, H. P. (2013): Auf dem Weg zu einem Recht der globalen Stadt – "C40" und der "Konvent der Bürgermeister" im globalen Klimaschutzregime. Zeitschrift für ausländisches öffentliches Recht und Völkerrecht, 673-704.

Balsiger, P. (2013): Embedding "Political Consumerism": A Conceptual Critique. EUI Working Papers MWP 2013/08. Website: http://cadmus.eui.eu/bitstream/handle/1814/27318/MWP_2013_08.pdf (viewed 2. Juli 2014). San Domenico di Fiesole: European University Institute.

BAMF – Federal Office for Migration and Refugees (2012): Klimamigration – Definitionen, Ausmaß und politische Instrumente in der Diskussion. Nürnberg: BAMF.

Bandura, A. (1997): Self-Efficacy: The Exercise of Control. New York: Freeman.

Bandura, A. and Locke, E. A. (2003): Negative self-efficacy and goal effects revisited. Journal of Applied Psychology 88, 87–99.

Banu, S., Hu, W., Hurst, C. and Tong, S. (2011): Dengue transmission in the Asia-Pacific region: impact of climate change and socio-environmental factors. Tropical Medicine & International Health 16 (5) (2011), 598-607.

Barber, B. (2013): If Mayors Ruled the World: Dysfunctional Nations, Rising Cities. New Haven: Yale University Press.

Baringhorst, S. (2006): Keine Reizwäsche aus Burma. Menschenrechte durch politisierten Konsum? In: Lamla, J. and Neckel, S. (eds.): Politisierter Konsum – Konsumierte Politik (Soziologie der Politiken). Wiesbaden: VS Verlag für Sozialwissenschaften, 233–259.

BBC – British Broadcasting Corporation (2007): All Countries Need to Take Major Steps on Climate Change: Global Poll. London: BBC World Service.

Beck, U. (1997): Was ist Globalisierung? Irrtümer des Globalismus. Antworten auf Globalisierung. Frankfurt/M.: Suhrkamp.

Beck, U. (2009): World at Risk. Cambridge: Polity Press.

Becker, L. J. (1978): Joint effect of feedback and goal setting on performance: A field study of residential energy conservation. Journal of Applied Psychology 63, 428–433.

Benhabib, S. (2006): Another Cosmopolitanism. Oxford: Oxford University Press.

Betsill, M. M. and Bulkeley, H. (2006): Cities and the multilevel governance of global climate change. Global Governance 12, 141–159.

Biermann, F. and Boas, I. (2010): Preparing for a warmer world. Towards a global governance system to protect climate refugees. Global Environmental Politics 10 (1), 60-88.

Biermann, F., Pattberg, P., von Asselt, H. and Zelli, F. (2009): The fragmentation of global governance architectures: a framework for analysis. Global Environmental Politics 9 (4), 14–40.

Bindoff, N. L., Stott, P. A., AchutaRao, K. M., Allen, M. R., Gillett, N., Gutzler, D., Hansingo, K., Hegerl, G., Hu, Y., Jain, S., Mokhov, I. I., Overland, J., Perlwitz, J., Sebbari, R. and Zhang, X. (2013): Detection and attribution of climate change: from global to regional. Chapter 10. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 867–928.

Bird, C. (2010). Local sustainable homes: how to make them happen in your community. Totnes: Green Books.

Blanco, G., de Coninck, H. and Würtenberger, L. (2012): The Technology Mechanism under the UNFCCC: Ways Forward. Policy Brief. London: Climate & Development Knowledge Network.

BMFSFJ – Federal Ministry of Family Affairs, Senior Citizens, Women and Youth (2010): Hauptbericht des Freiwilligensurveys 2009: Engagementpolitik, Zivilgesellschaft, soziales Kapital und freiwilliges Engagement in Deutschland 1999–2004–2009. Website: http://www.bmfsfj.de/RedaktionBMFSFJ/Broschuerenstelle/Pdf-Anlagen/3._20Freiwilligensurvey-Hauptbericht,property=pdf,bereich=bmfsfj,sprache=de,rwb=true.pdf (viewed 9. July 2014). Berlin: BMFSFJ.

BMU – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and UBA – Federal Environment Agency (2013): Umweltbewusstsein in Deutschland 2012. Berlin, Dessau: BMU, UBA.

BMUB – Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (2014): Hendricks legt Eckpunkte für "Aktionsprogramm Klimaschutz 2020" vor. BMUB Pressedienst Nr. 071/14 – Klimaschutz. Berlin: BMUB.

Bodansky, D. (1993): The United Nations Framework Convention on Climate Change: a commentary. Yale Journal of International Law (18), 451–558.

Bowerman, N. H. A., Frame, D. J., Huntingford, C., Lowe, J. A., Smith, S. M. and Allen, M. R. (2013): The role of short-lived climate pollutants in meeting temperature goals. Nature Climate Change 3, 1021–1024.

Brangwyn, B. and Hopkins, R. (2008). Transition Initiatives Primer. Website: http://www.transitionnetwork.org/sites/www.transitionnetwork.org/files/TransitionInitiativesPrimer%283%29.pdf (viewed 11. May 2014). Totnes: Transition Network.

Brechin, S. R. and Bhandari, M. (2011): Perceptions of climate change worldwide. Wiley Interdisciplinary Reviews on Climate Change 2 (6), 871–885.

Brown, J., Bird, N. and Schalatek, L. (2010): Climate Finance Additionality: Emerging Definitions and Their Implications. Berlin, London: The Heinrich Böll Foundation, ODI.

Buchanan, J. M. (1965): An Economic Theory of Clubs. Economica 32 (125), 1-14.

Bush, K. F., Luber, G., Kotha, S. R., Dhaliwal, R. S., Kapil, V., Pascual, M., Brown, D. G., Frumkin, H., Dhiman, R. C., Hess, J., Wilson, M. L., Balakrishnan, K., Eisenberg, J., Kaur, T., Rood, R., Batterman, S., Joseph, A., Gronlund, C. J., Agrawal, A. and Hu, H. (2011): Impacts of climate change on public health in India: future research directions. Environmental Health Perspectives 119 (6), 765.

Byrne, R., Smith, A., Watson, J. and Ockwell, D. (2011): Energy Pathways in Low-Carbon Development: From Technology Transfer to Socio-Technical Transformation. STEPS Working Paper 46. Brighton: STEPS Centre.

C40 Cities Climate Leadership Group (2012): Quanitifying the Emissions Benefit of Climate Action in C40 Cities. Berlin: C40.

C40 Cities Climate Leadership Group and Arup (2014): Climate Action in Megacities. C40 Cities Baseline and Opportunities. Volume 2.0. Berlin: C40, Arup.

Carbon Tracker Initiative (2012): Unburnable Carbon – Are the World's Financial Markets Carrying a Carbon Bubble? London: Carbon Tracker Initiative.

Carbon Tracker Initiative and Grantham Research Institute on Climate Change and the Environment (2013): Unburnable Carbon 2013. Wasted Capital and Stranded Assets. London: Carbon Tracker Initiative, Grantham Research Institute.

Caring for Climate, The Global Compact, UNEP – United Nations Environment Programme, WRI – World Resources Institute, CDP – Carbon Disclosure Project, WWF, Ceres and The Climate Group (2013): Guide for Responsible Corporate Engagement in Climate Policy. A Caring Climate Report. London: Caring for Climate.

cCCR – carbonn Cities Climate Registry (2014): About cCCR. Website: http://citiesclimateregistry.org/ (viewed 9. January 2014). Bonn: cCCR.

CDP – Carbon Disclosure Project (2013): Sector Insights: What is Driving Climate Change Action in the World's Largests Companies? Global 500 Climate Change Report 2013. London: CDP.

Chamberlin, S. (2009). The Transition Timeline. Totnes: Green Books.

Christensen, J. H., Kumar, K. K., Aldrian, E., An, S.-I., Cavalcanti, I. F. A., Castro, M. d., Dong, W., Goswami, P., Hall, A., Kanyanga, J. K., Kitoh, A., Kossin, J., Lau, N.-C., Renwick, J., Stephenson, D. B., Xie, S.-P. and Zho, T. (2013): Climate phenomena and their relevance for future regional climate change. Chapter 14. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 1217–1256.

Christian Aid (2007): Human Tide: The Real Migration Crisis. London: Christian Aid.

Chuffart, S. (2013): Technology Transfer and Dissemination Under the UNFCCC: Achievements and New Perspectives. Geneva, New York: Graduate Institute of International and Development Studies (HEI), Columbia Law School – Centre for Climate Change Law.

Church, J. A., Clark, P. U., Cazenave, A., Gregory, J. M., Jevrejeva, S., Levermann, A., Merrifield, M. A., Milne, G. A., Nerem, R. S., Nunn, P. D., Payne, A. J., Pfeffer, W. T., Stammer, D. and Unnikrishna, A. S. (2013): Sea level change. Chapter 13. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 1137–1177.

Ciais, P., Sabine, C., Bala, G., Bopp, L., Brovkin, V., Canadell, J., Chhabra, A., DeFries, R., Galloway, J., M. Heimann, Jones, C., Quéré, C. L., Myneni, R. B., Piao, S. and Thornton, P. (2013): Carbon and other biogeochemical cycles. Chapter 6. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 465–544.

Clarke, L., Jiang, K., Akimoto, K., Babiker, M., Blanford, G., Fisher-Vanden, K., Hourcade, J.-C., Krey, V., Kriegler, E., Löschel, A., McCollum, D. L., Paltsev, S., Rose, S., Shukla, P. R., Tavoni, M., van der Zwaan, B. and van Vuuren, D. P. (2014): Assessing transformation pathways. Chapter 6. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–143.

Climate Alliance (2014): Welcome to the Website of Climate Alliance! Website: www.climatealliance.org (viewed 2. January 2014). Frankfurt/M., Brussels: Climate Alliance.

Collins, M., Knutti, R., Arblaster, J., Dufresne, J.-L., Fichefet, T., Friedlingstein, P., Gao, X., Gutowski, W. J., Johns, T., Krinner, G., Shongwe, M., Tebaldi, C., Weaver, A. J. and Wehner, M. (2013): Long-term climate change: projections, commitments and irreversibility. Chapter 12. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 1029–1106.

Comiso, J. C. and Nishio, F. (2008): Trends in the sea ice cover using enhanced and compatible AMSR-E, SSM/I, and SMMR data. Journal of Geophysical Research 113, 22.

Comiso, J. C., Kwok, R., Martin, S. and Gordon, A. L. (2011): Variability and trends in sea ice extent and ice production in the Ross Sea. Journal of Geophysical Research 116, 19.

Connective Cities (2014): Connective Cities. Website: http://www.connective-cities.net (viewed 30. June 2014). Berlin: Städte-Plattform Connective Cities.

Copeland, L. (2013): Value change and political action: postmaterialism, political consumerism, and political participation. American Politics Research Advance online publication, doi: 10.1177/1532673X13494235.

Coughlin, T. and Grochowski, E. (2012): 2012–2016 Capital Equipment and Technology Report for the Hard Disk Drive Industry. Atascadero: Coughlin Associates.

Cramer, W., Yohe, G., Auffhammer, M., Huggel, C., Molau, U., Faus da Silva Dias, M. A., Solow, A., Stone, D. and Tibig, L. (2014): Detection and attribution of observed impacts. Chapter 18. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-94.

Cubasch, U., Wuebbles, D., Chen, D., Facchini, M. C., Frame, D., Mahowald, N. and Winther, J.-G. (2013): Introduction. Chapter 1. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 119–158.

Curtis, K. and Schneider, A. (2011): Understanding the demographic implications of climate change: estimates of localized populations under future scenarios of sea-level rise. Population and Environment 33 (1), 28-54.

Darlington, S. (1998): The ordination of a tree: The Buddhist ecology movement in Thailand. Ethnology 37 (1), 8.

David, V., Zhou, D. T., Hassan, E., Ahmed, M., Kumar, P., Jos, D., Olivier, H., Rogner, H., Sheikho, K. and Yamaguchi, M. (2014): Introductory chapter. Chapter 1. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–65.

Desertec Foundation (2013): Die DESERTEC Stiftung verlässt das Industriekonsortium Dii. Press Release. Website: http://www.desertec.org/de/presse/pressemitteilungen/130701-die-desertec-stiftung-verlaesst-das-industriekonsortium-dii/ (viewed 4. March 2014). Hamburg: Desertec Foundation.

Desertec Foundation (2014): Welche Zukunft wollen wir? Gemasolar gewinnt den DESERTEC Award 2014 Website: http://www.desertec.org/de/ (viewed 3. March 2014). Hamburg: Desertec Foundation.

Deutsche Bank Climate Change Advisors (2010): GET FiT Program. Global Energy Transfer Feed-in Tariffs for Developing Countries. Frankfurt/M.: Deutsche Bank.

Die Junge Wirtschaft (2013): Gemeinwohlökonomie im Reality-Check. Website: http://jwdaten.wko.at//jwmagazin/jwmagazin_2_13.pdf (viewed 10. March 2014). Vienna: Junge Wirtschaft Österreich.

Dörr, O. and Schmalenbach, K. (2012): Vienna Convention on the Law of Treaties. A Commentary. Berlin, Heidelberg: Springer.

Eberle, U., Brohmann, B. and Graulich, K. (2004): Nachhaltiger Konsum braucht Visionen. Ein Positionspapier. Darmstadt: Öko-Institut e.V.

Ekardt, F. (2014): Nach dem Altrip-Urteil: Von der Klagebefugnis zu Verfahrensfehlern, Abwägungsfehlern und Individualklage. Neue Zeitschrift für Verwaltungsrecht (NVwZ) 7, 393–396.

Edenhofer, O., Flachsland, C., Stavins, R. and Stowe, R. C. (2013): Identifying Options for a New International Climate Regime Arising from the Durban Platform for Enhanced Action. Policy Brief. Website: http://belfercenter.ksg.harvard.edu/files/berlin-workshop_digital4_2013.pdf (viewed 30. June 2014). Cambridge, MA: The Harvard Project on Climate Agreements, The Mercator Research Institute on Global Commons and Climate Change.

Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Kadner, S., Minx, J. and Brunner, S. (2014): Technical Summary. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC.

EKD – Evangelical Church in Germany (2008): Umkehr zum Leben – Nachhaltige Entwicklung im Zeichen des Klimawandels – Eine Denkschrift des Rates der Evangelischen Kirche in Deutschland. Munich: Gütersloher Verlagshaus.

EKD – Evangelical Church in Germany (2011): Klimaschutzbericht der Evangelischen Kirche. Website: http://www.ekd.de/download/S2011_III_i_Klimabericht.pdf (viewed 9. July 2014). Hannover: EKD.

EKD – Evangelical Church in Germany (2013a): Beschluss zum Klimaschutz. 6. Tagung der 11. Synode der EKD, Düsseldorf, 7. bis 13. November 2013. Website: http://www.kircheundgesellschaft.de/fileadmin/Dateien/Fachbereich_III/Dokumente/13_11_12_Synodalbeschluss_Klimaschutz.pdf (viewed 9. July 2014). Hannover: EKD.

EKD – Evangelical Church in Germany (2013b): Leitfaden für ethisch nachhaltige Geldanlage in der evangelischen Kirche. Hannover: EKD.

EKD – Evangelical Church in Germany (2014): Die Synode der EKD Schwerpunktthemen seit 1970. Website: http://www.ekd.de/ekd_kirchen/synodenthemen.html (viewed 2. June 2014). Hannover: EKD.

Erbguth, W. and Schlacke, S. (2014): Umweltrecht: Lehrbuch. 5. überarbeitete und erweiterte Auflage. Baden-Baden: Nomos.

Erling, U. M. (2010): Carbon Compliance – Vermögens- und Investitionsschutz in Zeiten des Klimawandels. Corporate Compliance Zeitschrift 5, 188–192.

EU Submission to the ADP (2013): Submission by Lithuania and the European Commission on Behalf of the European Union and its Member States, 16. September 2013. Website: http://unfccc.int/bodies/awg/items/6656.php (viewed 30. June 2014). New York: United Nations Framework Convention on Climate Change (UNFCCC).

EU Commission (2011): GPP in Practice – Lithuania's Central Purchasing Body Introduces GPP. Website: http://ec.europa.eu/environment/gpp/pdf/news_alert/Issue14_Case_Study33_Lithuania_CPMA.pdf (viewed 7. May 2014). Brussels: EU COM.

EU Commission (2012): GPP Green Public Procurement – A Collection of Good Practices – Clean Streets in Barcelona. Website: http://ec.europa.eu/environment/gpp/pdf/GPP_Good_Practices_Brochure.pdf (viewed 5. May 2014). Brussels: EU COM.

EU Commission (2013): Public Procurement in a Nutshell. Website: http://ec.europa.eu/trade/policy/accessing-markets/public-procurement (viewed 2. May 2014). Brussels: EU COM.

EU Commission (2014): Impact Assessment Accompanying the Communication. A Policy Framework for Climate and Energy in the Period from 2020 up to 2030. 2014 XXX Draft. Brussels: EU COM.

Exner, A. (2011): Solidarische Ökonomie statt „Gemeinwohl-Ökonomie". Website: http://www.social-innovation.org/?p=2548 (viewed 09. May 2014). Graz: Social Innovation Network.

Expertengruppe Wissenschaft für Nachhaltigkeit (2013): Wissenschaft für Nachhaltigkeit. Herausforderung und Chance für das baden-württembergische Wissenschaftssystem. Stuttgart: Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg.

Falke, J. (2004): Die Aarhus-Konvention und der Zugang zu Gerichten in Umweltangelegenheiten. In: Falke, J. and Schlacke, S. (eds.): Information – Beteiligung – Rechtsschutz. Neue Entwicklungen im Umwelt- und Verbraucherrecht. Berlin: Rhombos Verlag, 99-130.

Felber, C. (2012): Gemeinwohl-Ökonomie. Vienna: Deuticke.

Felber, C. (2014). Geld: Die neuen Spielregeln. Vienna: Deuticke.

Feola, G. and Nunes, R.J. (2013). Failure and Success of Transition Initiatives: A Study of the International Replication of the Transition Movement. Reading: Walker Institute.

Field, C., Barros, V., Mach, K. and Mastrandrea, M. (2014): Technical Summary. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-76.

Figueres, C. (2014): Faith Leaders Need to Find Their Voice on Climate Change. Website: http://www.theguardian.com/environment/2014/may/07/faith-leaders-voice-climate-change (viewed 2. June 2014). London: The Guardian.

Finke, P. (2014): Citizen Science. Das unterschätzte Wissen der Laien. Munich: oekom.

Fischedick, M., Roy, J., Abdel-Aziz, A., Acquaye, A., Allwood, J., Ceron, J.-P., Geng, Y., Kheshgi, H., Lanza, A., Perczyk, D., Price, L., Santalla, E., Sheinbaum, C. and Tanaka, K. (2014): Industry. Chapter 10. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–114.

Flato, G., Marotzke, J., Abiodun, B., Braconnot, P., Chou, S. C., Collins, W., Cox, P., Driouech, F., Emori, S., V. Eyring, Forest, C., Gleckler, P., Guilyardi, E., Jakob, C., Kattsov, V., Reason, C. and Rummukaine, M. (2013): Evaluation of climate models. Chapter 9. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 741–824.

Fleurbaey, M., Kartha, S., Bolwig, S., Chee, Y. L., Chen, Y., Corbera, E., Lecocq, F., Lutz, W., Muylaert, S., Norgaard, R. B., Okereke, C. and Sagar, A. (2014): Sustainable development and equity. Chapter 4. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–116.

Fossil Free (2014a): Commitments. Website: http://gofossilfree.org/commitments/ (viewed 2. June 2014). Brussels: Fossil Free Europe.

Fossil Free (2014b): It's Wrong to Profit from Wrecking the Climate. Website: http://gofossilfree.org/ (viewed 2. June 2014). Brussels: Fossil Free Europe.

Frank, W. (2013): Klimahaftung und Kausalität – Urteilsanmerkung zur Entscheidung des US Court of Appeals for the Ninth Circuit vom 21.9.2012 im Verfahren Native City of Kivalina v. Exxon Mobil et al. Zeitschrift für Umweltrecht (ZUR) 1, 28–32.

Frank, W. (2014): Überlegungen zur Klimahaftung nach Völkerrecht. Neue Zeitschrift für Verwaltungsrecht Extra 11, 1–8.

French, D. and Rajamani, L. (2013): Climate change and international environmental law: musings on a journey to somewhere. Journal of Environmental Law 25 (3), 437-461.

Friedlingstein, P., Houghton, J., Marland, G., Hackler, J., Boden, T. A., Conway, T. J., Canadell, J. G., Raupach, M. R., Clais, P. and Le Quéré, C. (2010): Update on CO_2 emissions. Nature Geoscience 3, 811–812.

Gabler Wirtschaftslexikon (2014): Begriff "Multi-Stakeholder-Initiative". Website: http://wirtschaftslexikon.gabler.de/Archiv/611744041/multi-stakeholder-initiative-v1.html (viewed 2. June 2014). Wiesbaden: Springer.

GEA – Global Environmental Assessment (2012): Global Energy Assessment – Toward a Sustainable Future. Vienna, Cambridge, New York: International Institute for Applied Systems Analysis (IIASA), Cambridge University Press.

Geden, O. (2008): Strategischer Konsum statt nachhaltiger Politik? Ohnmacht und Selbstüberschätzung des "klimabewussten" Verbrauchers. Transit – Europäische Revue 36, 132–141.

German Climate Finance (2014a): Adaptation Fund (AF). Website: http://www.deutscheklimafinanzierung.de/instrument/adaptation-fund-af/ (viewed 29. May 2014). Berlin, Bonn: Bread for the World, Germanwatch, The Heinrich Böll Foundation, Oxfam Germany.

German Climate Finance (2014b): Green Climate Fund (GCF). Website: http://www.deutscheklimafinanzierung.de/instrument/green-climate-fund-gcf/ (viewed 29. May 2014). Berlin, Bonn: Bread for the World, Germanwatch, The Heinrich Böll Foundation, Oxfam Germany.

German Climate Finance (2014c): Least Developed Countries Fund (LDCF). Website: http://www.deutscheklimafinanzierung.de/instrument/least-developed-countries-fund-ldcf/ (viewed 29. May 2014). Berlin, Bonn: Bread for the World, Germanwatch, The Heinrich Böll Foundation, Oxfam Germany.

German Climate Finance (2014d): Special Climate Change Fund (SCCF). Website: http://www.deutscheklimafinanzierung.de/instrument/special-climate-change-fund-sccf/ (viewed 29. May 2014). Berlin, Bonn: Bread for the World, Germanwatch, The Heinrich Böll Foundation, Oxfam Germany.

GHG – Greenhouse Gas Protocol (2014): City and Community GHG Accounting. Website: http://www.ghgprotocol.org/city-accounting. Washington, DC: GHG.

Global Climate Convergence (2014): Mother Earth Day to May Day. Website: http://globalclimateconvergence.org (viewed 9. July 2014). Madison, WI: Global Climate Convergence.

Gobitec (2014): Welcome to the GOBITEC Initiative. Website: http://www.gobitec.org/ (viewed 24. April 2014). Seoul: Hanns Seidel Foundation Korea.

Goldenberg, S. (10.04.2014): Harvard Faculty Members Urge University to Divest from Fossil Fuels. London: The Guardian.

Gordon, D. J. (2013): Between local innovation and global impact: cities, networks, and the governance of climate change. Canadian Foreign Policy Journal 19 (3), 288–307.

Greene, C. and Kammen, D. M. (2014): E360 Comment: Why the Fossil Fuel Divestment Movement Will Succeed. Yale: Yale School of Forestry and Environmental Studies.

Grin, J., Rotmans, J. and Schot, J. (2010): Transitions to Sustainable Development. New Directions in the Study of Long Term Transformative Change. New York, London: Routledge.

Groß, M., Hoffmann-Riem, H. und Krohn, W. (2005): Realexperimente. Ökologische Gestaltungsprozesse in der Wissensgesellschaft. Bielefeld: Transcript.

Grunwald, A. (2010): Wider die Privatisierung der Nachhaltigkeit. Warum ökologisch korrekter Konsum die Umwelt nicht retten kann. GAIA 19 (3), 178–182.

Gupta, S., Harnisch, J., Barua, D. C., Chingambo, L., Frankel, P., Garrido Vázquez, R. J., Gómez-Echeverri, L., Haites, E., Huang, Y., Kopp, R., Lefèvre, B., de Oliveira Machado-Filho, H. and Massetti, E. (2014): Cross cutting investment and finance issues. Chapter 16. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–63.

Haites, E., Yamin, F. and Höhne, N. (2013): Possible Elements of a 2015 Legal Agreement on Climate Change. Working Paper 16/13. Website: http://www.iddri.org/Publications/Collections/Idees-pour-le-debat/WP1613_EH%20FY%20NH_legal%20agreement%202015.pdf (viewed 30. June 2014). Paris: Institut du développement durable et des relations internationales (IDDRI).

Hanson, S., Nicholls, R., Ranger, N., Hallegatte, S., Corfee-Morlot, J., Herweijer, C. and Chateau, J. (2011): A global ranking of port cities with high exposure to climate extremes. Climatic Change 104, 89–111.

Hartmann, D. L., Klein Tank, A. M. G., Rusticucci, M., Alexander, L. V., Brönnimann, S., Abdul-Rahman Charabi, Y., Dentener, F. J., Dlugokencky, E. J., Easterling, D. R., Kaplan, A., Soden, B. J., Thorne, P. W., Wild, M. and Zhai, P. (2013): Observations: atmosphere and surface. Chapter 2. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 159–254.

Haya, B. (2009): Measuring Emissions Against an Alternative Future: Fundamental Flaws in the Structure of the Kyoto Protocol's Clean Development Mechanism. Berkeley, CA: University of California, Berkeley Energy and Resources Group.

Hedger, M. (2012): Stagnation or Regeneration: Technology transfer in the United Nations Framework Convention on Climate Change. In: Ockwell, O. and Mallet, A. (eds.) Low-Carbon Technology Transfer – From Rhetoric to Reality. London: Routledge.

Heinrichs, D., Aggarwal, R., Barton, J., Bharucha, E., Butsch, C., Fragkias, M., Johnston, P., Kraas, F., Krellenberg, K., Lampis, A., Ooi, G. L. and Vogel, J. (2011): Adapting Cities to Climate Change: Opportunities and Constraints. In: Hoornweg, D., Freira, M., Lee, M. J., Bhada-Tata, P. und Yuen, B. (eds.): Cities and Climate Change. Responding to an Urgent Agenda. The World Bank. Urban Development Series 1. Washington, DC: World Bank, 193–224.

Hijioka, Y., Lin, E., Pereira, J. J., Corlett, R. T., Cui, X., Insarov, G., Lasco, R., Lindgren, E. and Surjan, A. (2014): Asia. Chapter 24. In: IPCC – Intergovernmental Panel on Climate Change (ed.):

Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-68.

Hirschmann, A. O. (1970): Exit, Voice, and Loyalty. Responses to Decline in Firms, Organizations, and States. Cambridge, MA: Cambridge University Press.

Hirschmann, A. O. (1982): Shifting Involvements: Private Interest and Public Action. Princeton, NJ: Princeton University Press.

Höhne, N., Den Elzen, N. and Escalante, D. (2013): Regional GHG reduction targets based on effort sharing: a comparison of studies. Climate Policy 6, 3–27.

Holstenkamp, L. and Ulbrich, S. (2010): Bürgerbeteiligung mittels Fotovoltaikgenossenschaften. Marktüberblick und Analyse der Finanzierungsstruktur. Arbeitspapierreihe Wirtschaft & Recht Nr. 8. Lüneburg: Leuphana University.

Holzer, B. (2007): Einführung: Politik im Supermarkt. In: Geiselberger, H. (ed.): Und jetzt? Politik, Protest und Propaganda. Frankfurt/M.: Suhrkamp, 251–267.

Hopkins, R. (2005) (ed.): Kinsale 2021. An Energy Descent Action Plan. Website: http://transitionculture.org/wp-content/uploads/members/KinsaleEnergyDescentActionPlan.pdf (viewed 11. Mai 2014). Kinsale: Kinsale Further Education College.

Hopkins, R. (2008). Energiewende – Das Handbuch. Anleitungen für zukunftsfähige Lebensweisen. Frankfurt/M.: Zweitausendeins.

Hopkins, R. (2011). The Transition Companion. Making Your Community More Resilient in Uncertain Times. Totnes: Green Books.

Hopkins, R. (2013). The Power of Just Doing Stuff. Cambridge: Green Books.

Hörl, M. (2012): Die Gemeinwohl-Falle. Wie man mit Halb- und Unwahrheiten eine Gesellschaft aufwiegelt. Großgmain: ecobizz.

Horstmann, B. and Schulz-Heiss, G. (2014): Delivering International Adaptation Finance to Vulnerable Communities: A Study on Potentials and Limits of Social Investment Funds. Bonn: German Development Institute (DIE) (forthcoming).

Huber, W. (2007): Es ist nicht zu spät für eine Antwort auf den Klimawandel. Hannover: EKD.

ICJ – International Court of Justice (1999): Kasikili/Sedudu Island (Botswana/Namibia), Judgment. ICJ Reports, 1045-1109. The Hague: ICJ.

ICLEI – Local Governments for Sustainability (2014a): About ICLEI. Website: http://www.iclei.org (viewed 4. January 2014). Bonn: ICLEI.

ICLEI – Local Governments for Sustainability (2014b): ICLEI Local Government Climate Roadmap. Website: www.iclei.org/climate-roadmap (viewed 5. March 2014). Bonn: ICLEI.

ICSU – International Council for Science (2013): Future Earth Research for Global Sustainability. Draft Initial Design Report. Paris: ICSU.

ICTSD (2011): Fostering Low Carbon Growth: The Case for a Sustainable Energy Trade Agreement. Geneva: ICTSD.

IDMC – Internal Displacement Monitoring Centre and NRC – Norwegian Refugee Council (2013): Global Estimates 2012: People Displaced by Disasters. Geneva: IDMC, NRC.

IEA – International Energy Agency (2010): Energy Technology Perspectives 2010. Scenarios & Strategies to 2050. Paris: IEA.

IEA – International Energy Agency (2011): IEA Analysis on Fossil-Fuel Subsidies. Paris: IEA.

IEA – International Energy Agency (2013a): Redrawing the Energy-Climate Map. World Energy Outlook Special Report. Paris: IEA.

IEA – International Energy Agency (2013b): World Energy Outlook 2013 Factsheet. How Will Global Energy Markets Evolve to 2035? Paris: IEA.

IFEES – Islamic Foundation for Ecology and Environmental Science (2013): Activities/Projects. Website: http://www.ifees.org.uk/re-evaluation (viewed 2. June 2014). London: IFEES.

IIGCC – Institutional Investors Group on Climate Change (2014): IIGCC Website. Website: http://www.iigcc.org (viewed 10. June 2014). London: IIGCC.

ILC – International Law Commission (2014): Protection of the Atmosphere. Website: (http://legal.un.org/ilc/guide/8_8.htm (viewed 30. June 2014). New York: ILC (UN).

IMF – International Monetary Fund (2013): Energy Subsidy Reform: Lessons and Implications. Washington, DC: IMF.

Inglehart, R. F. (2008): Changing values among western publics from 1970 to 2006. West European Politics 31 (1–2), 130–146.

Insar Consult (2013): Benchmark-Analyse internationaler Städtenetzwerke und -initiativen. Studie im Auftrag der Deutschen Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Berlin: Insar Consult (unpublished).

IOM – International Organization for Migration (2009): Migration, Climate Change and the Environment: A Complex Nexus. Website: https://www.iom.int/cms/en/sites/iom/home/what-we-do/migration-and-climate-change/a-complex-nexus.html (viewed 25. March 2014). Geneva: IOM.

IPCC – Intergovernmental Panel on Climate Change (2000): IPCC Special Report Emission Scenarios. Geneva: IPCC.

IPCC – Intergovernmental Panel on Climate Change (2001): Climate Change 2001. The Scientific Basis. Contribution of Working Group I. Cambridge, New York: Cambridge University Press.

IPCC – Intergovernmental Panel on Climate Change (2007a): Climate Change 2007. The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report. Full Report. Cambridge, New York: Cambridge University Press.

IPCC – Intergovernmental Panel on Climate Change (2007b): Climate Change 2007. Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Fourth Assessment Report. Cambridge, New York: Cambridge University Press.

IPCC – Intergovernmental Panel on Climate Change (2013a): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Full Report. Cambridge, New York: Cambridge University Press.

IPCC – Intergovernmental Panel on Climate Change (2013b): Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press.

IPCC – Intergovernmental Panel on Climate Change (2014a): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC.

IPCC – Intergovernmental Panel on Climate Change (2014b): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC.

IPCC – Intergovernmental Panel on Climate Change (2014c): Summary for Policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Cambridge, New York: Cambridge University Press.

IPCC – Intergovernmental Panel on Climate Change (2014d): Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Cambridge, New York: Cambridge University Press.

ITUC – International Trade Union Confederation (2010): Trade Unions Recommendations for Cancun's Deliberations of the AWG-LCA. 16th Conference of the Parties (COP16). Website: http://www.ituc-csi.org/IMG/pdf/COP16_ITUC_Recommendations-2.pdf (viewed 9. July 2014). Brussels: ITUC.

Jackson, T. (2009): Wohlstand ohne Wachstum. Leben und Wirtschaften in einer endlichen Welt. Munich: oekom.

Jiménez Cisneros, B. E., Arnell, N. W., Benito, G., Cogley, J. G., Döll, P., Jiang, T. and Mwakalila, S. S. (2014): Freshwater resources. Chapter 3. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adapta-

tion and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–76.

Jonas, H. (1979): Das Prinzip Verantwortung. Versuch einer Ethik für die technologische Zivilisation. Frankfurt/M.: Suhrkamp.

Jordan, A., Rayner, T., Schroeder, H., Adger, N., Anderson, K., Bows, A., Le Quéré, C., Joshi, M., Mander, S., Vaughan, N. and Whitmarsh, L. (2013): Going beyond two degrees? The risks and opportunities of alternative options. Climate Policy 13 (6), 751–769.

Jordan, A., Wurzel, R. K. W. and Zito, A. R. (2003): 'New' Instruments for Environmental Governance? National Experiences and Prospects. London: Frank Cass.

Joughin, I., Smith, B. E. and Medley, B. (2014): Marine ice sheet collapse potentially under way for the Thwaites Glacier Basin, West Antarctica. Science 344 (6185), 735-738.

Julius Raab Stiftung (2012): Anschlag auf unseren Wohlstand? Wie die Gemeinwohl-Ökonomie unsere Soziale Marktwirtschaft zerstören will. Vienna: Julius Raab Stiftung.

Kals, E., Syme, G. J., Kärcher, J. D., Müller, M. M. and Nancarrow, B. E. (2005): Community views of fairness in environmental conflicts: Evidence from Germany and Australia. Journal of Environmental Systems 31 (2), 117–140.

KBSS – KlimaBündnis-Städte Schweiz (2014): KlimaBündnis-Städte Schweiz (KBSS). Weg vom Wachstum – Wege zur 2000-Watt-Gesellschaft! Website: http://www.klimabuendnis.ch/ (viewed 14. April 2014). Berne: KBSS.

Kemfert, C. and Horne, J. (2013): Good Governance of the Energiewende in Germany: Wishful Thinking or Manageable? Berlin: Hertie School of Governance.

Kirtman, B., Power, S. B., Adedoyin, J. A., Boer, G. J., Bojariu, R., Camilloni, I., Doblas-Reyes, F. J., Fiore, A. M., Kimoto, M., Meehl, G. A., Prather, M., Sarr, A., Schär, C., Sutton, R., Oldenborgh, G. J. v., Vecchi, G. and Wan, H. J. (2013): Near-term climate change: projections and predictability. Chapter 11. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 953–1008.

Klima-Allianz Deutschland (2014): Energiewende nicht kentern lassen! Website: http://www.die-klima-allianz.de/energiewende-nicht-kentern-lassen-grossdemonstration-am-10-mai-in-berlin (viewed 9. July 2014). Berlin: Klima-Allianz Deutschland.

Klimzug – Klimawandel in Regionen (2013): Über Klimzug. Website: http://www.klimzug.net/160.php (viewed 4. June 2014). Bonn: Federal Ministry of Education and Research (BMBF), Fördermaßnahme Klimzug.

Klimzug Nordhessen – Klimawandel in Regionen (2012): Klimawandel: Neue Gefahr durch Zecken und Mückenstiche? Website: http://www.klimzug.de/de/353.php (viewed 12. May 2014). Bonn: Federal Ministry of Education and Research (BMBF), Fördermaßnahme Klimzug.

Klöckner, C. and Verplanken, C. (2012): Yesterday's habits preventing change for tomorrow? The influence of automaticity on environmental behaviour. In: Steg, L., van den Berg, A. E. and de Groot, J. I. M. (eds.): Environmental Psychology – An Introduction. London, Chichester: Wiley, 197–209.

Kolstad, C., Urama, K., Broome, J., Bruvoll, A., Olvera, M. C., Fullerton, D., Gollier, C., Hanemann, W. M., Hassan, R., Jotzo, F., Khan, M. R., Meyer, L. and Mundaca, L. (2014): Social, economic and ethical concepts and methods. Chapter 3. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–130.

Kovats, S., Valentini, R., Bouwer, L. M., Georgopoulou, E., Jacob, D., Martin, E., Rounsevell, M. and Sossana, J.-F. (2014): Europe. Chapter 23. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-93.

Kraas, F. (2012): Das Hochwasser 2011 in Bangkok. Geographische Rundschau 64 (1), 58-61.

Kreft, S. and Bals, C. (2013): Warschau, Lima, Paris – Im Dreisprung zum Klimaabkommen. Ausblick auf den Klimagipfel COP 19 in Warschau. Hintergrundpapier. Website: https://germanwatch.org/de/download/8413.pdf (viewed 30. June 2014). Bonn, Berlin: Germanwatch e.V.

Kreft, S., Weischer, L., Bals, C., Eckstein, D., Gerber, K., Junghans, L., Kaloga, A., Schwarz, R. and Treber, M. (2013): Schwaches Ergebnis trotz Verlängerung beim Klimagipfel im Warschauer Stadion – Ein internationales Abkommen braucht neue Spieler, besseren Spielaufbau und südamerikanische Dynamik. Hintergrundpapier. Bonn: Germanwatch.

Kreibich, N. and Fechtner, H. (2013): Potentiale ausgeschöpft und Hürden überwunden? CDM und JI in der ersten Kyoto-Verpflichtungsperiode. Wuppertal: Wuppertal Institute for Climate, Environment and Energy.

Kriegler, E., Riahi, K., Petermann, N., Bosetti, V., Capros, P., van Vuuren, D. P., Criqui, P., Egenhofer, C., Fragkos, P., Johnson, N., Paroussos, L., Behrens, A. and Edenhofer, O. (2014): Assessing Pathways toward Ambitious Climate Targets at the Global and European Levels. A Synthesis of Results from the AMPERE Project. Berlin: AMPERE Project.

Kunreuther, H., Gupta, S., Bosetti, V., Cooke, R., Dutt, V., Ha-Duong, M., Held, H., Llanes-Regueiro, J., Patt, A., Shittu, E. and Weber, E. (2014): Integrated risk and uncertainty assessment of climate change response policies. Chapter 2. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–92.

Lamla, J. (2013): Verbraucherdemokratie. Politische Soziologie der Konsumgesellschaft. Berlin: Suhrkamp.

Lange, A., Löschel, A., Vogt, C. and Ziegler, A. (2010): On the self-interested use of equity in international climate negotiations. European Economic Review 54 (3), 359-375.

Le Quéré, C., Peters, G. P., Andres, R. J., Andrew, R. M., Boden, T. A., Ciais, P., Friedlingstein, P., Houghton, R. A., Marland, G., Moriarty, R., Sitch, S., Tans, P., Arneth, A., Arvanitis, A., Bakker, E., Bopp, L., Canadell, J. G., Chini, L. P., Doney, S. C., Harper, A., Harris, I., House, J. I., Jain, A. K., Jones, S. D., Kato, E., Keeling, R. F., Klein Goldewijk, K., Körtzinger, A., Koven, C., Lefèvre, N., Omar, A., Ono, T., Park, G.-H., Pfeil, B., Poulter, B., Raupach, M. R., Regnier, P., Rödenbeck, C., Saito, S., Schwinger, J., Segschneider, J., Stocker, B. D., Tilbrook, B., van Heuven, S., Viovy, N., Wanninkhof, R., Wiltshire, A. and Zaehle, S. (2013): Global Carbon Budget 2013. Earth System Science Data Discussion. Website: http://www.globalcarbonproject.org/carbonbudget/13/contributions.htm (viewed 30. June 2014). Canberra: Global Carbon Project.

Lee, T. (2011): Why do cities participate in global climate networks? Global Environmental Politics 13 (1), 108–128.

Lenton, T. M., Held, H., Kriegler, E., Hall, J. W., Lucht, W., Rahmstorf, S. and Schellnhuber, H. J. (2008): Tipping elements in the Earth's climate system. PNAS 105 (6), 1786–1793.

Levermann, A. (2014): Climate economics: make supply chains climate-smart. Nature 506, 27–29.

Liefferink, D., Veenman, S. and Wiering, M. (2013): Pioneers revisited: broadening the pioneers concept in European Union environmental policy. In: Monaghan, E., Wurzel, R., A. E. G., J., Gibbs, D., Connelly, J. and Eden, S. (eds.): New Climate Alliances. Gutachten des Centre for European Union Studies und dem Centre for Low Carbon Futures. York: Centre for Low Carbon Futures, 9–12.

Lindenberg, N. and Pauw, P. (2013): Minderungs- und Anpassungsfinanzierung sind grundverschieden – schmeißt sie nicht in einen Topf! Bonn: German Development Institute (DIE).

Locke, E. A. and Latham, G. P. (1990): A Theory of Goal-Setting and Task Performance. Englewood Cliffs, NJ: Prentice Hall.

Lucon, O., Ürge-Vorsatz, D., Ahmed, A. Z., Akbari, H., Bertoldi, P., Cabeza, L. F., Eyre, N., Gadgil, A., Harvey, L. D. D., Jiang, Y., Liphoto, E., Mirasgedis, S., Murakami, S., Parikh, J., Pyke, C. and Vilariño, V. (2014): Buildings. Chapter 9. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–105.

Marzeion, B. and Levermann, A. (2014): Loss of cultural and world heritage and currently inhabited places to sea-level rise. Environmental Research Letters 9, 7.

Mathesius, S., Hofmann, M., Caldeira, K. and Schellnhuber, H. J. (in preparation): Deep sea memory of high atmospheric CO_2 concentration.

McCann, E. J. and Ward, K. (eds.) (2011): Mobile Urbanism. Cities and Policymaking in the Global Age. Minneapolis, London: University of Minnesota Press.

McDonald, A. und Schrattenholzer, L. (2001): Learning rates for energy technologies. Energy Policy, 29, 255-261

McGranahan, G., Balk, D. and Anderson, B. (2007): The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. Environment & Urbanization 19 (1), 17–37.

McMichael, T., Montgomery, H. and Costello, A. (2012): Health risks, present and future, from global climate change. The BMJ 344, e1359.

Meinshausen, M., Meinshausen, N., Hare, W., Raper, S. C. B., Frieler, K., Knutti, R., Frame, D. J. and Allen, M. R. (2009): Greenhouse-gas emission targets for limiting global warming to 2°C. Nature 458, 1158–1161.

Meinshausen, M., Smith S. J., Calvin K., Daniel J. S., Kainuma, M. L. T., Lamarque, J-F., Matsumoto, K., Montzka, S. A., Raper, S. C. B., Riahi, K., Thomson, A., Velders, G. J. M. and van Vuuren, D. P. P. (2011): The RCP greenhouse gas concentrations and their extensions from 1765 to 2300. Climatic Change, DOI 10.1007/s10584-011-0156-z.

Mersmann, F. and Hermwille, L. (2014): Technology Cooperation. Update on the Technology Mechanism and Options for Using Carbon Markets. JIKO Policy Brief Nr. 1. Wuppertal: Wuppertal Institute.

Micheletti, M. (2003): Political Virtue and Shopping Individuals, Consumerism and Collective Action. New York: Palgrave Macmillan.

Micheletti, M. and Stolle, D. (2005): The concept of political consumerism. In: Sherrod, L. R. (ed.): Youth Activism – An International Encyclopedia. Westport: Greenwood Publishing, 238–250.

Micheletti, M., Stolle, D. and Berlin, D. (2012): Habits of sustainable citizenship: the example of political consumerism. In: Warde, A. and Southerton, D. (eds.): The Habits of Consumption, COLLeGIUM of Studies Across Disciplines in the Humanities and Social Sciences. Volume 12. Helsinki: Helsinki Collegium for Advanced Studies, 142–164.

Milne, J. L. and Field, C. B. (2012): Assessment Report from the GCEP Workshop on Energy Supply with Negative Carbon Emissions. Stanford: Global Climate and Energy Project, Stanford University.

Mistra Urban Futures (2014): Cape Town – City of Extremes. Website: http://www.mistraurbanfutures.org/en/node/13 (viewed 22. May 2014). Cape Town, Gothenburg, Greater Manchester: Mistra Urban Futures.

Monaghan, E., Wurzel, R., Jonas, A. E. G., Gibbs, D., Connelly, J. and Eden, S. (eds.) (2013): New Climate Alliances. Study. Birmingham: Centre for European Union Studies (CEUS), Centre for Low Carbon Futures.

Morgan, J., Tirpak, D., Levin, K. and Dagnet, Y. (2013): A Pathway to a Climate Change Agreement in 2015: Options for Setting and Reviewing GHG Emission Reduction Offers. Working Paper. Website: http://www.wri.org/sites/default/files/options_for_setting_and_reviewing_ghg_emission_reduction_offers.pdf (viewed 30. June 2014). Washington, DC: World Resources Institute (WRI).

Morton, R. B. and Williams, K. C. (2010): Experimental Political Science and the Study of Causality. Cambridge, New York: Cambridge University Press.

MPP – Medicines Patent Pool (2014): About the MPP. Website: http://www.medicinespatentpool.org/about/ (viewed 8. July 2014). Geneva: MPP.

Myers, N. (2005): Environmental Refugees. An Emergent Security Issue. Paper Presented at 13th OSCE Economic Forum, Prague, 23–27 May 2005. Website: http://www.osce.org/node/14851 (viewed 9. July 2014). Vienna: Organization for Security and Co-operation in Europe (OSCE).

Neuhoff, K., Fankhauser, S., Guerin, E., Hourcade, J. C., Jackson, H., Rajan, R. and Ward, J. (2010): Structuring International Financial Support to Support Domestic Climate Change Mitigation in Developing Countries. Cambridge, UK: Climate Strategies, University of Cambridge.

Nevens, F., Frantzeskaki, N., Gorissen, L. and Loorbach, D. (2013): Urban Transition Labs: co-creating transformative action for sustainable cities. Journal of Cleaner Production. Special Issue "Bridges for a More Sustainable Future: Uniting Continents and Societies" 50, 111–122.

Ngwadla, X., Abeysinghe, A. C. and Freitas, A. (2013): The 2015 Climate Agreement: Lessons from the Bali Road Map. Website: http://www.eurocapacity.org/downloads/2015ClimateAgreement.pdf (viewed 30. June 2014). Oxford: European Capacity Building Initiative (ECBI).

Niang, I., Ruppel, O. C., Abdrabo, M., Essel, A., Lennard, C., Padgham, J. and Urquhart, P. (2014): Africa. Chapter 22. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-115.

Nicholls, R. J., Marinova, N., Lowe, J. A., Brown S., Vellinga, P., de Gusmão, D., Hinkel, J. and Tol, R. S. J. (2011): Sea-level rise and its possible impacts given a 'beyond 4°C world' in the twenty-first century. Philosophical Transactions of the Royal Society A 13 369 (1934), 161–181.

Nordhaus, W. D. (2013): The Climate Casino: Risk, Uncertainty, and Economics for a Warming World. New Haven: Yale University Press.

Nordkirche (2014): Lübecker Gemeindegruppe testet ein Leben ohne Kunststoff. Website: http://www.umwelt-nek.de/leben-ohne-kunststoff/#more-805/ (viewed 2. June 2014). Lübeck: Evangelical Church in Germany.

North, P. (2010). Local Money: How to Make it Happen in your Community. Totnes: Green Books.

Nowotny, H., Scott, P. and Gibbons, M. (2011): Re-Thinking Science. Knowledge and the Public in an Age of Uncertainty. Oxford: Blackwell Publishers.

O'Hara, E. (2013): Local Communities Leading the Way to a Low-Carbon Society. Website: http://aeidl.eu/images/stories/pdf/transition-final.pdf (viewed 02. May 2014). Brussels: L'Association Européenne pour l'Information sur le Développement Local (AEIDL).

Ockwell, D., Haum, R., Mallet, A. and Watson, J. (2010): Intellectual property rights and low carbon technology transfer: Conflicting discourses of diffusion and development. Global Environmental Change 20, 729–738.

OECD – Organisation for Economic Co-operation and Development (2013): Mapping out Good Practices for Promoting Green Public Procurement. OECD Meeting of Leading Practitioners on Public Procurement, 11–12 February 2013, Paris. GOV/PGC/ETH(2013)3. Paris: OECD.

OECD – Organisation for Economic Co–operation and Development (2014): A Call for Zero Net Emissions. Paris: OECD.

Oekonews.at (2014): Frankreich: 50% aller staatlichen Dienstfahrzeuge bis 2016 elektrisch. Website: http://www.oekonews.at/index.php?mdoc_id=1093238 (viewed 12. August 2014). Orth/Donau: Oekonews.at.

Olson, M. (1965): The Logic of Collective Action: Public Goods and the Theory of Groups, Harvard University Press.

Oppenheimer, M., Campos, M., Birkmann, J., Luber, G., O´Neill, B. and Takahashi, K. (2014): Emergent risks and key vulnerabilities. Chapter 19. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-107.

ORF – Österreichischer Rundfunk (2014): Papst schreibt Enzyklika über Ökologie. Website: http://religion.orf.at/stories/2627394/ (viewed 25. Juni 2014). Vienna: ORF.

Osterhammel, J. (2009): Die Verwandlung der Welt. Eine Geschichte des 19. Jahrhunderts. Munich: Beck.

Ostrom, E. (2009): A Polycentric Approach for Coping with Climate Change. Policy Research Working Paper 5095. Washington, DC: World Bank.

OurVoices (2014): Bringing Faith to Climate Talks. Website: http://ourvoices.net/ (viewed 2. June 2014). London: Conservation Foundation.

Oxford Academics for Fossil Fuel Divestment (2014): The Open Letter. Website: http://oxfordacademicsfordivestment.wordpress.com (viewed 5. Juni 2014). Oxford, New York: Oxford Academics for Fossil Fuel Divestment.

Paech, N. (2012): Befreiung vom Überfluss: Auf dem Weg in die Postwachstumsökonomie. Munich: oekom.

Palmer, M. and Finlay, V. (2002): Faith in Conservation – New Approaches to Religions and the Environment. Washington, DC: World Bank.

Pauw, P. and Dzebo, A. (2014): Technische Fragen dürfen die Klimafinanzierung nicht ausbremsen. Die Aktuelle Kolumne. Bonn: German Development Institute (DIE).

Pauw, P. and Pegels, A. (2013): Private sector engagement in climate change adaptation in least developed countries: an exploration. Climate and Development 5 (4), 257-267.

Petrin, J. (2012). Nexthamburg: Bürgervisionen für eine neue Stadt. Hamburg: Edition Körber-Stiftung.

PIK – Potsdam Institute for Climate Impact Research (2014): Details on the 4th Nobel Laureates Symposium on Global Sustainability in Hong Kong from 8th to 11th October 2014. Website: http://www.nobel-cause.de/hong-kong-2014 (viewed 9. July 2014). Potsdam: PIK.

Pinkerton, T. and Hopkins, R. (2009). Local Food: How to Make it Happen in Your Community. Totnes: Green Books.

Polanyi, K. (1944): "The Great Transformation: The Political and Economic Origins of Our Time". New York: Farrar & Rinehart.

Porter, J. R., Xie, L., Challinor, A., Cochrane, K., Howden, M., Iqbal, M. M., Lobell, D. and Travasso, M. I. (2014): Food security and food production systems. Chapter 7. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-82.

Pörtner, H.-O., Karl, D., Boyd, P. W., Cheung, W., Lluch-Cota, S. E., Nojiri, L., Schmidt, D. and Zavialov, P. (2014): Ocean systems. Chapter 6. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-138.

Poteete, A. R., Janssen, M. A. and Ostrom, E. (2010): Working Together: Collective Action, the Commons, and Multiple Methods in Practice. Princeton, NJ: Princeton University Press.

PWC – Price Waterhouse Coopers, Significant and Ecofys (2009): Collection of Statistical Information on Green Public Procurement in the EU. Report on Data Collection Results. Arnheim: PWC.

Ralston, H., Horstmann, B. and Holl, C. (2004): Klimawandel. Eine Herausforderung für Tuvalu. Informationsbroschüre. Bonn, Berlin: Germanwatch.

Readfern, G. (2014): Pope Francis Urged to Back Fossil Fuel Divestment Campaign. Website: http://www.theguardian.com/environment/2014/apr/16/pope-francis-back-fossil-fuel-divestment-campaign-religions-groups (viewed 7. May 2014). London: The Guardian.

RELIEF – Research on Green Purchasing and ICLEI – The International Council for Local Environmental Initiatives (2002): Eco-Procurement – The Path to a Greener Marketplace. Freiburg: ICLEI European Secretariat.

Revi, A., Satterthwaite, D., Aragón-Durand, F., Corfee-Morlot, J., Kiunsi, R. B. R., Pelling, M., Roberts, D. and Solecki, W. D. (2014): Urban areas. Chapter 8. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-113.

RGI – Renewables-Grid-Initiative (2014): Mission Statement. Website: http://renewables-grid.eu/about/mission.html (viewed 6. March 2014). Berlin: RGI.

Rhein, M., Rintoul, S. R., Aoki, S., Campos, E., Chambers, D., Feely, R. A., Gulev, S., Johnson, G. C., Josey, S. A., Kostianoy, A., Mauritzen, C., Roemmich, D., Talley, L. D. and Wang, F. (2013): Observations: ocean. Chapter 3. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 255–297.

Robinson, A., Calov, R. and Ganopolski, A. (2012): Multistability and critical thresholds of the Greenland ice sheet. Nature Climate Change 2 (6), 429-432.

Romani, M. and Stern, N. (2011): Delivering Climate Finance: Principles and Practice for Funding the Fund. Policy Paper. London: Centre for Climate Change Economics and Policy. Grantham Research Institute on Climate Change and the Environment.

Sassatelli, F. and Davolio, F. (2010): Consumption, pleasure and politics: slow food and the politico-aesthetic problematization of food. Journal of Consumer Culture 10 (2), 202–232.

Schinke, B. and Klawitter, J. (2011): Desertec and Human Development at the Local Level in the MENA-Region. A Human Rights-Based and Sustainable Livelihoods Analysis. Stuttgart: Germanwatch and Bread for the World.

Schlacke, S. (2008): Überindividueller Rechtsschutz. Phänomenologie und Systematik überindividueller Klagebefugnisse im Verwaltungs- und Gemeinschaftsrecht, insbesondere am Beispiel des Umweltrechts. Tübingen: Mohr Siebeck.

Schlacke, S. (2014a): Grenzwert oder Politikziel? Dogmatik und Legitimität der 2°C-Leitplanke. In: Dilling, O. and Markus, T. (eds.): Ex Rerum Natura Ius? – Sachzwang und Problemwahrnehmung im Umweltrecht.Tagungsband anlässlich des 70. Geburtstags von Prof. Dr. Dr. h.c. Gerd Winter. Baden-Baden: Nomos, 93–103.

Schlacke, S. (2014b): Zur fortschreitenden Europäisierung des (Umwelt-)Rechtsschutzes. Neue Zeitschrift für Verwaltungsrecht (NVwZ) 1–2, 11–18.

Schlacke, S., Schrader, C. and, Bunge, T. (2010): Informationsrechte, Öffentlichkeitsbeteiligung und Rechtsschutz im Umweltrecht. Aarhus-Handbuch. Berlin: Erich Schmidt Verlag.

Schleich, J., Dütschke, E., Schwirplies, C. and Ziegler, A. (2014): Citizens' Perceptions of Justice in International Climate Policy – An Empirical Analysis. Working Paper Sustainability and Innovation No. 2. Karlsruhe: Fraunhofer ISI.

Schlesinger, M. E., Lindenberger, D. and Lutz, C. (2010): Energieszenarien für ein Energiekonzept der Bundesregierung. Studie. Basel, Cologne, Osnabrück: EWI, GWS, Prognos.

Schlesinger, M., Lindenberger, D. and Lutz, C. (2011): Energieszenarien 2011. Basel, Cologne, Osnabrück: ewi, gws, prognos.

Schneider, L. (2009): Assessing the additionality of CDM projects: practical experiences and lessons learned. Climate Policy 9 (3), 242–254.

Schneidewind, U. (2013a): Plädoyer für eine Bürgeruniversität. duzMAGAZIN 8, 30–31.

Schneidewind, U. (2013b): Transformative Literacy. Rahmen für den wissensbasierten Umgang mit der "Großen Transformation". GAIA 22 (2), 82–86.

Schneidewind, U. and Scheck, H. (2012): Die Stadt als „Reallabor" für Systeminnovationen. In: Rückert-John, J. (ed.): Soziale Innovation und Nachhaltigkeit. Perspektiven sozialen Wandels. Wiesbaden: Springer VS, 229–248.

Schneidewind, U. and Singer-Brodowski, M. (2013): Transformative Wissenschaft. Marburg: Metropolis.

Scholes, R., Settele, J., Betts, R., Bunn, S., Leadley, P., Nepstad, D., Overpeck, J. and Taboada, M. A. (2014): Terrestrial and inland water systems. Chapter 4. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-153.

Schoof, C. (2007): Marine ice-sheet dynamics. Part 1. The case of rapid sliding. Journal of Fluid Mechanics 573, 27–55.

SE4All – Sustainable Energy for All Initiative (2014): Sustainable Energy for All. Website: http://www.se4all.org (viewed 4. April 2014). Vienna: SE4All.

Seto, K. C., Dhakal, S., Bigio, A., Blanco, H., Delgado, G. C., Dewar, D., Huang, L., Inaba, A., Kansal, A., Lwasa, S., McMahon, J., Mueller, D., Murakami, S., Nagendra, H. and Ramaswami, A. (2014): Human settlements, infrastructure and spatial planning. Chapter 12. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–127.

Sikora, J. and Hoffmann, G. (2001): Vision einer Gemeinwohl-Ökonomie – auf der Grundlage einer komplementären Zeit-Währung. Cologne: Katholisch-Soziales Institut der Erzdiözese Köln.

Sims, R., Schaeffer, R., Creutzig, F., Cruz-Núñez, X., D'Agosto, M., Dimitriu, D., Figueroa Meza, M. J., Fulton, L., Kobayashi, S., Lah, O., McKinnon, A., Newman, P., Ouyang, M., Schauer, J. J., Sperling, D. and Tiwari, G. (2014): Transport. Chapter 8. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–117.

Smith, K. R., Woodward, A., Campbell-Lendrum, D., Chadee, D., Honda, Y., Liu, Q., Olwoch, J., Revich, B. and Sauerborn, R. (2014a): Human health: impacts, adaptation, and co-benefits. Chapter 11. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-69.

Smith, P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E. A., Haberl, H., Harper, R., House, J. I., Jafari, M., Masera, O., Mbow, C., Ravindranath, N. H., Rice, C. W., Abad, C. R., Romanovskaya, A., Sperling, F. and Tubiello, F. N. (2014b): Agriculture, Forestry and Other Land Use (AFOLU). Chapter 11. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–181.

Spalding-Fecher, R., Achanta, A. N., Erickson, P., Haites, E., Lazarus, M., Pahula, N., Pandey, N., Seres, S. and Tewari, R. (2012): Assessing the Impact of the Clean Development Mechanism, Report Commissioned by the High-Level Panel on the CDM Policy Dialogue. Luxembourg: UNCCD Secretariat.

Stanley, J., Loy, D. and Dorje, G. (2009): A Buddhist Response to The Climate Emergency. Somerville: Wisdom Publications.

Starkey, R. and Anderson, K. (2005): Investigating Domestic Tradable Quotas: A Policy Instrument for Reducing Greenhouse Gas Emissions From Energy Ese. Tyndall Technical Report 39. Manchester: Tyndall Centre for Climate Change Research.

Stavins, R., Ji, Z., Brewer, T., Conte Grand, M., den Elzen, M., Finus, M., Gupta, J., Höhne, N., Lee, M.-K., Michaelowa, A., Paterson, M., Ramakrishna, K., Wen, G., Wiener, J. and Winkler, H. (2014): International cooperation: agreements and instruments. Chapter 13. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report. Draft. Geneva: IPCC, 1–139.

Sterk, W., Beuermann, C., Dienst, C., Hillebrandt, K., Hermwille, L., Lechtenböhmer, S., Luhmann, H., Mersmann, F., Samadi, S., Thomas, S. and Wehnert, T. (2013b): Submission to the Ad Hoc Working Group on the Durban Platform for Enhanced Action, Workstream 1: The 2015 Agreement. Website: http://wupperinst.org/uploads/tx_wupperinst/ADP-WS1-Submission-Wuppertal-Institute.pdf (viewed 30. June 2014). Wuppertal: Wuppertal Institute.

Sterk, W., Beuermann, C., Luhmann, H.-J., Mersmann, F., Thomas, S. and Wehnert, T. (2013a): Input to the European Commission Stakeholder Consultation on the 2015 International Climate Change Agreement: Shaping International Climate Policy Beyond 2020. Website: http://epub.wupperinst.org/frontdoor/index/index/docId/4927 (viewed 30. June 2014). Wuppertal: Wuppertal Institute.

Stern, N. (2006): Stern Review: The Economics of Climate Change. London: HM Treasury.

Surminski, S. (2013): Private sector adaptation to climate risk. Nature Climate Change 3, 943–945.

Stiftung 2° (2013): Grundsatzpapier der Stiftung 2°. Deutsche Unternehmer für Klimaschutz. Website: http://www.stiftung-2grad.de/die-stiftung/grundsatzpapier/ (viewed 10. March 2014). Berlin: Stiftung 2°.

Stocker, T. F., Qin, D., Plattner, G.-K., Alexander, L. V., Allen, S. K., Bindoff, N. L., BreÅLon, F.-M., Church, J. A., Cubasch,U., Emori, S., Forster, P., Friedlingstein, P., Gillett, N., Gregory, J. M., Hartmann, D. L., Jansen, E., Kirtman, B., Knutti, R., Krishna Kumar, K., Lemke, P., Marotzke, J., Masson-Delmotte, V., Meehl, G. A., Mokhov, I. I., Piao, S., Ramaswamy, V., Randall, D., Rhein, M., Rojas, M., Sabine, C., Shindell, D., Talley, L. D., Vaughan, D. G. and Xie, S.-P. (2013): Technical Summary. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 33–115.

Stolle, D., Hooghe, M. and Micheletti, M. (2005): Politics in the supermarket: political consumerism as a form of political participation. International Political Science Review 26 (5), 245–269.

TEC – Technology Executive Committee (2013): Results and Success Factors of TNAs. TEC Brief. Bonn: UNFCCC Secretariat.

Thinktankmap (2014): A Worldwide Observatory of Climate Think Tanks. Website: http://www.thinktankmap.org (viewed 14. July 2014). Venice: International Center for Climate Governance.

Tilly, C. and Tarrow, S. (2006): Contentious Politics. Boulder, CO, London: Paradigm Publishers.

Touraine, A. (1993): La Voix et le Regard Sociologie des Mouvements Sociaux. Paris: Les Éditions du Seuil.

Transition Network (2014): Transition Network´s Draft Strategy 2014/2017. Website: http://www.transitionnetwork.org/strategy (viewed 8. July 2014). Totnes: Transition Network.

UBA – Federal Environment Agency and BMUB – Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (2014): Wirtschaftsfaktor Umweltschutz. Produktion – Außenhandel – Forschung – Patente: Die Leistungen der Umweltschutzwirtschaft in Deutschland. Berlin, Dessau: UBA, BMUB.

UN-Habitat – United Nations Human Settlements Programme (2011): Global Report on Human Settlements 2011: Cities and Climate Change. Nairobi: UN-Habitat.

UNCED – United Nations Conference on Environment and Development (1992): Rio Declaration on Environment and Development. Rio de Janeiro: UNCED.

UNEP – United Nations Environment Programme (2012b): Global Initiative for Resource Efficient Cities. Website: http://www.unep.org/pdf/GI-REC_4pager.pdf (viewed 11. June 2014). Paris: UNEP Division of Technology, Industry and Economics.

UNEP – United Nations Environment Programme (2012a): Asia and the Pacific Adaptation Network. Website: http://www.unep.org/roap/Activities/ClimateChange/AsiaandthePacificAdaptationNetwork/tabid/6837/Default.aspx (viewed 12. May 2014). Bangkok: UNEP Regional Office for Asia Pacific.

UNEP – United Nations Environment Programme (2013a): The Emissions Gap Report 2013. A UNEP Synthesis Report. Nairobi: UNEP.

UNEP – United Nations Environment Programme (2013b): Sustainable Public Procurement: A Global Review. Final Report. Nairobi: UNEP.

UNFCCC – United Nations Framework Convention on Climate Change (1995): The Subsidiary Bodies Established by the Convention. COP Decision 6/CP.1. Bonn: UNFCCC.

UNFCCC – United Nations Framework Convention on Climate Change (2001): Implementation of Article 4, paragraphs 8 and 9, of the Convention (Decision 3/CP.3 and Article 2, paragraph 3, and Article 3, paragraph 14, of the Kyoto Protocol). COP Decision 5/CP.7. Bonn: UNFCCC.

UNFCCC – United Nations Framework Convention on Climate Change (2010): The Cancun Agreements: Outcome of the Work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention. COP Decision 1/CP.1. Bonn: UNFCCC.

UNFCCC – United Nations Framework Convention on Climate Change (2011): Establishment of an Ad Hoc Working Group

on the Durban Platform for Enhanced Action. COP Decision 1/CP.17. Bonn: UNFCCC.

UNFCCC – United Nations Framework Convention on Climate Change (2012): Agreed Outcome pursuant to the Bali Action Plan. COP Decicion 1/CP.18. Bonn: UNFCCC.

UNFCCC- United Nations Framework Convention on Climate Change (2013a): Further advancing the Durban Platform. COP Decision 1/CP.19. Bonn: UNFCCC.

UNFCCC – United Nations Framework Convention on Climate Change (2013b): Warsaw International Mechanism for Loss and Damage Associated with Climate Change Impacts. COP Decision 2/CP.19. Bonn: UNFCCC.

UNIDO – United Nations Industrial Development Organization (2013): Industrial Development Report 2013. Sustaining Employment Growth: The Role of Manufacturing and Structural Change. Vienna: UNIDO.

van Vuuren, D. P., Edmonds, J., Kainuma, M., Riahi, K., Thomson, A., Hibbard, K., Hurtt, G. C., Kram, T., Krey, V., Lamarque, J.-F., Masui, T., Meinshausen, M., Nakicenovic, N., Smith, S. J. and Rose, S. K. (2011): The representative concentration pathways: an overview. Climatic Change 109, 5–31.

Vatican Radio (2014): Pope at Audience: If we Destroy Creation, It will Destroy Us. Website: http://www.news.va/en/news/pope-at-audience-if-we-destroy-creation-it-will-de (viewed 2. June 2014). Vatikanstadt: Offical Vatican Network.

Vaughan, D. G., Comiso, J. C., Allison, I., Carrasco, J., Kaser, G., Kwok, R., Mote, P., Murray, T., Paul, F., Ren, J., Rignot, E., Solomina, O., Steffen, K. and Zhang, T. (2013): Observations: cryosphere. Chapter 4. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press, 317–333.

Verein zur Förderung der Gemeinwohl-Ökonomie (2013): Handbuch zur Gemeinwohl-Bilanz. Vienna: Verein zur Förderung der Gemeinwohl-Ökonomie.

Verolme, H., Yamin, F., Menotti, V. and Fuhr, L. (2013): What Future for International Climate Politics? A Call for a Strategic Reset. Policy Paper. Berlin: The Heinrich Böll Foundation.

Vidican, G., Böhning, M., Burger, G., de Siqueira Regueira, E., Müller, S. and Wendt, S. (2014): Achieving Inclusive Competitiveness in the Emerging Solar Energy Sector in Morocco. DIE Studies 79. Bonn: German Development Institute (DIE).

Vieweg, M., Sterk, W., Hagemann, M., Fekete, H., Duscha, V., Cames, M., Höhne, N., Hare, B., Rocha, M. and Schmole, H. (2013): Squaring the Circle of Mitigation Adequacy and Equity: Options and Perspectives. Draft for Public Comment. Website: http://www.ecofys.com/files/files/mitigation-adequacy-and-equity_draft-report-for-comment.pdf (viewed 30. June 2014). Cologne, Wuppertal, Berlin, Karlsruhe: Ecofys, Wuppertal Institute, Fraunhofer Institute for Systems and Innovation Research, Climate Analytics, Institute for Applied Ecology.

Voigt, C. (2008): State responsibility for climate change damages. Nordic Journal of International Law 77, 1–22.

von Arnauld, A. (2012): Völkerrecht. Heidelberg, Munich, Landsberg: C.F. Müller.

WBGU – German Advisory Council on Global Change (1995): Scenario for the Derivation of Global CO_2-Reduction Targets and Implementation Strategies. Special Report. Berlin: WBGU.

WBGU – German Advisory Council on Global Change (1997): Targets for Climate Protection 1997. A Statement for the Third Conference of the Parties to the Framework Convention on Climate Change in Kyoto. Special Report. Berlin: WBGU.

WBGU – German Advisory Council on Global Change (2003): Climate Protection Strategies for the 21st Century. Kyoto and Beyond. Special Report. Berlin: WBGU.

WBGU – German Advisory Council on Global Change (2004): World in Transition – Towards Sustainable Energy Systems. Flagship Report. London: Earthscan.

WBGU – German Advisory Council on Global Change (2006): The Future Oceans – Warming Up, Rising High, Turning Sour. Special Report. Berlin: WBGU.

WBGU – German Advisory Council on Global Change (2008): World in Transition: Climate Change as a Security Risk. Flagship Report. London: Earthscan.

WBGU – German Advisory Council on Global Change (2009): Solving the Climate Dilemma: The Budget Approach. Special Report. Berlin: WBGU.

WBGU – German Advisory Council on Global Change (2010a): World in Transition: Future Bioenergy and Sustainable Land Use. Flagship Report. London: Earthscan.

WBGU – German Advisory Council on Global Change (2010b): Climate Policy Post-Copenhagen: A Three-Level Strategy for Success. Policy Paper 6. Berlin: WBGU.

WBGU – German Advisory Council on Global Change (2011): World in Transition – A Social Contract for Sustainability. Flagship Report. Berlin: WBGU.

WBGU – German Advisory Council on Global Change (2012): Financing the Global Energy-System Transformation. Policy Paper 7. Berlin: WBGU.

WBGU – German Advisory Council on Global Change (2013): World in Transition: Governing the Marine Heritage. Flagship Report. Berlin: WBGU.

WBGU – German Advisory Council on Global Change (2014): Human Progress within Planetary Guardrails: a Contribution to the SDG Debate. Policy Paper 8. Berlin: WBGU.

WCC – World Council of Churches (2014) Investment in Fossil Fuels is Off the Table for the WCC. Website: http://www.oikoumene.org/en/press-centre/news/investment-in-fossil-fuels-is-off-the-table-for-the-wcc (viewed 17. July 2014). Geneva: WCC.

weADAPT (2013): What is weADAPT? Website: http://weadapt.org/ (viewed 18. MaY 2014). Stockholm: Stockholm Environment Institute (SEI).

weADAPT (2014): Adaptation planning, research and practice. Website: http://www.weadapt.org (viewed 14. July 2014). Stockholm: Stockholm Environment Institute (SEI).

Wechsler, D. (2014): Crowdsourcing as a method of transdisciplinary research – tapping the full potential of participants. Futures 60, 14–22.

Weischer, L. and Morgan, J. (2013): The Solar Economy Club: Implementing a Leadership Club Approach to International Climate Policy. Berlin: Bundestagsfraktion Bündnis 90/Die Grünen.

Weischer, L., Morgan, J. and Patel, M. (2012): Climate clubs: can small groups of countries make a big difference in addressing climate change? Review of European Community & International Environmental Law 21 (3), 177–192.

Welzer, H. (2013). Der Abschied vom Wachstum als zivilisatorisches Projekt. In: Welzer, H. and Wiegandt, K. (eds.): Wege aus der Wachstumsgesellschaft. Frankfurt/M.: Fischer, 35–59.

Wessling, G. (2011). No future war gestern. In: oekom e.V. (ed.): Politische Ökologie. Post-Oil City. Die Stadt von morgen. Munich: oekom, 61–66.

Wissenschaftlicher Beirat Verbraucher- und Ernährungspolitik beim BMELV (2010): Wollen wirklich alle den „mündigen Verbraucher"? Wie Interessengruppen ein Leitbild instrumentalisieren. Website: http://www.bmelv.de/SharedDocs/Downloads/Ministerium/Beiraete/Verbraucherpolitik/2010_12_InteressengruppeMuendigerVerbraucher.pdf?__blob=publicationFile (viewed 2. June 2014). Berlin: BMELV.

Wong, P. P., Losada, I. J., Gattuso, J.-P., Hinkel, J., Khattabi, A., McInnes, K., Saito, Y. and Sallenger, A. (2014): Coastal Systems and low-lying areas. Chapter 5. In: IPCC – Intergovernmental Panel on Climate Change (ed.): Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report. Draft. Geneva: IPCC, 1-85.

World Bank (2012a): Turn Down the Heat. Why a 4 °C Warmer World Must be Avoided. Washington, DC: World Bank.

World Bank (2012b): New Report Examines Risks of 4 Degree Hotter World by End of Century. Website: http://www.worldbank.org/en/news/press-release/2012/11/18/new-report-examines-risks-of-degree-hotter-world-by-end-of-century (viewed 9. Juli 2014). Washington, DC: World Bank.

World Future Council (2009): Unleashing Renewable Energy Power in Developing Countries. Proposal for a Global Renewable Energy Policy Fund. Hamburg: World Future Council.

WRI – World Resources Institute (2008): CAIT: Climate Analysis Indicators Tool. Website: http://cait.wri.org/ (viewed 13. August 2008). Washington, DC: WRI.

WVS – World Values Survey (2014): WVS Wave 6, 2010–2014. Official Aggregate v.20140429. Aggregate File Producer: Asep/JDS, Madrid/Spain. Website: http://www.worldvaluessurvey.org/WVSDocumentationWV6.jsp (viewed 2. July 2014). Stockholm: WVS.

WWF (2013): The 2015 International Climate Change Agreement: Shaping International Climate Policy Beyond 2020. Consultation Submission. Website: http://ec.europa.eu/clima/consultations/docs/0020/organisation/wwf_en.pdf (viewed 30. June 2014). Brussels: WWF European Policy Office.

WWF, Ecofys and IMO – International Maritime Organization (2011): The Energy Report 2011. Berlin, Cologne, London: WWF, Ecofys, IMO.

Yale Center for Environmental Law and Policy (2012): Climate Change & the International Court of Justice. Website: http://envirocenter.yale.edu/climatechange/icj (viewed 5. June 2014). New Haven, CT: Yale Center for Environmental Law and Policy.

Zaccaro, S. J., Blair, V., Peterson, C. and Zazanis, M. (1995): Collective efficacy. In: Maddux, J. (ed.): Self-Efficacy, Adaptation and Adjustment. New York: Plenum, 305–328.

Zhang, Y. and Shi, H.-l. (2014): From burden-sharing to opportunity-sharing: unlocking the deadlock of climate change negotiation. Climate Policy 14 (1), 63–81.

Climate Protection as a World Citizen Movement

The 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) makes it unmistakeably clear: unacceptable climatic impacts, which are likely to escalate beyond the 2 °C guard rail, can only be avoided if further increases in greenhouse-gas concentrations are halted as soon as possible. The WBGU therefore recommends reducing CO_2 emissions from fossil fuels to zero by 2070 at the latest. This policy goal is both ambitious and incisive, because the zero target must be reached by every country, every municipality, every company and every citizen if the world as a whole is to become climate-neutral. However, the 2 °C line can only be held if a large proportion of actors – especially the OECD countries – start reducing their emissions much earlier. Global society as a whole has only a very limited carbon budget at its disposal; emissions should therefore peak by 2020 if possible, but certainly in the third decade at the latest. In this report the WBGU outlines a dual strategy for global climate protection based on interaction between multilateralism and civil society. To achieve this, on the one hand the Paris climate agreement targeted for late 2015 should exhibit certain characteristics set out by the WBGU. In particular, a process should be agreed to ensure compliance with the 2 °C guard rail. On the other hand, all civil-society actors should make their specific contributions towards decarbonization. In this way, an intricate responsibility architecture for the future of our planet can emerge in which vertical delegating and horizontal engagement are not contradictions, but complementary factors that reinforce each other.

German Advisory Council on Global Change (WBGU)

Secretariat
Luisenstraße 46
D-10117 Berlin

Phone: +49 30 26 39 48-0
E-Mail: wbgu@wbgu.de
Internet: www.wbgu.de

9 783936 191431
ISBN 978-3-936191-43-1