Environmental Science

Sunil Nautiyal · K. S. Rao
Harald Kaechele · K. V. Raju
Ruediger Schaldach *Editors*

Knowledge Systems of Societies for Adaptation and Mitigation of Impacts of Climate Change

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Environmental Science and Engineering

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Foreword

Responding adequately to climate change will pose tremendous challenges to any civilization anywhere in the world. While it is obvious that industrialized countries can afford the transition to sustainability, the challenges faced by decision makers in developing countries are daunting. Consequently, the initiative of the Alexander von Humboldt Foundation to sponsor the conference on "Knowledge Systems of Societies for Adaptation and Mitigation of Impacts of Climate Change" at the All India Institute for Social and Economic Change in Bangalore, India, was timely. As a major achievement, this conference brought together academics from various disciplines, decision makers and politicians from the Indian subcontinent and abroad, because tackling climate change needs concerted action on all levels.

It is now recognized that anthropogenic global warming is no longer an issue of the developed world only. Around the globe we see a copying of western lifestyles which is expressed in developing and emerging economies by fast economic growth. It is obvious that this will not lead to a climate-friendly future. Moreover, whatever the developed countries do in terms of climate protection, the pace of the growth in emerging economies will outpace the emission savings of the OECD countries. This will threaten livelihoods and constrain future development options, because it is well known that many countries in the South are most vulnerable. Climate change consequences would substantially add to the existing predicaments of poor and indigenous grassroots communities in South Asia which are inadequately prepared for adapting to unforeseen changes in their economic, social, and environmental contexts. Evidence of such vulnerability is already visible in India, which has faced extreme weather events over the last ten years and witnessed a decrease in foodgrain production. Nevertheless, climate change and its adverse consequences is not a regional phenomenon, but a problem of the global civilization.

There is no doubt that developing nations have a right to establish better living standards for their citizens, shape their infrastructure, and to alleviate poverty, but how this can be achieved without transgressing certain boundary conditions for environmental integrity in specific countries should increasingly be a matter for debate—and not for developing and emerging economies alone. All nations need to face a sea change in the coming decades under which priority shifts toward

developing strategies for the sustainable management of resources, because the current economic paradigm tends to destroy our natural capital. Sustainability in this context means increasingly decoupling material input and consumption, far-sighted management of land and water, which includes the capacity of these resources to regenerate, and a less consumptive lifestyle for individuals. Nevertheless, even with perfect adaptation to the unavoidable consequences of climate change, accelerated global warming will constrain our steering options in the next decades considerably. Consequently, we need concerted action—action which helps to reconcile climate protection targets and development goals.

As a step in this direction, the participants of the Alexander von Humboldt conference in Bangalore 2011 brought together diverse expertise from their subject domains to discuss these challenges and explored the human capacity present in India and Germany for innovative and path-breaking research in the field of climate change. This volume integrates selected contributions addressing the various issues of social, economic, policy, and technological challenges related to a transition paradigm.

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Potsdam, June 2013 Hans Joachim Schellnhuber

Message from Alexander von Humboldt Foundation

Maintaining a dynamic exchange of ideas and gaining new insights—this deep interest makes us human beings. Fostering und supporting people's scientific curiosity has been the Alexander von Humboldt Foundation's mission for 60 years now. Since its establishment in 1953, the Alexander von Humboldt Foundation sponsors top-level scientists and scholars from abroad who come to Germany with our fellowships and awards in order to work here in close cooperation with German colleagues. The fellowships and awards of the Alexander von Humboldt Foundation have earned a considerable reputation worldwide. We aim to support excellence and to create an expanding global network of cultural and scientific dialogue on the highest levels. Until today, the Alexander von Humboldt Foundation has sponsored more than 25,000 scientists and scholars from all over the world embracing over 130 countries and including 49 Nobel Prize winners. We never set any quota for countries of origin nor fields of research in the selection of future Humboldt fellows. Our only criterion is scientific excellence. So far, we have granted well above 5300 research fellowships and awards to excellent scientists and scholars from Asia, amongst them 1749 from India.

"Once a Humboldtian, always a Humboldtian"—from the very beginning this was the hallmark of the Alexander von Humboldt Foundation. The Humboldt sponsorship is enduring: the Foundation is a lifetime partner, maintaining the connections on a long-term basis through its alumni sponsorship programmes. Moreover, the Foundation encourages its alumni to undertake their own initiatives and collaborations across disciplinary and national borders. As a result, many Humboldtians make use of our extensive Alumni sponsorship programme. In this regard, in October 2011, the Humboldt Kolleg "Adaptive Management of Ecosystems: The Knowledge Systems of Societies for Adaptation and Mitigation of Impacts of Climate Change" took place in Bangalore. The Kolleg was hosted by Humboldt Alumnus Professor Dr. Sunil Nautiyal at the Institute for Social and Economic Change choosing a topic of major importance to the development in Asia. It served as a forum for scientific networking between Humboldtians and other young and experienced researchers. The Alexander von Humboldt Foundation especially appreciates Professor Nautiyal's initiative in the framework of the 60th anniversary of diplomatic ties between India and Germany under the motto

"Germany and India: Infinite Opportunities." Not only does this motto demonstrate the tight bonds of friendship existing between India and Germany, it is a friendship that exceeds the mere sphere of science and highlights the role of the two countries as global partners. It also holds the promise of further fruitful academic cooperation, which is being forwarded by initiatives such as the Humboldt Kolleg.

On behalf of the Alexander von Humboldt Foundation, I would like to thank Professor Dr. Sunil Nautiyal and the organizing committee at the Institute for Social and Economic Change, Bangalore, for their dedication and the initiative to conduct the Humboldt Kolleg whose scientific results are published, now. The Alexander von Humboldt Foundation is most grateful to its Humboldtians, who support our aims, our goals, and the next generation of researchers by living up to our motto "Once a Humboldtian, always a Humboldtian."—I wish you all the best of success and luck for your future plans.

February 2013

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Message from the German Consulate General in Bangalore

Climate change is one of the most difficult challenges facing humanity in the decades to come—with its effects already touching Indian livelihoods today. It is therefore most welcome that the presentations held at the International Humboldt-Kolleg in October 2011 in Bangalore on this subject are made available to a larger audience with this publication.

India, with its high population density, its rain-fed agriculture and its long coastlines, faces higher risks from climate change than most other nations. The effects of future sea-level rise, changes in the monsoon patterns or the melting of Himalayan glaciers threaten India's future development and the well-being of its citizens. I therefore, commend the Alexander-von-Humboldt alumni to have chosen to devote their 2011 Humboldt Kolleg to the impact of climate change, adaptation efforts and possible mitigating steps.

However, while India will need to undertake steps in adaptation and mitigation of climate change domestically, climate change is a global challenge and requires to be tackled globally. My own Government is fully aware of this and has set ambitious targets for Germany to mitigate climate change. This includes a reduction of 40% of its greenhouse gas emissions between 1990 and 2020, a cut of 20 % in its primary energy consumption from 2008 to 2020 and a share of 35 % of renewable energies in its electricity consumption by 2020.

Germany is also cooperating with India in its efforts to tackle climate change. Towards this end, Germany is supporting the work of the Indian Government's Bureau of Energy Efficiency, of the Ministry of New and Renewable Energy and of the Ministry of Environment and Forests. This support takes the form of loans, for example to launch new projects in solar energy, or of expert advice on issues such as analyzing solar radiation data. At the same time, a political dialogue takes place in the yearly Indo-German Energy Forum and its sub-groups, with a strong focus on renewables and energy efficiency.

It was an honour that the Humboldt-Kolleg could be organized in the prestigious Institute for Social and Economic Change. The Governor of Karnataka, H. E. Shri Hans Raj Bhardwaj and the then the Chief Minister of Karnataka, Shri D. V. Sadananda Gowda, graced the opening ceremony with their presence and remarks.

I congratulate Professor Dr. Sunil Nautiyal for his cooperative spirit and his strenuous efforts in putting this publication together. I wish him and his many contributors the large readership the publication deserves.

April 2013

Hans-Günter Löffler
Deputy Consul General of Germany, Bangalore

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Knowledge Systems of Societies for Adaptation and Mitigation of Impacts of Climate Change: Prologue

Sunil Nautiyal, K. S. Rao, H. Kaechele, K. V. Raju and R. Schaldach

India and Germany, as a mark of 60 years of diplomatic relations between them, hosted year-long programmes in their respective countries during 2011–2012. To strengthen the relationship further, a Year of Germany in India was organised under the motto 'Infinite Opportunities—Germany and India 2011–2012' with the theme, 'StadtRäume—CitySpaces'. In this purview the International Humboldt Kolleg convened by Sunil Nautiyal at the Institute for Social and Economic Change, Bangalore, with the support of the Alexander von Humboldt Foundation towards strengthening the future research collaboration between Germany and India.

In the present context, anthropogenic climate change is a major concern from the perspective of long term sustainability. It is a common challenge faced by all the countries of the world. However, some of the developing countries are highly vulnerable to climate change effects as they do not possess adequate resources—both financial and otherwise—to cope with climate change (UNFCCC 2009). Therefore, our common aim should be to find solutions to mitigate climate change and but also to adapt to unavoidable consequences for conserving our planet Earth and to ensure a liveable environment to future generations.

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The global climate pattern has been changing fast and observational evidence indicates that climate change in the 20th century have already affected a diverse set of physical and biological systems (IPCC 2001, 2007a). Scientific debates concerning the drivers of these changes have, over more than two decades of intensified research and discussions, reached the conclusion that there is no plausible explanation for the observed warming (of 0.1 °C per decade) for the last 50 years (IPCC 2007b) other than human activities such as the emission of greenhouse gases. With no changes in the current policy framework, the world appears set on a path of rising global temperatures of up to 6 °C, with catastrophic consequences on both the environment and livelihoods (OECD-IEA 2009). Even with respect temperature increases far below 6 °C, there is a broad consensus on the environmental challenges with far reaching implications for food production, natural ecosystems, freshwater supply and health care (IPCC 2007a). Climate change could also soon become a major security risk (WBGU 2008) in terms of large scale migration and conflicts over the existing resources (Reuveny 2007). Guiding the world through climate change effects and associated environmental uncertainties and maintaining its existing biodiversity may turn to be one of the most important political challenges of the 21st century. Our collective responsibility to effectively mitigate toughest climate change uncertainties requires global cooperation on an unprecedented scale (Stern 2009). The time frame available for avoiding potentially dangerous consequences is drawing to a close. In view of the fact that some of the industrialized economies have already started reducing emissions through a series of measures, the pressure has been increasing on the developing countries to agree to emission cuts of late particularly with respect to joint endeavours for protecting the environment. Many countries are still reluctant to commit themselves to legally binding CO_2 emission cuts mainly because of the lack of transparency observed in international climate policy. They have not adopted emission reduction targets so far, and as a result, the future impacts on the biological and physical systems of the planet Earth may turn out to become more catastrophic (UNFCCC 2009).

Climate change mitigation within the United Nations Framework Convention on Climate Change (UNFCCC), from Rio to Copenhagen (2009) to Doha (2012), has led to a set of policy responses. However, the present policy framework is dependent on reduction commitments/targets that the governments have agreed to; while keeping in view the opportunities for economic and social development. In the meantime, setting of reduction targets is driven by development considerations, i.e. it is for the governments to decide on the desirable reduction levels without compromising too much on economic development goals.

To help meet these reduction targets and also to make reductions more effective, there should be a degree of flexibility embedded in the mechanisms with a strong emphasis on international collaboration. The European Union (EU) has decided to follow a Burden Sharing strategy that includes all members of the Union which is highly appreciable. EU has developed an overall reduction scheme that while allowing some countries unable to reduce greenhouse gas emissions to benefit from Germany's reduction target of 21 % as compared to 1990 in the 1st

commitment period of the Kyoto protocol (2008–2012). The German government has done very significant work in mitigating the potential threats associated with climate change. In this endeavor, Germany not only has reached the Kyoto target but aims at a 40 % reduction of greenhouse gases until 2020 as compared to 1990 through various instruments such as prioritizing renewable energy sources and also providing market incentives while moving ahead with the twin track strategy, for example, increasing renewable energy resources and reducing energy consumption through developing various energy efficient measures (European Commission 2007; WBGU 2008).

We strongly feel that a mechanism should be introduced for a functioning Emission Trading System that would limit the collective greenhouse gas emissions within certain regions so as to provide an opportunity for allocating tradable greenhouse gas certificates to enterprises. This is relatively well defined in the case of EU, but we need to do much more in respect of developing countries to help create incentives for innovations to save certificates that can be sold within the regions at national and international rates. Other mechanisms for increasing the efficiency of climate change mitigation measures include the so called Clean Development Mechanism (CDM), Joint Implementation (JI) and the newly established Green Climate Fund. However, the present policy does not sufficiently address a measurable environmental goal such as predefined atmospheric carbon content at a certain given time which, with a certain probability, can lead to certain climatic conditions (UNEP 2012). There is also a lack of enforcement element in the climate policy. Leading climate scientists today are convinced of the fact that our present political environment with regard to mitigating climate change effects is driving us into an unsafe future. We seek a process that facilitates a consolidated and contextualised understanding, evoking a strategic response from among the various key constituencies between developed and developing nations. This understanding can then bring differentiated roles/agendas in addressing and targeting short, medium and long term issues/benchmarks relating to climate change.

India, with a huge diversity in land, topography, climate and socio-economic conditions, is divided into 15 agro-climatic zones. Further, based on several indicators, such as water availability, soil types, rainfall and pattern of rain-fall, edaphic factors, land use and land cover, a total of 127 sub-zones (agro-climatic sub regions) have been identified in India mainly for carrying out location specific research and development projects at the micro level. Although, several climate models have predicted global and regional scenarios for climate in different parts of the world, however, the significance and practical implementation of such models at the micro level is yet to be validated. This leads us to the conclusion that research on climate change and its impact only at the national level may not be a sound approach towards adaptation and mitigation measures at the micro level. Therefore, this volume includes research results from across the disciplines in order to understand the patterns and processes of the complex adaptive systems linked to impacts of climate change.

The commonly agreed approach in case of Germany and India is based on the development methods and plans for preparing suitable strategies toward mitigation

the threats related to climate change. First, this is in response to the suggestion made by India's Prime Minister and German Chancellor Angela Merkel to prepare a budget approach for climate action plans and the distribution of global carbon budget. Secondly, for combating potentially adverse impacts of climate change on food production, water supply, forestry and fisheries through adaptation and mitigation there is a need for an integrated interdisciplinary approach. India is highly vulnerable to projected climate change effects that affect millions in rural and urban areas, in addition to adversely impacting food production, water supply, fish production and forest biodiversity. Some sectors in Germany are also vulnerable to climate change that affects the relationship between human and ecosystems. Thus, there is a mutual need for developing and implementing programmes for adaptation and mitigation. Our joint endeavours should emphasize the following issues that need the involvement of State government, experts, institutions and stakeholders at national and international levels.

- Integrated efforts should aim at developing strategies for emission reductions, estimating vulnerability and uncertainties of different sectors on which peoples' livelihood is dependent and harmonising of development activities with respect to mitigation commitments.
- Efforts should be directed towards developing policies for livelihood sustainability and socio-economic development under projected climatic changes across agricultural landscapes of India and Germany. Considering Rural India as a key factor to coping with Climate Change is essential. Thus, there is a need for linking different agro-climatic zones of India to global problems. Technological support from Germany to India will further strengthen long term research programmes aimed at mitigating the potential threats of climate change.

In this light, the main objectives of this volume are: (i) to provide more meaningful ideas that help and support India's efforts towards handling climate change effects, particularly the implementation of Millennium Development Goals related to poverty and sustainable development; (ii) to promote effective two-way communication channels for enabling researchers to engage in integrated interdisciplinary research; (iii) to establish interdisciplinary research networks for carrying out integrated research towards strategies for the sustainable flow of ecosystem services and also for the economics of natural resource management, biodiversity conservation and sustainable livelihood in the context of changing climate. Issues related to traditional rights and the aspirations of people who are living in harmony with natural forested landscapes shall be discussed from the perspective of climate change; and (iv) to strengthen cooperation among researchers from different disciplines towards addressing the global climate change uncertainties.

We hope that the collection of research papers in this book will help developing better strategies to hybrid adaptation-mitigation responses, linking the 'science' and the 'practice' on the ground. Such efforts will certainly help increasing the resilience and coping capacity towards better policy formulation, policy implementation and policy assessment. This process should strategise to find entry

points at national level and international level in order to plug into the preparation of multidisciplinary research, while linking into policy processes and integrating climate-smart socio-economic development concerns in the 21st century as a mitigation-adaptation hybrid response.

Prime Minister Manmohan Singh and Chancellor Angela Merkel had acknowledged the importance of the Scientific and Technological Collaboration (STC) for promoting a dialogue between scientists of both the countries. Based on the agreements signed by the two nations in 1971 and 1974, the collaboration continues to fund and support joint research projects, workshops, seminars and exchanges between universities and scientific organisations in India and Germany . To date, the collaboration has supported 1,000 joint Indo-German research projects, involving 4,000 scientists from both the countries. With inputs from both the sides, a total of more than 100 workshops have been completed and 1,500 scientific publications produced (Research in Germany online, p 1).

The International Humboldt Kolleg was inaugurated by the Governor of Karnataka, H.E. Dr. Hans Raj Bhardwaj and then Chief Minister of Karnataka, Shri D.V. Sadananda Gowda. Their presence had heightened the very spirit of the conference. We express our deep sense of gratitude to H.E. and Hon'ble Chief Minister for addressing the International Humboldt Kolleg at ISEC. We take this opportunity to express deep, sincere and whole-hearted thanks and gratitude to the Alexander von Humboldt Foundation (AvH) Germany and Hon'ble President Professor Dr. Helmut Schwarz, for giving us the privilege to organise an International Humboldt Kolleg at ISEC, Bangalore, India which culminated in to this volume. We extend our sincere thanks to Dr. Judith Schildt, Deputy Head and Programme Director, Division Asia, Alexander von Humboldt Foundation for her kind cooperation and whole-hearted support. We are thankful to Mr. Hans-Günter Löffler, Deputy Consul General, German Consulate Office, Bangalore for his kind support and cooperation. We are thankful to ISEC faculty and staff for their wholehearted support and cooperation in organising this event.

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Accepting Climate Change Challenges: Gambling with the Future or Path-Finding for Long-Term Sustainability?

J. P. Kropp

1 Introduction

In recent 20 years, plenty of progress has been made in regard to climate impact and global change related research. While scientific knowledge about the unbridled process of global warming and its associated impacts has increased tremendously, societal and political responses to this challenge seems to be uncoordinated and not target driven. The failure of certain UNFCCC climate conferences (COPs) in discussing binding emission reductions is only one indication of this particular fact. Nevertheless, humanity is facing even more challenges in the 21st century. For example, marine resources are overexploited, tropical rainforests are disappearing, and fresh water resources are depleting (Ehrlich and Ehrlich 2013). While these processes alone cause gigantic problems, climate change will worsen and accelerate other processes like species extinction or vegetation change (cf., e.g. for fisheries: Perry et al. 2005; Brander 2007; Wernberg et al. 2013; vegetation change: Galbraith et al. 2010; Gottfried et al. 2012). Although the management of common property resources is difficult (cf. Eisenack et al. 2006), problems like overexploitation of natural assets can be solved regionally by establishing cooperation mechanisms (cf. Vollan and Ostrom 2010), however, the climate threat could add additional pressure to these life-supporting systems. Thus, climate change will define additional constraints for management regimes making the urgency for international climate agreement clear. Concerning international activities in climate research and climate policy, two different activities are prominent: (1) the negotiations about acceptable carbon budgets and burden sharing among countries (cf. e.g. WBGU 2009; Costa et al. 2011; Steinberger et al. 2012) and (2) insufficient research

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on adaptation, unharmonized adaptation actions, and the establishment of adaptation funds, which shall support adaptation to the unavoidable consequences of climate change. Certainly, these discussion threads are not independent. As negotiations about internationally binding carbon emission budgets failed, stakeholders and policymakers began to focus on adaptation. The reasons are quite simple. While the reduction of atmospheric greenhouse gases (GHGs) is an undertaking whose benefits are associated with the global civilisation in coming decades, adaptation can create immediate effects on a local scale. However, another point is important in this context. Looking into human history, adaptation was undoubtedly a need during the past millenniums, otherwise homo sapiens would not have survived. Thus, adaptation is well rooted in our history and therefore is vital as response to changing environmental constraints. Adaptation can also be understood as an activity that makes use of our environment, i.e. for food production, ore exploitation, etc., although human history show that civilizations may fail to respond adequately. Examples are e.g. the breakdown of the Maya or the disappearance of the Khmer culture (cf. for example, Haug et al. 2003; Buckley et al. 2010; Medina-Elizalde and Rohling 2012; Kennett et al. 2012).

Considering these facts one question is still unanswered, namely whether mankind can draw the right conclusions from this kind of failed adaptation, even though nowadays the situation has changed completely in comparison to ancient times. Today, environmental problems are no longer local and in some regions environmental constraints are already changing very rapidly. Thus, an alteration of societal thinking in regard to resource utilisation is urgently needed. Despite these circumstances, past experiences show that humankind is primarily applying a trial and error process in terms of adaptation, instead of developing clear environmental targets in regard to sustainable resource use and climate protection. Mid- to long-term forward looking decision making does not yet exist and consequently adaptation has taken a major role in political responses in regard to the climate change challenges. The question must asked: why do we think that regional adaptation, which needs huge local cooperation and only allows limited concerted action on national or international level is suitable to take care of as safe future for human civilisations? The answer is that climate change became not only a scientific problem, but a political problem as well. Certain countries start from different points in the “climate game”. Due to the accumulation of greenhouse gases (GHG) in development economies, which is substantially less in comparison to industrialized countries, developing economies requested for compensation for expected or experienced damages. From a short-term oriented point of view this is understandable, because development economies argue that they have only a minor responsibility for the current GHG emissions. Nevertheless, such a strategy will not help the global civilisation in terms of the need to really make progress in regard to the sustainability transition. Up to now neither industrialized nor developing economies have any real answers how a transformation to a low carbon economy may look like and how national policy making can support or accelerate such a process. For example, although India invested a lot in low carbon development, actual policies are insufficient to contribute to an achievement of the 2 °C

target (cf. Singh 2011). Moreover, recent policy plans to bring more than 450 coal fired plants on the grid (Ehrlich and Ehrlich 2013). Among some of the OECD countries, nations like Germany, Australia or Japan decided to implement energy turnarounds ("Energiewende"), but it is foreseeable that these efforts are by far too small to achieve the necessary, but ambitious climate protection. Concerning the time scale for climate action which is still around one decade, the postponing of necessary decisions and therefore a wait and see strategy is not an option, but may lead certain subsystems of the entire earth to the brink of collapse.

2 Are We Asking the Right Questions?

This rough description of processes is, of course, insufficient, because it is clear that we do not live in a homogenous world, e.g. with the similar livelihood conditions. In contrast, we observe large disparities over the entire earth in terms of livelihood conditions and development levels. While livelihood tries to define limits for a safe life for individuals, development policies often address the social and technological levels of societies and both facets of human life may be affected by climate change. However, we still need to ask the question, whether there is a need to bring all people to a similar livelihood or development level? This is a question which is clearly connected with the transition challenge. The simple copying of westernized lifestyles seems to be not an option. It is a fact that development agencies discover adaptation as a field for action causing huge investments in this area, but is it feasible that we tackle development and climate change adaptation challenges by such a strategy? At least some doubts remain because similar livelihoods have never existed everywhere on the earth and would not be desirable. This will, of course, neglect regional and cultural specificities. The central challenge is that any individual must have access to a sufficient amount of life supporting resources and how this associates to the exploitation and utilization of resources. There is a scientific debate about how to measure and define a sustainable lifestyle including the sink function of the atmosphere (cf., e.g. Bohringer and Jochem 2007; Dietz et al. 2009; Roy and Pal 2009). Is this, for example, a westernized lifestyle associated with cyclic resource use, or that of the people of Bhutan focusing more on individual happiness associated with less resource consumption?

Concerning these discussions, it is remarkable that our recent life-styles and even our development level are still dependent on fossil fuel use (Costa et al. 2011). A clear linear relationship has been identified clarifying the fact that transitions to low carbon societies are still pending in industrialized and developing countries (cf. Fig. 1).

Thus, the two unanswered questions still remain. First, how can we decouple our lifestyles from resource consumption. Second, how is it feasible to transform societies to low carbon societies. At the first glance both questions point in similar directions, but the problems are more difficult. While the first question can be

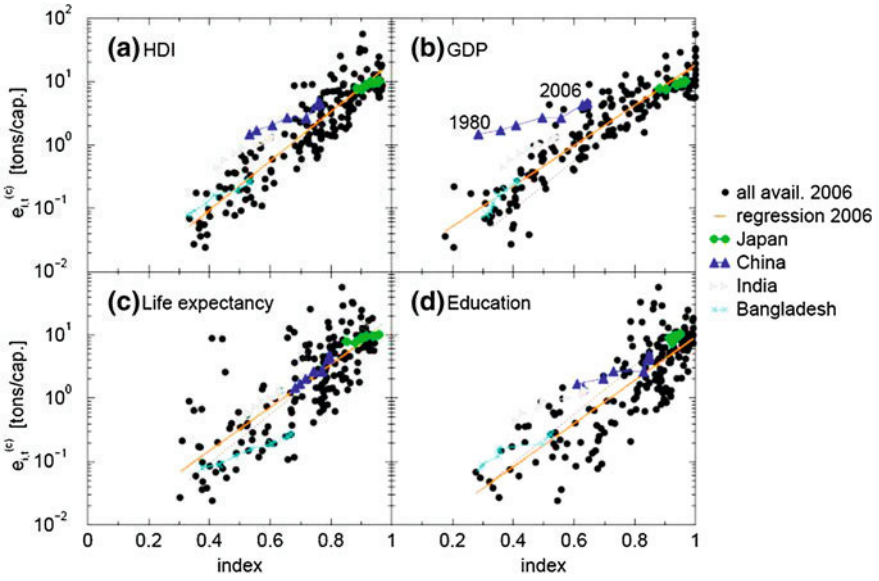

Fig. 1 Correlations between per capita emissions (CO_2) and the Human Development Index and its components. *Panels* **a–d** are cross-plots in semi-logarithmic representation, where each *filled circle* represents a country. **a** CO_2 emissions per capita versus the corresponding HDI values for the year 2006 (172 countries). **b–d** Depict the analogous for the HDI components, The Panels also include the trajectories (1980–2006) of Japan (*green*), China (*blue*), India (*grey*), and Bangladesh (*cyan*). For some countries, e.g. China, Japan efficiency gaining is observable, because the slope of the country trajectories is decreasing. For details cf. Costa et al. (2011)

answered via technological progress, e.g. via efficiency gains or the implementation of a circular flow economy, the second question requests nothing more than a new societal idea for the 21st century, i.e. people need to accept a completely new and sustainable lifestyle. Such societal changes are much more demanding than any technological challenge, because it needs time for implementation. Obviously, the latter challenge—how to transform societies—is not in the foreground of policy makers. As a consequence, adaptation is introduced as a kind of universal remedy. And it is not astonishing that development organisations like UNDP, GIZ, USAid, DFID, and others discovered that climate change may lead to hardships for everyone on the planet. Their major answer to climate change related challenges is adaptation. Nevertheless reviewing recent activities it must be stated here that a lot of these activities are often uncoordinated and less efficient in regard to the underlying root cause of climate change (cf. Ehrlich and Ehrlich 2013). In addition, very often climate change is used as an additional argument in order to support development action which is needed anyway, i.e. whether an action is motivated by climate change or not is indistinguishable from current management practices (cf. de Bruin et al. 2009). Consequently, development organisations try to influence climate policy and negotiations by putting adaptation into the center and often arguing that climate change may threaten official development aid, development successes and

Table 1 The systematic analysis of the ci: grasp adaptation database (www.ci-grasp.org) showed that for certain sectors the time horizon from the starting point until the finalization of an adaptation activity is around one decade (cf. for details Costa et al. 2013)

Adaptation sector	Understanding	Planning	Implementation	Average duration
Agriculture				
Soil conservation	–	4 years	5 years	9 years
Irrigation	2 years	2 years	3 years	7 years
Crop changes	2 years	2 years	5 years	9 years
Coastal adaptation				
Land use planning	2 years	–	8 years	10 years

will hit the poorest and marginalized people disproportionately (cf. OECD 2005; WB 2006). For development agencies this point of view is coherent, because they understand any process that improves the living conditions of the poor as adaptation, while climate change adaptation deals with the coping of the unavoidable consequences of climate change. Thus, is it appropriate to integrate adaptation, mitigation and development challenges? At least this is debatable. Some striking aspects of all adaptation activities are that a sound scientific basis for adaptation related research does not yet exist, the coordination efforts for any of these activities are at least similar to those of the climate negotiations, and it is foreseeable that climate funds will never be sufficient to solve the climate and development dilemma in parallel. Consequently, one mandatory prerequisite to the needs being fulfilled is comparable impact studies, which can answer the following: which regions or sectors are hit most by certain climate impacts and where consequently, adaptation funds can be utilised most efficiently. Thus, it is questionable whether an uncoordinated equal distribution of funds—even in developing countries—will lead us to a safe and sustainable world. Moreover, adaptation is often also understood as a learning process. This needs time (cf. Table 1), time which we do not have (cf. Peters et al. 2013), or in other words, a one-eyed orientation towards adaptation may disregard obvious solution options to the problem, which is to reduce greenhouse gases. Thus, adaptation without a clear orientation towards climate related problems will be less constructive. The real endeavor is not (economic and/or livelihood) equity for all, it is fairness in the international climate debates. Equity and fairness have similar meanings, but discussing them in detail make clear that there are differences and how far away we are from a real solution to the climate crisis. Equity is often applied in approaches dealing with the distribution of emission budgets among countries (WBGU 2009), fairness should recognize the different development stages, or even social targets, of the countries in regard to future transition pathways (cf. Costa et al. 2011), because economic growth is still on the top of the agenda of developing countries. Thus, although we need to change the neoclassical growth idea, this will not happen on a suitable time span, i.e. for a sustainability transition we need to make compromises.

3 What Happens When Westernized Lifestyles Spread Over Entire Planet

It is well-known that the westernized lifestyles consume resources and influence environmental quality. Rockström et al. (2009) showed that humanity is transgressing several physical boundaries of the entire planet already and made suggestions for binding thresholds. Economic growth, which seems to be our holy paradigm for human welfare, is a dearly bought advantage through the exploitation of human labor force in poorer countries and the utilization of cheap renewable and non-renewable resources from these countries. UNEP (2011) estimated that unsustainable lifestyles may triple resource consumption by 2050. Concerning four groups of resources, i.e. construction minerals, ores, fossil fuels, and biomass, UNEP (2011) suggested not to transgress 5–6 t/cap/yr. However, detailed analyses show that the intensity of resource consumption shows large regional disparities. In particular, the development status and population density seems to be important. It was stated that densely populated countries need fewer resources per capita for the same standard of living. This could be a spatial scale effect, which was also observed by Bettencourt et al. (2007a, b) for cities, but we need to be careful with hasty conclusions, because he showed also that there is a difference between basic and lifestyle related needs. However, focusing on certain countries the resource consumption differs broadly. While the global average is 8 t/cap/yr, i.e. above the UNEP suggestion, Canada consumes 24 t and countries like India or China consume 4 t/cap/yr. In particular, India or China show an overproportional economic growth that decreases environmental quality and resources and these examples make clear that changes are needed. Before one can decide to change policies or to apply readjustments one needs to measure the actual status of a country. Kuznets (1955) proposed an autonomous dynamics that during certain development stages environmental quality first decreases and then, after a considerable welfare level is attained (e.g. measured by gross domestic product (GDP) per capita), environmental consumption decreases (Kuznets hypothesis). This implies that for development, environmental quality is consumed for an increasing gross domestic product, while after the achievement of an acceptable livelihood level, technological progress cures environmental damages although GDP is still increasing. The problem with concepts like this is that they are valid for certain sectors or regions, but as a generalisation the concept is worthless. One reason is that it relies on GDP which measures just the value-added of an economy, but does not count for the costs of economic activities. Therefore, the development of more sophisticated indicators for global welfare was recently suggested (Fleurbaey 2009; Stiglitz et al. 2010), but not undisputed (Noll 2010). A temporary approach, before these suggestions will come into force, is therefore the idea to include the costs of environmental damages via emission trading which gives atmospheric pollution a price. Unfortunately, it has been not feasible to establish a global framework so far, thus the potential of such an instrument is less efficient than expected. Moreover, in the European Union the price for emission

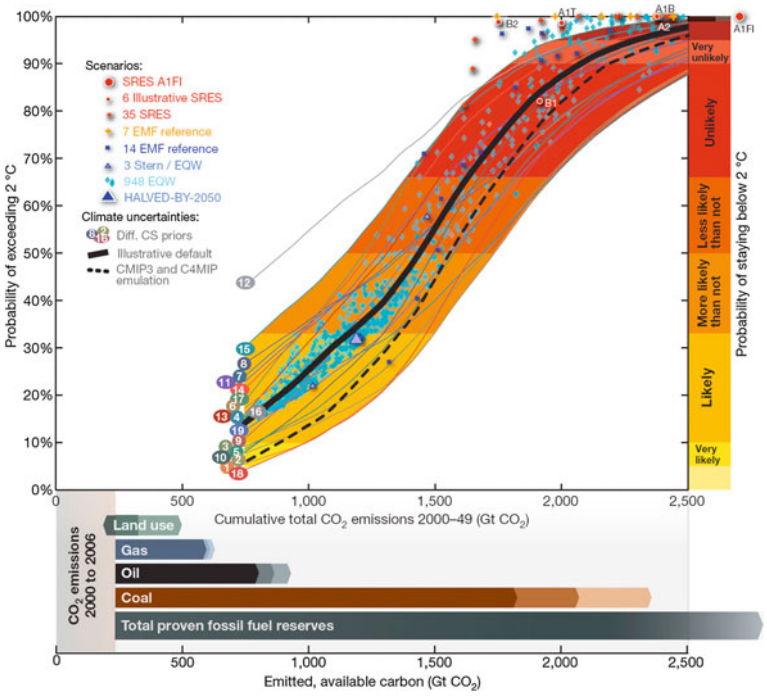

Fig. 2 The overshooting likelihood for a 2 °C warming versus CO_2 emissions in the first half of the 21st century. **a** Individual scenarios and smoothed (local linear regression smoother) probabilities for all climate sensitivity distributions (*numbered lines*). The proportion of CMIP3 AOGCMs26 and C4MIP carbon-cycle model emulations exceeding 2 °C is shown as *black dashed line*. Coloured areas denote the range of probabilities (*right*) of staying *below* 2 °C. **b** Total CO_2 emissions already emitted between 2000 and 2006 (*grey area*) and those that could arise from burning available fossil fuel reserves, and from land use activities between 2006 and 2049 (median and 80 % ranges). For details cf. Meinshausen et al. (2009)

certificates decreased to approx. 3 €/t (January 2013) as a result of too many certificates being on the market, which was caused by policy makers being afraid of overly negative effects for energy intensive industries. However, except for a few carbon trading systems, pricing concepts for environmental damage are still in their infancy. In order to support policy-makers, science can provide more valuable insights anyway by clarifying how the global (human) dynamics in certain sectors/region may threaten options for a safe life. Considering climate change we can clearly link this to the 2 °C target which keeps us away from the dangerous consequences of climate change (Fig. 2, cf. Meinshausen et al. 2009). For example, looking with more detail at other prominent sectors like food production, the dynamics of food production show alarming signs. It is undisputed that one result of the "green revolution" was to nourish millions of people and reduce the risk of hunger globally. Nevertheless, it is also a fact that the calorie intake shows quite different pattern globally. Moreover, food trading causes a lot

of side effects, e.g. highly efficiently produced food in the OECD whose unusable components are exported to developing nations destroying local markets and income options there. The globalization of agriculture in fact produces enough food, but that food is not equally distributed over the entire world. Moreover, economic and often not human needs drive this market. These economic needs utilize nature in an unsustainable way neglecting environmental damages.

What does this have to do with climate? Detailed analyses of long-term FAO food data shows good news, i.e. low calorie diets are decreasing, but in parallel there is a tendency towards high calorie diets and moreover new nourishing styles have emerged (Prajal et al. 2013). Considering these mechanisms, which are mainly driven be lifestyle changes, it is likely that this progress will result in a tripling of the emissions from the agricultural sector (cf. Fig. 3).

Unfortunately this is not the end of the story, because the real attribution of emissions from certain sectors is hard to estimate. The globalization of markets, trade activities and the associated transport implies that any product has an additional backpack of embodied emissions (Steinberger et al. 2012) and thus, more sound assessments for emission surveillance and reporting are needed. However, previous sections showed that lifestyles and material consumption forces climate change and that combating climate change is one cardinal question for a safe future. The question is how we would like to live in the future and what we need to do to achieve this?

Another example is the debate on future urbanisation which is currently a hot topic in science. It is estimated that approx. 50 % of the global population was living in cities by 2008 and is likely that this growth will proceed at an

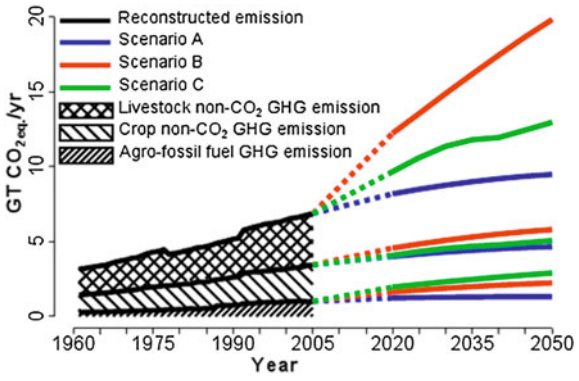

Fig. 3 Reconstructed and projected global total agricultural GHG emissions for three certain scenarios (*A* population growth only, *B* population growth and changes in dietary patterns, *C* change in population, diets and technology and management of agricultural land use). The total GHG emissions are decomposed into non-CO_2 GHG emission from livestock and crop and CO_2 emissions from use of fossil fuel in agriculture. The IPCC (2007) estimated a GHG emission from agriculture between 5 and 6 Gt CO_2. Considering changes in lifestyles and in the production style may lead to a tripling of agricultural emissions by 2050 (cf. Prajal et al. 2013)

unparalleled pace—mostly in developing countries. Moreover, it is estimated that cities are also responsible for approx. 80 % of the global emissions (UN 2007; Duren and Miller 2012). Other authors argued for a more detailed view and would not blame cities for their high emissions (cf. Dodman 2009; Satterthwaite 2008) and showed that in a lot of cities emissions are lower than those of the respective countries. Nevertheless, taking into account that cities concentrate human life, we need to discuss their climate relevance in the light of achievable sustainability. Cities are the location of human welfare, productivity, creativity, but also center of large social and economic disparities. It is still open whether sustainable cities are feasible or not and which kind of constraints we need to implement to get there. It is nothing more than the combination of two endeavours, i.e. how to develop an optimal city in physical terms and how to transform urban societies (cf. above). Unfortunately, due to the complexity of urban systems, it is not easy to define common planning and sustainability goals for cities which can diverge. For example, the heat wave burden from urban heat islands, which impacts human health in cities can be reduced, e.g. by introducing more open spaces, greens or white roofs (Lissner et al. 2012; Schubert and Grosman-Clarke 2012), but in parallel that may cause more traffic due to longer travelling distances, which could further increase emissions. In addition, systematic studies on cities performed by Bettencourt et al. (2007a, b) showed interesting effects for cities of certain sizes. It was emphasised that infrastructure volumes, like road surfaces, length of power grids, etc. grow sub-linearly with population and size, e.g. showing that cities really do provide a scale effect. Essential needs like water, housing and employment show a clear linear relation in regard to the population. The most important finding was that wealth volumes in terms of patents, electricity consumption, wages, bank deposits, etc. grow super linearly with the population. In particular, these latter points represent lifestyle changes and associated economic growth processes. What does this imply when discussing climate change? Hence for sustainability questions we need to define our analytical approaches carefully and with a systematic focus in order to assess gross effects. Coming back to food production, in this regard we can combine this with the challenge of emission reductions in cities as well. Which effects can be employed is shown by a study for the United Kingdom (Smith et al. 2005) making clear that food transport accounts for 25 % of all heavy goods vehicles causing 19 million tons of CO_2, while the overseas mileage for food transport is approx. four times higher than the UK mileage for ground transport. Transport of food by air has the highest CO_2 emissions per ton and is the fastest growing mode (140 % 1992–2002). Thus, emissions of CO_2 from the food transport sector are highly significant and growing. It can be assumed that this holds for other countries in a similar way. Consequently, it is obvious that more local food production may reduce transport emissions in this sector, but one need to assess how large the potential for urban food production really might be.

Kriewald et al. (2013) developed a methodology which describes urban regions and its hinterland as so-called urban-bioregions. By combination of certain databases, e.g. GRUMP population data, GlobCover land cover data, it was feasible