

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

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## 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 millennia, 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 shows 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 Röhling 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 be 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 a 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

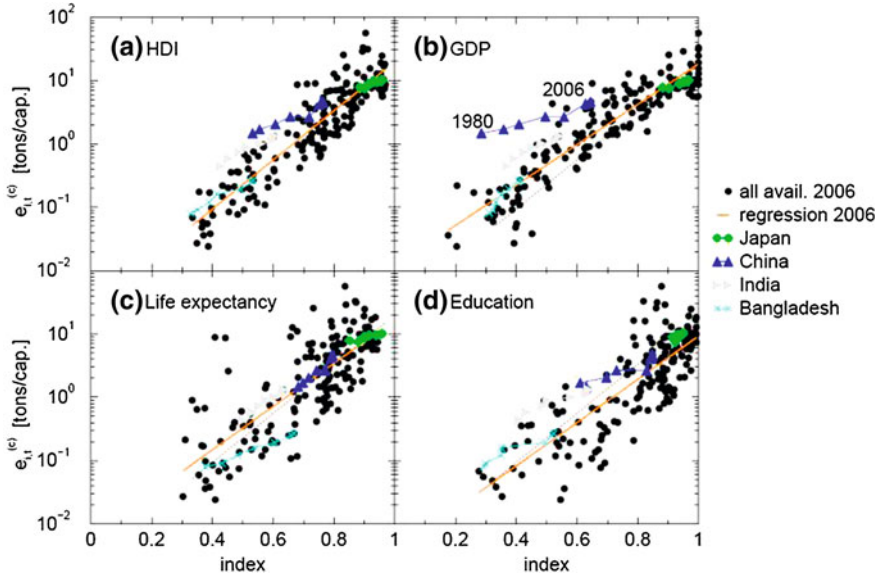
target (cf. Singh 2011). Moreover, recent policy plans to bring more than 450 coal fired plants on the grid (Ehrlich and Ehrlich 2013). Among some of the OECD countries, nations like Germany, Australia or Japan decided to implement energy turnarounds (“Energiewende”), but it is foreseeable that these 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 ( $\text{CO}_2$ ) 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**  $\text{CO}_2$  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

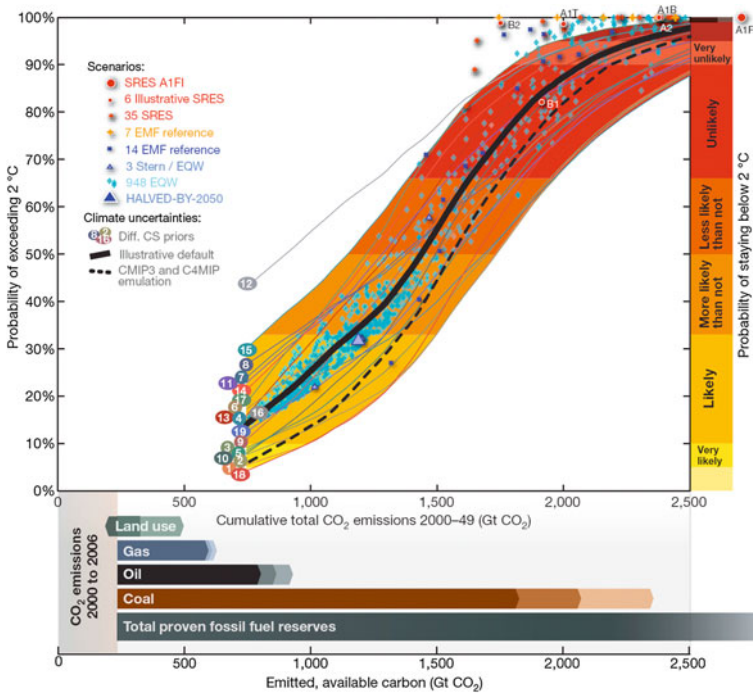
**Table 1** The systematic analysis of the ci: grasp adaptation database ([www.ci-grasp.org](http://www.ci-grasp.org)) showed that for certain sectors the time horizon from the starting point until the finalization of an adaptation activity is around one decade (cf. for details Costa et al. 2013)

Adaptation sector	Understanding	Planning	Implementation	Average duration
<i>Agriculture</i>				
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
<i>Coastal adaptation</i>				
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 (Fleurbay 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<sub>2</sub> 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<sub>2</sub> 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

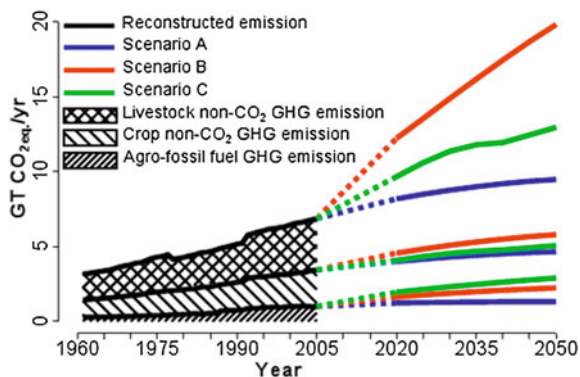


of side effects, e.g. highly efficiently produced food in the OECD whose unusable components are exported to developing nations destroying local markets and income options there. The globalization of agriculture in fact produces enough food, but that food is not equally distributed over the entire world. 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 by 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

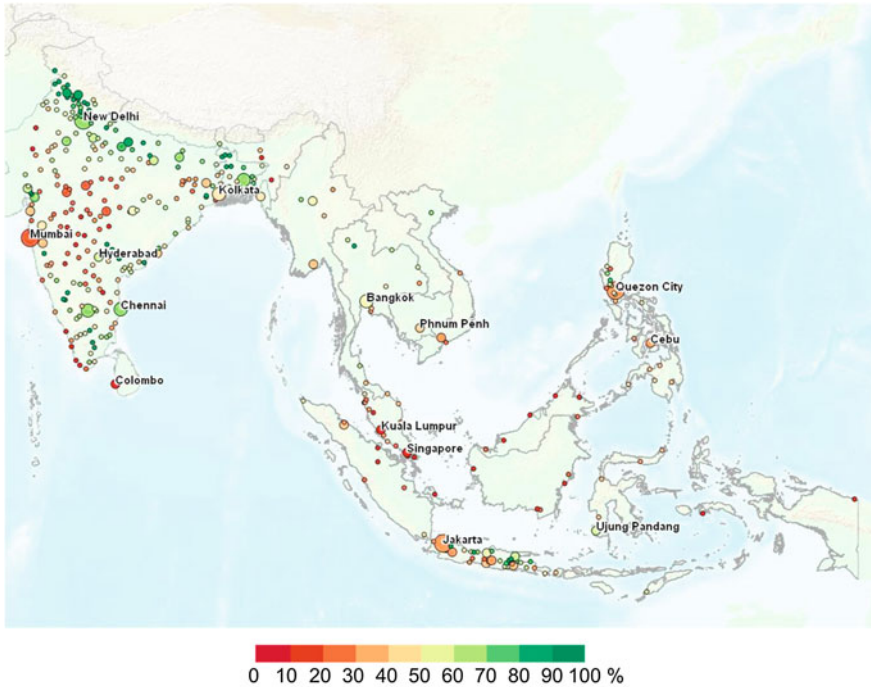


**Fig. 3** Reconstructed and projected global total agricultural GHG emissions for three certain scenarios (A population growth only, B population growth and changes in dietary patterns, C change in population, diets and technology and management of agricultural land use). The total GHG emissions are decomposed into non-CO<sub>2</sub> GHG emission from livestock and crop and CO<sub>2</sub> emissions from use of fossil fuel in agriculture. The IPCC (2007) estimated a GHG emission from agriculture between 5 and 6 Gt CO<sub>2</sub>. 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<sub>2</sub>, 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<sub>2</sub> emissions per ton and is the fastest growing mode (140 % 1992–2002). Thus, emissions of CO<sub>2</sub> 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.

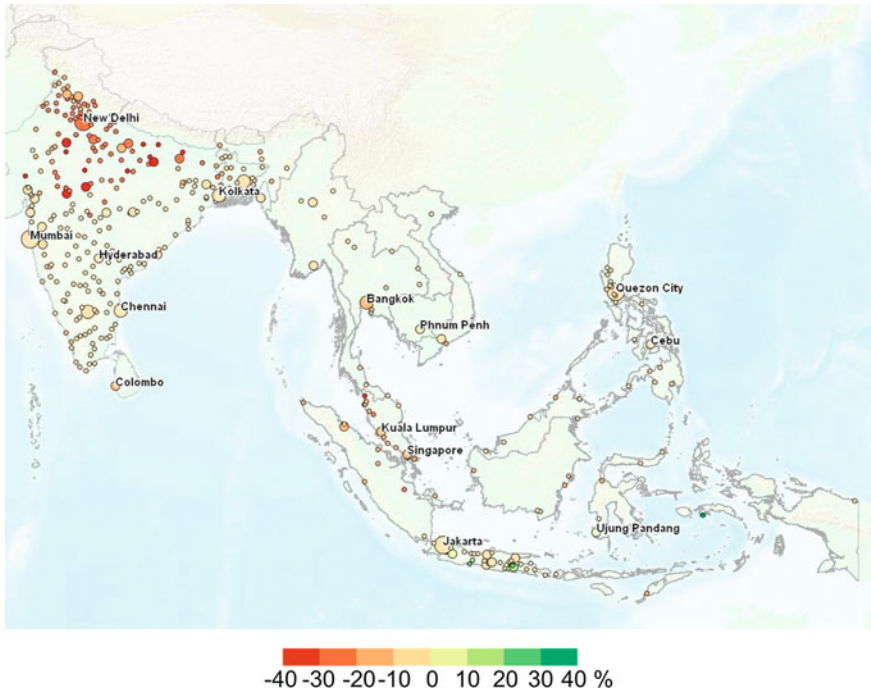
Kriewald et al. (2013) developed a methodology which describes urban regions and its hinterland as so-called urban-bioregions. By combination of certain databases, e.g. GRUMP population data, GlobCover land cover data, it was feasible



**Fig. 4** Carrying capacity for the South-East Asian Urban-Bio-Regions. The *bullet* size represents the size of a region, while the *color coding* indicates how much of the urban region can be nourished by the urban hinterland under current climate conditions. In this case the maximum achievable yield is calculated (cf. Kriewald et al. 2013). For a huge amount of cities food can be produced in the direct vicinity of a city, which would reduce emissions from transport considerably. For large agglomerations like Delhi, Kolkata or Chennai more than 70 % of food needs can be sustained by the urban hinterland. Note that the calculation consider current dietary patterns and land use

to detect urban agglomerations and their hinterland automatically, by applying the city clustering algorithm (Rozenfeld et al. 2011). The advantage of this approach is the consideration of actual urban (mega-) regions, i.e. not only administrative entities. This is essential, because the effects of urban regions is not isolated to single cities (administrative entities), but to urban agglomerations, e.g. greater Mexico City, Greater London, Greater New Delhi, etc. In a second step the urban hinterland and its agro-potential is systematically estimated (cf. Kriewald et al. 2013, for details). Considering the current land use it is easy to calculate the potential for peri-urban food production under current and future climate constraints. As a result, the approach provides a systematic overview of the nourishing potential of cities by its hinterland (Fig. 4).

Concerning a reorganisation of cities in terms of their food allocation, a considerable amount of greenhouse gas emissions from transport can be saved by such an approach. Moreover, the closing of material cycles is also feasible, e.g. for



**Fig. 5** Change of the carrying capacity in case of climate change in the year 2050 considering the A2/ECHAM4 scenario. Globally can be stated that approximately 80 % of urban-bio-regions will face a decrease in agricultural products', while most of the benefiting cities are located in the northern latitudes. In comparison to this situation the cities on the Indian subcontinent will suffer most from decreases in agriculture, for certain regions up to  $-40$  %. Again the calculations refer to actual diets and actual land use (for details cf. Kriewald et al. 2013)

urban waste, which can be used as fertiliser in the urban-bio-regions. As shown by this example, a critical review of our current urban life, supply and demand chains is needed not only in regard to the food supply problem, but also in regard to water, energy and consumption. Solutions are feasible, but need a change in our urban life paradigm. Such an approach shows how adaptation and mitigation can be reconciled efficiently in order to create win-win effects.

That such ideas could have a stimulating effect for the climate negotiations is shown in Fig. 5. In case of the A2 scenario (SRES 2000) the potential for urban food production may change tremendously. This will hold, in particular, in the Indo-Gangetic-Plain, which is one of the most productive region worldwide in terms of agriculture. In addition, detailed analyses show that for most of the cities in SE Asia, urban hinterland is already is used for agriculture, i.e. an extension of urban agriculture is not really an option. Thus, when climate changes affects agriculture, these regions may approach their environmental limits, i.e. neither extension, nor irrigation may be a solution for agricultural adaptation.

## 4 Managing Transitions and Making Them Happen

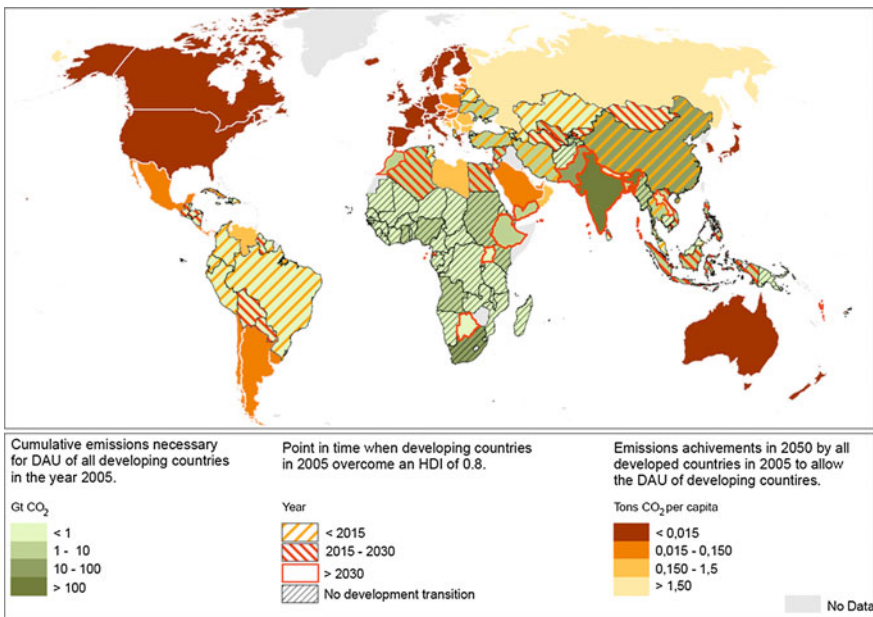
In the previous sections the multi-dimensionality of climate related challenges has been discussed. It was shown that implemented actions need to consider this as well, and that one-sided orientation, e.g. on adaptation, will not solve the problem in general. Peters et al. (2012) stated that an annual mitigation rate of approx. 3 %/yr is needed in order to keep global warming below 2 °C. The time horizon to take action for a safe future is less than one decade (WBGU 2009). Nevertheless, a concerted action is needed and a fair and clearly defined labour share between mitigation, adaptation and development efforts. This implies that clear climate related targets need to be defined, which should not be superimposed by other political goals.

Adaptation to climate change is needed for particularly risk prone areas, but should clearly focus on unavoidable consequences related to climate change. The mixture of unclear adaptation and development targets are not productive in terms of tackling climate challenges. Moreover, the needed national/international coordination for adaptation activities, which combines sensible risk minimization with adequate climate protection in an optimal case, makes it at least debatable whether adaptation alone is an adequate response strategy to address global climate change challenges. In addition, to avoid that adaptation efforts are not being negated by an accelerated climate change implies that our attention should turn to the core problem first, namely to constrain greenhouse gas emissions (cf. WB 2012). Costa et al. (2013) estimated the time horizons of certain adaptation measures (Table 1). He found that adaptation activities often last around one decade before they are finalized. This decade can be better used when focusing more on emission reduction agreements.

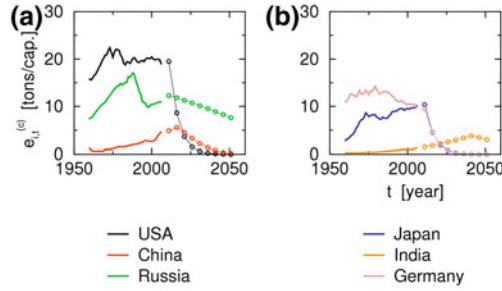
On the other hand we have to recognise that the international negotiations regarding ambitious climate protection fail. The major outcome of the recent Doha conference of the United Framework Convention of Climate Change (COP18) was the agreement for a second commitment phase of the Kyoto Protocol through 2020. How the world's two biggest greenhouse gas emitters—China and the United States—will be integrated is still an open issue. Moreover, it was agreed to work toward a universal climate change agreement covering all countries from 2020, to be adopted by 2015, and to find ways to scale up efforts before 2020 beyond the existing pledges to curb emissions. This is still a weak compromise because it does not take into account that we need to take action as soon as possible in the upcoming decade.

Why it is so difficult to implement an agreement? Despite the 2 °C target agreement equitable and fair burden sharing, i.e. in terms of national emission budgets, is generally unsolved. While development economies are still pointing out that they need to develop, the OECD mention that global civilization will never meet the targets without having the upcoming and existing larger emitters in the developing world on board. Of course, both is true, but what can be the way out of this trap? First, we have to ask how to account for the responsibility of

developed countries regarding historical CO<sub>2</sub> emissions (WBGU 2009). Second, it is essential to determine to what extent technological and political inertia impose limits to the range of strategies envisioning the implementation of reduction schemes. For developing countries, social and economic development is of particular importance. In order to tackle these challenges, the CO<sub>2</sub> allocation and reduction approach should rely on the Human Development Index (HDI, cf. UNDP 2008) or on other more advanced measurements of global welfare (e.g. Genuine Progress Indicator (GPI), cf. e.g. Lawn 2003). The idea for why we make this suggestion is the following. Developing countries can gain certain benefits from fossil fuel use for their own economic growth. This neoclassical growth is (for the moment) the major forcing factor for development progress and cannot be changed immediately. For example, a mine worker in India gains a monthly salary of around 2,000 Rupees and India has a huge amount of domestic coal. The utilization of these resources provide an enormous economic surplus. But it is needed to take care of development issues. Thus, developing countries can take benefits from cheap energy, but need to implement transition plans to low carbon societies, when the country transgresses the 0.8 HDI, the official level for an OECD country.



**Fig. 6** Global distribution of allowed emissions for a development as usual scenario from developing countries (*green shading*) and per capita CO<sub>2</sub> targets in 2050 for developed countries (*brown shading*) under the proposed framework to keep temperatures *below* 2 °C target, i.e. 1,000 Gt CO<sub>2</sub> with a 25 % overshooting probability (cf. Meinshausen et al. 2009). The period in time when developing countries are expected to reach an HDI of 0.8 is represented by the colored hatches and frames. For several countries, mainly in Africa, not development transition will be achieved before 2050 (cf. Costa et al. 2011 for details)



**Fig. 7** Examples of extrapolated CO<sub>2</sub> emissions per capita in agreement with the proposed reduction concept shown in Fig. 6. *Solid lines* stand for the historical emission while the *connected circles* represent extrapolated emissions when countries follow the reduction needed reduction schemes (for details cf. Costa et al. 2011). While USA, Japan and Germany have to implement rapidly, India has time, approx. until 2040 and China until 2018

Taking this into account introduces fairness in regard to historical responsibility, but also equity, because it considers the technological development level of a country (cf. Fig. 6). The whole framework keeps the global climate below the 2 °C target until 2050. We would not state that this strategy is the only option, it can, for example, be accompanied by an efficient and transnational emission trading scheme (ETS) in order to achieve emission goals faster. However, the suggested approach shows transition pathways for countries, which will work (in principle) without emission trading and international funds for ambitious climate protection. Countries can develop their one energy strategy and have the possibility to use fossil fuel until the approach of 0.8 HDI, which offers developing countries more time for action (cf. Fig. 7). Such a suggested framework can pave a road towards an internationally binding agreement on carbon dioxide emission constraints because it includes implicitly the welfare question, which is clearly connected with the availability of cheap energy in developing countries. Nevertheless, the suggested framework puts additional pressure on the OECD countries.

Taking the climate challenge seriously and considering the fact that we still have around one decade to constrain global warming to an acceptable level, we still need additional instruments which may help to accelerate humanity's response capabilities. In comparison agreements under the rooftop of the World Trade Organisation, which establishes patent free zones for least developed countries for AIDS and Malaria pharmaceuticals, it is also imaginable that similar for zero carbon technologies can be implemented. Such an agreement would have immediate effects on emissions and money from ETS systems could help to fulfil compensation for the respective patent holders. This would be much more efficient as uncoordinated investments, e.g. in regional adaptation or afforestation.

## 5 Summary

It was shown in this contribution that the current political debates about climate change related challenges is mainly about climate funds and adaptation. It seems that the reduction of GHG play a only role during annual climate conferences (COPs). One reason why this happens is, of course, the failure of these conferences to come to binding agreements about carbon budgets. Nevertheless, this is a dangerous development because adaptation cannot guarantee a safe and climate proof development. It is acknowledged that the Green Climate Fund can play an important role in avoiding social disruptions which may potentially be caused by climatic threats, however, a clear prioritisation of activities is needed. In parallel it must be emphasized that current negotiations about carbon budgets need more dynamics in order to open paths to further options. This can be the smart handling of intellectual property rights for low carbon technologies, global strategies for future near-city food production, or by new budget approaches that recognize development levels and recent responsibilities. Concerning the interwoven aspects of adaptation and mitigation, clear climate related targets should be defined, i.e. the success of these actions should be measurable and quantifiable in terms of their “climate efficiency”. This is important, because it can be expected that both, the climate negotiations and the implementation of adaptation will need at least a decade. A precondition for any of these activities is that science provides comparable impact assessments in the sense that policymakers can really decide where it is necessary to invest funds most efficiently.

Nevertheless, for humanity it is an ethical decision whether avoid the transgression of dangerous planetary boundaries keeping us in a range of acceptable changes or whether to take the risk of serious disruptions. Focussing on the latter decision, this bears a resemblance to a wait and see strategy. From the position of a local stakeholder it is understandable that adaptation is much more desirable as a response mechanism. Adaptation may help them to find local solutions, but most of them will not solve or support solving the major underlying problem, namely global warming. Mitigation should as well be in the focus of local decision makers, because several examples show that GHG reduction will reduce the risk of local damages considerably.

Science has made tremendous progress regarding the understanding of global processes and we are now entering a phase where scientific models can go down to smaller scales in order to calculate potentials and effects for regions. This allows the performing of more explicit assessments and helps highlight options for development or concrete solutions and opens time corridors for action. Humanity needs to come to a decision mode which proactively operates on sustainable options instead of just responding to recent experiences. In such a case, humankind is able to keep climate change related consequences to an acceptable level, when world leaders would like to do so.



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