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Chapter 4

Sustainable Development and Equity

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Chapter 4: Sustainable Development and Equity

Contents

Executive Summary

Since the first assessment report, the IPCC has considered issues of sustainable development (SD) and equity: acknowledging the importance to climate decision-making, and progressively expanding the scope to include: the co-benefits of climate actions for SD and equity, the importance of advancing broader SD objectives for effective climate response, the relevance of lifestyle and behaviour, the relevance of procedural equity to effective decision-making, and the relevance of ethical frameworks and equitable burden-sharing in assessing climate responses. In this Assessment Report, we further explore key dimensions of SD and equity, highlighting the significance of disparities across different groups, and the importance of advancing broader SD objectives and equity for an effective climate response. [4.1]

SD is variably conceived as development that preserves the interests of future generations, that preserves the ecosystem services on which continued human flourishing depends, or that harmonizes the co-evolution of three pillars (economic, social, environmental). Weak sustainability allows for the substitution of natural capital with human-made capital, while strong sustainability requires the preservation of certain critical forms of natural capital such as a stable climate system and biodiversity. Ensuring SD is less ambitious but more consensual than seeking a socially optimal pathway. [4.2]

SD is a framing issue in this Assessment Report because it is intimately connected to climate change. First, the climate threat constrains possible development paths, and sufficiently disruptive climate change could preclude any prospect for sustainable future **(high agreement, medium evidence)**. Thus, a stable climate is one objective of SD. Second, there are trade-offs between climate responses and broader sustainable development goals, because some climate responses can impose other environmental pressures, have adverse distributional effects, draw resources away from other developmental priorities, or otherwise impose limitations on growth and development. These trade-offs are studied in the sector chapters of this report, along with measures and strategies to minimize them. Options for equitable burden-sharing can reduce the potential for the costs of climate action to constrain development **(high agreement, medium evidence).** Third, there are multiple potential synergies between climate responses and broader sustainable development efforts. Not only can specific climate responses generate co-benefits for human and economic development, but at a more fundamental level, the capacities underlying an effective climate response overlap strongly with capacities for SD **(high agreement, medium evidence)**. [4.2]

Equity permeates the SD literature. First, intergenerational equity underlies the basic notion of sustainability. Intragenerational equity is often considered an intrinsic component of sustainable development in relation to the social pillar, yet not without its qualifications. Meeting the needs of the world's poor through the convergence of developing countries toward the standard of living of the world's richest populations based on the same consumption patterns and production processes, would be unsustainable and would threaten to exceed the regeneration and absorption capacity of the Earth which would itself undermine the well-being of poor communities in particular **(high agreement, high evidence)**. [4.2]

Notwithstanding the challenges, compelling arguments have been put forward that equity, in its multiple dimensions, be embraced as a fundamental component of sustainable development. In the particular context of international climate change relations, the arguments encompass three dimensions: a moral justification that draws upon ethical principles; a legal justification that appeals to existing treaty commitments and soft law agreements to cooperate on the basis of stated equity principles; and an effectiveness justification that argues that a fair arrangement is more likely to be agreed internationally and successfully implemented domestically. **(medium agreement, medium evidence)** [4.2]

The latter justification is based on the fact that the climate change problem is a classic commons problem, and thus an effective solution relies on collective action, which is more likely to be agreed and effectively implemented if it is perceived to be fair in both its terms and the procedures through which they were decided. This reinforces a regime's legitimacy, increasing countries' commitment to fulfilling its requirements and reducing the risks of defection and a cooperative collapse. A relatively small set of core equity principles that are well-grounded in moral philosophy serve as the basis for most discussions of equitable burden-sharing in a climate regime: responsibility (for GHG emissions), capacity (ability to pay for mitigation, but sometimes other dimensions of mitigative capacity), the right to sustainable development, and equality (often interpreted as an equal entitlement to emit). Various quantitative indicators can help illuminate how these various equity principles reflect on the "common but differentiated responsibilities and respective capabilities" of different nations or national groupings, and burden-sharing frameworks – both resource-sharing and burden-sharing – have been developed that draw in various ways on these equity principles. [4.2]

A useful set of determinants from which to examine the prospects for and impediments to sustainable development and equity are: the legacy of development; governance and political economy; population and demography; human and social capital; behaviour, culture and values; technology; natural resource endowments; and finance and investment. While it is possible to envision an evolution of each of these determinants as a driver (rather than barrier) to a sustainable development transition, each is also deeply embedded and highly inertial, posing profound challenges. [4.3]

Governing a transition toward a more sustainable development pathway is inevitably challenging because it involves multiple agents that hold vested interests, varying degrees of agency and power, and differential access to decision-making authority. This all reflects a political economy that conditions and mediates several realms of policy, organization, discourse and action, from international to national to local to individual levels. [4.3]

A society' transition towards sustainable development can be facilitated by enhancements to human capital based on individual knowledge and skills, and social capital based on mutually beneficial formal and informal relationships. At the level of individual values and behaviour, sustainable development poses 'social dilemmas' where short-term narrow individual interests conflict with the longer term social interests, with values that transcend selfishness and promote the welfare of others being favourable to a sustainable development transition. However, formation of values and their translation into behaviours is mediated by a many factors, including the available set of market choices and lifestyles, the tenor of dominant information sources (including advertisements and popular culture), the culture and priorities of formal and civil institutions, the prevailing governance structures. All of these are embedded in and conditioned by the prevailing political economy, which imposes tight structural constraints on the ability for individuals to make substantive, lasting, and impactful change at the personal level. [4.3]

Technology and finance both are strong determinants of future societal paths. While society's current systems of allocating resources and prioritizing efforts toward investment and innovation is in many ways robust and dynamic, there are some fundamental tensions with the underlying ideals of sustainable development. First, the financial and technological innovation systems are not structured to balance the three pillars of sustainable development: they are highly responsive to short-term financial motivations, but are sensitive to broader social and environmental costs and benefits only to the relatively limited extent that they are internalized by regulation, taxation, laws and social norms. Second, while they are quite responsive to market demand that is supported by purchasing power, they are only indirectly responsive to needs, and particularly insensitive to "the essential needs of the world's poor, to which overriding priority should be given". Third, they operate with a time horizon that is too short to be sensitive to "the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987) [4.3]

The global consumption of goods and services has increased dramatically over the last decades, in both absolute and per capita terms, and is a key driver of environmental degradation, including global warming (high agreement, robust evidence). This trend involves the spread of high-consumption life-styles in some countries and sub-regions, while in other parts of the world large populations continue to live in poverty. There are high disparities in consumption both between and within countries. [4.4]

Two basic types of decoupling can be identified at the global scale and in the long term: the decoupling of material resource consumption (including fossil fuels) and environmental impact (including climate change) from economic growth, and the decoupling of economic growth from human well-being. The first type – the dematerialization of the economy, i.e. of consumption and production – is generally considered crucial for meeting sustainable development and equity goals, including mitigation of climate change. Production-based (territorial) accounting suggests some decoupling of impacts from economic growth has occurred, especially in industrialized countries, but the extent of this decoupling is significantly diminished based on a consumption-based accounting. The consumption-based emissions are more strongly associated with GDP than production-based emissions, because wealthier countries satisfy a higher share of their final consumption of products through net imports compared to poorer countries. Ultimately, absolute levels of resource use and environmental impact – including GHG emissions – generally continue to rise with GDP **(high agreement, robust evidence).** The second type of decoupling – of human well-being from economic growth – is a more controversial and novel concept than the first, at least in the context of climate change mitigation. There are ethical controversies about the measure of well-being and the use of subjective data for this purpose. There are also empirical controversies about the relationship between subjective well-being and income, some recent studies across countries finding a clear relationship between average levels of ladder-of-life satisfaction and per capita income, while the evidence about the long-term relationship between satisfaction and income is less conclusive and quite diverse among countries. Studies of emotional well-being do identify clear satiation points beyond which further increases in income no longer improve individuals' ability to do what matters most to their emotional well-being. Furthermore, income inequality has been found to have a marked negative effect on average subjective well-being, due to perceived fairness and general trust in the case of low income groups. [4.4]

How development paths unfold in the future will impact both emissions and mitigative capacity. Yet the link between individual characteristics of the development paths (in particular, GDP growth rate) and emissions is ambiguous (high agreement, robust evidence). In fact, understanding how development paths impact on emissions and mitigative capacity, and, more generally, how development paths can be made more sustainable and more equitable in the future requires in-depth analysis of the mechanisms that underpin these paths. Of particular importance are the processes that may generate path dependence and lock-ins, notably "increasing returns" but also use of scarce resources, switching costs, negative externalities or complementarities between outcomes. [4.5, 4.6]

The study of transitions between pathways is an emerging field of literature, notably in the context of technology transitions. Yet analyzing how to transition between pathways remains a major scientific challenge. To do so, models should simultaneously capture processes relevant for the short- term and for the long-term. And output-wise, models should provide information on the relationships between the economy, society, and the environment, and on the distribution of economic activity, notably across income groups, especially in the perspective of assessing the possible future evolution of well-being. [4.5, 4.7]

This chapter has focused on examining ways in which the broader objectives of equitable and sustainable development provide a policy frame for an effective, robust, and long-term response to the climate problem. While building both mitigative capacity and adaptive capacity relies to a profound extent on the same factors as those that are integral to equitable and sustainable development (high agreement, medium evidence), mitigation and adaptation measures can strongly affect broader SD and equity objectives, (high agreement, robust evidence) and it is thus necessary to assess their broader implications. Implications of measures can be assessed using alternative frameworks: the three pillars (economic, social, environmental), capital (productive, human, natural, social), and well-being. As risk is a central aspect of sustainability, the analysis of mitigation measures and measures should not stop with central estimates of consequences for SD and equity, but examine likelihood of potential impacts. [4.6, 4.8]

4.1 Introduction

4.1.1 Key messages of previous IPCC reports

This chapter seeks to place climate change, and climate change mitigation in particular, in the context of equity and sustainable development. Prior IPCC assessments have sought to do this as well, progressively expanding the scope of assessment to include broader and more insightful reflections on the policy-relevant contributions of academic literature.

The IPCC *First Assessment Report* (FAR) (IPCC, 1990) underscored the fundamental nature of equity and sustainable development to climate policy. While the FAR gave only cursory consideration to broader sustainable development objectives in its evaluation of potential response strategies, focusing primarily on efficiency and effectiveness with respect to mitigation specifically, its more important contribution was to squarely and explicitly place the imminent negotiations on a global climate regime within an equity and sustainable development rubric. Specifically, in response to its mandate to identify “possible elements for inclusion in a framework convention on climate change”, the IPCC specifically and prominently put forward the “endorsement and elaboration of the concept of sustainable development” for negotiators to consider as part of the convention’s Preamble. It also noted that a key issue would be “how to address equitably the consequences for all” – and in particular, “whether obligations should be equitably differentiated according to countries’ respective responsibilities for causing and combating climate change and their level of development”. This set the stage for the ensuing negotiations of the UNFCCC, which ultimately included explicit appeals to equity and sustainable development, including in its Preamble, its Principles (Article 2), its Objective (Article 3), and its Commitments (Article 4).

The IPCC *Second Assessment Report* (SAR) (IPCC, 1995), published after the UNFCCC was signed, maintained this focus on equity and sustainable development. As with the FAR, the SAR’s assessment of potential response strategies treated broader sustainable development objectives only briefly, although it reflected a growing appreciation for the prospects for sustainable development co-benefits and reiterated the policy relevance of equity and sustainable development. It did this most visibly within a special section of the Summary for Policymakers, which presented “Information Relevant to Interpreting Article 2 of the UN Framework Convention on Climate Change”, including *“*Equity and social considerations” and “Economic development to proceed in a sustainable manner”. Notably, the SAR added an emphasis on procedural equity, recognizing that a climate regime cannot be equitable in its structure and implementation if it is not designed through a legitimate process that empowers all actors to effectively participate, and arguing for the need to build capacities and strengthen institutions, particularly in developing countries.

The IPCC *Special Report on Emission Scenarios* (SRES) (Nakicenovic et al., 2000) conveyed important lessons from the academic study of development pathways. The SRES demonstrated that broader sustainable development goals can contribute indirectly, yet substantially, to reducing emissions. This IPCC contribution reflected a change in the scientific literature, which had in recent years expanded its discussion of sustainable development to encompass analyses of lifestyles, culture, and behaviour, complementing its traditional techno-economic analyses. It also reflected a recognition that economic growth (especially as currently measured) is not the sole goal of societies across the globe. The SRES thus provided insights into how policy intervention can decouple economic growth from emissions and well-being from economic growth, showing that both forms of decoupling are important elements of a transition to a world with low greenhouse gas (GHG) emissions.

The IPCC *Third Assessment Report* (TAR) (IPCC, 2001) maintained and deepened the consideration of broader sustainable development objectives in its assessment of potential response strategies. Moreover, and perhaps owing to a growing appreciation for the severity of the climate challenge, the TAR stressed the need for an ambitious and encompassing response, and was thus more attentive to the potential for climate-focused measures to conflict with basic development aspirations. It thus articulated the fundamental equity challenge of climate change to be ensuring “that neither the impact of climate change nor that of mitigation policies exacerbates existing inequities both within and across nations”, specifically because “restrictions on emissions will continue to be viewed by many people in developing countries as yet another constraint on the development process”. The TAR recognized, in other words, the need to deepen the analysis of equitable burden-sharing as a basis for an equitable climate regime, but even more fundamentally as a means to avoid undermining prospects for sustainable development in developing countries. More generally, the TAR observed that equitable burden-sharing is not solely an ethical matter; even from a rational-actor game-theoretic perspective, an agreement in which the burden is equitably shared is more likely to be signed by a large number of countries, and thus to be more effective and efficient. Equitable burden-sharing would provide the basis by which the developing countries could earnestly engage in a global climate effort.

The IPCC *Fourth Assessment Report* (AR4) (IPCC, 2007) further expanded the consideration of broader sustainable development objectives in its assessment of potential response strategies. It stressed the importance of civil society and other non-government actors in designing climate policy and equitable sustainable development strategies in general. The AR4 focused more strongly than previous assessments on the distributional implications of climate policies, noting that conventional climate policy analysis that is based too narrowly on traditional utilitarian or cost-benefit frameworks will neglect critical equity issues including human rights implications and moral imperatives. Even more straightforwardly, it neglects both the distribution of costs and benefits of a given set of policies, and the further distributional inequities that arise when these policies are implemented in a world where the poor have limited scope to influence policy adoption and implementation. This is particularly problematic, the AR4 notes, in integrated assessment model (IAM) analyses of “optimal” mitigation pathways, because climate impacts do not affect the poor exclusively, or even mainly, through changes in real incomes. Nor do these approaches satisfactorily account for uncertainty and risk, which is treated differently by the poor compared with the rich, due to their higher risk aversion and lower access to assets and financial mechanisms, such as insurance, that buffer against shocks.

The AR4 went on to outline alternative ethical frameworks including rights-based and capabilities-based approaches, suggesting how they can inform climate policy decisions. In particular, the AR4 discussed the implications of these different frameworks for equitable international burden-sharing. It is these approaches that have inspired the environmental justice framework and informed its approach to climate policy decisions, both at the national and international levels.

The IPCC *Special Report on Renewable Energy Sources and Climate Change Mitigation* (SRREN) (IPCC, 2011) deepened the consideration of broader sustainable development objectives in assessing renewable energies options, noting particularly that while they can be synergistic (for example, through helping to expand access to energy services, increase energy security, and reduce other environmental pressures), they also pose challenges (such as those relating to increasing pressure on land resources, and affordability) and that trade-offs must be negotiated in a manner that is sensitive to equity considerations.

The IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) (IPCC 2012a) raised key further dimensions of sustainable development and equity, including the distinction and interplay between incremental and transformative changes – both of which are necessary – and emphasized the importance of values in justifying the basis for decision-making, e.g., a human rights framework vs utilitarian cost-benefit analysis.

Building upon the progressively more sophisticated understanding of the sustainable development and equity context of climate change as found in the scientific literature and reflected in the prior IPCC assessments, this Fifth Assessment Report (AR5) elaborates further on key dimensions and expands the treatment in important directions.

4.1.2 The narrative focus and key messages of this chapter

In keeping with the previous IPCC assessments, this chapter considers sustainable development and equity as matters of policy relevance for climate change decision-makers. It examines the ways in which climate change is in fact inextricably linked with sustainable development and equity. It examines these links with the aim of drawing policy-relevant conclusions regarding equitable and sustainable responses to climate change.

In one direction, the link is self-evident: an effective climate response is necessary for equitable and sustainable development to occur. The disruptions that climate change would cause in the absence of an effective societal response are sufficiently severe (AR5 WGI, AR5 WGII) to severely compromise development, even taking into account future societies' ability to adapt (Shalizi and Lecocq, 2010). Nor is this development likely to be equitable, as an increasingly inhospitable climate will most seriously undermine the future prospects of those nations, communities, and individuals that are already most in need of development. Without an effective response to climate change, including both timely mitigation and proactive adaptation, development can be neither sustainable nor equitable.

In recent years, the academic community has come increasingly to appreciate the extent to which SD and equity are also needed as frameworks in which to assess and prioritize climate responses: given the various trade-offs and synergies between the options for a climate response and the various determinants and components of SD, the design of an effective climate response must respect the demands for development and equity and exploit the synergies. A climate strategy that does not fit this frame runs the risk either of being ineffective for lack of consensus and earnest implementation or of jeopardizing SD just as unabated climate change would. Therefore, a shift toward more equitable and sustainable modes of development may provide the only context in which an effective climate response can be realized.

The scientific community is coming to understand that climate change is but one example of how humankind is pressing up against its planetary limits (Millennium Ecosystem Assessment, 2005a; Rockström et al., 2009a). Technical measures can certainly help in the near-term to alleviate climate change. However, the comprehensive and durable strategies society needs are those that recognize climate change shares its root causes with other dimensions of the global sustainability crisis, and that without addressing these root causes, robust solutions may not be accessible.

This chapter, and many parts of this report, uncovers ways in which a broader agenda of sustainable development and equity may support and enable an effective societal response to the climate challenge, by establishing the basis by which mitigative and adaptive capacity can be built and sustained. In examining this perspective, this chapter focuses on several broad themes.

4.1.2.1 Consumption, disparities and well-being

The first theme relates to well-being and consumption. We have long understood the relationship between aggregate levels of consumption and environmental pressures, including GHG emissions. What we are increasingly understanding is the significance of high-consumption lifestyles in particular and consumption disparities (Sec. 4.4). An important part of this literature relates to the methodologies for understanding and calculating the environmental impacts across national boundaries of different modes of consumption, through consumption-based accounting and GHG footprint analysis (Sec. 4.4). Important research is now being undertaken on the relationship between well-being and consumption, and how to moderate consumption and its impacts without sacrificing well-being – and indeed, while enhancing it. More research is now available on the importance of behaviour, lifestyles and culture, and their relationship to over-consumption.

At the same time, there are more data and research available to help understand "under-consumption", i.e., poverty and deprivation, and its impacts on well-being more broadly, and specifically on the means by which it undermines mitigative and adaptive capacity. Energy poverty is one critical example, linked directly to climate change, of under-consumption that is highly correlated with weakening of livelihoods, lack of resilience, and limiting of mitigative and adaptive capacity. Overcoming under-consumption and reversing over-consumption, while maintaining and advancing human well-being, are fundamental dimensions of a transition to a sustainable development pathway, and are equally critical to resolving the climate problem (see Sec. 4.5).

4.1.2.2 Equity at the national and international scales

Given the disparities evident in consumption patterns, the distributional implications of climate response strategies are critically important. As recent history shows, understanding how policies affect different segments of the population is critical to designing and implementing politically acceptable and effective national climate response strategies. A just transition would be helpful to build the level of public support needed for the substantial techno-economic, institutional and lifestyle shifts needed to reduce emissions substantially and enable adaptive responses.

At the international level, an equitable regime with fair burden-sharing is likely to be a necessary condition for an effective global response (Sec. 4.2, 4.7). Given the urgency of the climate challenge, a rather rapid transition will be required if the global temperature rise is to be kept below any of the politically discussed targets, such as 1.5°C or 2°C over pre-industrial levels, with global emissions peaking as soon as 2020. Particularly in a situation calling for a concerted global effort, the most promising response is a cooperative approach "that would quickly require humanity to think like a society of people, not like a collection of individual states" (Victor 1998).

While scientific assessments cannot define what is equitable and how equity should be interpreted in implementing the Convention and climate policies in general, they can help illuminate the implications of alternative choices and their ethical basis (Sec 4.7, also Chapter 3, Chapter 13).

4.1.2.3 Building institutions and capacity for democratic governance

Charting an effective and viable course through the climate challenge is not merely a technical exercise. It will involve myriad and sequential decisions, among states and civil society actors, supported by the broadest possible constituencies. (Sec. 4.3) Such a process requires the education and empowerment of diverse actors to participate in systems of decision-making that are designed and implemented with procedural equity as a deliberate objective. This is true at the national as well as international levels, where effective governance relating to global common resources, in particular, is not yet mature.

Any given approach to addressing the climate challenge has potential winners and losers. The political feasibility of that approach will depend strongly on the distribution of power, resources, and decision-making authority among those potential winners and losers. In a world characterized by profound disparities, systems of democratic engagement and governance are needed to enable a polity to come to equitable and sustainable solutions to climate. This applies to decisions relating to finance and technology (4.3).

4.2 Approaches and indicators

This section maps out the various conceptual approaches to the issues of sustainable development (4.2.1), equity (4.2.2), and their linkages to climate change and climate policy.

4.2.1 Sustainability and sustainable development (SD)

4.2.1.1 Defining and measuring sustainability

The most frequently quoted definition is from *Our Common Future* (World Commission on Environment and Development (WCED), 1987), the Brundtland Report:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- *the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and*
- *the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.*

This definition acknowledges a tension between sustainability and development (Jabareen, 2006), and that for developing countries, development objectives are for basic needs to be met for all citizens and secured in a sustainable manner (Murdiyarso, 2010). One of the first definitions of SD (Prescott-Allen, 1980) referred to a process of development that is compatible with the preservation of ecosystems and species.

A popular conceptualization of SD goes beyond securing needs and preserving the environment and involves three “pillars” or three “bottom-lines” of sustainability: environmental, economic, and social aspects (Dobson, 1991; Elkington, 1998; Flint and Danner, 2001; Pope et al., 2004; Sneddon et al., 2006; Murdiyarso, 2010; Okereke, 2011). There is some variation in the articulation of the three spheres, with some arguing for an equal appraisal of their co-evolution and mutual interactions, and others considering that there is a hierarchy and that economic activities are embedded in the social matrix, which is itself grounded in the ecosphere – this debate may affect relative priorities for action (Levin, 2000; Fischer et al., 2007). This broad SD framework is equally relevant for rich countries concerned with growth, well-being, human development, and lifestyles.

An important distinction opposes weak sustainability to strong sustainability approaches (Neumayer, 2010). The former rely on the assumption that human-made capital can replace natural resources and ecosystem services with a high degree of substitutability, and that what matters is the aggregate value of all capital stocks. The notion of strong sustainability, in contrast, relies on the view that certain critical natural stocks – such as the climate system and biodiversity – cannot be replaced by human-made capital and must be preserved. Weak sustainability is often believed to be inherent to economic modelling that aggregates all forms of capital together, as in the genuine savings indicator introduced in Box 4.2.1 (Dietz and Neumayer, 2007). But economic models and indicators can accommodate any degree of substitutability between different forms of capital (Fleurbaey and Blanchet, 2013). The question of substitutability also arises regarding the various forms of natural capital (Dietz and Neumayer, 2007). A different but related issue is whether one should evaluate development paths only in terms of human well-being or also take account of natural systems as intrinsically valuable (McShane, 2007; Attfield, 2008). While respecting other species implies a form of strong sustainability, it is not a precondition. It can also be argued on the grounds that human flourishing requires a preserved natural environment that can provide critical ecosystem services (Millennium Ecosystem Assessment, 2005a).

Box 4.2.1 Sustainable development indicators (SDI)

When SD started to become an integral consideration in policy-making, SDI initiatives flourished in the early 1990s. Conceptual frameworks for SDIs help focus and clarify what to measure, what to expect from measurement and what kind of indicators to use. Pressure-state-response (PSR) and capital accounting-based (CAB) frameworks, in particular, were widely used to assess sustainability.

The PSR approach was further modified as driving force-state-response (DSR) by UNCSD (2001) and driving force-pressure-state-impact-response (DPSIR) by UNEP (UNEP, 1997, 2000, 2002). The System of Integrated Environmental-Economic Accounting (SEEA) of the United Nations offers a wealth of information about the state of ecosystems and is currently under revision and expansion.[1] The CAB approach is embodied in the Adjusted Net Savings indicator of the World Bank (2003, 2011). It is based on the economic theory of "genuine savings" that is summarized at the end of this box.

General presentations and critical assessments of SDIs can be found in a large literature (Daly, 1996; Aronsson et al., 1997; Pezzey and Toman, 2002; Lawn, 2003; Hamilton and Atkinson, 2006; Asheim, 2007; Dietz and Neumayer, 2007; Neumayer, 2010; Martinet, 2012; Mori and Christodoulou, 2012; Fleurbaey and Blanchet, 2013). This literature is pervaded by a concern for comprehensiveness – recording all important aspects of well-being, equity, and nature preservation for current and future generations – and accuracy – avoiding arbitrary or unreliable weighting of the relevant dimensions when synthesizing multidimensional information.

The CAB approach assumes that social welfare over current and future generations is a function of the current stocks of manmade and natural capital: $W(S_t)$. Its evolution can be written as $\frac{dW}{dt} = p_t \frac{dS}{dt}$, where the "accounting price" vector p_t is the vector of partial derivatives of W with respect to each stock (Dasgupta and Mäler, 2000). The path of generational welfare[2] U_τ for $\tau \geq t$, is said to *sustain* the current level U_t if welfare is never lower than this level along the path. The current level is said to be *sustainable* is there exists a feasible path that sustains it (Pezzey and Toman, 2002; Asheim, 2007).

If the discounted utilitarian criterion is used, $W(S_t) = \int_t^\infty e^{-\rho(\tau-t)} U_\tau(S_t) d\tau$, under time consistency assumptions one also has $\frac{dW}{dt} = \rho W(S_t) - U_t(S_t)$. Therefore, if "genuine savings" $p_t \frac{dS}{dt}$ are negative, one has $\rho W(S_t) < U_t(S_t)$, which implies that $U_\tau(S_t) < U_t(S_t)$ at some future date τ because $\rho W(S_t)$ is a weighted average of $U_\tau(S_t)$ over all future dates. Negative genuine savings thus imply that the current welfare $U_t(S_t)$ will not be sustained (Fleurbaey, 2009). This test is valid even if the utilitarian criterion is not used in policy decisions. If the policy does rely on the utilitarian criterion and $W(S_t)$ is maximal at the contemplated path, more can be said because there is no feasible path that avoids this downturn, so that current welfare is then unsustainable (Hamilton and Clemens, 1999; Pezzey, 2004).

Let the maximum sustainable level of $U_\tau(S_t)$ for $\tau \geq t$, i.e., the greatest level u such that $U_\tau(S_t) \geq u$ for all $\tau \geq t$, be denoted $V(S_t)$. Its evolution can be written as $\frac{dV}{dt} = q_t \frac{dS}{dt}$, where q_t is the vector of "maximin prices", the partial derivatives of V. If this quantity is positive, necessarily $U_t(S_t) \leq V(S_t)$ and the current level $U_t(S_t)$ is sustainable in the future, though it may not be sustained along the contemplated path (Cairns and Martinet, 2012).

In conclusion, one obtains two CAB indicators. Non-negative genuine savings at discounted utilitarian prices are necessary for a sustained path (and negative genuine savings at these prices are sufficient for unsustainability if the path is discounted utilitarian optimal); positive genuine savings at

[1] Documentation is available at http://unstats.un.org/unsd/envaccounting/seearev/.

[2] Welfare, or equivalently well-being, for a generation can be measured in any way that is deemed relevant (in particular, it need not be a narrow notion of economic utility).

maximin prices are sufficient for sustainability. The indicators $p_t \frac{dS}{dt}$ and $q_t \frac{dS}{dt}$ can be decomposed by sectors if the contribution of each sector of the economy to the evolution of stocks $\frac{dS}{dt}$ can be identified (Asheim and Wei, 2008).

Computing CAB indicators compounds the difficulty of comprehensively estimating the evolution of capital stocks with the difficulty of computing the accounting prices. While market prices do provide relevant information in a perfectly managed economy (a striking result due to Weitzman (1976)), they may be very misleading in actual conditions (Dasgupta and Mäler, 2000; K.J. Arrow et al., 2010).

Sustainability is closely related to resilience (WG2-Sections 2.4 and 20.3, Folke et al. (2010), Gallopin (2006), Goerner et al. (2009)) and vulnerability (Kates, 2001; Clark and Dickson, 2003). A key premise of this direction of research is that social and biophysical processes are interdependent and co-evolving (Polsky and Eakin, 2011). The biosphere itself is a complex adaptive system, the monitoring of which is still perfectible (Levin, 2000; Thuiller, 2007).

Various approaches toward achieving sustainability are discussed in 4.5. Although SD is a contested concept, there are internationally agreed principles of SD adopted by heads of states and governments at the 1992 UN Conference on Environment and Development and reaffirmed at subsequent review and implementation conferences (United Nations, 1992a, 1997, 2002, 2012a). One guiding principle is: "The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations" (1992 Rio Declaration Principle 3). The Rio principles were reaffirmed at the June 2012 summit level UN Conference on SD.

4.2.1.2 Links with climate change and climate policy

The literature on the complex relations between climate change, climate policies, and sustainable development is large (Swart et al., 2003; Robinson et al., 2006; Bizikova et al., 2007; Sathaye et al., 2007; Thuiller, 2007; Akimoto et al., 2012; Janetos et al., 2012). The links between SD and climate issues are examined in detail in Chapter 20 of WG2. Mapping out these links is also important in the WG3 report; this subsection puts the relevant components of the report in perspective.

Three main linkages can be identified, each of which contains many elements. First, the climate threat constrains possible development paths, and sufficiently disruptive climate change could preclude any prospect for sustainable future (Chapter 19 of WG2). In this perspective, a stable climate is one objective of SD, and thus an effective climate response (both mitigation and adaptation) is necessarily an integral part of an effective SD strategy.

Second, there are trade-offs between climate responses and broader sustainable development goals, because some climate responses can impose other environmental pressures, have adverse distributional effects, draw resources away from other developmental priorities, or otherwise impose limitations on growth and development. These trade-offs are studied in the sector chapters of this report, along with measures and strategies to minimize them, and section 4.7 examines options for equitable burden-sharing to reduce the potential for the costs of climate action to constrain development. Conversely, development along existing trends contributes to climate (and other environmental) pressures. Section 4.4 examines if such trade-offs can be loosened by changing behavioural patterns and decoupling emissions and growth, and/or decoupling growth and well-being.

Third, there are multiple potential synergies between climate responses and broader sustainable development efforts. Climate responses may generate co-benefits for human and economic development in several well-documented ways, e.g., when low-carbon and energy-efficient technologies enhance livelihood opportunities, or reduce other environmental pollutants. (Section 3.9 contains a detailed presentation of the notion of co-benefits, and Chapter 6 contains a summary of the co-benefits of mitigation policies identified in the sectoral chapters of the WG3 report.) At a more fundamental level, capacities underlying an effective climate response overlap strongly with capacities for SD, as discussed in section 4.6, and the drivers and barriers to SD are important determinants of the prospects for an effective climate response as well, as analyzed in section 4.3. Conversely, lack of development and poverty are characterized by a lack of basic capacities that raises vulnerability to the climate and makes effective mitigation difficult, as discussed in section 4.3 and chapter 5. Moreover, formulating climate responses as a component of a broader strategy of equitable and sustainable development may be a key factor to ensuring cooperation between countries and gathering political support within countries, as discussed in 4.2.2 and in the review of burden-sharing in section 4.7.

The trade-offs and synergies between climate response and development are given many concrete illustrations in the next chapters of this report, and the analysis of the positive and negative implications of climate responses for broader SD objectives in these chapters is introduced and summarized in section 4.8. Developing a successful strategy for sustainable development requires exploiting the opportunities created by the synergies between climate policy and sustainable development, and "mainstreaming" climate issues into the design of sustainable development strategies (Metz et al., 2002; Brown and Corbera, 2003; Swart et al., 2003; Olsen, 2007; Gupta and Grijp, 2010; Murdiyarso, 2010). The WG2 and WG3 volumes of this Assessment Report can be viewed as resources for the design of such a strategy. The analysis of development paths from the point of view of SD is examined in section 4.5, and the design of scenarios is analyzed in chapter 6.

FAQ 4.1 Why does IPCC need to think about sustainable development? If we respond to climate change won't sustainable development follow?

Climate change is a threat to sustainable development. Addressing the climate risks is therefore needed in order to achieve sustainable and equitable development for the coming generations. Though addressing climate is necessary, it is not sufficient, as there are other threats such as the depletion of natural resources, pollution hazards, inequalities, or geopolitical tensions. As policymakers are concerned with the broader issues of sustainable development, it is important to reflect on how climate risks and policies fit in the general outlook. Moreover, preparing societies to move to sustainable development pathways provides a favourable setting for building mitigative and adaptive capacity ultimately needed to address climate change.

4.2.2 Equity and its relation to sustainable development and climate change

Equity plays a key role in research and policy debates about sustainable development and climate issues. It arises both with respect to distributive equity (distribution of resources in specific contexts such as burden-sharing, distribution of well being in the broader context of social justice, see sections 4.4, 4.7, 4.8) and procedural equity (participation in decision-making, see 4.3). Various aspects of the general concept, as developed in social ethics, have been introduced in Chapter 3. The aim of this subsection is to analyze the links between equity, SD, and climate issues. Note that in this chapter the terms equity, fairness, and justice are given similar meanings and are used interchangeably.

Equity *between* generations underlies the very notion of sustainable development. There has been a recent surge of research on intergenerational equity, motivated by dissatisfaction with the tradition of discounting the utility of future generations in the analysis of growth paths (see, e.g., Asheim (2007), Roemer and Suzumura (2007) for recent syntheses). The debate on discounting has been reviewed in Chapter 3. This literature has delivered original simple arguments in favour of sustainability. A first argument is that a path in which well-being decreases at some point in time is obviously inequitable when an investment in favour of the disadvantaged future has a positive rate of return, so that, when increasing the investment, the future becomes better-off than the present before the latter becomes as poor as the former was initially (Asheim et al., 2001). Another argument in favour of sustainability is that it is easy to justify giving a strong priority to the future when many future generations are worse off than the present generation, even in absence of a positive rate of return to investments. Indeed, investing for many of the future generations equally may not benefit each of them much, but is nevertheless worthwhile by a mere application of the Pigou-Dalton transfer principle[3] (Asheim et al., 2012).

Equity *within* every generation is often considered an intrinsic component of sustainable development in relation to the social pillar. This is clearly expressed in the Brundtland Commission's elevation of "*the essential needs of the world's poor, to which overriding priority should be given"* as a fundamental objective of sustainable development. This reflects considerably greater prioritization to equity than the status quo, in which humanity has chronically failed to meet the essential needs of a large fraction of its population. Indeed, continued failure to resolve these inequities may be politically unsustainable, especially in a world that is increasingly materially capable of meeting those needs. The Millennium Development Goals (MDGs), adopted in 2000, might be seen as one indication of a more explicit global commitment to lessen inequities (United Nations, 2000).

Yet, the relation between equity within generations and sustainable development is complex. It is evident that if meeting the needs of the world's poor meant that developing countries must converge toward the standard of living of the world's richest populations based on the same consumption patterns and production processes, it would unsustainable and would threaten to exceed the regeneration and absorption capacity of the Earth (Millennium Ecosystem Assessment, 2005a; Rockström et al., 2009a; Steffen et al., 2011; Intergovernmental Panel on Climate Change, 2014). Such a scenario would not likely play out well for the world's poor. As articulated by Okerere (2011), environmental issues are interwoven with the fabric of racial, social and economic injustice, with environmental costs and benefits often distributed such that those who already suffer other socio-economic disadvantages tend to bear the greatest burden.

Still, despite the formidable challenges, compelling arguments have been put forward that equity, in its multiple dimensions, be embraced as a fundamental objective of sustainable development. While recognizing the complexity of the issue, we focus here on one key dimension of equity that is of central importance to deliberations about an effective global response to climate change. As in many other contexts, fundamental questions of resource allocation and burden-sharing arise in climate change. Economic theories of fair allocation have examined various notions of equity (e.g., minimal rights, solidarity, no-envy, egalitarian-equivalence) and their relevance to climate change as a problem of collective action (Moulin, 2003; Raymond, 2003; Thomson, 2011). Here we examine the three primary lines of argument that have been put forward to justify equitable burden-sharing in the climate context. (Section 4.7 examines the details of burden-sharing principles and frameworks in a climate regime.)

Moral justification: The first justification is the normative claim that it is morally proper to allocate burdens associated with our common global climate challenge according to ethical principles. The broad set of ethical arguments for ascribing moral obligations to individual nations has been reviewed in Chapter 3, drawing implicitly upon a cosmopolitan view of justice, which posits that the rights and duties that obtain between people within nations also obtain between people of different nations.

Legal justification*:* The second justification is the legal claim that countries have accepted treaty commitments to act against climate change that include the commitment to share the burden of action equitably. This claim derives from the fact that signatories to the UNFCCC have agreed that: "Parties should protect the climate system for the benefit of present and future generations of humankind, *on the basis of equity and in accordance with their common but differentiated*

[3] The Pigou-Dalton transfer principle says that making a redistributive transfer between two unequally endowed individuals reduces inequality and increases social welfare (Chakravarty, 2009).

responsibilities and respective capabilities." This agreement echoes the 1992 Rio Declaration on Environment and Development(United Nations, 1992b), reaffirmed at the 2012 Rio Conference on Sustainable Development (United Nations, 2012a), which elaborates further on the connection between burden-sharing and underlying ethical principles: "States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit to sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command." (Rio Declaration on Environment and Development, Principle 7). While the definition of equity is not elaborated in quantified detail in the UNFCCC, it does give it practical meaning by assigning distinct qualitative obligations to categories of countries that were defined according to level of development. (See 4.7.3.1.)

These specific legal statements are further buttressed by a body of soft law and norms relating to the nature of obligations and their relation to principles such as moral responsibility (Stone, 2004). The no-harm rule is a widely recognised principle of customary international law whereby a State is duty-bound to prevent, reduce or control the risk of serious environmental harm to other States. For example, nations have expressly recognized (most notably in the Stockholm Convention of 1972 and reiterated in Rio Declaration of 1992) that they have "the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction." The 1992 Rio Declaration further notes that "National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution..."

Another further legal justification notes that climate change adversely affects a range of human rights that are incorporated in widely ratified treaties, and raises the prospect that states are thus obliged to protect peoples and individuals from climate change-related human rights violations (Aminzadeh, 2006; Humphreys, 2009; Knox, 2009; Wewerinke and Yu III, 2010; Bodansky, 2010). This concern has been formally recognized by the United Nations Human Rights Council (in Resolutions 7/23 and 10/4), but has not reached definitive legal resolution (Posner, 2007; Bodansky, 2010).

Effectiveness justification: The third justification is the positive claim that equitable burden-sharing will be necessary if the climate challenge is to be effectively met. This claim derives from the fact that climate change is a classic commons problem (Soroos, 1997; Buck, 1998; Folke, 2007; Folke et al., 2010) (Also see section 13.2.2.1). Actors (whether states, firms or individuals) receive the full benefits of emitting GHGs, but bear a negligible share of the costs (climate change impacts), thus creating an incentive for all rational emitters to over-emit. Or, put another way, individuals bear the full costs of mitigation, but receive only a negligible share of the benefits (avoided climate change), thus the incentive for all rational mitigators to under-mitigate relative to the global optimum. Posed the first way, we have the classic tragedy of the commons; posed the second way, we have the free-rider problem. But however posed, the scenario is one in which individually rational decision-making leads to an outcome that is collectively disastrous.

As with any commons problem, the solution lies in collective action (Ostrom, 1990). This is true at the global scale as well as the local, only more challenging to achieve (Ostrom et al., 1999). In the case of climate, an actor then justifies the cost of additional mitigation not because it is compensated by the direct benefits of reduced climate change, but rather because it induces comparable mitigation action among other actors. Inducing that cooperation relies, to an important degree, on convincing others that one is doing one's fair share, i.e., not free riding. It is for this reason that notions of equitable burden-sharing are considered important in motivating actors to effectively respond to climate change. They are even more important given that actors are not as equal as the proverbial "commoners," where the very name asserts homogeneity (Milanović et al., 2007). To the contrary, there are important asymmetries or inequalities between stakeholders (Okereke et al., 2009; Okereke, 2010): asymmetry in contribution to climate change (past and present), in vulnerability to the impacts of climate change, in capacity to mitigate the problem, and in power to decide on solutions (i.e. ways of addressing climate change can reduce or further exacerbate inequity). Other aspects of the relation between intragenerational equity and climate response include the gender issues noted in 4.2.1.2, and the role of virtue ethics and citizen attitudes in changing lifestyles and behaviours (Dobson, 2007; Lane, 2012), a topic analyzed in 4.4.

Young (2013) has identified three general conditions under which the successful formation and eventual effectiveness of a collective action regime may hinge on equitable burden-sharing. The first condition is the absence of actors who are powerful enough to coercively impose their preferred burden-sharing arrangements on other members. In the case of climate, the distribution across countries of geopolitical power and GHG emissions precludes this. The second condition, which climate change also satisfies, is that standard utilitarian methods of calculating costs and benefits are not straightforwardly applicable to regime participation. In this situation, a reliable calculus of expected returns cannot be used to buttress a convincing strategy of shrewd bargaining. The third condition is that regime effectiveness relies on a long-term commitment of members to implement its terms. The perception of fairness – in both the terms of the arrangements and the procedures through which they were decided – reinforces the regime's legitimacy, increasing countries' commitment to fulfilling its requirements and reducing the risks of defection and a cooperative collapse. Conversely, regimes that many members find unfair will be vulnerable to festering tensions that jeopardize the regime's effectiveness (Young, 2012). Specifically, any attempt to protect the climate by keeping living standards low for a large part of the world population will face strong political resistance, and will almost certainly fail (Roberts and Parks, 2007; Baer, Kartha, et al., 2009). While costs of participation may provide incentives for non-cooperation or defection in the short-term, a climate regime is not a one-shot game; cooperation at one time and in one venue is seen in both theory and practice to facilitate broader and longer-term cooperation, with the many associated benefits. Clearly, the climate negotiations are ongoing, not a one-shot game, and they are embedded in a much broader global context; climate change is only one of many global problems – environmental, economic, and social – that will require effective cooperative global governance if development – and indeed human welfare – is to be sustained in the long term (Kjellén, 2004; Singer, 2004; Jasanoff, 2004; Speth and Haas, 2006).

The effectiveness of a regime can also be expected to be enhanced by equitable burden-sharing when the underlying equity principles tend to place higher obligations on countries that can more easily fulfil them than on countries that would face hardship doing so. In the context of climate change, the main equity principles under discussion (see 4.7.3.1) generally assign greater burdens to developed countries, which have more resources to invest in emission reductions, and lower burdens to developing countries, whose resources are limited and constrained by immediate demands, such as the struggle to eradicate poverty, that are more politically pressing than the threat of climate impacts.

Despite these three lines of justification, the question of the role that equity does or should play in the establishment of global climate policy and burden-sharing in particular is nonetheless controversial. (Victor, 1998). The fact that there is no universally accepted global authority to enforce participation is taken by some to mean that sovereignty, not equity is the prevailing principle. Such a conception implies that the bottom-line criterion for a self-enforcing (Barrett, 2005) cooperative agreement would be simply that everyone is no worse off than the status quo. This has been termed "International Paretianism" (Posner and Weisbach, 2010), and its ironic, even perverse results have been pointed out: "an optimal climate treaty could well require side payments to rich countries like the United States and rising countries like China, and indeed possibly from very poor countries which are extremely vulnerable to climate change - such as Bangladesh." (Ibid., p. 86).

However, the assumption that nations can be treated as unified rational actors, maximizing their discounted economic costs and benefits, is neither theoretically nor empirically robust. Both critics and advocates of the importance of equity in the climate negotiations acknowledge that governments can choose to act on moral rather than purely self-interested principles, either because of or in spite of the expressed desires of their citizens and domestic interest groups (DeCanio and Fremstad, 2010; Posner and Weisbach, 2010, 2012; Baer, 2013; Jamieson, 2013). Whether or not states behave as rational actors, given the significant global gains to be had from cooperation, this leaves ample room for discussion of the role of equity in the distribution of those global gains, while still leaving all parties better off (Stone, 2004).

Box 4.2.2 Co-benefits and equity

The distributional co-benefits of climate policy are analyzed in 3.10.1.2 in terms of impacts on consumer and producer surplus and related rents. In this box we explain how to make use of standard distributional objectives derived from a social welfare function (3.4.6, 3.6.1-2).

Suppose that the overall objective of the policy-maker is $W(u_1, \dots, u_n)$, where u_i measures individual i's well-being (or whatever magnitude is deemed relevant to assess an individual situation). Normalising the function so that $W(u, \dots, u) \equiv u$, one can write (Atkinson, 1970):

$$W(u_1, \dots, u_n) = \bar{u}(1 - I(u_1, \dots, u_n)),$$

where an upper bar denotes the average value, and $I(u_1, \dots, u_n)$ is an inequality index that measures the impact of inequalities in well-being on social welfare. This formula can then be used as in Equation 3.9.1 in order to isolate the impact of a policy on the distribution of well-being.

Figure 4.2.1 summarizes the main relations between the notions of this section, in particular the potentially conflicting developmental and environmental goals of policy-makers, the conceptual and practical equity underpinnings, and the complex interactions between SD and climate policy.

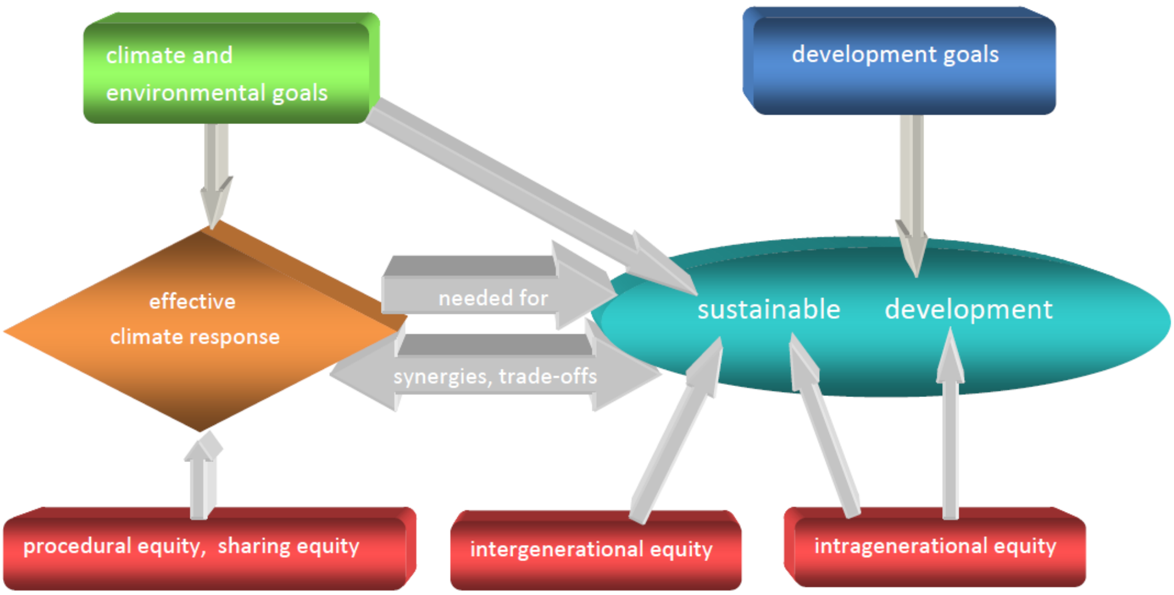

Figure 4.2.1 Links between SD, equity, and climate policy

4.3 Determinants, drivers and barriers

This section explores the determinants of sustainable development and equity, emphasizing their relationship with climate change mitigation. Determinants refer to social processes, properties, and artefacts, as well as natural resource endowments, which together condition and mediate the course of societal development, and thus the prospects for sustainable development. Those determinants that facilitate SD we call drivers, and those that inhibit SD are barriers.

The determinants discussed in this section are a set that usefully highlights key factors of interest to decision-makers concerned with the prospects and impediments for sustainable development. The determinants considered are: the legacy of development, governance and political economy, population and demography, human and social capital, behaviour, culture and values, technology and innovation processes, natural resource endowments, and finance and investment. This section briefly discusses how each of these determinants influences the extent to which societies can balance the economic, social and environmental pillars of SD, whilst highlighting synergies and potential trade-offs for the building of mitigation and adaptation capacity and realisation of effective and equitable mitigation and adaptation strategies.

It is important to state some caveats. First, there is no definitive set of factors that can objectively be called the fundamental causal determinants of societal development. Factors are interdependent, characterized by feedbacks that blur the distinction between cause and effect, and their relevance depends on time and place (see the analogous discussion in the context of drivers of GHG emissions in section 5.3.). The discussion of determinants in this section could have been organized differently (for example, governance and political economy could have been separated and each examined in considerably more detail), or other determinants could have been added, such as leadership (Jones and Olken, 2005), randomness (Holling, 1973; Arthur, 1989), or human nature (Wilson, 1978). While these are popularly perceived as strong determinants of the course of societal development, they are less amenable to deliberate intervention by policy-makers and other decision-makers.

Second, analysis based on any framework of determinants (or drivers) must be interpreted with caution. Consider the I-PAT identity (Impact = Population x Affluence x Technology) introduced by Ehrlich and Holdren (1971), a straightforward accounting framework that decomposes an arbitrary environmental impact into the three key contributions, which was developed to help resolve the controversial question as to whether population growth was a key driver of environmental degradation and how it could be mitigated by better technologies. Its refinement – the Kaya identiy (Kaya, 1990) – was adopted by the energy community for use in analyzing emissions, and has served as a useful initial step beyond simple mono-causal analysis. Yet, its value for meaningful quantitative decompositions and explanatory power has been shown to be severely limited (O'Neill et al., 2001). The underlying distinction between the number of emitting units and emissions per unit does not necessarily have to assume that the emitting units are individual people; households may actually be the more appropriate emitting units (MacKellar et al., 1995). Alternatively, one could also assume that it is the number of engines or fires or any CO2 emitting human-made devices. Depending on these choices the whole issue is framed very differently and hence the conclusions and recommendations derived tend to be different. Additionally, the identity is based on the assumption of homogeneity of the emitting units, i.e. that every person added to the population (at a given level of national affluence and technology) causes the same environmental impact, which is evidently incorrect. Further, the three components are clearly not independent as the rate of population growth is closely related to affluence and the efficiency of technology is related to both of them. And finally, a decomposition of this sort tends to be meaningless when the components move into different directions, e.g. population shrinks while income per person increases. Additionally, studies demonstrate that informal institutions can play a mediating role in regulating resource use in contexts of rising populations (Mazzucato and Niemeijer, 2002).

FAQ 4.2 What are the main drivers of a transition toward SD?

There are many factors that determine the development path, and simple accounting formulas like Kaya, though helpful, do not suffice to capture the complexity of the causal mechanisms determining the course of societal development. Among the main factors that can be influenced by policy decisions, one can list governance, human and social capital, technology, and finance. Population size, behaviors and values are also important factors. Managing the transition toward SD also requires taking account of path dependence and potential favorable or unfavorable lock-ins (e.g. via infrastructures), and attention to the political economy in which all of these factors are embedded.

4.3.1 Legacy of development

Following World War II, diverse relations – security, economic, and humanitarian – between rich nations and poor nations were comingled and addressed under the umbrella of "development" (Sachs, Wolfgang, 1999). Differing perspectives on the mixed outcomes of six decades of development, and what the outcomes may indicate about underlying intentions and capabilities, inform different actors in different ways as to what will work to address climate change and the transition to SD. During the 1950s and 1960s, for example, expectations were firmly implanted that poverty could and would be reduced dramatically by the end of the century (Rist, 2003). It was widely believed that economic development could be instigated and sustained through aid, both financial and in kind, from richer nations. Development was seen as a process of going through stages starting with transforming traditional agriculture through education, the introduction of new agricultural technologies, improved access to capital for farm improvements, and the construction of transportation infrastructure to facilitate markets. Improved agriculture would release workers for an industrial stage and thereby further improve opportunities for education and commercial development in cities. As development proceeded, nations would increasingly acquire their own scientific capabilities and, later, sophisticated governance structures to regulate finance and industry in the public good, becoming well-rounded, well-governed economies.

By the 1970s, however, it was clear that development was not on a path to fulfilling these linear expectations because: 1) contributions of aid from the rich nations were not at the levels promised; 2) technological and institutional changes were only partially successful, proved inappropriate, or had unpredicted, unfortunate consequences; 3) requests for military aid and the security and economic objectives of richer nations in the context of the Cold War were frequently given priority over poverty reduction; and 4) graft, patronage, and the favouring of special interests diverted funds from poverty reduction. As beliefs that nations naturally went through stages of development faded in the early 1980s, trade, with its implied specialization, was invoked as the path to economic growth. Diverse efforts were made to improve how development worked, but with only modest success, leaving many in both rich and poor nations concerned about the process and prospects (United Nations, 2011a).

Layering the goal of environmental sustainability onto the goal of poverty reduction in development further compounded the legacy of unmet expectations, particularly since the 1980s. There have been difficulties determining sustainable pathways as well as difficulties in implementing appropriate technologies, monitoring adequately for environmental responses, and governing for sustainability (Sanwal, 2010) -see section 4.3.2 below-. The negotiation of new rules for the mobility of private capital and the drive for globalization of the economy also came with new expectations for development (Stiglitz, 2002). The Millennium Development Goals (MDG) to be met by 2015 are an example of how such expectations could be realized in the rapidly evolving times of the global financial economy. In this respect, however, significant improvements are largely in China and India where economic growth accelerated through private capital flows independent of the MDG process. Excluding these countries, the record is mixed at best and still poor in Africa (Keyzer and Wesenbeeck, 2007; Easterly, 2009; United Nations, 2011a).

Since the 1990s, historic greenhouse gas emissions became regarded as yet another contentious legacy of development (Klinsky and Dowlatabadi, 2009; Müller et al., 2009; Baer, Athanasiou, et al., 2009). The developed nations had become rich through the early use of fossil fuels and land transformations that put greenhouse gases in the atmosphere, imposing costs on all people, rich and poor, through adverse climate effects that will persist over centuries to come (Srinivasan et al., 2008). The connections between causal responsibility and moral responsibility are thus not sharp.

The resulting legacy of such unmet development and sustainability expectations is open to multiple interpretations. In richer nations, the evidence can be interpreted to support the diverse views of fiscal conservatives who oppose aid, libertarians who oppose both humanitarian and environmental interventions, progressives who urge that more needs to be done to reach social and environmental goals, and some environmentalists who urge dematerialization and depopulation as the only solution. In poorer nations, the legacy is similarly taken as support for various views, including a distrust of rich nations who have not delivered development and environmental assistance as promised, cynicism toward the intentions when it is provided, and also a wariness of its unpredicted outcomes. In both developed and developing nations, however, these diverse informed sentiments among the public, policy makers, and climate negotiators contribute to what philosopher Stephen Gardiner refers to as the “perfect moral storm” of climate policy (Gardiner, 2006).

The international arrangements embodied in the UNFCCC acknowledge the legacy of development, in that they oblige Parties to contribute “on the basis of common but differentiated responsibilities and respective capabilities” (UNFCCC, 1992) based on level of development. However, some analysts of climate negotiations argue that the legacy of development so clouds global climate negotiations that the possibility for reaching a global climate and development agreement is highly unlikely. Thus nations should proceed with ad hoc agreements and voluntary efforts (Victor, 2004) and that decisions on the mechanisms for reducing greenhouse gases and questions of development should be better negotiated separately (Posner and Sunstein, 2007; Posner and Weisbach, 2010). However, given the richer nations' record of meeting development commitments, poorer nations may be unwilling to accept separate negotiations (Stone, 2004; Sanwal, 2011).

4.3.2 Governance and political economy

Governance and political economy are criticals determinants for SD, equity and climate mitigation because they circumscribe the process through which these goals and how to attain them are articulated and contested. Conversely, the quest for equity and climate mitigation in the context of SD inspires the understanding and practice of governance (Biermann et al., 2009; Okereke et al., 2009). Governance in the broadest sense refers to the processes of interaction and decision-making among actors involved in a common problem (Kooiman, 2003; Hufty, 2011). It goes beyond notions of formal government or political authority and integrates other actors, networks, informal institutions and incentive structures operating at various levels of social organization (Rosenau, 1990; Chotray and Stoker, 2009). In turn, climate governance has been defined as the mechanisms and response measures "aimed at steering social systems towards preventing, mitigating or adapting to the risks posed by climate change” (Jagers and Stripple, 2003). From this definition, it can be seen as an all-encompassing phenomenon covering how society understands and addresses all determinants of climate change and sustainability. In practice, however, its use is often narrower with emphasis frequently placed on the overt political actors and processes that shape visions and approaches for global sustainability and climate mitigation.

Many scholars have highlighted the unique challenges associated with governing for sustainable development and climate change. First, it involves rethinking the ways society relates to the biophysical system. This is pertinent in the context of the growing evidence of the impact of human activity on the planet and the understanding that extra-ordinary degrees of irreversible damage and harm are distinct possibilities if the right measures are not taken within adequate timescale (Millennium Ecosystem Assessment, 2005b; Rockström et al., 2009b). Additional complexities are caused by persistent scientific uncertainties about magnitude, timing, impact and locality of change (Intergovernmental Panel on Climate Change, 2007). Second, governing for sustainability and climate change involves complex intergenerational considerations. On the one hand, cause and effect of climate change are separated by decades, often generations, and on the other hand, those who bear the costs of mitigation may not be the ones to reap the benefits of avoided harm (Biermann, 2007). Third, effective response to climate change appears to require a fundamental restructuring of the global economic and social systems which in turn would involve overcoming the inertia associated with behavioural patterns and crafting new institutions that promote equity and sustainability (Meadows et al., 2004; Millennium Ecosystem Assessment, 2005b) This challenge is exacerbated by the huge mismatch between the planning horizon needed to address climate change and the tenure of decision makers. In addition, there is the problem that the effects of climate change are sometimes most felt in places far removed from the point of pollution, which implies that the urgency felt by those who suffer the harm may not be shared by those that cause the problem (Hulme, 2009). Fourth, climate governance cuts across several realms of policy and organisation. The governance of climate mitigation and adaptation is an element of a complex and evolving arena of global environmental governance, which deals with other, and often overlapping, issues such as biodiversity loss, desertification, ozone depletion, trade, energy security and international development. Sites of climate change governance and policy-making are thus multiple and are not confined to the UNFCCC and national rule-making processes (Okereke et al., 2009; Andonova et al., 2009) -see chapters 13-15 of this report, notably figure 13.1 for a visual summary-. Here, the key problem is how to achieve coordination and synergy across these various issues and governance sites. Too much issue linkage can result in further complexity and “overloading” while inadequate linkages can lead to redundancies, inefficiencies and negative trade-offs (Zelli, 2011).

The fifth attribute of global SD and climate governance is that it implicates multiple scales and multiple agents that hold vested interests and varying degrees of power and authority. Climate governance has been characterized by an increasing segmentation of different layers and clusters of rule-making and rule-implementing, fragmented both vertically between supranational, international, national and subnational layers of authority and horizontally between different parallel rule-making systems (Biermann et al., 2009). Some of the most notable agents of governance are multiple and include a range of public, private and hybrid actors, such as governments, cities, multilateral organizations, corporations, non-governmental organizations, communities and even individual entrepreneurs (Hoffmann, 2011; Bulkeley and Schroeder, 2011). This proliferation of actors has prompted the multiplication of spheres of authority and inspired “new modes of governance” beyond traditional command and control measures, such as self-governance, enabling, provision and public-private partnerships (Pattberg, 2010).

All of this explains why climate governance has attracted more political contestation and controversy than any other issue in relation to global equity and SD. Some of the main aspects of this controversy include: (i) who should participate in decision making; (ii) how to modulate power asymmetry among stakeholders; (ii) how to share responsibility among actors; (iv) what ideas and institutions should govern response measures, and (v) where should interventions most focus? Questions of justice are deeply embedded in these five domains, aggravated by the high stakes involved and especially the stark asymmetry among states in terms of cause, effect, and capability to respond to the problem (Okereke and Dooley, 2010; Okereke, 2010). It is precisely in deciding how these questions are settled (or not) that governance exerts its greatest influence on climate mitigation, equity and SD.

Scholars have long analysed climate governance focusing on the above key controversies and cognate categorisations with a cacophony of possible solutions being volunteered. The defining paradox is that increase in awareness and activity has not resulted in corresponding progress towards global climate equity and SD. First, concerning participation, some have suggested a departure from the top-down approach implied in the UNFCCC and Kyoto Protocol towards a more voluntary and bottom-up approach (Rayner, 2010). Others suggest limiting participation to the key greenhouse gas emitting countries (Eckersley, 2012). However, both suggestions have been vehemently opposed on the basis that such schemes will further marginalize those most vulnerable to climate change and exacerbate issues of inequity (Aitken, 2012; Stevenson and Dryzek, 2012).

Second, on allocation of responsibility, agreement has been elusive not the least because parties and other key actors have different conceptions of justice (Okereke, 2008). Moreover, an explicit debate about these conflicting conceptions and how to reconcile them has yet to take place on key platforms for climate governance. Third, on the question of sector focus, progress has been made in identifying key sectors that need to be targeted to achieve meaningful and rapid decarbonisation. However, relevant policies have been stalled by a combination of factors prominent among which are finance, politics and vested interests.

Precisely, a defining image of the climate governance landscape is that key actors have vastly disproportionate capacities and resources, including political, financial and cognitive resources that are necessary to steer the behaviour of the collective within and across territorial boundaries (Dingwerth and Pattberg, 2009). A central element of governance related to this asymmetry is the concept of authority, defined in terms of claims to legitimacy as well as ability to excise power or influence outcomes (Weber, 1978). Authority then characterizes the extent to which institutions, actors or individuals, based on their capacities and resources, are able to facilitate and/or constrain the agency of others. It enhances the ability of actors to influence mitigation options leading to winners and losers.

The problem, however, does not reside simply in capacity, resource and power-related asymmetries among actors but rather in the fact that those that wield the greatest authority either consider it against their interest to facilitate rapid progress towards a global low carbon economy or insist that every solution must be aligned to increase their authority and material gains (Sæverud and Skjærseth, 2007; Giddens, 2009; Hulme, 2009; Lohmann, 2009, 2010; Okereke and McDaniels, 2012; Wittneben et al., 2012). The most notable effect of this is that despite some exceptions, the prevailing organization of the global economy around free market capitalism has provided the context for the sorts of governance practices of climate change that have dominated to date (Newell and Paterson, 2010).

It is instructive that many of the specific governance initiatives discussed in Chapters 13-15 of this report, whether organized by states or among novel configurations of actors, have focused on creating new markets or investment opportunities. This applies, for example, to carbon markets (Paterson, 2009), carbon offsetting in energy and land-use sectors (Bumpus and Liverman, 2008; Lovell et al., 2009; Corbera and Schroeder, 2011; Corbera, 2012), investor-led governance initiatives such as the Carbon Disclosure Project (Kolk et al., 2008) or partnerships such as the Renewable Energy and Energy Efficiency Partnership (Parthan et al., 2010). Market-oriented initiatives can be a potent tool in achieving low carbon transition. However, due to power–asymmetry and other political economic forces, such programs are also very vulnerable to "capture" by special interests and against the original purposes for which they are conceived. Several authors have discussed this problem in the context of the CDM and the EU-ETS (Böhm, Misoczky and Moog 2012; Clò, 2010; Helm, 2010; Lohmann, 2006, 2008; Okereke and McDaniels, 2012). This "predication of sustainable development on liberal economic philosophy" (Bernstein, 2001) necessarily constrains how the pursuit of SD might be carried out, even while it generates opportunities to bring new actors into the process of governing climate change.

Governing for sustainability and climate change opens up a variety of questions that require closer attention. First, there is a need to understand whether indeed there is a real shift "from government to governance", which could illuminate the actual role that formal policy prescriptions adopted by governments at multiple scales play in determining the process and outcomes of a transition towards sustainability or a "climate safe" world (Adger and Jordan, 2009). Second, and related, there is a need to explore if and how different modes of governance translate into positive outcomes across all dimensions of sustainability and draw lessons regarding their effectiveness and distributional implications, or any existing trade-offs. Despite some merits, the "decentralization" that governance involves *per se* makes it difficult to establish responsibilities, and ensure transparency and accountability in any transition towards sustainability. For this reason, it has been argued that states, through conventional command-and-control approaches, including taxation, should still be regarded as key agents in steering such transitions (Eckersley, 2004; Weale, 2009). Finally, it is critical to pay attention to how these modes of governance are defined in the first place, by whom and for whose benefit, which presses home the impossibility of disconnecting sustainability and climate change governance from existing trends in global capitalism and political economy.

4.3.3 Population and demography

Population variables, including size, density, growth rate as well as age, sex, education and settlement structures, play a determinant role in countries' SD trajectories. Their drivers – in particular fertility, mortality and migration – are reciprocally influenced by countries' development paths, including evolving policies, socio-cultural trends, as well as by changes in the economy (Bloom 2011) . In the context of climate change, population trends have been shown to matter both for mitigation efforts as well as for societies' adaptive capacities to climate change (O'Neil et al. 2001). Current demographic trends show distinct patterns in different parts of the world. While population sizes are already on a declining trajectory in Eastern Europe and Japan, they are set for significant further increase in many developing countries (particularly in Africa and south-western Asia) due to a very young population age structure and continued high levels of fertility. As most recent population projections show, the world's population is almost certain to increase to between 8 and 10 billion by mid-century. After that period, uncertainty increases significantly, with the future trend in birth rates being the key determinant (Lutz and KC, 2010; United Nations, 2011b; Lee, 2011; Scherbov et al., 2011). The population of Sub-Saharan Africa will almost certainly double and could still increase by a factor of three or more depending on the course of fertility over the coming decades, which depends primarily on progress in female education and the availability of reproductive health services (Bongaarts, 2009; Bloom, 2011; Bongaarts and Sinding, 2011).

Declining fertility rates together with continued increases in life expectancy result in significant population ageing around the world, with the current low fertility countries being most advanced in this process. This population ageing is widely considered a major challenge for the solvency of social security systems. For populations that are still in the process of fertility decline, the expected burden of ageing is a more distant prospect, and the declining birth rates are expected to bring some near term benefits. This phase in the universal process of demographic transition, when the ratio of children to adults is already declining and the proportion of elderly has not yet increased, is considered a window of opportunity for economic development, which may also result in an economic rebound effect leading to higher per capita consumption, and potentially emissions (Bloom and Canning, 2000).

Low development is widely understood to contribute to high population growth, which declines only after the appearance of widespread access to key developmental needs such as peri-natal and maternal healthcare, and female education and empowerment Conversely, high population growth is widely regarded as an obstacle to SD, because it tends to make efforts such as the provision of clean drinking water and agricultural goods and the expansion of health services and school enrolment rates an uphill battle (Dyson, 2006; Potts, 2007; Pimentel and Paoletti, 2009). This has given rise to the fear of a vicious circle of a low level of development leading to high population growth and environmental degradation that in turn inhibits the development that would be necessary to bring down fertility (Caole and Hoover, 1958; Ehrlich and Holdren, 1971; Dasgupta, 1993). However, history shows that countries can break this vicious circle with the right social policies, with an early emphasis on education and family planning, prominent examples being South Korea and Mauritius, which in the 1950s were used as textbook examples of countries trapped in such a vicious circle (Meade, 1967).

With respect to adaptation to climate change, the literature on population and environment has begun to explore more closely people's vulnerability to climate stressors, including variability and extreme events, and to analyze their adaptive capacity and reliance on environmental resources to cope with adversities and adapt to gradual changes and shocks (Bankoff et al., 2004; Adger et al., 2009) - see also Working Group II report. Generally speaking, not only the number of people matters, but also their composition by age, gender, place of residence and level of education, as well as the institutional context that influences people's decision-making and development opportunities. People have differential vulnerabilities even within households depending on age, gender and level of education, a fact that is increasingly considered by impact studies (Dyson, 2006). One widely and controversially discussed form of adaptation can be international migration induced by climate change. A major recent review of this topic has concluded that much environmentally induced migration is likely to be internal migration and there is very little science-based evidence for assessing possible consequences on large international migration streams (The UK Government Office for Science, 2011).

4.3.4 Values and behaviours

Climate change uncertainties, long-term predictions, and the scale of the problem are often used to justify limited action, insofar as they combined lead to personal and collective discounting of the problem and the need for urgent actions. Research has identified a range of individual and contextual predictors of behaviours in favour or against climate mitigation, ranging from individuals' psychological needs to cultural and social orientations towards time and nature (Swim et al., 2009). Below we discuss some of these factors, focusing on human values that influence individual and collective behaviours and affect our priorities and actions concerning the pursuit of SD, equity goals and climate mitigation. Values provide "guides for living the best way possible" for individuals, social groups and cultures (citing Rohan, 2000; Pepper et al., 2009). Individuals are understood to acquire values through socialization and learning experience (ibid) and so can be seen to be dialectally related to education, governance systems and other determinants discussed elsewhere in Section 4.3.

Pepper et al. (2009) propose to use Shalom Schwartz's value theory (1992, 1994) to understand behavioural motivations. Schwartz's value theory enables the systematic study of the relationship between a wide spectrum of human values and other constructs, including self-reported socially and ecologically conscious consumer behaviour (Pepper et al., 2009). This perspective defines values as "enduring beliefs that pertain to desirable end states or behaviours, transcend specific situations, guide selection or evaluation of behaviour and events and are ordered by importance" (Schwartz and Bilsky, 1987). Ten motivational value types are identified by Schwartz's theory, grouped into four higher order types according to the total pattern of relations of compatibility of and conflict among values. The ten values form a continuum of related motivations, giving rise to a circular structure (Figure 4.3.1).

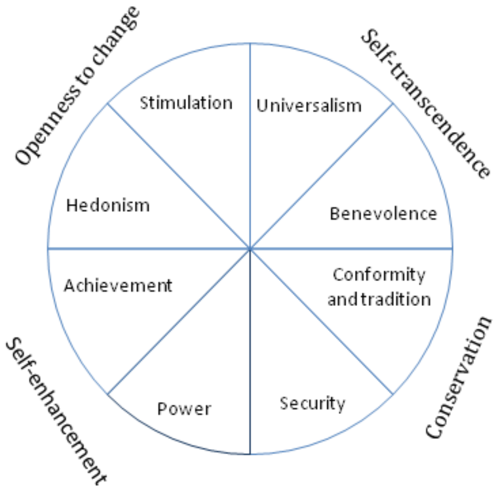

Figure 4.3.1 Model of relations among motivational types of values, higher order value types (in periphery) and bipolar value dimension. Source: Adapted from Schwartz (1994).

The particular relevance of values to ecologically conscious behaviour and SD is related to the nature of environmental issues as 'social dilemmas' where short-term narrow individual interests conflict with the longer term social interests (Pepper et al., 2009). Researchers have thus demonstrated the importance of values that transcends selfishness and promote the welfare of others (including nature) – i.e. those belonging to Schwartz's 'self-transcendence' type – for this behavioural domain (ibid).

However, the impact of values on behaviour is mediated by a range of factors such that the predictive power of values for ecologically conscious behaviour is often low (ibid). In fact, this 'value-action' gap (see below and Section 4.4) suggests that pursuing climate mitigation and SD globally probably requires substantial efforts to change behaviour in the short term while at the same time fostering a transformation of human values in the long term (e.g. progressively changing conceptions and attitudes toward biophysical systems and human interaction) (Gladwin et al., 1995; Leiserowitz et al., 2005; Vlek and Steg, 2007; Folke, Jansson, Rockstrom, et al., 2011). Changing human values would require a better understanding of cross-cultural behavioural differences that in turn relate to historical developments, environmental, economic and political contexts, and genetics, in complex relationships of potential complementarity and co-evolution (Norenzayan, 2011).

Incentivizing behavioural change (in the short and long term) would require changes in formal and civil institutions and governance, as well as in values (Jackson, 2005a; Folke, Jansson, Rockstrom, et al., 2011; Fischer et al., 2012). Removing perverse subsidies for environmentally harmful products, favouring greener consumption and technologies, adopting more comprehensive forms of biophysical and economic accounting, and providing safer and more secure working conditions are also considered central for achieving pro-SD behavioural change (Lebel and Lorek, 2008; Sukhdev et al., 2010; Le Blanc, 2010; Thøgersen, 2010). Yet behaviour experiments (Osbaldiston and Schott, 2012) suggests that there is no "silver bullet" for fostering ecologically conscious behaviour, as favourable responses to an issue at stake (e.g. energy conservation) are triggered by different stimuli, including information, regulation or economic rewards, and influenced by the nature of the issue itself. Furthermore, people are able to "express both relatively high levels of environmental concern and relatively high levels of materialism simultaneously" (Gatersleben et al., 2010). This suggests the need to be issue, context and culturally aware when supporting institutional reforms or designing specific actions to foster pro-SD behaviour, insofar as both environmental and materialistic concerns must be addressed. Overall, these complexities underscore the difficulties in changing peoples' beliefs, preferences, routines and practices on multiple fronts, such as in the domain of consumption (see Section 4.4).

4.3.5 Human and social capital

Human and social capital influence individual and collective responses to the challenge of sustainability, equitable development and both climate mitigation and adaptation. Human capital results from individual and collective investments in acquiring knowledge and skills that become useful for improving wellbeing (Iyer, 2006). Such knowledge and skills can be acquired through formal schooling and training, as well as informally through customary practices and institutions, including communities and families. Human capital can thus be viewed as a component of human capability, understood as humans' ability to lead lives they have reason to value (Sen, 1997, 2001). Human capability refers in turn to a person's ability to achieve a given list of "functionings" or achievements, which depend on a range of personal and social factors, including age, gender, health, income, nutritional knowledge and education, and environmental conditions, among others -see Clark (2009) and Schokkaert (2009) for a review of Sen's capability approach and its critiques-.

Economists have long considered improvements in human capital a key explanatory reason behind the evolution of economic systems, in terms of growth and constant innovation (Schultz, 1961; Healy and Cote, 2001). Macro-economic research shows a strong correlation between low levels of economic development and low levels of human capital and vice versa (Schultz 2003; Iyer 2006), whilst micro-economic studies reveal a positive relationship between increases in the quantity and quality of formal education and future earnings (Duflo 2001). Gains in human capital can be positively correlated to economic growth and efficiency, but also to nutritional, health and education standards (Schultz 1995). As such, improvements in human capital provide a basis for SD, because they shape countries' socio-economic systems and influence people's ability to make informed choices.

Indeed, it is well-known that individuals' formal education and informal knowledge systems can contribute simultaneously to their wellbeing and to fostering resource sustainability in particular contexts, thus providing the basis for the resilience of socio-ecological systems (Berkes et al., 2000; Armitage et al., 2011; Ruiz-Mallén and Corbera, 2013). Human capital often also explains the development and survival of business ventures (Colombo and Grilli, 2005; Patzelt, 2010; Gimmon and Levie, 2010), which are often an important source of innovation and diffusion of principles and technologies that can contribute to human and equitable development and to ambitious climate mitigation and adaptation goals (Marvel and Lumpkin, 2007; Terjesen, 2007). Studies suggest that knowledge (or lack of) by local populations and individuals on climate change and what to do about it can act as a strong driver or barrier to individual and individual action (Semenza et al., 2008; Sutton and Tobin, 2011). For this reason, researchers have proposed didactical methods to improve the understanding of climate change science and potential responses across higher education curricula (Kagawa and Selby, 2010; Burandt and Barth, 2010).

However, a growing body of literature in economics and geography -reviewed in Chapters 2 and 3 and in WGII- has shown that the diversity of environmental, socio-economic, educational and cultural contexts in which individuals make decisions significantly shape their willingness and/or ability to engage in mitigation and adaptation action (Lorenzoni et al., 2007). It is important to distinguish between formally acquired scientific knowledge on climate change, traditional knowledge on climate-related issues and values, beliefs, preferences and perceptions over the validity of both types of knowledge, as well as over the meaning and relevance of personal engagement. Formal (and more robust scientific) knowledge on climate issues alone does not explain or lead to individual responses to the climate challenge (Whitmarsh, 2009; Wolf and Moser, 2011; Berkhout, 2012), in the same way that it has resulted insufficient to agree on significant and equitable mitigation commitments in UNFCCC negotiations and national policy contexts (Sarewitz, 2011). There is evidence of cognitive dissonance and strategic behaviour in both mitigation and adaptation arenas. Denial mechanisms that overrate the costs of changing lifestyles; blame others; and that cast doubt on the effectiveness of individual action, or the soundness of scientific knowledge have been documented (Stoll-Kleemann et al., 2001; Norgaard, 2011; McCright and Dunlap, 2011).

There exist different formulations of social capital that can be traced back to the work of influential scholars, such as Bordeaux, Coleman, Putnam and Fukuyama (Gamarnikow and Green, 1999). As there is not a unique definition of the term, we adopt here an encompassing definition provided by a synthesis paper on the issue and that defines social capital as the institutions, the relationships, the attitudes and values that govern interactions among people and contribute to economic and social development (Grootaert and Bastelaer, 2002). Fukuyama, for example, offers a more succint definition as the shared norms or values that promote social cooperation, which are founded in turn on actual social relationships, including trust and reciprocity (Fukuyama, 2002).

Social capital materializes in the form of family bonds and ties, friendship and collective networks, associations, and other more or less institutionalized forms of collective action. Social capital is thus generally perceived as an asset for both the individuals that participate from such norms and networks and for the respective group/society, insofar as they can derive benefits from information, participating in decision-making and belonging to the group. The concept, however, has been criticized for being too ambiguous and lexically conducive to linking social relationships with a utilitarian ethos and to move the development agenda away from class struggles and critical engagements with capital (Fine, 1999).

Social capital research has often concluded that the presence of social capital can be linked to successful social outcomes in education, employment, family relationships, and health (Gamarnikow and Green, 1999), as well as to economic development and participatory, democratic governance (Woolcock, 1998; Fukuyama, 2002; Doh and McNeely, 2012). However, studies that report specifically on the relationship between social capital, sustainable development, equity, and climate change mitigation are still relatively scarce and inconclusive. Scholars have shown that social capital can be instrumental for people to collectively fight injustices and reduce their conditions of poverty and vulnerability (Woolcock and Narayan, 2000). In the field of environmental studies, for example, it has been argued that social capital can be a pre-condition for accessing and benefiting from resources (Bebbington, 1999; Diaz et al., 2002), in the same way that it can foster climate change mitigation and adaptation responses (Adger, 2003). However, social capital can also be sustained on unfair social norms and institutions that perpetuate an inequitable access to the benefits provided by social organisation (Woolcock and Narayan, 2000). In particular instances, social capital can be founded upon illegal behaviours and organisational practices that result disfunctional for society. Social networks of corruption or criminal organisations, for example, can perpetuate the uneven distribution of public resources, and undermine societies' cohesion and physical security.

4.3.6 Technology

Technology has been a central element of human, social, and economic development since ancient times (Jonas, 1985; Mokyr, 1992). It can be regarded as a key means to achieving equitable SD, by enabling economic and social development whilst using environmental resources more efficiently. The development and deployment of the overwhelming majority of technologies is mediated by markets and carried out by private firms, where the requisite technological capacity and investment resources tend to be found. This process provides abundant incentives for technological innovation in response to the effective demand of purchasers (Baumol, 2002). It does not, however, necessarily address the basic needs of those members of society with insufficient market demand to influence the decisions of innovators and investors, nor does it provide an incentive to reduce externalized costs, such as the costs of GHG pollution (Jaffe et al., 2005).

Fundamental objectives of equitable and sustainable development are still unmet. For example, the basic energy and nutritional needs of large parts of the world’s population remain unfulfilled. An estimated 2.6 billion people worldwide relied on highly-polluting and unhealthy traditional biomass cook stoves for household cooking and heating in 2010, and 1.3 billion people did not have access to electricity (International Energy Agency, 2012). Similarly, the Food and Agricultural Organization (FAO) indicates that almost 870 million people (most of which are in developing countries) were chronically undernourished in 2010–12 (FAO, 2012). Achieving the objectives of equitable SD demands the fulfilment of such basic and other developmental needs. The challenges is therefore to design, implement, and provide support for technology innovation and diffusion processes that respond simultaneously to social and environmental goals, which at present do not receive adequate incentives through traditional markets.

It is well known that there exist numerous barriers that can impede the development and diffusion of relevant technologies and approaches (Negro et al., 2012). Accordingly, a systematic assessment of the adequacy and performance of the relevant innovation systems is required, which includes the scale of the investments, the allocation among various objectives and options, the efficiency by which inputs are converted into outputs, and how effectively the outputs are utilized for meeting the objectives (Sagar and Holdren 2002; Sanwal 2011; Aitken 2012). Many reports and analyses have suggested that investments in innovation for public goods such as clean energy and energy access need to be enhanced (Nemet and Kammen, 2007; AEIC, 2010; Bazilian et al., 2010) such that the scale of these activities are commensurate with these complex objectives. Innovation in and diffusion of new technologies require skills and knowledge from both developers and users, as well as different combinations of enabling policies, institutions, markets, social capital and financial means depending on the type of technology and the application being considered (Bretschger, 2005; Winkler et al., 2007, Dinica, 2009; Blalock and Gertler, 2009; KU Rao and Kishore, 2010; JP Weyant, 2011; Jänicke, 2012). These kinds of capabilities and processes may themselves require novel mechanisms and institutional forms (Bonvillian and Weiss, 2009; Sagar et al., 2009).

Different countries, of course, may use different policy instruments and approaches to achieve this objective. (See Chapter 15). The creation of demand for technologies that contributes to equitable SD while mitigating climate change should be seen as complementary to the steps mentioned in the previous paragraphs. In fact the role of government policy in advancing the development and diffusion of technologies that have a public goods nature cannot be overstated. In the case of renewable energy technologies, for example, it has been shown that intermittent policy subsidies, governments' changing R&D support, misalignments between policy levels, sectors and institutions can greatly impede the diffusion of these technologies (Negro et al., 2012). Similarly, in agriculture, while there are many intersections between mitigation and SD in agriculture through options such as 'sustainable agriculture', the potential for leveraging these synergies is contingent on appropriate and effective policies (Smith et al., 2007).

Sometimes there may be a clear alignment between achieving equitable SD benefits and meeting climate goals such as provision of clean energy to the rural poor. But in meeting multiple objectives, potential for conflicts and trade-offs between equitable SD and climate mitigation objectives can also arise. For example, the likelihood that fossil-fuels will maintain their significant share in energy supply for the near-to-medium future (International Energy Agency, 2012) explains the current exploration of new or well-established mitigation options, such as biofuels or nuclear power, and other approaches like carbon capture and storage (CCS) and geo-engineering approaches, including solar radiation management and carbon dioxide removal techniques to avoid a dangerous increase of the Earth's temperature (Crutzen, 2006; Rasch et al., 2008; Intergovernmental Panel on Climate Change, 2012b). While such technological options may indeed help mitigate global warming, they also pose risks of adverse environmental and social consequences, and thus give rise to concerns about their regulation and governance (Mitchell, 2008; Pimentel et al., 2009; de Paula Gomes and Muylaert de Araujo, 2011; Shrader-Frechette, 2011; Jackson, 2011; Scheidel and Sorman, 2012; Scott, 2013; Diaz-Maurin and Giampietro, 2013).

The public perception and acceptability of technologies is country and context-specific, mediated by age, gender, knowledge, attitudes towards environmental risks and climate change, and policy procedures (Shackley et al., 2005; Pidgeon et al., 2008; Wallquist et al., 2010; Corner et al., 2011; Poumadere et al., 2011; Visschers and Siegrist, 2012) and therefore resolution of these kinds of trade-offs and conflicts may not be easy. Yet the trade-offs and synergies between the three dimensions of SD, as well as the impacts over socio-ecological systems across geographical scales will need to be systematically considered, which in turn will require incorporation of multiple stakeholder perspectives. Assessment of energy technology options, for example, will need to include impact on landscapes' ecological and social dimensions – accounting for multiple values – and on energy distribution and access (Wolsink, 2007; Zografos and Martinez-Alier, 2009).

Lastly, there are some crosscutting issues, such as regimes for technology transfer (TT) and intellectual property (IP) that are particularly relevant to international cooperation in meeting these global challenges. Even progress under the UNFCCC has been limited, both within cooperative-implementation programs (e.g. TT under the CDM has been limited to selective conditions and mainly to a few countries (Dechezleprêtre et al., 2009; Seres et al., 2009; Wang, 2010)) and within the negotiations. In part, there are very divergent views on such issues in the climate arena since they also touch upon economic competitiveness (Ockwell et al., 2010). As earlier, perspectives are shaped by perceived national circumstances, capabilities, and needs, yet these issues do need to be resolved – in fact, there may be no single approach that will meet all needs. Different IPR regimes, for example, are required to meet development objectives at different stages of development (Correa, 2011). Recent analyses (Boldrin and Levine, 2013) and empirical studies of China's experience in wind power, solar power and LED sectors that suggest that IP rights can pose obstacles for technology transfer and further innovation (Wang, Wang, and Jiang, 2013; Wang, Wang, and Xu, 2013) provide impetus for further analysis and exploration to develop IP and TT regimes that further international cooperation to meet climate, SD, and equity objectives.

4.3.7 Natural resources

Countries' level of endowment with renewable and/or non-renewable resources influences development pathways and determines their environmental and economic performance. The location, types, quantities, long-term availability and the rates of exploitation of non-renewable resources, including fossil fuels and minerals, and renewable resources such as fertile land, forests, or freshwater shape the organization of national economies (e.g. in terms of trade balance and rent potential), their agricultural and industrial production systems, and countries' role in global geo-political and trade systems. This configuration evolves over time to reflect changes in global economic trends, in international politics or in consumption patterns, both nationally and internationally. Ultimately, it influences the rate of economic growth and its distribution among societies members, along with the amount of finance available for re-investment in the numerous socio-economic domains that affect human wellbeing (e.g. education and health). In the context of climate change, natural resource endowments affects the level and profile of GHG emissions, and correspondingly are a major determinant of mitigation opportunities, the cost of mitigation, the distribution of those costs, and ultimately the level of political commitment to climate action.

It has been argued that we are currently witnessing a shift in the world's historical trend toward declining the use of natural resource per unit of economic output, particularly due to reductions in resource efficiency in the Asia-Pacific region over the last decade (Schandl and West, 2010). In parallel, there has been an unprecedented growth in the dependency of developed countries on natural resources and materials from developing and emerging economies, coupled with a steady increase in the exploitation of natural resources that would continue in the near future under current growth rates and technologies, and a reconfiguration of global commodity chains and geo-political relations due to the appearance of new actors from emerging economies, including both public and private actors (Muradian et al., 2012; Bruckner et al., 2012). These trends, which highlight the intricate relationship between material extraction, economic growth, global political economy, and global environmental change (Krausmann et al., 2009a), also underscore the manner in which natural resource endowments are strong determinants of the future prospects and challenges in the pursuit of SD (Van der Ploeg, 2011; Muradian et al., 2012).

Governments in resource-rich countries can in principle benefit greatly from those resources. They can increase their bargaining power over the conditions for extraction of natural resources, and translate increased national revenues into potential investments in human development, for example in education and health services, particularly if well-functioning institutions and policies are in place (Mehlum et al., 2006). It has been suggested that both domestic and international factors, such as robust human capital formation, migration policy and countries' global economic integration, are key to explaining whether oil resources result in a key developmental "curse" or a "blessing" (Brunnschweiler and Bulte, 2008; Bearce and Hutnick, 2011; Kurtz and Brooks, 2011; Rudra and Jensen, 2011).

Simultaneously, serious challenges face resource-rich countries. Those resource-rich countries characterized by governance problems, such as rent-seeking behaviour, corruption and weak judiciary and political institutions, have more limited capacity to distribute resource extraction rents, as well as to increase income per capita (Mehlum et al., 2006; Pendergast et al., 2011; Bjorvatn et al., 2012). Furthermore, these countries also face risks associated with an over-specialization on agriculture and resource-based exports that can undermine other productive sectors – through increases in exchange rates and with an increasing reliance on importing countries and regions' economic growth trajectories (Muradian et al., 2012). Van der Ploeg (2011) shows that many resource-rich countries have negative genuine savings, i.e. they do not fully reinvest their resource rents in foreign assets or productive capital (e.g., buildings, roads, machines, human capital, or health), which in turn impoverishes present and future generations and undermines both natural capital and human development prospects. In some countries, an increase in primary commodity exports can lead to the rise of socio-environmental conflicts due to the increasing exploitation of land and mineral resources (Martinez-Alier et al., 2010; Muradian et al., 2012). These conflicts may, in some contexts, result in a decrease of the extraction rates of some resources and translate into an over-exploitation of others, such as fisheries (Mitchell and Thies, 2012). Not all research supports this view, however, with some suggesting a negative relationship between resource abundance and civil conflict, with abundance associated with a reduced probability of the onset of war (Brunnschweiler and Bulte, 2009).

Scholars are thus far away from definitive conclusions on the inter-relationships between resource endowments and use, and in-country development pathways, including varying degrees of social welfare and conflict, and prospects for SD. Recent reviews, for example, remark the need to continue investigating current resource booms and busts and documenting the latter's effect on national economies, policies, and social well-being, and to draw historical comparisons across countries and different institutional contexts (Wick and Bulte, 2009; Deacon, 2011; van der Ploeg, 2011). But, what is clear is that the state and those actors involved in the use of natural resources play a critical role in ensuring a fair distribution of any benefits and costs resulting from resource use within and beyond countries (Banai et al., 2011). Further, economic valuation studies have for a long time noted that systematic valuations of both positive and negative externalities yield information that can be important to policy-making relating to resource exploitation, in some cases demonstrating even that the exploitation of land and mineral resources is not socially optimal (De Groot, 2006; Thampapillai, 2011).

These considerations are relevant for climate mitigation policy. An example of a policy initiative based on recognizing the full costs of resource exploitation is the Ecuadorian government's recent choice to keep millions of oil barrels underground in exchange of global contributions for avoided emissions, representing an innovative way to secure national rents while avoiding the depletion of natural capital and reducing global GHG emissions (Rival, 2010; Martin, 2011). This is unique counter-example to the prevailing dynamic, in which a given country with abundant fossil fuel reserves has, in theory, a strong economic interest in exploiting such reserves, and thus in avoiding the adoption of policies that could constrain such exploitation. Opportunity costs are only one of the factors influencing countries' mitigative capacity (Winkler et al., 2007a) but they are sufficiently important to raise the issue of compensating resource-rich countries against forgone benefits, particularly if they are requested to participate in global mitigation efforts (Ramanathan and Xu, 2010). Additionally, if this given country faces increased exposure to climate variability and extreme events, the forgone benefits of resource rents may undermine its ability to absorb increasing adaptation costs. In this regard, a recent analysis of the relationship between countries' adoption of mitigation policies and their vulnerability to climate change confirms that countries which may suffer considerable impacts of climate change in the future, which include many resource-rich developing countries, do not show a strong commitment to either mitigation or adaptation, whilst countries exhibiting strong political commitment and action towards mitigation are also active in promoting adaptation policies. This is an indication that vulnerability is unlikely to prevail over the free-rider problem of mitigation and the development concerns of many developing countries (Tubi et al., 2012).

4.3.8 Finance and investment

The financial system is the set of financial actors – along with the institutions govern them – that mediate the allocation of financial resources to productive investments, with the aim of reaping future gains. It is the medium by which society defers today's consumption and devotes resources to securing future well-being. Fundamentally, the system of finance and investment is a direct expression of a society's priorities and its attitude toward the future. As such, it is a key determinant of society's development pathway and thus its prospects for a sustainable development transition.

Even while it mediates society's investments in future well-being, the finance system is characterized by several structural tensions with the ideals of sustainable development. First, the global finance system is motivated by financial profits, and thus focuses by design on the economic pillar. The environmental and social justice pillars of sustainable development are integrated only to the limited extent that market actors are compelled by regulation, taxation, laws and social norms to internalize social and environmental costs and benefits. Climate change, identified as the "greatest and widest-ranging market failure ever seen" (Stern and Treasury, 2007), is but one obvious example of a large societally important cost that is neglected by capital markets, which is reflected by the manner in which they value and assess fossil fuel reserves (Campanale, Mark and Leggett, Jeremy, 2011).

Second, the financial system is insensitive to the declining marginal utility of income (Layard et al., 2008), or equivalently, it is indifferent to the choice between investments that contribute to the financial betterment of a poor person versus a rich person. While markets are quite responsive to demand that is supported by purchasing power, they are only indirectly responsive to needs, and particularly insensitive to "the essential needs of the world's poor, to which overriding priority should be given" (World Commission on Environment and Development (WCED), 1987).

Third, the financial system evaluates investments with a short time horizon that is not sensitive to "the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987). The underlying economic issue of discounting, which been discussed in detail in Chapter 3 and section 4.2, is one relevant factor: a typical discount rate of 5%, say, costs and benefits accrued fifty years hence are discounted by more than a factor of ten; at 100 years, they are rendered virtually invisible. Additionally, there are various governance, organizational and sociological mechanisms further contributing to short-termism (Tonello, 2006; Marginson and McAulay, 2008). In such a context it is difficult for the financial system in its current form to accommodate principles of long-term sustainability.

These disconnects between our current financial system and the objectives of sustainable development have become more important during the recent period of rapid financialization of the global economy. This period has been characterized accelerated growth of the financial sector flows and profit share relative to the “real” economy of goods production and services provision, along with an increasing role of the financial system in mediating short-term speculation as distinct from long-term investment (Epstein, 2005; Krippner, 2005; Palley, 2007; Dore, 2008).

The challenges are felt especially in developing countries, which are constrained by a generally lower capacity to mobilize private sector capital toward SD objectives, and for climate change adaptation and mitigation of GHG emissions in developing countries in particular. This is due to a number of complex interrelated factors, including the comparatively high overall cost of doing business; market distortionary policies such as subsidies for conventional fuels; absence of credit-worthy off-takers; low access to early-stage financing; lower public R&D spending; too few wealthy consumers willing to pay a premium for “green products”; social and political instability; poor market infrastructure, and weak enforcement of the regulatory frameworks. These usually increase the investment risk factor. Establishing better mechanisms for leveraging private sector finance through innovative financing can help (EGTT, 2008), but there are also risks in relying on the private sector as market-based finance focuses on short term lending and private financing in times of abundant liquidity may seek potential high returns rather than constitute a source of stable long-term climate finance (Akyuz, 2012).

Even mechanisms that are specifically designed and implemented for the purpose of generating SD benefits have faced difficulty. Consider the the Kyoto Protocol's Clean Development Mechanism (CDM), which has uncertain value in financing real additional emission reductions in developing countries , as well as being concentrated on particular technologies and unevenly spread across the world, showing a significant bias towards emerging economies and leaving the African continent aside (Boyd et al., 2009; UNEP/Risø Centre on Energy, 2011). (See Chapter 13.) The CDM as it was in the first phase of the Kyoto Protocol did not meaningfully contribute to development goals such as improving energy access amongst the world’s poorest people and industrialization in the poorer countries (Olsen, 2007; Corbera and Jover, 2012).

While some developing countries are able to mobilize some domestic financial resources to support efforts toward SD, the needs for many developing countries exceed their own financial capacity. Accordingly, their ability to pursue SD, and climate change mitigation and adaptation actions in particular, can be severely constrained by lack of finance. The international provision of finance, alongside technology transfer, can help to alleviate this problem, as well as being consistent with principles of equity, international commitments, and arguments of effectiveness (see section 4.2.1 and 4.7.3.1). Under international agreements, in particular Agenda 21 and the Rio Conventions of 1992, and reaffirmed in subsequent UN resolutions and programs including the 2012 UN Conference on Sustainable Development (United Nations, 2012a), developed countries have committed to provide financial resources to developing countries.

In the context of climate specifically, the UNFCCC Parties have established three funds to support meaningful climate action in developing countries: the Special Climate Change Fund (SCCF), to support mitigation, adaptation and technology transfer to developing countries; the Least Developed Countries Fund (LDCF), to support the preparation of National Adaptation Plans; and the Adaptation Fund, to support adaptation programs and projects in developing countries. Additionally, in 2010, the Green Climate Fund was established at the 16th session of the Conference of the Parties (COP-16) and COP-17 decided to undertake a work program on long-term finance with the aim of contributing to the ongoing efforts to scale up the mobilization of climate change finance after 2012 (UNFCCC, 2011). As such it will analyze options for the mobilization of resources from a wide variety of sources, public and private, bilateral and multilateral, including alternative sources and relevant analytical work on climate-related financing needs of developing countries. At COP-18 in 2012, a decision to develop an institutional arrangement to address loss and damage of developing countries from climate change was adopted, which is expected to further increase the financing required.

Funding from the Global Environment Facility (GEF) shows great unevenness in supporting mitigation and adaptation projects through the above-mentioned operational funds. From its inception in 1991 until June 2011 the GEF Trust Fund has funded 755 mitigation projects costing US$3.39 billion and attracting US$19.9 billion in co-funding, spread across 156 developing countries and economies in transition, which represents a fraction of what is required for mitigation and adaptation compared to current estimates of needs of developing countries. A total of 47 projects have been funded through the LDCF for a total of US$178.6 million and another 32 through the SCCF for a total of US$127.74 million. The GEF Strategic Priority on Adaptation (SPA) program distributed US$50 million between 2004 and 2010, aiming to show how adaptation planning and assessment can be practically translated into full-scale projects. In addition, the World Bank's Strategic Climate Fund (SCF) and the Clean Technology Fund (CTN) are scheduled to "sunset" once a "new financial architecture is effective" (World Bank, 2008). All these initiatives are complemented by multilateral, bilateral or single-country funding initiatives designed to support mitigation and adaptation projects and programs, with a diversity of priorities and levels of disbursement.

Such diversity, however, has led scholars to advocate for a better integration of climate funding and development aid to ensure coordination and increase the effectiveness of financial transfers (Smith et al., 2011), as well as to suggest ways of improving funds governance and management approaches. Recent analyses of the AF, for example, highlight difficulties in targeting vulnerable areas and populations due to a lack of clear, accepted definitions, nor strong incentives to consider vulnerability or related information, such as weather events attribution, in the evaluation of project proposals (Van Renssen, 2011; Horstmann, 2011; Hulme et al., 2011).

4.4 Production, trade, consumption and waste patterns

This section concerns the consumption of goods and services by households, consumption trends and disparities, and the relationship between consumption and GHG emissions. It also discusses the components and drivers of consumption, efforts to make consumption (and production) more sustainable, and how consumption affects well-being. We also review approaches to consumption-based accounting of GHG emissions (carbon footprinting) and their relationship to territorial approaches. Hence, while subsequent chapters analyse GHG emissions associated with specific sectors and transformation pathways, we focus here on a particular group (consumers) and examine their emissions in an integrated way.

The section considers two types of decoupling, at the global scale and in the long term: The decoupling of material resource consumption (including fossil carbon) and environmental impact (including climate change) from economic growth or economic development ("dematerialization"); and the decoupling of human well-being from economic growth. The first type (see Sec. 4.4.1 and 4.4.3) is generally considered crucial for meeting sustainable development and equity goals (UNEP, 2011); yet while some dematerialization has occurred (see below), absolute levels of resource use and environmental impact have continued to rise (Krausmann et al., 2009b). This has inspired debates relevant to the second type of decoupling (Jackson, 2005b, 2009; Assadourian, 2010), including discussion of reducing consumption levels in wealthier countries. We address this topic (Sec. 4.4.4) by examining how income and income inequality affect dimensions of well-being. While the second type of decoupling represents a "stronger" form than the first, it is also a more controversial and a more novel concept, at least in a climate change context (yet programmes to address reduced excessive consumption were mandated in Chapter 4.5 of Agenda 21 (United Nations, 1992c).

4.4.1 Consumption patterns, inequality and environmental impact

The global annual use (extraction) of material resources – i.e., ores and industrial minerals, construction materials, biomass, and fossil energy carriers – increased eightfold during the 20th century, reaching about 55 Gt in 2000, while the average resource use per capita (the metabolic rate) doubled, reaching 8.5-9.2 tonnes per capita per year in 2005 (Krausmann et al., 2009b; UNEP, 2011). The *value* of the global consumption of goods and services (the global GDP) has increased six-fold since 1960 while consumption expenditures per capita has almost tripled (Assadourian, 2010). Consumption-based GHG emissions increased between 1990 and 2009 in the world's major economies, except the Russian Federation, ranging from 0.1-0.2% per year in the EU27, to 4.8-6.0% per year in China (Peters et al., 2012) (see Chapter 5).

Global resource consumption has risen slower than GDP, especially since around 1970, indicating some decoupling of economic development and resource use, signifying an increase in resource productivity by about 1-2% annually at the global level (Krausmann et al., 2009b; UNEP, 2011). This dematerialization of economic activity has been most pronounced in the industrialized countries. Metabolic rates across countries are highly unequal, varying by a factor of 10 or more, due in large part to variations in economic development, but there is also significant cross-country variation in the relation between GDP and resource use (ibid.).

While for the world's many poor people, consumption is driven mainly by the need to satisfy basic human needs, it is an increasingly common pattern across cultures to find meaning, contentment and acceptance primarily through consumption (2010). This pattern is often referred to as "consumerism", defined as a cultural paradigm where "the possession and use of an increasing number and variety of goods and services is the principal cultural aspiration and the surest perceived route to personal happiness, social status and national success" (Assadourian, 2010). Consumerist lifestyles in industrialized countries seem to be imitated by the growing elites (Pow, 2011) and middle-class populations in developing countries (Cleveland and Laroche, 2007; Gupta, 2011). Together with the unequal distribution of income in the world (Sec. 4.2), the spread of consumerism means that a large share of goods and services produced are "luxuries" that only the wealthy are able to pay for, while the poor are unable to afford even the most basic goods and services (Khor, 2011).

Furthermore, the spread of consumerism as incomes rise is one of the "mega-drivers" of global resource use and environmental degradation (2010). Hence a disproportionate part of the GHG emissions arising from production are linked to the consumption of goods and services by a relatively small portion of the world's population. This is illustrated by the great variation in the per capita life-cycle GHG emissions of consumption ("carbon footprint") between countries and regions at different income levels ("Consumption-based accounting of CO2 emissions"; Hertwich and Peters, 2009; Peters et al., 2011) (see below and Annex II). For example, the average carbon footprint per person per year varies from 1-2 tonnes for many African and Asian countries, to 10-20 tonnes in Europe, to more than 28 tonnes for the United States, Hong Kong and Luxemburg (Hertwich and Peters, 2009).[4]

As these figures indicate, the carbon footprint is strongly correlated with per capita consumption expenditure (see Sec. 4.5). Across countries, Hertwich and Peters (2009) found an expenditure elasticity of 0.57 for all GHGs – i.e., as nations become wealthier, the per capita carbon footprint increases by 57% for each doubling of consumption (Figure 4.4.1). Within countries, similar relationships have been found between household expenditure and carbon footprint (Hertwich, 2011). In the United Kingdom, the mean per capita CO_2 emissions of households with the highest disposable income was 10.4 tonnes, versus 7.4 tonnes for those in the lowest income category (Druckman and Jackson, 2009). A multi-country study found expenditure elasticities of household energy consumption ranging from 0.64 in Japan to 1.0 in Brazil (Lenzen et al., 2006). Because wealthier countries meet a higher share of their final demand from (net) imports than do less wealthy countries, consumption-based emissions are more closely associated with GDP than are

[4] The figures refer to year 2001. The analysis excludes countries in the Middle East (except Turkey) and a disproportionate share of poor countries.

territorial emissions (Figure 4.4.2), the difference being the emissions embodied in trade (see Sec. 4.4.2., Ch. 5 and Ch. 14).

The relationship between specific consumption patterns and environmental impact has been studied intensely in recent years (Tukker et al., 2010a). In industrialized countries, mobility (automobile and air transport), food (mainly meat and dairy) and housing (including the use of energy-using products) are responsible for the largest proportion of consumption-related GHG emissions. Together they account for 70% to 80% of all life-cycle impacts. A similar pattern exists for the carbon footprint of consumption ("Consumption-based accounting of CO2 emissions"; Druckman and Jackson, 2009; Hertwich, 2011). At the global scale, 72% of GHG emissions are related to household consumption, 10% to government consumption and 18% to investments (Hertwich and Peters, 2009). Food is the most important consumption category, accounting for nearly 20% of GHG emissions, followed by housing/shelter (19%), mobility (17%), services (16%), manufactured products (13%), and construction (10%). Food and services are more important in poor countries, while at high expenditure levels, mobility and the consumption of manufactured goods cause the largest GHG emissions (ibid) (see Chapter 14).

The effects of non-income factors such as geography, energy system, production methods, household size, diet and lifestyle also affect per capita carbon footprints and other environmental impacts (Tukker et al., 2010a) so that the effects of increasing income varies considerably between regions and countries (Lenzen et al., 2006; Hertwich, 2011; Homma et al., 2012), cities (Jones and Kammen, 2011) and between rural and urban areas (Lenzen and Peters, 2010). The factors responsible for variations in carbon footprints across households at different scales are further discussed in Chapters 5, 12 and 14.

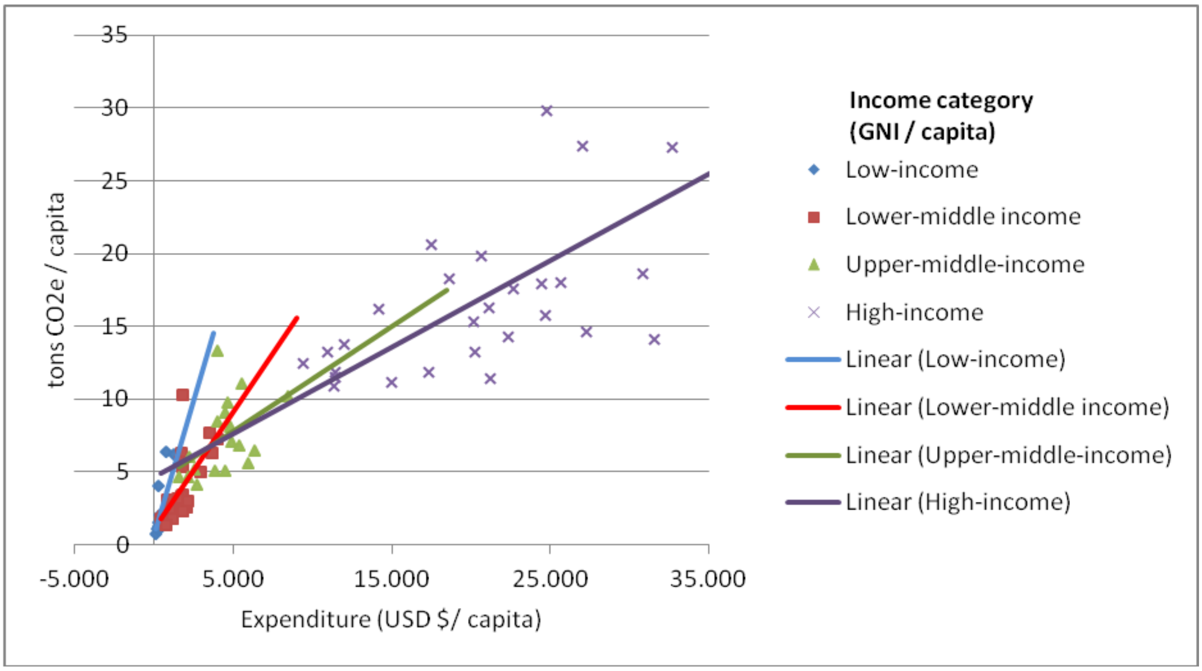

Figure 4.4.1 Relationship between final consumption ($/capita) and carbon footprint (tCO2e/capita) for countries classified according to income (GNI per capita, World Bank Atlas method). Data refer to year 2001. Source: Adapted from Hertwich and Peters **(2009)**. [Note from the authors: Will be updated to year 2010 or 2011]

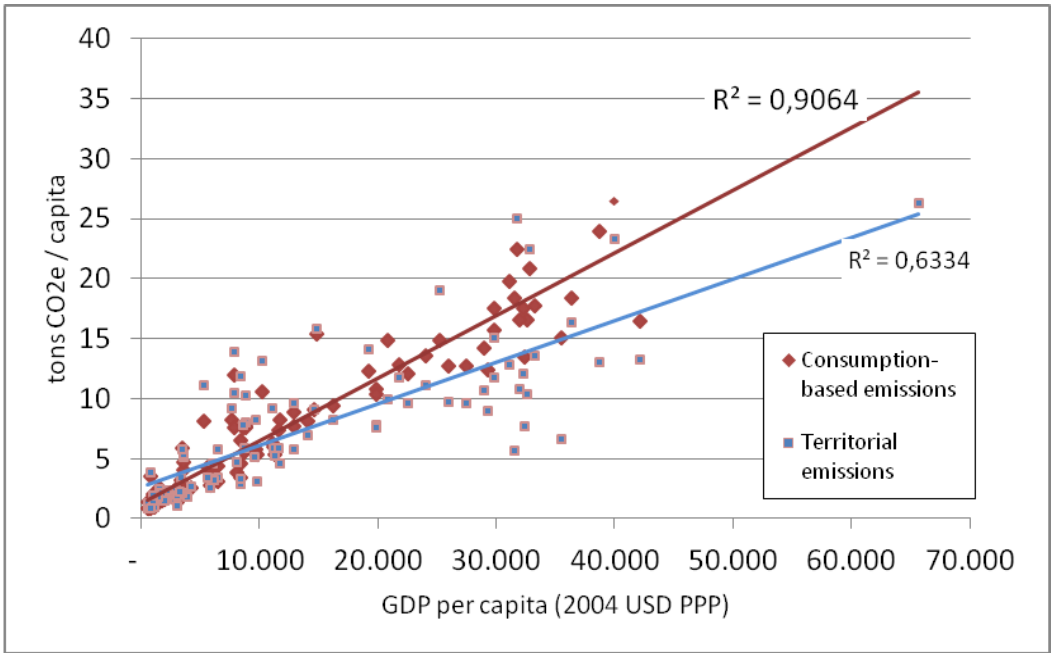

Figure 4.4.2 Relationship between the wealth (GDP, USD 2004 PPP) and GHG emissions (CO2e) of countries, for 92 countries. Data refer to year 2004. The red colour shows consumption-based emissions and the blue colour territorial emissions. Source: Adapted from Steen-Olsen et al. **(2012)**. Data sources: GTAP and World Bank. [Note from the authors: Will be updated to year 2010 or 2011]

4.4.2 Consumption patterns and carbon accounting

4.4.2.1 Carbon footprinting (consumption-based GHG emissions accounting)

Carbon (or GHG) accounting refers to the calculation of the GHG emissions associated with economic activities at a given scale or with respect to a given unit. GHG accounting has traditionally focused on emission sources, but in recent years there has been a growing interest in analyzing the drivers of emissions by calculating the GHG emissions that occur along the supply chain of a functional unit such as a product or household (Peters, 2010). The result of this consumption-based emissions accounting is often referred to as "carbon footprint", even if it involves other GHGs along with CO_2 (see Annex II). A carbon footprint in principle includes all emissions generated during the life-cycle of a good or service – i.e., from production and distribution to end-use (final consumption) and disposal or recycling.

Carbon footprinting starts from the premise that the GHG emissions associated with economic activity are generated at least partly as a result of people's attempts to satisfy certain functional needs and desires (Lenzen et al., 2007; Druckman and Jackson, 2009; Bows and Barrett, 2010). These are needs and desires expressed in the consumer demand for goods and services, and this demand drives the production processes that consume material and energy resources and emit pollutants. Emission drivers are not limited to individuals' consumption behaviour, however, but include also the wider contexts of consumption such as transport infrastructure, production and marketing systems, energy systems (see Sec. 4.3 and below). Carbon footprints have therefore been estimated with respect to different functional units at different scales, including products, households, companies, cities, countries and regions (Peters, 2010; Pandey et al., 2011).[5]

[5] The emissions associated with the functional unit (but physically not part of the unit) are referred to as "embodied carbon", "carbon flows" or similar terms. A carbon footprint is expressed in CO_2e (GWP100) per unit for a given time period (typically one year; for products the time frame is the product life cycle (see Annex II). Using the GTP metric instead of the GWP100 one can sometimes change a carbon footprint significantly.

There is no single accepted carbon footprinting methodology (Pandey et al., 2011), although several international carbon footprint standards have been developed, e.g. for products (Bolwig et al., 2011). Nor is there one widely accepted definition of carbon footprint. Peters (2010) proposes this definition, which allows for all possible applications across scales: "The 'carbon footprint' of a functional unit is the climate impact under a specific metric that considers all relevant emission sources, sinks and storage in both consumption and production within the specified spatial and temporal system boundary".

Calculating the carbon footprint of products can enable a range of climate mitigation actions (Sinden, 2009; Bolwig and Gibbon, 2010). Informing consumers about the climate impact of products through labelling or other means can influence purchasing decisions in a more climate-friendly direction and at the same time enable product differentiation (Edwards-Jones et al., 2009; Weber and Johnson, 2012). Carbon footprinting can also help companies reduce GHG emissions cost-effectively by identifying the various emission sources within the company and along the supply chain, including in other countries and in shipping and aviation (Sinden, 2009; Sundarakani et al., 2010; Lee, 2012). Those emissions can be reduced directly, or by purchasing offsets in carbon markets. Some also argue that a company's success at reducing its carbon footprint can inspire confidence in its general performance, but this effect is not well researched, and in the United Kingdom, Sullivan and Gouldson (2012) found limited investor interest in the climate change-related data provided by retailers (see also Chapter 15). There is both theoretical and empirical evidence of a positive relationship between a company's environmental and financial performance (Delmas and Nairn-Birch, 2011; Griffin et al., 2012). The specific effect of carbon footprinting on company financial performance and investor valuation is not well researched, however, and the results are ambiguous. In the United Kingdom, Sullivan and Gouldson (2012) found limited investor interest in the climate change-related data provided by retailers, while a from the United States and Canada concludes that investors do care about companies' GHG emission disclosures, whether these occur through a voluntary scheme or informal estimates (Griffin et al., 2012). A longitudinal study of firms in the United States across found that increasing carbon emissions positively impact financial performance when using accounting based measures while it has a negative impact on market based measures of financial performance; supply-chain (versus company-level) emissions significantly drive these findings (Delmas and Nairn-Birch, 2011). (See also Chapter 15.)

Product carbon footprinting could also have unintended effects, such as increasing costs and reducing demand for products made abroad, including in developing countries (Edwards-Jones et al., 2009; Erickson et al., 2012). Implementation of carbon footprint standards through certification schemes may also affect competitiveness and trade (Brenton et al., 2009) and could violate WTO trade rules. Furthermore, a one-sided focus on GHG emissions in product development and consumer choice could involve serious (and unnoticed) trade-offs with other sustainability dimensions (Finkbeiner, 2009). For example, products or systems fulfilling similar functions may show similar carbon footprints but differ significantly with respect to other environmental impacts, notably those related to emissions of toxic substances (Laurent et al., 2012). These observations suggest a need to use more broadly encompassing concepts and tools to assess and manage sustainability.

Choice of accounting method

In the last decade, new accounting methods for assessing GHG emissions have emerged and proliferated in response to interest in 1) determining whether nations are reducing emissions (Bows and Barrett, 2010; Peters et al., 2011, 2012), 2) allocating GHG responsibility ("Consumption-based accounting of CO2 emissions"; Peters and Hertwich, 2008; Bows and Barrett, 2010), 3) assuring the accountability of carbon markets (Stechemesser and Guenther, 2012), 4) determining the full implications of alternative energy technologies (Von Blottnitz and Curran, 2007; Martínez et al., 2009; Cherubini et al., 2009; Soimakallio et al., 2011), 5) helping corporations become greener (Wiedmann et al., 2009), and 6) encouraging consumers to reduce their carbon footprints (Bolwig and Gibbon, 2010; Jones and Kammen, 2011). Most methods simply address CO_2; some also include other GHGs, while others also consider a range of non-GHG environmental impacts. Methods differ, with normative implications, on whether consumers or producers of products are responsible; whether emissions embedded in past or potential replacement of capital investments are included; and whether indirect emissions, for example, through global land-use change resulting from changing product prices, are included (Finkbeiner, 2009; Plevin et al., 2010; Plassmann et al., 2010).

Most emissions accounting methods use a life-cycle assessment approach, but differ as to whether the analysis uses environmentally extended economic input-output (EIO) tables to assess emissions (LCA-EIO) or the analysis tailors the approach to the best data and assumptions for the particular uses to which the analysis may be put. LCA-EIO provides analytical consistency across products but incorporates historic average emissions by economic sector level (Wiedmann and Minx, 2007). Tailored approaches such as activity-based or process LCA can use more recent and specialized data, be more forward-looking, and address incremental changes. Hybrid LCA methods combining LCA-EIO and process-LCA are increasingly been applied (Suh and Nakamura, 2007; Williams et al., 2009; Peters, 2010). Global, multi-region input-output (MRIO) models are a type of EIO model in which imports to a region are modelled using the technology of the region of origin (as opposed using the technology of the importing region) and are considered state-of-the-art for assigning "consumer responsibility" (Druckman and Jackson, 2009; Wiedmann, 2009). Comprehensive uncertainty analyses of process LCA and EIO-type models are generally rare but with important exceptions (Finnveden et al., 2009; Lenzen et al., 2010). See Annex II for further discussion of these methods.

Systems of GHG emissions accounting are constructed according to certain conventions and purposes ("Consumption-based accounting of CO2 emissions"). Better ways may be excessively expensive given the plausible importance of the value of better information in the decision process. Some interests will plead for standardized techniques based on past data because it favours them. Others will argue for tailored approaches that make their technologies or products look good. Producers favour responsibility being assigned to consumers, as do nations that are net exporters of industrial goods. Controversies over accounting approaches play into issues of GHG and environmental governance more broadly. Whether a consumption decision in one country affects GHG emissions in other countries through the supply chain depends heavily on whether those other countries have and enforce GHG policies. Whether carbon markets are effective or not depends on good accounting and enforcement, but what will be enforced will depend on the accounting measures agreed upon.

4.4.2.2 Consumption-based versus territorial approaches to GHG accounting

Consumption-based accounting of GHG emissions (or carbon footprinting) at national level differs from the production-based or territorial framework because of imports and exports of goods and services that, directly or indirectly, involve GHG emissions ("Consumption-based accounting of CO2 emissions"; Peters et al., 2011). The territorial framework allocates to a nation those emissions that are physically produced within its territorial boundaries. The consumption-based framework allocates the emissions associated with (released by the supply chain of) goods and services consumed within a nation irrespective of their territorial origin. The difference in inventories calculated based on the two frameworks are the emissions embodied in trade (Peters and Hertwich, 2008; Bows and Barrett, 2010) (Annex II gives details on accounting methods). It should be noted that territorial and consumption-based accounting of emissions as such represent pure accounting identities measuring the emissions embodied in goods and services that are produced or consumed, respectively, by an individual, firm, country, region, etc. Responsibility for these emissions only arises once it is assigned within a normative or legal framework, such as a climate agreement, specifying rights to emit or obligations to reduce emission based on one of these metrics (see below). As detailed below, the two approaches function differently in a global versus a fragmented climate policy regime.

Steckel et al. (2010) show that within a global regime that internalizes a cost of GHG emissions, the two approaches are theoretically equivalent in terms of their efficiency in inducing mitigation. For example, with a global cap-and-trade system with full coverage (i.e., an efficient global carbon market) and given initial emission allocations, countries exporting goods benefit from export revenues, with costs related to GHG emissions and any other negative impacts of production of those goods priced in, such that the choice of accounting system has no influence on the efficiency of production. Nor will it influence the welfare of countries, irrespective of being net exporters or importers of emissions, since costs associated with these emissions are fully internalized in product prices and will ultimately be borne by consumers. In practice, considerations such as transactions costs and information asymmetries would influence the relative effectiveness and choice of accounting system.

In the case of a fragmented climate policy regime, one argument put in favour of a consumption-based framework is that, unlike the territorial approach, they do not allow current emissions inventories to be reduced by outsourcing production or relying more on imports to meet final demand. Hence, it is argued, this approach gives a fairer illustration of responsibility for current emissions (Peters and Hertwich, 2008; Bows and Barrett, 2010). Carbon footprinting also increases the range of mitigation options by identifying the distribution of GHG emissions among different activities, final uses, locations, household types, etc. This enables better targeting of policies as well as voluntary actions by citizens, corporations, and cities (Bows and Barrett, 2010; Jones and Kammen, 2011).

On the other hand, reducing emissions at the “consumption end” of supply chains requires changing deeply entrenched lifestyle patterns and specific behaviours among many actors with diverse characteristics and preferences, as opposed to among the much fewer actors emitting GHGs at the source. It has also been pointed out that – identical to the accounting of production-based emissions – there is no direct one-to-one relationship between changes in consumption-based and global emissions (Jakob and Marschinski, 2012) – i.e., if some goods or services were not consumed, global emissions would not necessarily decrease by the same amount of emissions generated for their production. This has been shown for China (Peters et al., 2007) and India (Dietzenbacher and Mukhopadhyay, 2007): while these countries are large net exporters of embodied carbon, territorial emissions would remain roughly constant or even increase if they were to withdraw from international trade (and produce their entire current consumption domestically instead). That is, without international trade, consumption-based emissions of these countries’ trade partners would likely be reduced, but not global emissions.

For this reason, it has been argued that a more detailed understanding of the underlying determinants of emissions is needed than what is currently provided by either territorial or consumption-based accounts, in order to guide policies that will effectively reduce global emissions in a fragmented climate policy regime (Jakob and Marschinski, 2012). In particular, a better understanding of system interrelationships in a global economy is required in order to be able to attribute how, e.g., policy choices in one region affect global emissions by transmission via world market prices and associated changes in production and consumption patterns in other regions. Furthermore, as market dynamics and resource use are driven by both demand and supply, it is conceivable to rely on climate policies that target the consumption as well as the production side of emissions, as is done in some other policy areas.

FAQ 4.3 IPCC and UNFCCC focus primarily on GHG emissions within countries. Aren't consumers responsible for all the emissions linked to the goods and services they use, even if they come from other countries?

For any given country, it is possible to compute the emissions embodied in its consumption or those emitted in its productive sector. The consumption-based framework for GHG emission accounting allocates the emissions released during the production and distribution (i.e. along the supply chain) of goods and services to the final consumer and the nation (or another territorial unit) in which she resides, irrespective of the geographical origin of these goods and services. The territorial or production-based framework allocates the emissions physically produced within a nation's territorial boundary to that nation. The difference in emissions inventories calculated based on the two frameworks are the emissions embodied in trade. Consumption-based emissions is more strongly associated with GDP than is territorial emissions. This is because wealthier countries satisfy a higher share of their final consumption of products through net imports compared to poorer countries.

FAQ 4.4 What kind of consumption has the greatest environmental impact?

The relationship between consumer behaviours and their associated environmental impacts is well understood. Generally, higher consumption lifestyles correspond to greater environmental impacts, which connects distributive equity issues with the environment. Beyond that, research has shown that food accounts for the largest share of consumption-based GHG emissions (carbon footprints) with nearly 20% of the global carbon footprint, followed by housing, mobility, services, manufactured products, and construction. Food and services are more important in poor countries, while mobility and manufactured goods account for the highest carbon footprints in rich countries.

4.4.3 Sustainable consumption and production – SCP

The concepts of "sustainable consumption" and "sustainable production" represent, respectively, demand- and supply-side perspectives on sustainability. Moisander el al. (2010) remind us that the efforts by producers to minimize the environmental or social impact of a product are futile if consumers do not buy the good or service. Conversely, sustainable consumption behaviour depends on the availability and affordability of such products in the marketplace. Below we introduce the international policy developments that have been key drivers of the increasing research efforts in these areas, and then we discuss the two perspectives in turn.

4.4.3.1 SCP policies and programmes

The idea of sustainable consumption and production (SCP) was first placed high on the policy agenda at the 1992 Earth Summit in Rio de Janeiro and was made part of Agenda 21. The World Summit on Sustainable Development in 2002 led to the development of a 10-year Framework of Programmes (10YFP) initiated in 2003 as The Marrakech Process (Tukker et al., 2010b; Schrader and Thøgersen, 2011; Pogutz and Micale, 2011). The 10YFP was formalised in a document adopted by the Rio+20 conference in 2012 that stated:

> *"Fundamental changes in the way societies produce and consume are indispensable for achieving global sustainable development" [... and] "support for regional and national initiatives is necessary to accelerate the shift towards [SCP] in order to promote social and economic development within the carrying capacity of ecosystems by addressing and, where appropriate, decoupling economic growth from environmental degradation by improving efficiency and sustainability in the use of resources and production processes and reducing resource degradation, pollution and waste" (United Nations, 2012b, p. 2).*

National and regional SCP policies have also been developed lately (see Ch. 10.11.3). For example, in 2008, the European Commission approved the "Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan", which includes proposals that aim to "contribute to improving the environmental performance of products and increase the demand for more sustainable goods and production technologies" and to "encourage EU industry to take advantage of opportunities to innovate" (European Commission, 2008). Other international organizations have placed new emphasis on SCP, for example, the Worldwatch Institute (Worldwatch Institute, 2010) and United Nations Industrial Development Organization (UNIDO, 2011). Such policies and initiatives differ as to whether they involve a strong or weak approach to sustainability (Sec. 4.2), i.e., whether they target a general substitution of fossil technologies and of material growth paths or "merely" an increase in the demand for sustainable products.

4.4.3.2 Sustainable consumption and lifestyle

A rich research literature on sustainable consumption has developed over the past decade, including several special issues of international journals (Tukker et al., 2010b; Le Blanc, 2010; Kilbourne, 2010; Black, 2010; Schrader and Thøgersen, 2011). Several books, such as *Prosperity without Growth* (Jackson, 2009), discuss the unsustainable nature of current lifestyles, development trajectories, and economic systems, and how these could be changed in more sustainable directions. Several definitions of sustainable consumption have been proposed within policy, business and academia (Pogutz and Micale, 2011). At the Oslo symposium on Sustainable Consumption in 1994, sustainable consumption (and production) was defined as the "use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardize the needs of future generations" (Norwegian Ministry of Environment, 1994). At another meeting in Oslo, in 2005, scientists proposed a more encompassing and integrating perspective:

> *"The future course of the world depends on humanity's ability to provide a high quality of life for a prospective nine billion people without exhausting the Earth's resources or irreparably damaging its natural systems … In this context, sustainable consumption focuses on formulating strategies that foster the highest quality of life, the efficient use of natural resources, and the effective satisfaction of human needs while simultaneously promoting equitable social development, economic competitiveness, and technological innovation" (Tukker et al., 2006).*

This perspective encompasses not only demand-side but also production issues, and it addresses all three pillars of sustainable development (social, economic and environmental) as well as equity and well-being, illustrating the complexity of sustainable consumption and its connections to a range of other issues.

Research has demonstrated that consumption practices and patterns are influenced by a range of economic, informational, psychological, sociological, and cultural factors, operating at different levels or spheres in society, including the individual, the family, the locality, the market and the work place (Thøgersen, 2010). Furthermore, consumers' preferences are often constructed in the situation (rather than pre-existing) and their decisions are highly contextual (Weber and Johnson, 2009) and often inconsistent with values, attitudes, and perceptions of themselves as responsible and green consumers and citizens (Barr, 2006; de Barcellos et al., 2011), as elaborated below. (See the discussion of behaviour in Ch. 2 and 3).

The sustainable consumption of goods and services can be viewed in the broader context of lifestyle and everyday life. For example, Hall (2011) observes that ethical consumer discourses inform everyday family consumption processes and narratives. Conversely, sustainable consumption practices are bound up with perceptions of identity, ideas of good life, and so on, and considered alongside other concerns such as affordability and health. Ethical consumption choices are also negotiated among family members with divergent priorities and interpretations of sustainability. Choosing a simpler lifestyle ("voluntary simplifying") seems to be related to environmental concern (Shaw and Newholm, 2002; Huneke, 2005), but frugality, as a more general trait or disposition, is not (Lastovicka et al., 1999; Pepper et al., 2009).

Other research draws attention to the constraints placed on consumption and lifestyle choices by factors beyond the influence of the individual, family or community, which tends to lock consumption into unsustainable patterns by reducing "green agency" at the micro level (Thøgersen, 2005; Pogutz and Micale, 2011). These structural issues include product availability, cultural norms and beliefs, and working conditions which favour a "work-and-spend" lifestyle (Sanne, 2002). Brulle and Young (2007) found that the growth in personal consumption in the USA during the 20th century is partly explained by the increase in advertising, after controlling for disposable income, demographics, and income distribution. The effect of advertising on spending is concentrated on luxury goods (household appliances and supplies and automobiles) while it is nonexistent in the field of basic necessities (food and clothes). Observations such as these make Moisander et al. (2010) question the individualistic view of the consumer as a powerful political agent and market actor. Instead, they propose that green consumer behaviour be analyzed in the context of the different networks of power that constitute the conditions of subjectivity and agency in a market that is highly shaped by the political economy in which it is embedded.

The strength and pervasiveness of political economy factors such as those mentioned above, and the inadequate attention to them by policy, is an important cause of the lack of real progress towards more sustainable consumption patterns (Thøgersen, 2005; Tukker et al., 2006; Le Blanc, 2010). Furthermore, the unsustainable lifestyles in industrialized countries are being replicated by the growing elites (Pow, 2011) and middle-class populations in developing countries (Cleveland and Laroche, 2007; Gupta, 2011). Finally, we observe that SC studies are generally done in a consumer culture context, which tends to compromise discussion of instances where sustainable consumption has pre-empted the consumer culture.

4.4.3.3 Consumer attitudes to the environment and to carbon footprinting

Despite the overwhelming impact of structural factors on consumer practices, choices and behaviour, it is widely agreed that the achievement of more sustainable consumption patterns also depends on how consumers value environmental quality and other dimensions of sustainability (Jackson, 2005a; Thøgersen, 2005; Bamberg and Möser, 2007). It also depends on whether people believe that their consumption practices make a difference to sustainability (Frantz and Mayer, 2009; Hanss and Böhm, 2010), which in turn is influenced by their value priorities and how much they trust the environmental information provided to them by scientists, companies, and public authorities (Kellstedt et al., 2008). The motivational roots of sustainable consumer choices seem to be substantially the same, although not equally salient in different national and cultural contexts (Thøgersen, 2009; Thøgersen and Zhou, 2012).

In a survey of European attitudes towards sustainable consumption and production (Gallup Organisation, 2008a), 84% of EU citizens said that the product's impact on the environment is "very important" or "rather important" when making purchasing decisions. Similarly, 77% said they always or often take energy efficiency into account when buying electricity or fuel-consuming products. These attitudes are rarely reflected in behaviour, however. There is plenty of evidence demonstrating the presence of an "attitude-behaviour" or "values-action" gap whereby consumers expressing "green" attitudes fail to adopt sustainable consumption patterns and lifestyles (Barr, 2006; Young et al., 2010; de Barcellos et al., 2011). To a large measure, this gap can be attributed to many other goals and concerns competing for the person's limited attention (Weber and Johnson, 2009). The impact of multiple competing goals and limited attention is reflected in the substantial difference in the level of environmental concern that Europeans express in opinion polls when the issue is treated in isolation, and when the environment is assessed in the context of other important societal issues. For example, in 2008, 64% of Europeans said protecting the environment was "very important" to them personally when the issue was presented in isolation (Gallup Organisation, 2008b) while only 4% pointed at environmental pollution as one of the two most important issues facing their country at the moment (Gallup Organisation, 2008a). When there are many important issues competing for the person's limited attention and resources, those that appear most pressing in everyday life are likely to prevail.

The likelihood that a person will act on his or her environmental concern is further diminished by a range of factors affecting everyday decisions and behaviour, including the structural factors mentioned above, but also more specific factors such as habit, high transactions costs (i.e., time for information search and processing and product search), availability, affordability, and the influence of non-green criteria such as quality, size, brand, and discounts (Young et al., 2010). Some of these factors differ across different product categories and within sectors (McDonald et al., 2009). The impact of all of these impeding factors is substantial, calling into question the capacity of "the green consumer" to effectively advance sustainable consumption and production (Csutora, 2012).

Third-party eco-labels and declarations have proven to be an effective tool to transform consumer sustainability attitudes into behaviour in many cases (Thøgersen, 2002). One of the reasons is that a trusted label can function as a choice heuristic in the decision situation, allowing the experienced consumer to make sustainable choices in a fast and frugal way (cf. Chapter 2 and Thøgersen et al. (2012)). Labelling products with their carbon footprint may help to create new goals (e.g., to reduce CO_2 emissions) and to attract and keep attention on those goals, in the competition between goals (Weber and Johnson, 2012). According to the Gallup survey mentioned above, there is strong support for product carbon labelling in Europe: 72% of EU citizens thought that carbon labelling should be mandatory. However, only 10% of European consumers found the carbon footprint to be the most important information that an eco-label should contain (Gallup Organisation, 2008a). In Australia, Vanclay et al. (2010) found a strong purchasing response of 20% when a green-labelled product (indicating relatively low life-cycle CO_2 emissions) was also the cheapest, and a much weaker response when green-labelled products were not the cheapest. Hence, consumers, at least in developed countries, show interest in product carbon footprint information and many consumers would prefer carbon-labelled products and firms over others, other things being equal (Bolwig and Gibbon, 2010). But consumers are also sceptical about "climate-friendly" claims made by retailers and producers (ibid.). Finally, it is important to note that the impeding factors and the related "attitudes-behaviour" gap severely limit how far one can get towards sustainable consumption with labelling and other information-based means alone.

Research on these topics in the developing world is lacking. Considering the notion of a hierarchy of needs (Maslow; Chai and Moneta, 2012) and the challenges facing consumers in developing countries, carbon footprints and other environmental declarations might be seen as a luxury concern that only developed countries can afford. Countering this view, Kvaløy et al. (2012) find environmental concern in developing countries at the same level as in developed countries. Furthermore, eco-labelled products increasingly appear at retail level in developing countries, especially in supermarkets targeting the urban middle and upper classes (Roitner-Schobesberger et al., 2008; Thøgersen and Zhou, 2012).

4.4.3.4 Sustainable production

Research and initiatives on sustainable production have been concerned with increasing the resource efficiency of, and reducing the pollution and waste from, the production of goods and services through technological innovations in process and product design at the plant and product levels, and, more lately, through system-wide innovations at the level of the value chain or production network (Pogutz and Micale, 2011). Policies that incentivise certain product choices have also been developed (see Ch. 10.11.3). Eco-efficiency (Schmidheiny and WBSCD, 1992) is the main management philosophy guiding sustainable production initiatives among companies (Pogutz and Micale, 2011) and is expressed as created value or provided functionality per caused environmental impact. Moving towards a more eco-efficient production thus means creating the same or higher value or functionality while causing a lower environmental impact. Discussions of eco-efficiency involve consideration of multiple environmental impacts across scales, ranging from global impacts like climate change over regional impacts associated with air and water pollution, to local impacts caused by use of land or water.

A strong increase in the eco-efficiency of production is a pre-requisite for developing a sustainable society (Pogutz and Micale, 2011). The I=PAT equation expresses the environmental impact I as a product of the population number P, the affluence A (value created or consumed per capita), and a technology factor T perceived as the reciprocal of eco-efficiency. Considering the foreseeable growth in P and A, and the current unsustainable level of I for many environmental impacts it is clear that the eco-efficiency (1/T) must increase many times (a factor 4 to 20)[6] to ensure a sustainable production. While a prerequisite, even this kind of increases in eco-efficiency may not be sufficient since A and T are not mutually independent due to the presence of rebound – including market effects; indeed, sometimes a reduction in T (increased eco-efficiency) is accompanied by an even greater growth in A, thereby increasing the overall environmental impact I (Pogutz and Micale, 2011).

With its focus on the provided function and its broad coverage of environmental impacts, life cycle assessment, LCA, is an environmental analysis tool that is frequently used for evaluation of the eco-efficiency of products or production activities (Hauschild, 2005; Finnveden et al., 2009) (see Annex II.4.2). LCA has been standardized by the International Organization for Standardization (ISO 14040 and ISO 14044) and is a key methodology underlying standards for ecolabelling and environmental product declarations. LCA is also the analytical tool underlying DFE (design for environment) methods that support the reduction of the life cycle impacts of products (Bhander et al., 2003; Hauschild et al., 2004).

With the globalization and outsourcing of industrial production, analyzing the entire product life cycle (or product chain) gains increased relevance when optimizing the energy and material efficiency of production. A life-cycle approach will reveal the potential problem shifting that is inherent in outsourcing and that may lead to increased overall resource consumption and GHG emissions of the product over its life cycle in spite of reduced impacts of the mother company (Shui and Harriss, 2006; Li and Hewitt, 2008; Herrmann and Hauschild, 2009). Indeed, a life cycle-based assessment is generally needed to achieve resource and emissions optimization across the product chain. It must consider all stages in the product chain, including transportation and the use and end-of-life ones. Especially the use stage can be very important for products that use electricity or fuels to function (Wenzel et al., 1997; Samaras and Meisterling, 2008; Yung et al., 2011; Sharma et al., 2011). Improvement potentials along product chains can be large, in particular when companies shift from selling only products to delivering product-service systems (Manzini and Vezzoli, 2003). Exchange of flows of waste materials or energy can also contribute to increasing eco-efficiency. Under the heading of “industrial symbiosis”, such mutually beneficial relationships between independent industries have emerged at multiple locations, generally leading to savings of energy and sometimes also materials and resources (Chertow and Lombardi, 2005; Chertow, 2007; Sokka et al., 2011) (see Ch. 10.5).

While the broad coverage of environmental impacts supported by LCA is required to avoid unnoticed problem shifting between impacts, a more narrow focus on climate mitigation in relation to production would be supported by considering energy efficiency, which, like resource and eco-efficiency, can be addressed at different levels from the individual process over the production facility and the product chain (or life cycle) up to a higher level industrial system (industrial symbiosis). At the process level, the operation of the individual process and consideration of the use-stage energy efficiency in the design of the machine tools and production equipment would be addressed.[7] Improvements in energy efficiency of manufacturing processes have focused on both the design and operation of a broad variety of processes (Gutowski et al., 2009; Duflou et al., 2010; Herrmann et al., 2011; Kara and Li, 2011), finding improvement potentials at the individual process level of up to 70% (Duflou et al., 2012), and on the system of processes at the plant level by re-using e.g. waste heat from one process for heating in another (Hayakawa et al., 1999). Exergy analysis and

[6] Factor 4 to factor 20 increases can be calculated depending on the expected increases in P and A and the needed reduction in I (Von Weizsäcker et al., 1997; Schmidt-Bleek, 2008).

[7] See Ch. 10.4 for further discussion of energy and resource efficiency in the manufacturing of material products.

energy pinch analysis are used to identify potentials for reutilization of energy flows in other processes (Creyts and Carey, 1999; Bejan, 2002).

Analyses of the social dimensions of production systems have addressed such issues as worker conditions (Riisgaard, 2009), farm income (Bolwig et al., 2009), small producer inclusion into markets and value chains (Bolwig et al., 2010; Mitchell and Coles, 2011) and the role of standards in fostering sustainability (Bolwig et al., In press; Gibbon et al., 2010). Recently, the LCA methodology has been elaborated to include assessment of social impacts along the life-cycle of products, such as labour rights (Dreyer et al., 2010), in order to support the identification and assessment of problem shifting and trade-offs between environmental and social dimensions (Hauschild et al., 2008).

4.4.4 Relationship between consumption and well-being

As noted earlier, global material resource consumption continues to increase despite substantial gains in resource productivity or eco-efficiency, causing further increases in GHG emissions and overall environmental degradation. In this light it is relevant to discuss whether human well-being or happiness can be decoupled from consumption or growth (Ahuvia and Friedman, 1998; Jackson, 2005b; Tukker et al., 2006). We do this here by examining the relationship between different dimensions of well-being and income (and income inequality) across populations and over time.

Happiness is an ambiguous concept that is often used as a catchword for subjective well-being (SWB). SWB is multidimensional and includes both cognitive and affective components (Kahneman et al., 2003). The former refers to the evaluative judgments individuals make when they think about their life and are found in life satisfaction or ladder-of-life data, whereas affective or emotional well-being refers to the emotional quality of an individual's everyday experience and are captured by surveys about the intensity and prevalence of feelings along the day (Kahneman and Deaton, 2010).[8] Camfield and Skevington (2008) examine the relationship between SWB and quality of life (QoL) as used in the literature. They find that SWB and QoL are virtually synonymous; that they both contain a substantial element of life satisfaction, and that health and income are key determinants of SWB or QoL, while low income and high inequality are both associated with poor health and high morbidity.

The "Easterlin paradox" refers to an emerging body of literature suggesting that while there is little or no relationship between SWB and the aggregate income of countries or long-term GDP growth, there is robust evidence that *within* countries, those with more income are happier (Easterlin, 1973, 1995). Absolute income is, it is argued, only important for happiness when income is very low, while relative income (or income equality) is important for happiness at a wide range of income levels (Layard, 2005; Clark et al., 2008). These insights have been used to question whether economic growth should be a primary goal of government policy (for rich countries), instead of, for example, focusing on reducing inequality within countries and globally, and on maximizing subjective well-being. For instance, Assadourian (2010) argues against consumerism on the grounds that increased material wealth above a certain threshold does not contribute to subjective well-being.

The Easterlin paradox has been contested in comparisons across countries (Deaton, 2008) and over time (Stevenson and Wolfers, 2008; Sacks et al., 2010), on the basis of the World Gallup survey of well-being. These works establish a clear linear relationship between average levels of ladder-of-life satisfaction and the logarithm of GDP per capita across countries, and find no satiation point beyond which wealthier countries have no further increases in subjective well-being. Their time series analysis also suggests that economic growth is on average associated with rising happiness over time. On this basis they picture a strong role for absolute income and a more limited role for relative income comparisons in determining happiness.

[8] Kahneman and Deaton (2010) define emotional well-being as "the frequency and intensity of experiences of joy, fascination, anxiety, sadness, anger, and affection that makes one's life pleasant or unpleasant".

These results contrast with studies of emotional well-being, which generally find a weak relationship between income and well-being at higher income levels (Kahneman and Deaton 2010). In the US, for example, Kahneman and Deaton (2010) find a clear satiation effect, i.e. beyond around $75,000 annual household income (just above the mean US household income) further increases in income no longer improve individuals' ability to do what matters most to their emotional well-being.[9] But even for life satisfaction, there is contrasting evidence. In particular, in Deaton (2008) there is a lot of variation of SWB between countries at the same level of development, and in Sacks et al. (2010) the long term positive relationship between income and life satisfaction is weakly significant and sensitive to the sample of countries (see also Graham (2009), Easterlin et al. (2010), Di Tella and MacCulloch (2010)). An important phenomenon is that all components of SWB, in various degrees, adapt to most changes in objective conditions of life, except a few things, such as physical pain (Kahneman et al., 2003; Layard, 2005; Clark et al., 2008; Graham, 2009; Di Tella and MacCulloch, 2010).

The great variability of SWB data across individuals and countries and the adaptation phenomenon suggest that these data do not provide indices of well-being that are comparable across individuals and over time. Respondents have different standards when they answer satisfaction questions at different times or in different circumstances. Therefore, the weakness of the observed link between growth and SWB is not only debated, but it is quite compatible with a strong and firm desire in the population for ever-growing material consumption (Fleurbaey, 2009). Decoupling growth and well-being may be more complicated than suggested by raw SWB indicators.

It has been found that inequality in society has a marked negative effect on average SWB. For example, using General Social Survey data from 1972 to 2008 in the United States, Oishi et al. (2011) found that Americans were on average happier in years with less national income inequality than in years with more inequality. They further demonstrated that this inverse relation between income inequality and happiness was explained by perceived fairness and general trust in the case of lower-income respondents: These Americans trusted other people less and perceived other people to be less fair in the years with more national income inequality than in the years with less national income inequality.

4.5 Development pathways

4.5.1 Development pathways: definition and examples

Though widely used in the literature, the concept of development path has rarely been defined.[10] According to AR4, a development path is "an evolution based on an array of technological, economic, social, institutional, cultural, and biophysical characteristics that determine the interactions between human and natural systems, including consumption and production patterns in all countries, over time at a particular scale" (IPCC, 2007, Glossary, p. 813). AR4 also indicates that "alternative development paths refer to different possible trajectories of development, the continuation of current trends being just one of the many paths".

Though the AR4 definition suggests that a development path is global, the concept is used in the literature to describe development trajectories at other scales: regional (e.g., Li and Zhang (2008)), national (e.g., Poteete (2009)) and subnational (e.g., Dusyk et al. (2009) at provincial scale and

[9] This includes such as aspects as spending time with people they like, avoiding pain and disease, and enjoying leisure. It is stressed that this result is based on a comparison across US households and do not refer to the effects of a *change* in a person's income.

[10] Development path and development pathway are synonymous. We prefer to use development path because a "development pathway" already has a precise signification in another field, namely biology (in which it denotes "a sequence of biological or biochemical events that are involved in embryological or cellular development" (National Cancer Institute (NCI), 2011)).

Yigitcanlar et Velibeyoglu (2008) at city scale). In the present report, a development path will characterize all the interactions between human and natural systems in a particular territory, regardless of scale.

Development path is a holistic concept. It is thus broader than the development trajectory of a particular sector, or of a particular group of people within a society. As a result, a wide range of economic, social and environmental indicators are necessary to describe a development path, not all of which may be amenable to quantitative representation.

As defined by AR4, however, a "path" is not a random collection of indicators. It has an internal narrative and causal consistency that can be captured by the *determinants* of the interactions between human and natural systems. The underlying assumption is that the observed development trajectory – as recorded by various economic, social and environmental indicators – can be explained by identifiable drivers. This roots the concept of development path in the (dominant) intellectual tradition according to which history has some degree of intelligibility, while another tradition holds that history is a chaotic set of events that is essentially not intelligible (Schopenhauer, 1819). This choice has two important methodological consequences.

Looking backward, assessing past development paths amounts not only to describing how a given society has evolved over time, but also to understanding the mechanisms that have shaped this evolution. A large literature describes observed development trajectories for given territories and analyses the underlying processes. In the field of economics only, this literature encompasses most of the growth literature and a large part of the (macro) development literature.[11] In the present chapter, section 4.3 reviews the drivers of sustainable development literature, and Chapter 5 reviews the determinants of GHG emissions.

Looking forward, the elaboration of scenarios is based on a conception of the causal mechanisms and assumptions about the future evolution of exogenous variables. There is, again, a large literature of forward-looking studies that construct plausible development paths for the future and that examine the way by which development might be steered towards one path or another. Box 4.5.1 briefly reviews the main forward-looking development paths published since AR4.

Box 4.5.1. Prospective Development Paths, new developments since AR4

Forward-looking development paths aim at illuminating the universe of possible futures, and at providing a sense of how these futures might be reached or on the contrary avoided. Plausible paths can be constructed using various techniques, ranging from simulations with numerical models to qualitative scenario construction or group forecasting exercises (Van Notten et al., 2003).

New sets of plausible development paths for the future have been proposed in the literature since the AR4 review (Sathaye et al. (2007), Sec. 12.2.1.2). At the global scale, they include, inter alia, the World Bank 2010 climate smart path (World Bank, 2010), the Tellus Institute scenarios (Raskin et al. (2010)), and degrowth strategies (Martínez-Alier et al., 2010).

In addition, a set of new scenarios is being developed under the IAMC consortium (Moss et al., 2010) to update the 2000 SRES scenarios (Nakicenovic and Swart, 2000). These scenarios are constructed based on factors that would make mitigation and adaptation easier or harder for any given target

[11] This literature can itself be divided in two main groups: papers aimed at identifying individual mechanisms that drive development trajectories, and papers aimed at identifying broad patterns of development. One example of the former is the so-called "EKC" literature on the relationships between GDP and emissions, discussed in Chapter 5. One example of the latter is the so-called "investment development path" literature, which, following Dunning (1981), identifies stages of development for countries based on the direction of foreign direct investment flows and the competitiveness of domestic firms on international markets.

(what is called "shared socio-economic pathways"); climate policy assumptions; and representative concentration pathways (RCPs). They are described in detail in Chapter 6, [though Chapter 6 database of scenario is based on RCPs only].

Since AR4, there has also been considerable effort in designing sectoral pathways, e.g., on biodiversity (Leadley et al., 2010; Pereira et al., 2010), health (Etienne and Asamoa-Baah, 2010), or agriculture (Paillard et al., 2010).

At the national level, a relevant event since AR4 is the emerging "green growth" concept (OECD, 2011). The term does not have a consensus definition, but there is agreement that green growth "is about making growth processes resource efficient, cleaner and more resilient without necessarily slowing them" (Hallegate et al., 2011), effectively reconciling the economic and environmental pillars of sustainable development. The green growth debate has spurred many short- to medium-term scenario exercises at national or regional level (e.g. Republic of Korea (2009), Jaeger et al. (2011)); as well as renewed discussions on sustainable development trajectories (e.g.,(Jupesta et al. 2011)).

Similarly, there is growing research on the ways by which societies can transition towards a "low carbon economy" or a "low carbon society", considering not only mitigation and adaptation to climate change, but also the need for social, economic and technological transitions (P. R. Shukla, Dhar, et Mahapatra 2008).

4.5.2 Path dependence and lock-ins

An important issue for policy-making is to understand how and to which extent the mechanisms that drive the pathways create "path dependence" – the tendency for past decisions and events to self-reinforce, thereby diminishing and possibly excluding the prospects for alternatives to emerge. If path dependence is identified ex ante, it provides a basis for making better-informed decisions. For example, development of inter-city highways may make further extension of the road network more likely (if only for feeder roads) but also make further extension of rail networks less cost-effective by drawing out traffic and investment financing [see Chapter 12]. Taking these mechanisms into account does not necessarily mean that the inter-city highway system is not socially beneficial – it merely acknowledges that the presence of an extensive highway system influences and may diminish the future prospects for alternative transportation investments.

Page (2006) provides a taxonomy and distinguishes between outcome-dependent processes – in which the outcome at one period depends on past outcomes – and equilibrium-dependent processes – in which the long-run distribution over outcomes depends on past outcomes. Second, he distinguishes between recent path dependence, in which outcome at year *t* depends only on outcomes at recent periods, and early path dependence, in which outcomes at year *t* depend only on the outcomes of a finite set of early periods. In the latter case, outcomes at year *t* are *locked-in*.

Page (2006) also explores the mechanisms underlying path- and equilibrium-dependence. Best known are "increasing returns" mechanisms – those in which an outcome in one period increases the probability of generating that same outcome in the next period, which comprise, inter alia, increasing returns to scale, learning by doing, induced technological change, or agglomeration economies. The concept of increasing returns has a long tradition in economic history, and the implications of increasing returns mechanisms have been systematically explored over the past three decades or so, notably around issues of monopolistic competition (Dixit and Stiglitz, 1977), international trade (Krugman, 1979), economic geography (Fujita et al., 1999), economic growth (Romer, 1990), industrial organizations or adoption of technologies (Arthur, 1989).

Yet increasing returns are neither sufficient nor necessary to generate path- and equilibrium-dependence. They are not sufficient because competing increasing returns can cancel out. And they are not necessary because other mechanisms might generate path- and equilibrium-dependence. For example, choices typically involve the use of scarce resources, such as land, labour or exhaustible natural resources. Decisions made at one point in time thus constrain future agents' options, either temporarily (for labour) or permanently (for exhaustible resources). Similarly, in the presence of switching costs – e.g., costs attached to premature replacement of long-lived capital stock – decisions made at one point in time can partially or totally lock-in decision-makers' subsequent choices (Farrell and Klemperer, 2007). The key message is that it is essential to look broadly for mechanisms that may generate path-and equilibrium-dependence when analyzing the determinants of pathways (past or anticipated).

Lock-in is the most extreme manifestation of path dependence. Though widely used in the economic and innovation literature, "lock-in" does not have a single definition, but rather various (if related) meanings. In the presence of switching costs, decisions made at one point in time can partially or totally lock-in decision-makers' subsequent choices – making it very costly to reverse ex post choices that were not necessarily economically distinguishable ex ante (Farrell and Klemperer, 2007). One famous example is the competition between technology standards, for example between the AZERTY and the QWERTY keyboards, or between the VHS and BETAMAX video standards. In the economic geography literature, similarly, positive feedback such as agglomeration economies can also lock in the growth/expansion path of locations/regions once initial choices are made (Fujita et al., 1999).

Lock-ins are not "good" or "bad" per se (Shalizi and Lecocq, 2009), but identifying risks of "bad" lock-ins and taking advantage of possible "good" lock-ins matters for policy-making, so that ex ante decisions are not regretted ex post (Liebowitz and Margolis (1995)). The literature, however, underlines that lock-ins do not stem only for lack of information. There are also many cases in which rational agents might make decisions based only on part of the information available, because of, inter alia, differences between local and global optimum, time and resource constraints on the decision-making process or information symmetry (Foray, 1997) ; which points to the process of decision-making (See 4.3.2 on Governance and Political Economy.) .

4.5.3 Strategies towards sustainable development paths

There are many conceptions about how to make our development path sustainable. While most proponents of sustainable development agree with the Brundtland Report's objectives to reconcile social, economic and environmental goals, models of sustainable development have emerged in many different forms and combinations. A common theme is that technology can bring benefits for environmental protection. Von Weizsäcker et al. (1997), for example, argued that technical innovation could cut global resource use in half while doubling wealth, for a four-fold productivity increase; a 2009 follow-up argues that productivity can actually increase by a factor of five through improvements in resource and energy productivity innovation in industry, technical innovation and policy (Von Weizsäcker et al., 2009). There is also widespread support for a dramatic increase in energy efficiency and change in energy use from fossil fuels to renewable sources (Flavin and Lenssen, 1994).

Some have supported the idea of separating economic from ecological issues (Gallopín, 2003). One approach argues that sustainable development is predominantly of concern in the developing world (McCormick, 1991) and therefore, the process of implementing sustainable development should be accompanied by a high level of growth benefiting the poor. From the perspective of a *sustainable economic development*, the underlying assumption is that economic affluence is the best way to overcome most of the problems faced by societies (Allaby, 1983). This perspective is in line with the "status quo" approach described in Hopwood et al. (2005), which considers that economic prosperity is "the driver towards sustainability".

In the climate change debate, this perspective leads some to argue that instead of investing in mitigation, wealthier countries should make direct transfers to poorer countries to support development, on the assumption that richer future generations in developing countries will be more able to cope with the impacts of (unmitigated) climate change (Schelling, 1995, 2006). The need for change is recognized, but primarily when it focuses on building sustainable economies that provide strategic economic advantages in the global economy. Moreover, as has been strongly argued (Jasanoff 2004; Singer 2004; Speth and Haas 2006; Kjellen 2008), climate change is only one of many global problems – environmental, economic, and social – that will require effective cooperative global governance if development – and indeed human welfare – is to be sustained. A contrasting line of thought is that sustainability is primarily about ecological issues – which, from this point of view, should be predominant in the debates about sustainable development (Gallopín, 2003).

Beyond the deep connection between meeting human needs and preserving the natural environment, alternative paradigms of sustainable development are considering the idea that sustainable development is a multidimensional process which requires strong interlinkages between economic, environmental, socio-cultural, political and technological factors to be effectively achieved (Hopwood et al., 2005; Udo and Jansson, 2009).

Hopwood et al. (2005) and O'Brien (2011) suggest a "transformatory approach" which embraces the view that environmental degradation and inequities will persist unless a strong commitment to social equity is achieved in order to promote access to economic opportunities, livelihood and good health. This approach also recognizes environmental justice as a key determinant of social transformation, which may lead to fulfilling human needs and enhancing the quality of life.

Other approaches stress the need to embrace a plurality of perspectives on sustainable development, but with a greater emphasis on freedom-oriented development (Gallopín, 2003; Sneddon et al., 2006). This implies recognizing, for instance, the need for innovative approaches relating to people-centred development and right-based approaches to development (NGLS, 2002).

Feminist scholars have advanced sustainable development approaches that build on women's experiences and aspirations. They have raised the need to take a fuller account of gender relations affecting fertility, childbirth and resource consumption in proposing solutions to environmental and social problems (Arizpe et al., 1994) and called for placing "social reproduction" at the centre of new development perspectives. Di Chiro (2008), paraphrasing Bakker and Gill (2003), defines social reproduction as "the intersecting complex of political-economic, socio-cultural, and material environmental processes required to maintain everyday life and sustain human cultures and communities on a daily basis and inter-generationally".

There are interesting regional perspectives. For instance, there is growing research in India and China on sustainable development approaches that aim to build a "low-carbon economy" or "low-carbon society" and, in the process, meet the mitigation and adaptation challenges of climate change, including the need for social, economic and technological transitions (Sukla et al., 2008). Studies in China show that controlling emissions without proper policies to counteract the negative effects will have an adverse impact on the country's economic development, reducing its per capita income and the living standards of both urban and rural residents (Wang Can et al., 2005; Wang Ke, 2008). China is developing indicators for low-carbon development and low-carbon society (UN (2010), with many citations) with specific indicators tested on selected cities and provinces (Fu, Jiafeng et al., 2010), providing useful data on challenges and gaps as well as the need for clearly defined goals and definitions of "low-carbon" and its sustainable development context.

4.5.4 Indicators of sustainability for development paths

In this section we examine how sustainability can be assessed on development path scenarios. Ideally, models that produce development paths should (i) be framed in a consistent macroeconomic framework, (ii) impose the relevant technical constraints in each sector, such as views about the direction of technical change, (iii) capture the key relationships between economic activity and the environment, e.g., energy and natural resources consumption or greenhouse gases emissions, (iv) have a horizon long enough to assess "sustainability" – a long-term horizon which also implies, incidentally, that the model must be able to represent structural and technical change – yet (v) recognize short-term economic processes critical for assessing transition pathways, such as market imbalance and rigidities, all this while (vi) providing an explicit representation of how economic activity is distributed within the society, and how this retrofits into the growth pattern.

The review of indicators in section 4.2 reveals that no sustainability indicator in circulation provides a direct evaluation of the risk of future downturns in well-being or in the state of the ecosystems. Martinet (2011) proposes a general approach in which thresholds can be posited for well-being or for various natural or man-made stocks and which can explicitly deal with uncertainty. Sustainability is considered to be achieved when the predicted future path remains forever above the defined thresholds. When the future is uncertain, sustainability can be assessed by the probability that thresholds will be crossed.

However, section 4.2 distinguishes between two sustainability issues. One is to predict whether the current situation (welfare, environment) will be preserved in the future: Are we on a sustained development path, i.e., a path without downturn? Another is to determine whether the current generation's decisions leave it possible for future generations to achieve such a path: Is a sustained development path possible given what the current generation does? The latter does not require predicting future decisions, only future constraints and opportunities. For instance, negative genuine savings is a sufficient condition for a negative answer to the former question, whereas positive net investment at maximin prices is a sufficient condition for a positive answer to the latter question. Standard predictions of GDP and human development are inspired by the former, whereas Green GDP and the ecological footprint are concerned with the latter.

In this light, a straightforward indicator of sustainability for the first question, in line with Martinet's proposal, could take the form of a family of curves describing the future evolution of a relevant indicator (e.g., of well-being or of the state of the environment) at different probabilities – or at different degrees of confidence if probabilities are hard to specify. Figure 4.5.1 illustrates the idea by comparing hypothetical scenarios involving (a) a risky path that promises high growth on average but with a growing risk of unsustainability over time, and (b) a less risky path that promises less on average but is more secure for sustainability.

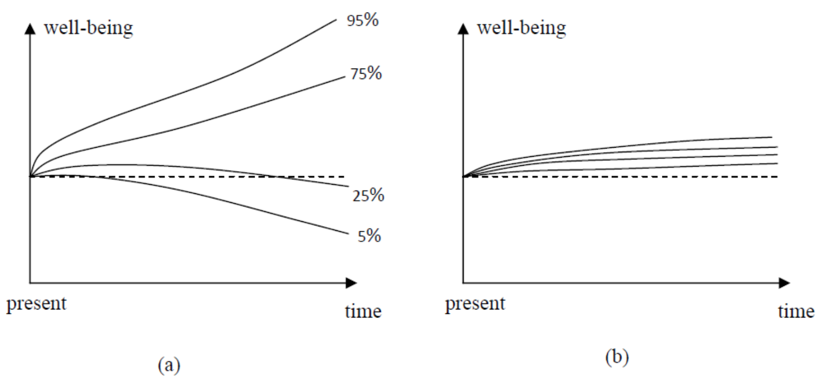

Figure 4.5.1 Sustainability of the current path measured by risk curves. (The probability that the path will fall below a curve is equal to the number assigned to this curve.)

An appealing criterion for the second question would focus on the comparison between the current situation and the greatest sustainable level (of whatever quantity one seeks to sustain) for future generations. The former is known, albeit imperfectly, and the latter can be predicted in probabilistic terms. The probability that the former is greater than the latter then provides a good indicator of the risk of unsustainability.

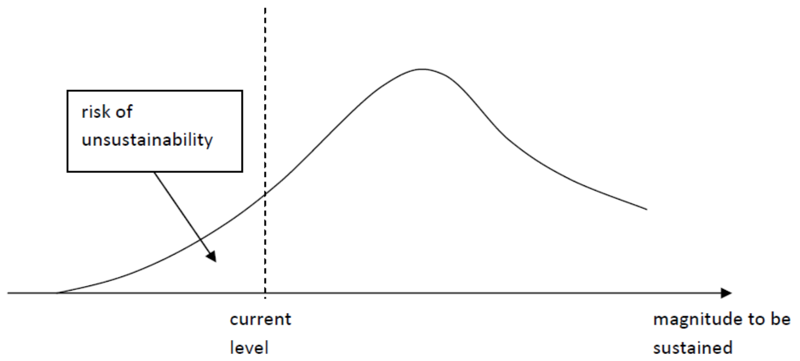

Figure 4.5.2 Possibility of a sustainable path measured by the comparison of current level with future sustainable level. (The bell curve is the probability density of the latter.)

The curve displayed in Figure 4.5.2 also provides information about the risk of the future sustainable level falling well below desirable levels. For a given risk of unsustainability, one may prefer a situation with a lower probability for catastrophic situations. Again, variants of this indicator that involve only qualitative descriptions of confidence can readily be constructed.

4.5.5 Transition between development paths: Frameworks for analysis

Shifting from a high- to a low-emissions development path could potentially be as important for climate mitigation as implementing "climate" policies (Halsnaes et al., 2011). However, it is not easy to devise transition strategies given the complexity of the system and the associated uncertainties. In addition, a development path results from the interactions of decisions by multiple agents, at all levels. Thus public policies[12] alone cannot trigger changes in pathways, and cooperation between governments, markets and civil societies are necessary (Sathaye et al., 2007).

A central theme of the present report is to explore the conditions of a transition towards development paths with lower emissions, globally (Chapter 6), sectorally (Chapters 7-12) and regionally (Chapters 13-15). The present section discusses frameworks within which transitions between pathways can be analyzed. Two key strands of the literature are reviewed. First, the conceptual frameworks that stem from the growing literature on technological transitions are presented. Second, the conceptual basis of the economic modelling of development paths (the results of which are reviewed in details in Chapter 6) are discussed.

Frameworks stemming from the technological transitions literature

Changes in technologies, their causes, and their implications for societies have been actively studied in social sciences since the late 18th century by historians, economists and sociologists. A common starting point is the observation that "technological change is not a haphazard process, but proceeds in certain directions" (Kemp, 1994). For example, processors tend to become faster, planes to become lighter, etc. To characterize these regularities, scholars have developed the concepts of *technological regime* (Nelson and Winter, 2002) and *technological paradigms* (Dosi, 1982; Dosi and Nelson, 1994). Technological regimes refer to shared beliefs among technicians about what is feasible. Technological paradigms refer to the *selected* set of objects engineers are working on, and to the *selected* set of problems they choose to address.

The determinants of changes in technological regimes (such as the development of information technologies) are a subject of intense research. The development of radical innovations (e.g., the steam engine) is seen as a necessary condition. But the drivers of radical innovation themselves are not clearly understood. In addition, once an innovation is present, the shift in technological regime is not a straightforward process: The forces that maintain technological regimes (e.g., increasing

[12] Both "climate" and "non-climate" – though that distinction is being over time as climate considerations pervade all spheres of public action.

returns to scale, vested interests, network externalities) are not easy to overcome – all the more so that new technologies are often less efficient, in many respects, than existing ones, and competing technologies may coexist (Arthur, 1989)see 4.5.2 above). History thus suggests that the diffusion of new technologies is a slow process (Kemp, 1994) (Fouquet, 2010).

Over the past 20 years, a subset of technology scholars has focused more specifically on "sustainability transitions". They study the formation of new socio-technical configurations and develop frameworks for analyzing prevailing socio-technical structures, with two major perspectives (Truffer and Coenen, 2012): the multi-level perspective on socio-technical systems (Geels, 2002) and concept of technological innovations systems (Bergek et al., 2008).

The multi-level perspective on socio-technical systems distinguishes three levels of analysis: niche innovations, socio-technical regimes, and socio-technical landscape (Geels, 2002). Technological niche is the micro-level where radical innovations emerge. Socio-technical regimes correspond to an extended version of the technological regime discussed above. And the socio-technical landscape corresponds to the regulatory, institutional, physical and behavioural environment within which the innovations emerge. The last level has a lot of inertia. Changes in socio-technical regimes emerge from interactions between these three levels, with several possible paths depending on how these interactions proceed. Geels and Schot (2007) introduce a typology with four different paths. *Transformation paths* correspond to cases where moderate changes in the landscape at a time where niche innovation are not yet developed result in a modification in the direction of development paths – an example of which is the implementation of municipal sewer systems in Dutch cities (Geels, 2006). *De-alignment and realignment* correspond to sudden changes in the landscape that cause actors to lose faith in the regime; if no clear replacement is ready yet, a large range of technologies may compete until one finally dominates and a new equilibrium is reached. One example of such path is the transition from horse-powered vehicles to cars. If new technologies are already available, then a *transition substitution* might occur, as in the case of the replacement between sailing and steamships between 1850 and 1920. Finally, *reconfiguration* might occur when innovations are initially adopted as part of the regime and progressively subvert it into a new one, an example of which is the transition from traditional factories to mass production in the United States.

The Technological Innovation Systems approach (Bergek et al. 2008) adopts a systemic perspective by considering all relevant actors, their interactions and the institutions relevant for innovation success. Early work in this approach argues that beside market failures, "system failures" such as, inter alia, actor deficiencies, coordination deficits or conflicts with existing institutional structures (institutional deficits) can explain unsuccessful innovation (Jacobsson and Bergek, 2011). More recent analysis focus on core processes critical for innovation. The Technological Innovation Systems concept was developed to inform public policy on how to better support technologies deemed sustainable with an increasing focus on "system innovations" as opposed to innovation in single technologies or products (Truffer and Coenen, 2012).

Economic frameworks for modelling transitions in the context of sustainable development

A first approach to analyzing transitions between development paths using economic models consists of building several plausible images of the future with a model (e.g., general equilibrium model), and compare them (comparative statics). The focus is on the internal consistency of each image, and on the distance between them. By construction, however, the paths from the present on to each possible future, let alone the transitions between paths, are left out of the analysis.

Comparative statics, however, can already provide insights on the sustainable character of the long-term images, to the extent that the model captures critical variables for sustainability such as natural resources use or impact of economic activity on the environment (e.g., GHG emissions). This is a challenge because it is difficult to construct robust relationships between aggregate monetary indicators and physical flows, since national accounts typically add up multiple products with very different material and energy contents, and very different prices. Similarly, static models can provide some insights on the social components of sustainability to the extent they include some form of representation of the *distribution* of economic activity within the society, notably across income groups (see Section 4.4.1). Again, the associated data challenge is significant.

Still, one needs dynamic models in order to depict the path towards desirable (or undesirable) long-term futures. However, the relevance of dynamic models for discussing transitions depends on their structure, content, and way they are used. Most of the modelling literature on climate mitigation relies on Solow-like growth models (Solow, 1956). In this model, long-term growth is ultimately driven by the sum of population growth and exogenous total factor productivity growth (exogenous technical change), and it is always possible to adapt savings rate to reach a balanced growth path in the long-run. In the simplest version of the Solow model, there is thus only one “pathway” to speak of, as determined by human fertility and human ingenuity. “Transition” (rather short-term adjustments) will typically take the form of a temporary savings rate aimed at adjusting the capital to labour ratio to the optimal level given exogenous labour and technology growth. As a result, Solow growth models have limited utility in explaining observed patterns of short-term growth (e.g. Easterly (2002)).

Discussions about transitions are richer when models differentiate short-term economic processes from long-term ones. The general point is that the technical, economic and social processes represented in the models often exhibit more rigidities in the short- than in the long-run. . As Solow (2000) suggests, at short-term scales, “something sort of ‘Keynesian’ is a good approximation, and surely better than anything straight ‘neoclassical’. At very long time scales, the interesting questions are best studied in a neoclassical framework and attention to the Keynesian side of things would be a minor distraction”. Among those rigidities, a lot of attention has been paid to long-lived physical capital, the premature replacement of which is typically very costly (Shalizi and Lecocq, 2009), and the dynamics of which have important implications for the costs, timing and direction of climate policies (see e.g., (Wing 1999) (Lecocq et al., 1998)). However, other important rigidities include, inter alia, rigidities associated with the location of households and firms, changes which take time; the preferences of individuals; the production technologies of firms; or the system of institutions, for example the institutions that drive labour market response to price shocks (Céline Guivarch et al. 2011). Such rigidities may not only affect the transition, but may also lead to bifurcations towards different long-term outcome (i.e., equilibrium-dependence and not just path-dependence as in section 4.5.2) (Hallegatte et al., 2007).

A second key element for the analysis of transitions is to relax the full information hypothesis under which many models are run. If information increases over time, there is a rationale for a sequential decision-making framework (Arrow et al., 1996), in which choices made at one point can be re-considered in light of new information. Thus, the issue is no longer to select a path once and for all, but to make the best first-step (or short-term) decision, given the structure of uncertainties and the potential for increasing information over time. Inertia plays an especially important role in this context, as the more choices made at one point constrain future opportunity sets, the more difficult it becomes to make advantage of new information (e.g., Ha-Duong et al. (1997)). Another way by which uncertainty can be captured in models is to abandon the intertemporal optimization objective altogether and use simulation models instead, with decisions made at any time based on imperfect expectations. Such shift has major implications for the transition path, but this route is still largely unexplored (Sassi et al. 2010). Figure 4.5.3 maps these different forms of models.

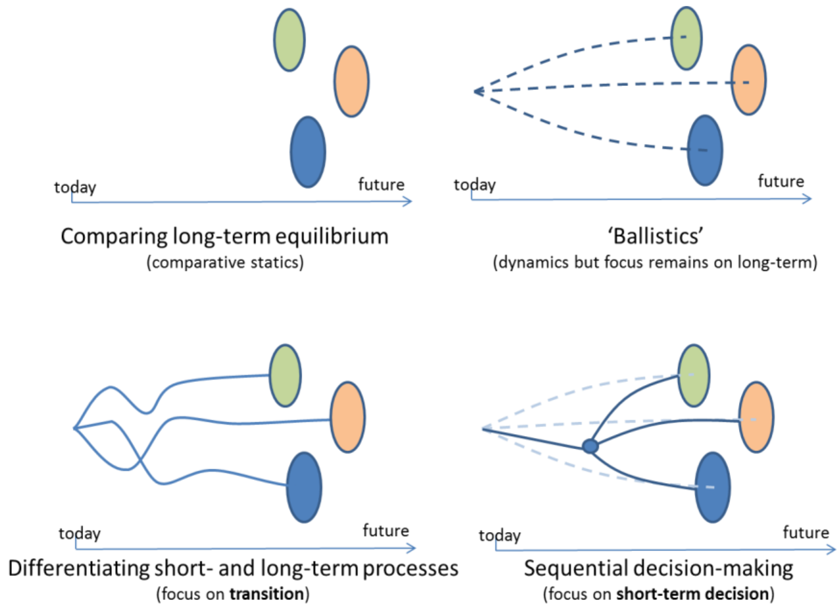

Figure 4.5.3 Evolution of conceptual thinking about sustainable development pathways: Towards a realistic view of transitions

No model today meets all these specifications. Current models can be classified along two major fault lines: bottom-up vs. top-down, and long-term vs. short-term. By design, computable general equilibrium (CGE) models provide a comprehensive macroeconomic framework, and they can be harnessed to analyze distributional issues, at least amongst income groups, but they typically fail to embark key technical constraints. Conversely, bottom-up engineering models provide a detailed account of technical potentials and limitations, but their macro-engine, if at all, is most often rudimentary. Emerging "hybrid" models developed in the context of climate policy assessment are steps towards closing this gap. A similar rift occurs with regard to time horizon. Growth models like Solow's are designed to capture key features of long-term development paths, but they do not include short- or medium-term economic processes such as market rigidities. On the other hand, short-term models (econometric or structural) will meet requirement but are not designed to look deep in the future. Again, emerging models include short-/medium-term processes into analysis of growth in the long-run, but this pretty much remains an open research field.

4.6 Mitigative capacity and mitigation, and links to adaptive capacity and adaptation

The concept of mitigative capacity initially stressed financial resources and access to technology but soon expanded to include the availability of renewable resources, possibilities for greater efficiency, and governance, including scientific, capabilities, even political willingness and other factors (Winkler et al., 2007b). The concept of adaptive capacity arose in the process of differentiating between levels of vulnerability to the consequences of climate change. Adaptive capacity and mitigative capacity were soon found to be quite similar(Yohe, 2001; Burch and Robinson, 2007; Burch, 2010; Pelling, 2010)(Winkler et al., 2007b)(Winkler et al. 2007b). Next, some mitigative and adaptive responses were found to be complementary, thus more valuable to undertake, blurring the distinction between mitigative and adaptive capacity, and leading to the argument that there is simply "response capacity"(Tompkins and Neil Adger, 2005; Wilbanks, 2005). As climate change occurred more rapidly than expected, adaptive capacity took on greater importance (Paavola and Adger, 2006; Adger, 2006).

There are multiple and strong relationships between mitigation, adaptation, and sustainable development (Pelling, 2010; Burch, 2011). The more effective is mitigation, the easier it will be for nations to adress environmental sustainability and achieve social justice without also having to adapt to climate change. Being able to adapt to climate change more readily means more efforts can be dedicated to SD. Simlarly, mitigative and adaptive capacities now merge with sustainability development capacity (Udo and Jansson, 2009). There is now a literature on adaptive environmental governance (Folke et al., 2005; Folke, 2007; Brunner and Lynch, 2010). Adaptation, morever, has become central to ecosystem management in practice (Holling, 1978; Walters and Holling, 1990; McFadden et al., 2011; Williams, 2011). More recently, the idea that the earth's system has moved from the Holocene into the Anthropocene (Crutzen and Stoermer, 2000), where people are the most important drivers of the earth's dynamics, adaptation plays an even larger, indeed dominant, role in SD (Chapin III et al., 2010; Folke, Jansson, Rockström, et al., 2011; Polasky et al., 2011; Biermann et al., 2012). Complementing this shift in understanding, there is now a literature on developing for environmental and social system resilience so that the consequences of climate change have smaller, more temporary consequences (Fatma Denton and Thomas Wilbanks, 2012) as well as a literature stressing that transformational shifts and a new form of capacity will be necessary to cope in the Anthropocene (Kates et al., 2012).

4.7 Integration of framing issues in the context of sustainable development

Chapters 2 and 3 of this report review the framing issues related to risk and uncertainty (Chapter 2) and social, economic and ethical considerations guiding policy (Chapter 3). They examine how these issues bear on climate policy, both on the mitigation and on the adaptation side of our response to the challenge of climate change. Their general analysis is also directly relevant to the understanding of sustainable development and equity goals. This section briefly examines how the notions developed in these chapters shed light on the topic of the present chapter. This section then draws on this broader perspective to introduce to the issues of equity in burden-sharing in some detail.

4.7.1 Risk and uncertainty in sustainability evaluation

The sustainability ideal seeks to minimize risks that compromise future human development (sections 4.2 and 4.5). This objective is less ambitious than maximizing an expected value of social welfare over the whole future. It focuses on avoiding setbacks on development, and is therefore well in line with Chapter 2 (Sec. 2.3) highlighting the difficulty of applying the standard decision model based on expected utility in the context of climate policy, and it is directly akin to the methods of risk management listed there (Subsec. 2.3.2.3 and Sec. 2.6), in particular those focusing on worst-case scenarios. The literature on adaptation has similarly emphasized the concept of resilience, which is the ability of a system to preserve its functions in a risky and changing environment (WG2-Sections 2.4 and 20.3, Folke et al. (2010), Gallopin (2006)).

This chapter has reviewed the actors and determinants of support for policies addressing the climate challenge (sections 4.3 and 4.6). Among the relevant considerations, one must include how risk perceptions shape the actors' awareness of the issues and their willingness to do something about them. Chapter 2 (Sec. 2.5) has described how framing and affective associations can be effective and manipulative, how absence or presence of a direct experience of climate extremes makes individuals distort probabilities, and how gradual changes are easy to underestimate.

Risk and uncertainty are also relevant to the dimension of equity, in relation to sustainability, because various regions of the world and communities within those regions are submitted to unequal degrees of climate risk and uncertainty. Better information about the distribution of risks between regions and countries also affects the policy response and negotiations. Lecocq and Shalizi (2007) argue that reduced uncertainty about the location of impacts may reduce incentives for mitigation, and Lecocq and Hourcade (2010) show that the optimal level of mitigation may also decrease.

4.7.2 Socio-economic evaluation

Chapter 3 has reviewed the principles of social and economic evaluation and equity in a general way. In section 3.4 it recalls that there is now a consensus that methods of cost-benefit analysis that simply add up compensating or equivalent variations are consistent and plausible only under very specific assumptions (constant marginal utility of income and absence of priority for the worse off) which are empirically dubious and ethically controversial. It is thus necessary to introduce weights that embody suitable ethical concerns and restore consistency of the evaluation. Adler (2011) also makes a detailed argument in favour of this "social welfare function" approach to cost-benefit analysis. This approach is followed by Anthoff et al. (2009), refining on previous use of equity weights by Fankhauser et al. (1997) and Tol (1999). Note that an advantage in having a well-specified methodology for the choice of weights is the ability to reach more precise conclusions, and to transparently relate such conclusions to ethical assumptions (such as the degree of priority to the worse off).

Chapter 3 describes the general concepts of social welfare and individual well-being. In applications to the assessment of development paths and sustainability, empirical measures are needed. Several methods are discussed in Stiglitz et al. (2009) and Adler (2011). In particular, the capability approach (Sen, 2001, 2009) is well known for its broad measure of well-being that synthesizes multiple dimensions of human life and incorporates considerations of autonomy and freedom. Most applications of it do not directly rely on individual preferences (Alkire, 2010). Fleurbaey and Blanchet (2013) defend an approach that relies on individual preferences, in a similar fashion as money-metric utilities. Some authors (e.g., Layard et al. (2008)) even propose to use satisfaction scores directly as utility numbers. This is controversial because different individuals use different standards when they answer questions about their satisfaction with life (Graham, 2009).

One reason why well-being may be useful as a guiding principle in the assessment of sustainability, as opposed to a more piecemeal analysis of each pillar, is that it helps evaluate the weak versus strong sustainability distinction. As explained in Sec. 4.2, weak sustainability assumes that produced capital can replace natural capital, whereas strong sustainability requires natural capital to be preserved. From the standpoint of well-being, the possibility to substitute produced capital to natural capital depends on the consequences on living beings. If the well-being of humans depends directly on natural capital, if there is option value in preserving natural capital because it may have hidden useful properties that have yet to be discovered, or if non-human living beings depend on natural capital for their flourishing, this gives powerful reasons to support a form of strong sustainability.

Additionally, Chapter 3 (in particular Sec. 3.1 and 3.2) mentions other aspects of equity that are relevant to policy debates and international negotiations on climate responses. Chapter 3 discusses these issues at the level of ethical principles, and given the importance of such issues in policy debates about mitigation efforts, they will be developed in more detail in the next subsection, discussing how these principles have been applied to the issue of burden-sharing in climate regime, and used to develop indicators of obligation and burden-sharing frameworks based on those indicators.

4.7.3 Equity and burden-sharing in the context of international cooperation on climate change

Throughout this chapter, we have examined the links between equity, sustainable development, climate change and climate policy. This subsection discusses the specific issue of equitable burden-sharing, first highlighting the general equity principles that are typically invoked in discussions of equitable burden-sharing, and finally reviewing several categories of burden-sharing frameworks that have been presented as options for the allocation of burdens in an international climate regime.

FAQ 4.5 Why is equity relevant in climate negotiations?

The international climate negotiations under the UNFCCC are working toward a collective global response to the threat of climate change. As with any cooperative undertaking, the total required effort will be allocated in some way among countries, including both domestic action and international financial support. At least three lines of reasoning have been put forward to explain the relevance of equity in allocating this effort: (i) a *moral* justification that draws upon widely applied ethical principles, (ii) a *legal* justification that appeals to existing treaty commitments and soft law agreements to cooperate on the basis of stated equity principles, and (iii) an *effectiveness* justification that argues that an international collective arrangement that is perceived to be fair has greater legitimacy and is more likely to be internationally agreed and domestically implemented, reducing the risks of defection and a cooperative collapse.

4.7.3.1 Equity principles pertinent to burden-sharing in an international climate regime

Though the UNFCCC clearly invokes the vision of equitable burden-sharing, Parties did not articulate its meaning in any quantified detail. They had, however, agreed on general guidance as to the allocation of obligations among countries by identifying categories of countries based primarily on per capita income and assigning them distinct obligations: developed countries (listed in Annex 1) are distinguished from developing countries (often called "non-Annex 1" countries), and are obliged to "take the lead on combating climate change and the adverse effects thereof". A subset of Annex 1 countries consisting of wealthier developed countries (and listed in Annex 2) are further obliged to provide financial and technological support to developing countries to enable them to meet their UNFCCC obligations.

Beyond this, however, the burden-sharing arrangement is unspecified. Because there is no absolute standard of equity, countries (like people) will tend to advocate interpretations of the UNFCCC and equity in general which tend to favour their (often short term) interests (Heyward, 2007; Lange et al., 2010; Kals and Maes, 2011). It is tempting in this light to say that no reasoned resolution is possible, and to advocate, a purely procedural resolution (Müller, 1999). However, there is a basic set of shared ethical premises and precedents that apply to the climate problem, and impartial reasoning (as behind a Rawlsian (Rawls, 2000) "veil of ignorance") can help put bounds on the plausible interpretations of what equity may mean in the burden sharing context. Even in the absence of a formal, globally agreed burden-sharing framework, such principles are important in establishing expectations of what may be reasonably required of different actors. They influence the nature of the public discourse, the concessions individuals are willing to grant, the demands citizens are inclined to impose on their own governments, and the terms in which governments represent their nogitiating positions both to other countries and to their own citizens.

Chapter 3 reviews the overarching equity principles in the philosophical literature and their implications for thinking about different aspects of climate change. Here we assess the applied literature regarding burden-sharing in a global climate regime, which draws upon the general literature and understanding of ethics, with emphasis on the particular equity principles laid out in UNFCCC Article 3.

From the perspective of an international climate regime, many analysts have considered the range of principles for equitable burden-sharing, taking into account the major characteristics of climate change and its causes (Rose, 1990; Hayes and Smith, 1993; Baer et al., 2000; Metz et al., 2002; Ringius et al., 2002; Aldy et al., 2003; Ghersi et al., 2003; Gardiner, 2004; Caney, 2005, 2009, 2010; Heyward, 2007; Page, 2008; Vanderheiden, 2008; Winkler, Jayaraman, et al., 2011). The principles of equitable burden-sharing have been most frequently applied to costs of mitigation, though similar issues arise with regard to adaptation (Baer, 2006; Jagers and Duus-Otterstrom, 2008; Dellink et al., 2009; Grasso, 2010; Hartzell-Nichols, 2011).

We discuss these principles, organized along four key dimensions – responsibility, capacity, equality, and the right to sustainable development, expanding on the moral philosophical arguments presented in Chapter 3.

Responsibility

There has been an extensive discussion of responsibility in the climate literature, distinguishing moral responsibility from causal responsibility, and substantially focused on the moral significance of knowledge of harmful effects (Neumayer, 2000; Caney, 2005; Müller et al., 2009). Common sense ethics (and legal practice) hold persons responsible for harms or risks they knowingly impose, and furthermore for harms or risks that could reasonably been foreseen, and, in certain cases, regardless of whether they could have been foreseen. In the climate context, responsibility is a fundamental principle, appearing in the UNFCCC in the form *"common but differentiated responsibilities,"* and alluded to in the statement noting that "the largest share of historic emissions has originated in developed countries." Responsibility most directly relates to responsibility for contributing to the climate problem, via emissions of greenhouse gases. It is thus closely connected to the Polluter Pays principle, and the burden-sharing principles which derive from it hold that countries should be accountable for their contribution to greenhouse gas emissions and their impacts.

Responsibility can be taken to include not only current emissions, but cumulative historical emissions as well (Grübler and Fujii, 1991; Smith, 1991; Neumayer, 2000; Rive et al., 2006; Wei et al., 2012). This has been justified on three main grounds. First, climate change and its impacts results from the stock of accumulated historic emissions in the atmosphere. Second, the total amount of net greenhouse gases that can be emitted to the atmosphere must be constrained (to a level determined by society's particular choice of global climate stabilization goal), and thus constitutes a finite common resource, and users of this resource should be accountable for that use since it depletes the resource and precludes the access of others whether that use is current or historical. Third, historical emissions reflect the use of a resource from which benefits have been derived, i.e., wealth, fixed capital, infrastructure, and other physical and technological assets. These benefits constitute a legacy based in part on consuming a common resource that (a) should be paid for, and (b) provides a basis for mitigative capacity (Shue, 1999; Caney, 2006, 2010). The latter argument carries the notion of responsibility further back in time, assigning responsibility for the emissions of previous generations to current generation, to the extent that they have inherited benefits from those earlier generations. This argument links responsibility with the capacity equity principle discussed below (Gardiner, 2011). If conventional development continues, the relative responsibility of some nations who currently have relatively low cumulative emissions would match and exceed by mid century the relative responsibility of some nations who currently have high responsibility (Höhne and Blok, 2005; Botzen et al., 2008), on an aggregate – if not per capita – basis. Such analyses do not necessarily provide an ethical argument that the future threat of emissions imposed by a nation ought to determine the responsibility of a nation to respond. However, they do illustrate that the relative distribution of responsibility among countries could vary substantially over time, and that a burden-sharing framework must dynamically reflecting evolving realities if they are to faithfully reflect ethical principles. A second point illustrated by such analyses is that projections of future emissions provide a basis for understanding *where* mitigation might productively be undertaken, though not necessarily *who* should be obliged to bear the costs.

Each nation's responsibility for emissions is typically defined (as in the IPCC inventory methodologies) to entail emissions within the nation's territorial boundary. An alternative interpretation, which was considered early on (Fermann, 1994) and has become more salient as international trade has grown more important, is to include emissions embodied in internationally traded goods that are consumed by a given nation. Recent studies (Lenzen et al., 2007; Pan et al., 2008; Peters et al., 2011) have provided a quantitative basis for better understanding the implications of a consumption-based approach to assessing responsibility. In general, at the aggregate level, developed countries are net importers of emissions, and developing countries are net exporters. The relevance of this to burden-sharing may depend on further factors, such as the distribution between the exporting and importing country of the benefits of carbon-intensive production, and the presence of other climate policies such as border carbon tariffs (See also Sections 3.9, 4.4 and 4.5.)(See also Sections 3.9, 4.4 and 4.5.)

Many analysts have suggested that all emissions are not equivalent in how they translate to responsibility, distinguishing the categories of “survival emissions”, “development emissions”, and “luxury” emissions (Agarwal and Narain, 1991; Shue, 1993; Baer, Kartha, et al., 2009; Rao and Baer, 2012).

Determining responsibility for current, present and future emissions in order to allocate responsibility raises methodological questions. In addition to the standard questions about data availability and reliability, there are also equity-related questions to address. For instance, there are various rationales for determining how far in the past historical emissions should be reckoned. One rationale is that the 1990s should be the earliest date, reflecting the timing of the First IPCC Assessment Report and the creation of a global regime that imposed obligations to curb emissions (Posner and Sunstein, 2007). Some argue that the date should be earlier, corresponding to the time that climate change was became reasonably suspected of being a problem, and greenhouse gas emissions thus identifiable as a pollutant worthy of policy action. For example, based on the published warnings issued by scientific advisory panels to the United States presidents Johnson (U.S. National Research Council Committee on Atmospheric Sciences, 1966; MacDonald et al., 1979) and Carter (MacDonald et al., 1979), and the first G7 Summit Declaration highlighting climate change as a problem and seeking to prevent further increases of carbon dioxide in the atmosphere (Group of 7 Heads of State, 1979), one might argue for the 1970s or 1960s. Others argue that a still earlier date is appropriate because the damage is still caused, the stock depleted, and the benefits derived, regardless of whether there is either a legal requirement or knowledge. They would argue that the date may be as early as can be allowed by the availability of emissions data and plausible scientific inference of emissions rates.

Another issue is the question of accounting for the residence time of emissions into the atmosphere, as an alternative to simply considering cumulative emissions over time. In the case of carbon dioxide, responsibility could include past emissions that are no longer resident in the atmosphere, on the grounds that those emissions (a) have contributed to the warming and climate damages experienced so far, and upon which further warming and damages will be additive, and (b) have been removed from the atmosphere predominantly to the oceans, where they are now causing ocean acidification, which is itself a serious environmental problem (See AR5 WGI Chapter 6).

Capacity (or, Ability to Pay)

Beyond the obligation to act that arises from a moral responsibility for causing emissions, a second motivation for action arises from the capacity to contribute to solving the climate problem (Shue, 1999; Caney, 2010). Generally, this is interpreted to mean that the more one can afford to contribute, the more one should, and this is precisely how societies tend to distribute the costs of preserving or generating societal public goods, i.e., most societies have progressive income taxation.

This view can be apply at the level of countries, or at a lower level, recognizing inequalities between individuals. Smith et al. (1993) suggested GDP as an income based measure of ability-to-pay, subject to a threshold value, determined by an indicator of quality of life. This was developed in Kartha et al. (2009) and Baer et al. (2010), taking into account intra-national disparities.

As discussed in section 4.6, response capacity refers to more than just financial wherewithal, encompassing also other characteristics that affect a nation’s ability to contribute to solving the climate problem. It recognizes that effective responses require not only financial resources, but also technological, institutional, and human capacity. This issue has been treated by Winkler, Letete and Marquard (2011) by considering Human Development Index as a complement to income in considering capacity. Capacity, even in this broader sense, can be distinguished from mitigation potential, which refers to the presence of techno-economic opportunities for reducing emissions due to, for example, having renewable energy resources that can be exploited, a legacy of high-carbon infrastructure that can be replaced, or a rapidly growing capital stock that can be built based on low-carbon investments.. Mitigation potential is a useful characteristic for determining where emissions reductions can be located geographically for reasons of cost-effectiveness, but this can be distinguished from burden-sharing *per se*, in the sense of determining on normative grounds which country should pay for those reductions. This distinction is reflected in the economist's notion that economic efficiency can be decoupled from equity (Coase, 1960).

Equality

Equality means many things, but a common understanding in international law is that each human being has equal moral worth and thus should have equal rights. This has been argued to apply to access to common global resources, and has found its expression in the perspective that each person should have an equal right to emit (Grubb, 1989; Agarwal and Narain, 1991). This equal right is applied by some to current and future flows, and by some to the cumulative stock as well. (See further below.)

Some analysts (Caney, 2009) have noted, however, that a commitment to equality does not necessarily translate into an equal right to emit. Egalitarians generally call for equality of a total package of "resources" (or "capabilities" or "opportunities for welfare") and thus may support inequalities in one good to compensate for inequalities in other goods (Starkey, 2011). For example, one might argue that poor people who are disadvantaged with respect to access to a resources such as food or drinking water may be entitled to a greater than per capita share of emissions rights. Second, some individuals may have greater needs than others. For example, poorer people may have less access to alternatives to fossil fuels because of higher cost or less available technologies, say, and thus be entitled to a larger share of emission rights.

Others have suggested that equality can be interpreted as requiring equal sacrifices, either by all parties, or by parties who are equal along some relevant dimension. Then, to the extent that parties are not equal, more responsibility (Gonzalez Miguez and Santhiago de Oliveira, 2011) or capacity (Jacoby et al., 2009) would imply more obligation, all else being equal.

Right to development

The right to development approach is closely related to the notion of *need* as an equity principle, in that it posits that the interests of poor people and poor countries in meeting basic needs are a global priority (Andreassen and Marks, 2007). In particular, compared to the need to solve the climate problem, meeting basic needs has clear moral precedence, or, at the very least, it should not be hindered by measures taken to address climate change.

The UNFCCC acknowledges "the legitimate priority needs of developing countries for the achievement of sustained economic growth and the eradication of poverty" and recognizes that "economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties."

4.7.3.2 Frameworks for equitable burden-sharing

There are various ways of interpreting the above equity principles and applying them to the design of a burden-sharing framework. It is helpful to categorize climate change burden-sharing frameworks into two broad classes. The first, "resource-sharing" frameworks, are aimed at applying ethical principles to establish a basis for sharing the available agreed "global carbon budget". The second, "effort-sharing" frameworks, are aimed at applying ethical principles to establish a basis for sharing the costs of the global climate response. The resource-sharing frame is the natural point of departure if climate change is posed as a tragedy of the commons type of collective action problem; if it is posed as a free-rider type of collective action problem, the effort-sharing perspective is more natural perspective. Neither of these framings is objectively the "correct" one, just as neither collective action framing of the climate change problem is correct. Both can inform policymakers judgments in different ways. Indeed, the two approaches are complementary: any given resource-sharing framework implies a particular distribution of the effort, and any given effort-sharing framework implies a particular distribution of the resource. Within these two broad categories, burden-sharing frameworks are typically formulated as emission entitlements to be used in a cost-effective allocation mechanism such as a trading system or global climate fund through which countries with obligations greater than their domestic mitigation potential can fund reductions in countries with obligations that are less than their domestic mitigation potentia. (See Chapter 13.)

One important dimension along which both resource sharing and burden-sharing proposals can be compared is the number of categories into which countries are grouped. The UNFCCC in fact had three categories – Annex I, Annex II (the OECD countries within Annex I), and non-Annex 1. Many of the proposals discussed below reproduce this binary distinction. Others increase the number of "bins" to as many as six (the South/North Dialogue). Finally, many others eliminate any qualitative categories, instead allocating emissions rights or obligations on the basis of a continuous index.

Resource sharing approaches

The resource-sharing approach starts by acknowledging that global greenhouse gas sink capacity, or "atmospheric space", is finite and exhaustible, with its size defined by the agreed climate stabilization target. Emissions by any one nation directly reduce the amount that can be used by other nations.

The most straightforward of resource sharing approaches is an equal per capita approach (Grubb, 1990; Agarwal and Narain, 1991; Jamieson, 2001), which is premised on the equal rights to the atmospheric commons to all individuals, and allocates emission allowances to each country in proportion to its population, consistent with the target global emission pathway. In response to the concern that an equal per capita allocation would provide an incentive for more rapid population growth, some analysts have argued that the effect would be negligible in comparison to other factors affecting population, and others have proposed solutions such as holding population constant as of some agreed date (Jamieson, 2001), establishing standardized growth expectations (Cline, 1992), or allocating emission in proportion only to adult population (Grubb, 1990).

In response to the concern that unrealistically rapid reductions would be required in those countries whose current emissions are far above the global average, some have proposed a gradual transition from grandfathered emission rights to per capita emission rights (Grubb and Sebenius, 1992; Welsch, 1993; Meyer, 2004). This rationale applies specifically to a framework intended to determine actual physical emission pathways, in which case an immediate per capita framework would lead to a global distribution of mitigation action that would not be economically efficient. For a framework intended to assign endowments in rights to emit, rather than emissions, the rationale is questionable: the opportunity to acquire additional allocations through emissions trading or some other transfer system would allow a cost-effective transition and lessen, though not eliminate, the political challenges, of an immediate equal per capita allocation.

A variant on the above that aims to address the concern that many developing countries would be required to reduce their emissions from very low levels is "Common but Differentiated Convergence" (Höhne et al., 2006), under which a developing country is required to begin converging only once its per capita emissions have exceeded a specified (and progressively declining) threshold. Chakravarty et al. (2009) put forward a variant that looked beyond average national indicators of emissions by examining the distribution of emissions across individuals at different income levels within each country.

Extending the concept of equal per capita rights to include the historical and future carbon budget gives the "equal cumulative per capita emission rights" family of frameworks (Bode, 2004; German

Advisory Council on Global Change (WBGU), 2009; Oberheitmann, 2010; CASS/DRC Joint Project Team, 2011; Jayaraman et al., 2011). This approach accounts for the fact that some countries (which tend to be higher income countries that industrialized earlier) have consumed more than an equal per capita share of the total global budget. This results in a negative allocation for the future, which some analysts have linked to the notion of a "carbon debt" or "climate debt" (Pickering and Barry, 2012) and tried to quantify and monetize (Smith, 1991; den Elzen et al., 2005), and which is a subset of a larger "ecological debt", explored for example by Srinivasan et al. (2008).

Effort sharing approaches

In contrast with the resource sharing frame, the "effort sharing" frame begins by looking at the costs to be incurred from reducing GHG emissions to an agreed level, and asking how those costs should be fairly divided (effort sharing approaches can also address adaptation costs in a way that resource sharing approaches do not). Two of the equity principles discussed above are typically drawn upon to suggest how to equitably share the costs of solving a problem: "those who bear *responsibility* for causing the problem should pay", and "those who have the *capacity* to solve the problem should pay". Many of the philosophers engaged with the question of burden-sharing in the climate regime have argued that obligations should be proportional in some fashion to responsibility and capacity. (See, for example the analyses of Shue (1993); or Caney (2005)). These principles are widespread in proposed climate policy architectures as well (Klinsky and Dowlatabadi, 2009).

An early effort-sharing approach was the Brazilian proposal to use historic responsibility for emissions and thus global temperature rise as a basis for setting Kyoto Protocol targets. This approach has been quantitatively analyzed (Höhne and Blok, 2005) and discussed in the global political context recently (Gonzalez Miguez and Santhiago de Oliveira, 2011). Various approaches have developed an indicators based on capacity alone such as GDP/capita (Wada et al., 2012) as a basis for effort-sharing, or have combined capacity and responsibility, including the Greenhouse Development Rights framework (Kartha et al., 2009) and close variants (2011)(Yue and Wang, forthcoming; Cao, 2008), which take into account a "development threshold" defined at an income level modestly above a global poverty line. Some frameworks introduce indicators of mitigation potential, either alongside indicators of capacity and responsibility (e.g., (Den Elzen et al., 2007)) or solely (Den Elzen et al., 2010).

4.8 Implications for subsequent chapters

4.8.1 Why sustainability and equity matter

The primary implication of this chapter as a framing for subsequent chapters is to underscore the importance of explicitly scrutinizing the candidate mitigation technologies, approaches, and policies for their broader equity and sustainability implications. This is because the relevant stakeholders and decision-makers have various priorities, in particular regarding economic and human development, which may conflict with climate goals. This report would not be as useful if it focused on climate issues and disregarded the broader context in which decisions are made.

In the context of seeking a balance between multiple objectives and addressing the trade-offs between development and climate response, the idea of sustainable development has gained a lot of popularity. Moreover, there are important synergies which make sustainable development appear not just as a compromise but as a truly favourable frame for long-term planning and the promotion of climate effective responses.

Equity considerations are pervasive in this perspective, as they underpin the very ideas of sustainability and of development, but also appear prominently in the debates about practical allocations of costs and benefits of specific climate policies, in particular emission rights as discussed in 4.7, thereby determining the participation and involvement of various stakeholders.

Hence, the analyses of mitigation technologies, approaches, and policies presented in this assessment report are especially helpful and policy-relevant to the extent they are not limited to their mitigation potential and the corresponding cost per tCO2 equivalent, but also assess how these mitigation options contribute to (or undermine) broader sustainable development and on equity objectives.

4.8.2 Three levels of analysis of sustainability consequences of climate policy options

Various definitions and indicators of SD have been introduced in this chapter (in particular in 4.2,.4.5). This subsection offers a simple taxonomy of approaches for the assessment of sustainability.

Long-term evolution of the three pillars. The outcomes of climate policy options can generally be observed in the three spheres related to the three pillars of sustainable development: the economic, the social, and the environmental sphere. Sustainability in the economy refers to the preservation of standards of living and the convergence of developing economies toward the level of developed countries. Sustainability in the social sphere refers to fostering the quality of social relations and reducing causes of conflicts and instability, such as excessive inequalities and poverty, lack of access to basic resources and facilities, and discriminations. Sustainability in the environmental sphere refers to the preservation of biodiversity, habitat, and natural resources.

Long-term evolution of well-being. The way the three spheres (and pillars) flourish can be viewed as contributing to the preservation of well-being for humans as well as for other living creatures. Human well-being depends on economic, social, and natural goods, and the other living beings depend on the quality of the ecological system. It may therefore be convenient to summarize the multiple relevant considerations by saying that the ultimate end result, for sustainability assessment, is the well-being of all living beings. Measuring well-being is considered difficult for humans because there are controversies about how best to depict individual well-being, and about how to aggregate over the whole population. However, as explained in Chapter 3 and Section 4.7, many of the difficulties are exaggerated and practical methodologies have been developed. Truly enough, it still remains difficult to assess the well-being of all living beings, humans and non-humans together.

But, even if current methodologies fall short of operationalizing comprehensive measures of well-being of that sort, it is useful for experts who study particular sectors to bear in mind that a narrow notion of living standards for humans does not cover all the aspects of well-being for the purposes of assessing sustainability. It is also useful to try to assess how various interactions between the three spheres can impact on well-being. When there are trade-offs between different aspects of the economic, social, and ecological dimensions, one has to make an assessment of their relative priorities. Well-being is the overarching notion that helps thinking about such issues.

Current evolution of capacities. Sustainability can also be assessed in terms of capital or capacities, as suggested by some indicators such as genuine savings. Preserving the resources transmitted to the future generation is a key step in guaranteeing a sustainable path. Again, it is useful to think of the capacities underlying the functioning of the three spheres: economic, social, ecological. The economic sphere needs various forms of productive capital and raw materials, infrastructures and a propitious environment, but also human capital, institutions, governance, and knowledge. The social sphere needs various forms of institutions and resources for sharing goods and connecting people, which involve certain patterns of distribution of economic resources, transmission of knowledge, and forms of interaction, coordination and cooperation. The ecological sphere needs to keep the bases of its stability, including habitat, climate, and biological integrity. In general, climate policy options can affect capacities in all of these spheres, to varying degrees.

4.8.3 Sustainability and equity issues in sectoral chapters

[Note from the authors: We will revise this section based on (i) on the actual topics related to SD and equity covered by subsequent chapters (i.e., after completion of Table 4.8.1 below) and on (ii) the use of indicators as presented in the sectoral chapters. Include a table including the indicators that are included in the report and assess them. (Note at end of table a disclaimer recognizing that there are many other indicators.)]

Sustainability and equity issues are addressed throughout the present report. Based on a detailed description of SD and equity issues (mainly rooted in the "three pillars" approach for SD, see section 4.8.2), it provides a map and a reader's guide for the report from the SD and equity perspective. Table 4.8.1 shows that sustainable development and equity issues are addressed throughout the report, reflecting increased attention paid to the link between mitigation, development and equity in the literature.

Most of the discussions in subsequent chapters are framed in the terms of SD and equity implications of different mitigation options. This is the "development in the climate lens" approach outlined in IPCC AR4 Ch.12. Table 6.5 sums up the co-benefits and risks tradeoffs (see section 6.6.2) identified in Chapters 7-11 for individual mitigation options. "Climate in the development lens" approaches that analyze the implications of key development policies for mitigation and mitigative capacity are less often addressed, revealing a gap in the literature [Note from the authors: See SOD of Chapters 5, 6 and policy chapters].

Table 4.8.1 also points to gaps in the literature on SD and equity. Some topics, such as health co-benefits and risk tradeoffs associated with mitigation policies, appear already well covered in the literature. Others, on the other hand, are scarcely addressed, notably distributional issues (both distributional implications of mitigation policies and implications of different distributional settings for climate policies); and employment issues. Those are very important gaps in the literature as those are among the key sustainable development goals that policymakers will consider.

Sustainability indicators at the sector level have a very limited role to play in the assessment of global sustainability. The reason is that sustainability involves the combination of actions and conditions (co-evolution) in various parts of the society, the economy, and the environment. It is the combination that makes sustainability possible, not any single part in isolation. There is no simple formula that would compute general sustainability as a function of sectoral indicators, except with the genuine savings approach that relies on capital accounting (see Box 4.2.1). Consider for instance the transportation sector. The development of a particular form of transportation may be compatible with sustainability only provided that other sectors evolve in a specific way. It may even happen that the best contribution to sustainability that the transportation sector can make depends on how other sectors evolve. For instance, when high density urbanization is developed, the most sustainable organization of transportation (network, modality) may be quite different from the best formula for low density habitat. What happens in the energy sector is also of course of key relevance for the transportation sector.

Table 4.8.1 Map of sustainable development and equity issues within AR5 WGIII. [Note from the authors: Final Table will include section numbers in all cells (and not just xes) as other chapters SOD become available]

		Sectoral chapters					
	6 **Transition**	7 **Energy**	8 **Transport**	9 **Buildings**	10 **Industry**	11 **Land Use**	12 **Cities**
Equity							
Distribution (Within countries, income categories, across countries and over time)					10.4 Demand reduction: New products may be targetted for poor more. Material efficiency: Marginal/disposal Land site will be freed , a valuable asset may be freed for redistribution to other better alternative activity.		
Procedural equity (Participation / involvement, including institutional issues)					10.4 Recycling: increase participation and involvment of different sectors	x	
Economic							
Costs [1]		7.8 Levelized cost of energy (LCOE) for various low carbon energy supply technologies show broad ranges, indicating that costs are dependent on location and country-specific conditions. The overall LCOE of many low carbon technologies has come down considerably since AR4. However, French and US nuclear reactors have seen a strong increase in their investment over the past few decades to meet efficiency and safety standards. Investment costs of CCS plants also remain higher compared to conventional plants, and with no commercial large-scale coal-fired CCS power plant in operation, the estimation of their projected costs are carried out on the basis of design studies and a few existing pilot projects. Altering future energy supply to reduce GHG emissions may also require investments in ancillary infrastructure beyond those needed in a BAU future, imposing additional costs, although these future costs are uncertain and difficult to define.	x	x	10.4; 10.8 Increase in productivity via reduced use of energy or raw materials inputs and resultant production cost reduction	x	x
Income					10.4 Material efficieny and recycling in different industries increase income	x	

National budgets, international trade, growth					10.4 Demand reduction material efficiency and recyling, energy efficiency and renewables promote a decline in trade deficit.		
New technologies					10.4 Demand reduction: New technology to meet new product /service will emerge; New technological development linked to material efficiency and recycling; New technology linked to new industrial processes	x	
Induced effect on long lived capital stock when there is path dependancy					10.4 Demand reduction reduces need for landfill /waste disposal sites		
Social							
Poverty alleviation		7.9 There is a correlation between modern energy consumption and economic and social development, both within and across countries. Higher Human Development Index (HDI) correlates well with higher energy consumption, and higher per capita emissions. This trend continue up to 100 GJ per capita, and tends to flatten beyond this point.		x	10.4 Recicling: poor in informal waste recyling market can get better opportinity in formal recycling sector.	x	
Access to and affordability of basic services		7.9 More than 1.3 billion people worldwide, especially the rural poor in sub-Saharan Africa and Asia are estimated to lack access to electricity and between 2.7 to 3 billion are estimated to lack access to modern fuels for heating and cooking. Income poverty and cost of technology are critical impediments to widening access to energy services.	x				
Food security						x	
Education and learning					10.4 Demand reduction, material efficiency and recycling imply new lifestyle and ethic concept away from use and throw, sharing. New technologies require new skill development		
Employment				x	10.4 recycling, material efficiency: job creation due to new market segments	x	

Health		7.9 Beyond their GHG emissions, energy supply options differ with regard to their overall environmental and health impacts. Combustion-related emissions cause substantial human and ecological impacts, leading to the pre-mature deaths of 2.5 million people due to outdoor pollution and over 2 million children per year due to high levels of indoor pollution. Reducing biomass and fossil fuel combustion can reduce many forms of pollution and may thus yeild co-benefits for human wellbeing and ecosystems.	x	x	10.8.1		
Displacements					10.4 Demand reduction, material efficieny and recycling: Reduced threat of displacement from reduced demand for landfill sites		
Others							
<u>Environmental</u>							
End-of-life of capital stock							
Local pollution and global emissions					10.4; 10.8.1 Reduced pollution due to energy efficiency, renewables and production reduction		
Biodiversity				x	10.4 Demand reduction, material efficieny and recycling: less use of natural resources.	x	
Land-use					See displacements	x	
Water, soils and other natural resources			x	x	10.4 Demand reduction, material efficiecny and recycling: less use of natural resources. 10.4.2; 10.4.4; 10.4.5 New technologies for cement, pulp and paper and aluminium production reduce water use	x	

	Policy chapters			
	13	14	15	16
	Global	Regional	National	Finance
Equity				
Distribution (Within countries, income categories, across countries and over time)		14.1 We study regional distribution emissions as they develop over time (production and consumption-based); we also provide information on intra-regional and inter-regional distribution of key development outcomes	We mainly dealt with distribution within countries at any one moment in time. This was for instance discussed in relation to fuel taxes which are not found to be generally regressive as often believed. In fact, in many (particularly low-income) countries they are progressive.	16.2 Distribution across countries and over time is addressed in so far as information on current financial flows are presented, including their origin and destination. Moreover estimates for future investment required in different scenarios are assessed. We refer to the UNFCCC commitment of developed countries to assist developing countries in their mitigation and adaptation efforts, especially the USD 100 billion commitment from 2009. However, we do not indicate how much exactly should be provided by whom and to whom. Time wise we will come to the conclusion that there is no robust evidence to favour a rapid and massive deployment of low-carbon technologies to avoid lock-in effects over a time-phased action supported by an expected cost digression of future technological innovation.
Procedural equity (Participation / involvement, including institutional issues)				16.5Procedural equity will be addressed implicitly when discussing governance issues regarding climate finance, especially by presenting the recent developments on national level, where a number of independent funds has been established to improve ownership and alignment ot national demand and interest.
Economic				
Costs [1]			We focus mainly on allocative efficiency costs but mentiona also political costs and distribution of costs.	
Income				
National budgets, international trade, growth		We discuss the tole of trade for emission transfers between regions		
New technologies		We discuss opportunities for technological transfer between regions	We speak of the costs that are implied by the barriers to the adoption and development of new technologies.	
Induced effect on long lived capital stock when there is path dependancy				

Social				
Poverty alleviation		We discuss poverty differences and the challenges of poverty reduction		
Access to and affordability of basic services				
Food security			The issues of food security is indirectly involved mainly in the discussion of bioenergy development and the possible conflicting demands for land.	
Education and learning				
Employment			Employment effects are not analysed extensively. We believe that there is little that can be said with certainty on the general relationship between employment and climate policy.	
Health			Ancillary benefits or costs of various policies such as reduction in black carbon for human health are mentioned but not exhaustively analyzed per se.	
Displacements				
Others				
Environmental				
End-of-life of capital stock				
Local pollution and global emissions			Ancillary benefits or costs of various policies for local pollution are mentioned but not in detail analyzed.	
Biodiversity			Ancillary benefits or costs of various policies for biodiversity are mentioned briefly particularly in relation to REDD.	
Land-use		We discuss regional differences in land use patterns and the trade-offs with poverty reduction	Ancillary benefits or costs of various policies for land use are dealt with very briefly	
Water, soils and other natural resources				

4.9 Gaps in knowledge and data

- The relationship between countries' human capital levels and their national and international engagement in climate change policy would benefit from additional studies.
- There is a need to investigate further how developing countries can best pull together the resources and capabilities to achieve SD and climate mitigation objectives and how to leverage international cooperation to support this process.
- There is a need to explore the development of economic and policy frameworks for the compensation of foregone benefits from exploiting fossil fuels in resource-rich countries.
- There is no comprehensive evaluation of funding necessary to implement UNFCCC mitigation and adaptation activities and clear methodologies and processes are needed as a basis for accurate estimates.
- There is a need to better assess the unrealized potential for reducing the environmental impact of economic activity and to understand how this potential can be realized.
- The relative importance in a transition toward SD of changes in values, as opposed to standard economic instruments influencing behaviors and economic activity, remains hard to assess.
- A better understanding is needed of the potential of frugality (life-styles and consumption patterns involving lower expenditures on goods and services) versus ecologically-conscious behaviour (lifestyles and consumption patterns involving less use of material resources and less environmental harm without necessarily reducing expenditure) for promoting sustainable development and equity.
- A better understanding is needed of the non-economic motivations for climate-friendly behaviours, particularly regarding the respective role of social considerations or values (e.g. universalism regarding fellow human beings) versus ecological considerations (universalism regarding the environment), and the extent to which these drivers can be separated.
- The predictive power of values for ecologically conscious consumer behaviour is often low, typically less than 20%, due to a range of factors operating at different levels. There is need to better understand the causes of this 'value-action gap' regarding especially behaviours that increase or limit GHG emissions
- The measurement of well-being, for the purpose of public policy, remains a controversial field, and there is a need to better understand the potential uses of subjective data, and also to seek ways to improve the quality of data on well-being.
- The current methodologies for the construction of scenarios do not yet deliver sufficiently detailed and sufficiently long-term data in order to assess development paths at the bar of sustainability and equity.
- Economic models could substantially improve by integrating transition issues (short-medium term) into long-term analysis, and also by adopting a sequential structure compatible with the resolution of uncertainty over time.

References

Adger W.N. (2003). Social capital, collective action, and adaptation to climate change. *Economic Geography* **79**, 387–404.

Adger W.N. (2006). *Fairness in Adaptation to Climate Change*. MIT Press, 337 pp., (ISBN: 9780262012270).

Adger W.N., and A. Jordan (2009). Sustainability: exploring the processes and outcomes of governance. In: *Governing Sustainability*. Cambridge University Press, Cambridge pp.3–31, (ISBN: 9780521732437).

Adger W.N., I. Lorenzoni, and K. O'Brien (2009). *Adapting to Climate Change. Thresholds, Values, Governance*. Cambridge University Press, Cambridge (GBR), 514 pp., (ISBN: 9780521764858).

Adler M. (2011). *Well-being and fair distribution : beyond cost-benefit analysis*. Oxford University Press, New York, (ISBN: 9780195384994).

AEIC (2010). *A Business Plan for Americas Energy Future*. American Energy Innovation Council.

Agarwal A., and S. Narain (1991). Global Warming in an Unequal World: A Case of Environmental Colonialism. Centre for Science and the Environment.

Ahuvia A.C., and D.C. Friedman (1998). Income, Consumption, and Subjective Well-Being: Toward a Composite Macromarketing Model. *Journal of Macromarketing* **18**, 153 –168. (DOI: 10.1177/027614679801800207).

Aitken M. (2012). Changing climate, changing democracy: a cautionary tale. *Environmental Politics* **21**, 211–229.

Akimoto K., F. Sano, A. Hayashi, T. Homma, J. Oda, K. Wada, M. Nagashima, K. Tokushige, and T. Tomoda (2012). Consistent assessments of pathways toward sustainable development and climate stabilization. *Natural Resources Forum*, n/a–n/a. (DOI: 10.1111/j.1477-8947.2012.01460.x).

Akyuz Y. (2012). *Key Issues in the Organisation of and Government Intervention in Finance to Developing Countries: Lessons from Recent Experiences, South Centre Policy Brief Number 14*. Available at: http://www.southcentre.org/index.php?option=com_content&view=article&id=1902%3Akey-issues-in-the-organization-of-and-government-intervention-in-finance-in-developing-countries-lessons-from-recent-experience&catid=142%3Aglobal-financial-and-economic-crisis&Itemid=67&lang=en.

Aldy J.E., S. Barrett, and R.N. Stavins (2003). Thirteen plus one: a comparison of global climate policy architectures. *Climate Policy* **3**, 373–397. (DOI: 10.1016/j.clipol.2003.09.004).

Alkire S. (2010). *Human Development: Definitions, Critiques, and Related Concepts*. UNDP. Available at: http://ideas.repec.org/p/hdr/papers/hdrp-2010-01.html.

Allaby M. (1983). *Macmillan dictionary of the environment*. Macmillan, London, (ISBN: 9780333347362).

Aminzadeh S.C. (2006). Moral Imperative: The Human Rights Implications of Climate Change, A. *Hastings International and Comparative Law Review* **30**, 231.

Andonova L.B., M.A. Betsill, and H. Bulkeley (2009). Transnational Climate Governance. *Global Environmental Politics* **9**, 52–73. (DOI: 10.1162/glep.2009.9.2.52).

Andreassen B.A., and S.P. Marks (Eds.) **(2007).** *Development As a Human Right: Legal, Political, and Economic Dimensions*. FXB Center for Health and Human Rights, 350 pp., (ISBN: 0674021215).

Anthoff D., C. Hepburn, and R.S.J. Tol (2009). Equity weighting and the marginal damage costs of climate change. *Ecological Economics* **68**, 836–849. (DOI: 10.1016/j.ecolecon.2008.06.017).

Armitage D., F. Berkes, A. Dale, E. Kocho-Schellenberg, and E. Patton (2011). Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change* **21**, 995–1004. (DOI: 10.1016/j.gloenvcha.2011.04.006).

Aronsson T., P.-O. Johansson, and K.-G. Löfgren (1997). *Welfare measurement, sustainability, and green national accounting : a growth theoretical approach*. Edward Elgar Pub., Cheltenham UK ;Brookfield Vt. US, (ISBN: 9781858984858).

Arrow K.J., William R. Cline, Karl-Goran Maler, Mohan Munasinghe, R. Squitieri, and Joseph E. Stiglitz (1996). Intertemporal Equity, Discounting, and Economic Efficiency. In: *Climate Change 1995: Economic and Social Dimensions of Climate Change, Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change*. James P. Bruce, Hoesung Lee, Erik F. Haites, (eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA pp.125–144, .Available at: http://www.ipcc.ch/ipccreports/sar/wg_III/ipcc_sar_wg_III_full_report.pdf.

Arthur W.B. (1989). Competing Technologies, Increasing Returns, and Lock-In by Historical Events. *The Economic Journal* **99**, 116–131.

Asheim G. (2007). *Justifying, characterizing, and indicating sustainability*. Springer, Dordrecht, the Netherlands, (ISBN: 9781402061998).

Asheim G.B., W. Buchholz, and B. Tungodden (2001). Justifying Sustainability. *Journal of Environmental Economics and Management* **41**, 252–268. (DOI: 10.1006/jeem.2000.1137).

Asheim G., T. Mitra, and B. Tungodden (2012). Sustainable recursive social welfare functions. *Economic Theory* **49**, 267–292.

Asheim G.B., and T. Wei (2008). Sectoral Income. *Environmental and Resource Economics* **42**, 65–87. (DOI: 10.1007/s10640-008-9204-1).

Assadourian E. (2010). Transforming Cultures: From Consumerism to Sustainability. *Journal of Macromarketing* **30**, 186 –191. (DOI: 10.1177/0276146710361932).

Atkinson A.B. (1970). On the measurement of inequality. *Journal of Economic Theory* **2**, 244–263.

Attfield R. (Ed.) **(2008).** *The ethics of the environment*. Ashgate, Farnham, England ; Burlington, VT, 620 pp., (ISBN: 9780754627869).

Baer P. (2006). Adaptation: Who Pays Whom? In: *Fairness in Adaptation to Climate Change*. W.N. Adger, (ed.), MIT Press, .

Baer P. (2013). Who should pay for climate change? "Not me". *Chicago Journal of International Law* **13**.

Baer P., T. Athanasiou, S. Kartha, and E. Kemp-Benedict (2009). Greenhouse Development Rights: A Proposal for a Fair Global Climate Treaty. *Ethics, Place & Environment* **12**, 267–281. (DOI: 10.1080/13668790903195495).

Baer P., T. Athanasiou, S. Kartha, and E. Kemp-Benedict (2010). Greenhouse Development Rights: A Framework for Climate Protection that is "More Fair" than Equal per Capita Emissions Rights. In: *Climate Ethics: Essential Readings*. S.M. Gardiner, S. Caney, D. Jamieson, H. Shue, (eds.), Oxford University Press, New York pp.215–230, (ISBN: 9780195399622). Available at: http://www.oup.com/us/catalog/general/subject/Philosophy/EthicsMoralPhilosophy/Environmental Ethics/?view=usa&sf=toc&ci=9780195399622.

Baer P., J. Harte, B. Haya, A.V. Herzog, J. Holdren, N.E. Hultman, D.M. Kammen, R.B. Norgaard, and L. Raymond (2000). Equity and Greenhouse Gas Responsibility. *Science* **289**, 2287. (DOI: 10.1126/science.289.5488.2287).

Baer P., S. Kartha, T. Athanasiou, and E. Kemp-Benedict (2009). The Greenhouse Development Rights Framework: Drawing Attention to Inequality within Nations in the Global Climate Policy Debate. *Development and Change* **40**, 1121–1138. (DOI: 10.1111/j.1467-7660.2009.01614.x).

Bamberg S., and G. Möser (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology* **27**, 14–25. (DOI: 10.1016/j.jenvp.2006.12.002).

Banai A., M. Ronzoni, and C. Schemmel (2011). *Social Justice, Global Dynamics. Theoretical and empirical perspectives*. Routledge, Oxon.

Bankoff G., G. Frerks, and D. Hilhorst (2004). *Mapping Vulnerability. Disastres, Development & People*. Earthscan, London, 236 pp., (ISBN: 1853839647).

De Barcellos M.D., A. Krystallis, M.S. de Melo Saab, J.O. Kügler, and K.G. Grunert (2011). Investigating the gap between citizens' sustainability attitudes and food purchasing behaviour: empirical evidence from Brazilian pork consumers. *International Journal of Consumer Studies* **35**, 391–402. (DOI: 10.1111/j.1470-6431.2010.00978.x).

Barr S. (2006). Environmental action in the home: Investigating the "value-action" gap. *Geography* **91**, 43–54.

Barrett S. (2005). *Environment And Statecraft: The Strategy of Environmental Treaty-making*. Oxford University Press, 460 pp., (ISBN: 9780199286096).

Baumol W.J. (2002). *The Free Market Innovation Machine: Analyzing the Growth Miracle of Capitalism*. Princeton University Press, 348 pp., (ISBN: 9780691096155).

Bazilian M., P. Nussbaumer, E. Haites, M.I. Levi, M. Howells, and K.K. Yumkella (2010). Understanding the Scale of Investment for Universal Energy Access. *Geopolitics of Energy* **32**, 21–42.

Bearce D.H., and J.A.L. Hutnick (2011). Toward an Alternative Explanation for the Resource Curse: Natural Resources, Immigration, and Democratization. *Comparative Political Studies* **44**, 689–718. (DOI: 10.1177/0010414011401211).

Bebbington A. (1999). Capitals and capabilities: A framework for analyzing peasant viability, rural livelihoods and poverty. *World Development* **27**, 2021–2044. (DOI: 10.1016/S0305-750X(99)00104-7).

Bejan A. (2002). Fundamentals of exergy analysis, entropy generation minimization, and the generation of flow architecture. *International Journal of Energy Research* **26**, 0–43. (DOI: 10.1002/er.804).

Bergek A., S. Jacobsson, B. Carlsson, S. Lindmark, and A. Rickne (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy* **37**, 407–429. (DOI: 10.1016/j.respol.2007.12.003).

Berkes F., J. Colding, and C. Folke (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* **10**, 1251–1262. (DOI: 10.2307/2641280).

Berkhout F. (2012). Adaptation to climate change by organizations. *Wiley Interdisciplinary Reviews: Climate Change* **3**, 91–106. (DOI: 10.1002/wcc.154).

Bernstein S. (2001). *The Compromise of Liberal Environmentalism*. Columbia University Press.

Bhander G.S., M. Hauschild, and T. McAloone (2003). Implementing life cycle assessment in product development. *Environmental Progress* **22**, 255–267. (DOI: 10.1002/ep.670220414).

Biermann F. (2007). “Earth system governance” as a crosscutting theme of global change research. *Global Environmental Change-Human and Policy Dimensions* **17**, 326–337. (DOI: 10.1016/j.gloenvcha.2006.11.010).

Biermann F., K. Abbott, S. Andresen, K. Backstrand, S. Bernstein, M.M. Betsill, H. Bulkeley, B. Cashore, J. Clapp, C. Folke, A. Gupta, J. Gupta, P.M. Haas, A. Jordan, N. Kanie, T. Kluvankova-Oravska, L. Lebel, D. Liverman, J. Meadowcroft, R.B. Mitchell, P. Newell, S. Oberthur, L. Olsson, P. Pattberg, R. Sanchez-Rodriguez, H. Schroeder, A. Underdal, S. Camargo Vieira, C. Vogel, O.R. Young, A. Brock, and R. Zondervan (2012). Navigating the Anthropocene: Improving Earth System Governance. *Science* **335**, 1306–1307. (DOI: 10.1126/science.1217255).

Biermann F., M.M. Betsill, J. Gupta, N. Kanie, L. Lebel, D. Liverman, H. Schroeder, and B. Siebenhüner (2009). *Earth System Governance: People, Places and the Planet. Science and Implementation Plan of the Earth System Governance Project. Earth System Governance Report 1*. International Human Dimensions Programme, Bonn.

Bizikova L., J. Robinson, and S. Cohen (2007). Linking climate change and sustainable development at the local level. *Climate Policy* **7**, 271–277.

Bjorvatn K., M.R. Farzanegan, and F. Schneider (2012). Resource Curse and Power Balance: Evidence from Oil-Rich Countries. *World Development* **40**, 1308–1316. (DOI: 10.1016/j.worlddev.2012.03.003).

Black I. (2010). Sustainability through anti-consumption. *Journal of Consumer Behaviour* **9**, 403–411. (DOI: 10.1002/cb.340).

Blalock G., and P.J. Gertler (2009). How firm capabilities affect who benefits from foreign technology. *Journal of Development Economics* **90**, 192–199. (DOI: 10.1016/j.jdeveco.2008.11.011).

Le Blanc D. (2010). Sustainable consumption and production: Policy efforts and challenges. *Natural Resources Forum* **34**, 1–3. (DOI: 10.1111/j.1477-8947.2010.01292.x).

Bloom D.E. (2011). Seven billion and counting. *Science* **333**, 562–569.

Bloom D.E., and D. Canning (2000). Public health - The health and wealth of nations. *Science* **287**, 1207–+. (DOI: 10.1126/science.287.5456.1207).

Von Blottnitz H., and M.A. Curran (2007). A review of assessments conducted on bio-ethanol as a transportation fuel from a net energy, greenhouse gas, and environmental life cycle perspective. *Journal of Cleaner Production* **15**, 607–619. (DOI: 10.1016/j.jclepro.2006.03.002).

Bodansky D. (2010). *Climate Change and Human Rights: Unpacking the Issues*. Social Science Research Network, Rochester, NY. Available at: http://papers.ssrn.com/abstract=1581555.

Bode S. (2004). Equal emissions per capita over time – a proposal to combine responsibility and equity of rights for post-2012 GHG emission entitlement allocation. *European Environment* **14**, 300–316. (DOI: 10.1002/eet.359).

Boldrin M., and D.K. Levine (2013). The Case Against Patents. *Journal of Economic Perspectives* **27**, 3–22. (DOI: 10.1257/jep.27.1.3).

Bolwig S., and P. Gibbon (2010). Counting Carbon in The Marketplace: Part 1 - Overview Paper. In: *Counting Carbon in the Market Place*. OECD, Paris. Available at: http://www.oecd.org/dataoecd/29/40/42886201.pdf.

Bolwig S., P. Gibbon, and G. Henningsen (2011). Part 1 - Overview Paper. In: *Counting Carbon in the Market Place*. OECD, Paris.

Bolwig S., P. Gibbon, and S. Jones (2009). The Economics of Smallholder Organic Contract Farming in Tropical Africa. *World Development* **37**, 1094–1104. (DOI: 10.1016/j.worlddev.2008.09.012).

Bolwig S., S. Ponte, A. Du Toit, L. Riisgaard, and N. Halberg (2010). Integrating Poverty and Environmental Concerns into Value-Chain Analysis: A Conceptual Framework. *Development Policy Review* **28**, 173–194. (DOI: 10.1111/j.1467-7679.2010.00480.x).

Bolwig S., L. Riisgaard, P. Gibbon, and S. Ponte (In press). Challenges of Agro-Food Standards Conformity: Lessons from East Africa and Policy Implications. *European Journal of Development Research*.

Bongaarts J. (2009). Human population growth and the demographic transition. *Philosophical Transactions of the Royal Society B-Biological Sciences* **364**, 2985–2990. (DOI: 10.1098/rstb.2009.0137).

Bongaarts J., and S. Sinding (2011). Population Policy in Transition in the Developing World. *Science* **333**, 574–576. (DOI: 10.1126/science.1207558).

Bonvillian W.B., and C. Weiss (2009). Stimulating Innovation in Energy Technology. *Issues in Science and Technology* **26**, 51–56.

Botzen W.J.W., J.M. Gowdy, and J.C.J.M. van den Bergh (2008). Cumulative CO2 emissions: shifting international responsibilities for climate debt. *Climate Policy* **8**, 569–576. (DOI: 10.3763/cpol.2008.0539).

Bows A., and J. Barrett (2010). Cumulative emission scenarios using a consumption-based approach: a glimmer of hope? *Carbon Management* **1**, 161–175. (DOI: 10.4155/cmt.10.17).

Boyd E., N. Hultman, J.T. Roberts, E. Corbera, J. Cole, A. Bozmoski, J. Ebeling, R. Tippman, P. Mann, K. Brown, and D.M. Liverman (2009). Reforming the CDM for sustainable development: lessons learned and policy futures. *Environmental Science & Policy* **12**, 820–831. (DOI: 10.1016/j.envsci.2009.06.007).

Brenton P., G. Edwards-Jones, and M.F. Jensen (2009). Carbon Labelling and Low-income Country Exports: A Review of the Development Issues. *Development Policy Review* **27**, 243–267. (DOI: 10.1111/j.1467-7679.2009.00445.x).

Bretschger L. (2005). Economics of technological change and the natural environment: How effective are innovations as a remedy for resource scarcity? *Ecological Economics* **54**, 148–163. (DOI: 10.1016/j.ecolecon.2004.12.026).

Brown K., and E. Corbera (2003). Exploring equity and sustainable development in the new carbon economy. *Climate Policy* **3**, S41–S56. (DOI: 10.1016/j.clipol.2003.10.004).

Bruckner M., S. Giljum, C. Lutz, and K.S. Wiebe (2012). Materials embodied in international trade - Global material extraction and consumption between 1995 and 2005. *Global Environmental Change-Human and Policy Dimensions* **22**, 568–576. (DOI: 10.1016/j.gloenvcha.2012.03.011).

Brulle R.J., and L.E. Young (2007). Advertising, Individual Consumption Levels, and the Natural Environment, 1900–2000. *Sociological Inquiry* **77**, 522–542. (DOI: 10.1111/j.1475-682X.2007.00208.x).

Brunner R., and A. Lynch (2010). *Adaptive governance and climate change*. American Meteorological Society, Boston, Mass., xix, 404 pp., (ISBN: 9781878220974).

Brunnschweiler C.N., and E.H. Bulte (2008). The resource curse revisited and revised: A tale of paradoxes and red herrings. *Journal of Environmental Economics and Management* **55**, 248–264. (DOI: 10.1016/j.jeem.2007.08.004).

Brunnschweiler C.N., and E.H. Bulte (2009). Natural resources and violent conflict: resource abundance, dependence, and the onset of civil wars. *Oxford Economic Papers-New Series* **61**, 651–674. (DOI: 10.1093/oep/gpp024).

Buck S.J. (1998). *The Global Commons: An Introduction*. Island Press, 244 pp., (ISBN: 9781559635516).

Bulkeley H., and H. Schroeder (2011). Beyond State/Non-State Divides: Global Cities and the Governing of Climate Change. *European Journal of International Relations*. (DOI: 10.1177/1354066111413308). Available at: http://ejt.sagepub.com/content/early/2011/10/14/1354066111413308.

Bumpus A.G., and D.M. Liverman (2008). Accumulation by decarbonization and the governance of carbon offsets. *Economic Geography* **84**, 127–155.

Burandt S., and M. Barth (2010). Learning settings to face climate change. *Journal of Cleaner Production* **18**, 659–665. (DOI: 10.1016/j.jclepro.2009.09.010).

Burch S. (2010). Transforming barriers into enablers of action on climate change: Insights from three municipal case studies in British Columbia, Canada. *Global Environmental Change* **20**, 287–297. (DOI: 10.1016/j.gloenvcha.2009.11.009).

Burch S. (2011). Sustainable development paths: investigating the roots of local policy responses to climate change. *Sustainable Development* **19**, 176–188. (DOI: 10.1002/sd.435).

Burch S., and J. Robinson (2007). A framework for explaining the links between capacity and action in response to global climate change. *Climate Policy* **7**, 304–316.

Cairns R.D., and V. Martinet (2012). An Environmental-Economic Measure of Sustainable Development. Economix.

Camfield L., and S.M. Skevington (2008). On Subjective Well-being and Quality of Life. *Journal of Health Psychology* **13**, 764 –775. (DOI: 10.1177/1359105308093860).

Campanale, Mark, and Leggett, Jeremy (2011). *Unburnable Carbon – Are the world's financial markets carrying a carbon bubble?* Available at: http://www.carbontracker.org/wp-content/uploads/downloads/2012/08/Unburnable-Carbon-Full1.pdf.

Caney S. (2005). Cosmopolitan Justice, Responsibility, and Global Climate Change. *Leiden Journal of International Law* **18**, 747–775.

Caney S. (2006). Environmental Degradation, Reparations, and the Moral Significance of History. *Journal of Social Philosophy* **37**, 464–482. (DOI: 10.1111/j.1467-9833.2006.00348.x).

Caney S. (2009). Justice and the distribution of greenhouse gas emissions. *Journal of Global Ethics* **5**, 125–146. (DOI: 10.1080/17449620903110300).

Caney S. (2010). Climate change and the duties of the advantaged. *Critical Review of International Social and Political Philosophy* **13**, 203–228. (DOI: 10.1080/13698230903326331).

Cao J. (2008). *Reconciling Human Development and Climate Protection: Perspectives from Developing Countries on Post-2012 International Climate Change Policy*. Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, Cambridge, MA. Available at: http://belfercenter.ksg.harvard.edu/publication/18685/reconciling_human_development_and_climate_protection.html.

Caole A.J., and E.M. Hoover (1958). *Population Growth and Economic Development in Low Income Countries*. Princeton University Press, Princeton.

CASS/DRC Joint Project Team (2011). Equitable access to sustainable development: Carbon budget account proposal. In: *Equitable access to sustainable development: Contribution to the body of scientific knowledge*. BASIC expert group, Beijing, Brasilia, Cape Town and Mumbai pp.35–58, .Available at: http://www.erc.uct.ac.za/Basic_Experts_Paper.pdf.

Chai A., and A. Moneta (2012). Back to Engel? Some evidence for the hierarchy of needs. *Journal of Evolutionary Economics* **22**, 649–676. (DOI: 10.1007/s00191-012-0283-3).

Chakravarty S.R. (2009). *Inequality, polarization and poverty: advances in distributional analysis*. Springer, New York, 178 pp., (ISBN: 9780387792521).

Chakravarty S., A. Chikkatur, H. de Coninck, S. Pacala, R. Socolow, and M. Tavoni (2009). Sharing global CO2 emission reductions among one billion high emitters. *Proceedings of the National Academy of Sciences* **106**, 11884–11888. (DOI: 10.1073/pnas.0905232106).

Chapin III F.S., S.R. Carpenter, G.P. Kofinas, C. Folke, N. Abel, W.C. Clark, P. Olsson, D.M.S. Smith, B. Walker, O.R. Young, F. Berkes, R. Biggs, J.M. Grove, R.L. Naylor, E. Pinkerton, W. Steffen, and F.J. Swanson (2010). Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends in Ecology & Evolution* **25**, 241–249. (DOI: 10.1016/j.tree.2009.10.008).

Chertow M.R. (2007). "Uncovering" Industrial Symbiosis. *Journal of Industrial Ecology* **11**, 11–30. (DOI: 10.1162/jiec.2007.1110).

Chertow M.R., and D.R. Lombardi (2005). Quantifying Economic and Environmental Benefits of Co-Located Firms. *Environmental Science and Technology* **39**, 6535–6541.

Cherubini F., N.D. Bird, A. Cowie, G. Jungmeier, B. Schlamadinger, and S. Woess-Gallasch (2009). Energy- and greenhouse gas-based LCA of biofuel and bioenergy systems: Key issues, ranges and recommendations. *Resources, Conservation and Recycling* **53**, 434–447. (DOI: 10.1016/j.resconrec.2009.03.013).

Chotray V., and G. Stoker (2009). *Governance theory and practice: A cross-disciplinary approach*. Palgrave Macmillan, London.

Clark D.A. (2009). Capability Approach. In: *The Elgar Companion to Development Studies*. Edward Elgar, pp.32–44, (ISBN: 9781843764755).

Clark W.C., and N.M. Dickson (2003). Sustainability science: The emerging research program. *Proceedings of the National Academy of Sciences* **100**, 8059–8061. (DOI: 10.1073/pnas.1231333100).

Clark A.E., P. Frijters, and M.A. Shields (2008). Relative income, happiness, and utility: An explanation for the Easterlin paradox and other puzzles. *Journal of Economic Literature* **46**, 95–144.

Cleveland M., and M. Laroche (2007). Acculturaton to the global consumer culture: Scale development and research paradigm. *Journal of Business Research* **60**, 249–259. (DOI: 10.1016/j.jbusres.2006.11.006).

Cline W.R. (1992). *The Economics of Global Warming*. Institute for International Economics, Washington, D.C.

Coase R.H. (1960). The problem of social cost. *Journal of Law and Economics* **3**, 1–44.

Colombo M.G., and L. Grilli (2005). Founders' human capital and the growth of new technology-based firms: A competence-based view. *Research Policy* **34**, 795–816. (DOI: 10.1016/j.respol.2005.03.010).

Consumption-based accounting of CO2 emissions Available at: http://www.pnas.org/content/107/12/5687.short.

Corbera E. (2012). Problematizing REDD+ as an experiment in payments for ecosystem services. *Current Opinion in Environmental Sustainability* **4**, 612–619. (DOI: 10.1016/j.cosust.2012.09.010).

Corbera E., and N. Jover (2012). The undelivered promises of the Clean Development Mechanism: insights from three projects in Mexico. *Carbon Management* **3**, 39–54.

Corbera E., and H. Schroeder (2011). Governing and implementing REDD+. *Environmental Science & Policy* **14**, 89–99. (DOI: 10.1016/j.envsci.2010.11.002).

Corner A., D. Venables, A. Spence, W. Poortinga, C. Demski, and N. Pidgeon (2011). Nuclear power, climate change and energy security: Exploring British public attitudes. *Energy Policy* **39**, 4823–4833. (DOI: 10.1016/j.enpol.2011.06.037).

Correa C. (2011). *The Role of Intellectual Property Rights in Global Economic Governance*. Initiative for Policy Dialogue Working Paper Series, Columbia University and UNDP.

Creyts J.C., and V.P. Carey (1999). Use of extended exergy analysis to evaluate the environmental performance of machining processes. *Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering* **213**, 247–264. (DOI: 10.1243/0954408991529861).

Crutzen P.J. (2006). Albedo enhancement by stratospheric sulfur injections: A contribution to resolve a policy dilemma? *Climatic Change* **77**, 211–219. (DOI: 10.1007/s10584-006-9101-y).

Crutzen, and E. Stoermer (2000). The Anthropocene. *Global Change Newsletter* **41**, 17–18.

Csutora M. (2012). One More Awareness Gap? The Behaviour–Impact Gap Problem. *Journal of Consumer Policy* **35**, 145–163. (DOI: 10.1007/s10603-012-9187-8).

Daly H.E. (1996). *Beyond growth : the economics of sustainable environment*. Beacon Press, Boston, Mass., (ISBN: 0807047090 9780807047095 0807047082 9780807047088).

Dasgupta P. (1993). *An Inquiry into Well-being and Destitution*. Oxford University Press, Oxford.

Dasgupta P., and K.-G. Mäler (2000). Net national product, wealth, and social well-being. *Environment and Development Economics* **5**, 69–93.

Deacon R. (2011). The Political Economy of the Natural Resources Curse: A Survey of Theory and Evidence. *Foundations and Trends® in Microeconomics* **7**, 111–208. (DOI: 10.1561/0700000042).

Deaton A.S. (2008). Income, Health, and Well-Being around the World: Evidence from the Gallup World Poll. *Journal of Economic Perspectives* **22**, 53–72.

DeCanio S.J., and A. Fremstad (2010). *Game Theory and Climate Diplomacy*. E3 Network. Available at: http://www.e3network.org/papers/Basic_Game_Anlaysis.pdf.

Dechezleprêtre A., M. Glachant, and Y. Ménière (2009). Technology transfer by CDM projects: A comparison of Brazil, China, India and Mexico. *Energy Policy* **37**, 703–711. (DOI: 10.1016/j.enpol.2008.10.007).

Dellink R., M. den Elzen, H. Aiking, E. Bergsma, F. Berkhout, T. Dekker, and J. Gupta (2009). Sharing the burden of financing adaptation to climate change. *Global Environmental Change* **19**, 411–421. (DOI: 10.1016/j.gloenvcha.2009.07.009).

Delmas M.A., and N. Nairn-Birch (2011). Is the tail wagging the dog? An empirical analysis of corporate carbon footprints and financial performance. Institute of the Environment and Sustainability, University of California. Available at: http://escholarship.org/uc/item/3k89n5b7.

Diaz H.L., R.D. Drumm, J. Ramirez-Johnson, and H. Oidjarv (2002). Social capital, economic development and food security in Peru's mountain region. *International Social Work* **45**, 481–+.

Diaz-Maurin F., and M. Giampietro (2013). A "Grammar" for assessing the performance of power-supply systems: Comparing nuclear energy to fossil energy. *Energy* **49**, 162–177. (DOI: 10.1016/j.energy.2012.11.014).

Dietz S., and E. Neumayer (2007). Weak and strong sustainability in the SEEA: Concepts and measurement. *Ecological Economics* **61**, 617–626. (DOI: 10.1016/j.ecolecon.2006.09.007).

Dietzenbacher E., and K. Mukhopadhyay (2007). An Empirical Examination of the Pollution Haven Hypothesis for India: Towards a Green Leontief Paradox? *Environmental and Resource Economics* **36**, 427–449. (DOI: 10.1007/s10640-006-9036-9).

Dingwerth K., and P. Pattberg (2009). World Politics and Organizational Fields: The Case of Transnational Sustainability Governance. *European Journal of International Relations* **15**, 707–743. (DOI: 10.1177/1354066109345056).

Dinica V. (2009). Biomass power: Exploring the diffusion challenges in Spain. *Renewable and Sustainable Energy Reviews* **13**, 1551–1559. (DOI: 10.1016/j.rser.2008.10.002).

Dixit A.K., and J.E. Stiglitz (1977). Monopolistic Competition and Optimum Product Diversity. *The American Economic Review* **67**, 297–308.

Dobson A. (1991). *The Green reader: essays toward a sustainable society*. Mercury House, San Francisco, 280 pp., (ISBN: 1562790102).

Dobson A. (2007). Environmental citizenship: towards sustainable development. *Sustainable Development* **15**, 276–285. (DOI: 10.1002/sd.344).

Doh S., and C.L. McNeely (2012). A multi-dimensional perspective on social capital and economic development: an exploratory analysis. *Annals of Regional Science* **49**, 821–843. (DOI: 10.1007/s00168-011-0449-1).

Dore R. (2008). Financialization of the global economy. *Industrial and Corporate Change* **17**, 1097–1112. (DOI: 10.1093/icc/dtn041).

Dosi G. (1982). Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. *Research Policy* **11**, 147–162. (DOI: 10.1016/0048-7333(82)90016-6).

Dosi G., and R.R. Nelson (1994). An introduction to evolutionary theories in economics. *Journal of Evolutionary Economics* **4**, 153–172. (DOI: 10.1007/BF01236366).

Dreyer L., M. Hauschild, and J. Schierbeck (2010). Characterisation of social impacts in LCA. *The International Journal of Life Cycle Assessment* **15**, 247–259. (DOI: 10.1007/s11367-009-0148-7).

Druckman A., and T. Jackson (2009). The carbon footprint of UK households 1990–2004: A socio-economically disaggregated, quasi-multi-regional input–output model. *Ecological Economics* **68**, 2066–2077. (DOI: 10.1016/j.ecolecon.2009.01.013).

Duflou J.R., K. Kellens, T. Devoldere, W. Deprez, and Wim Dewulf (2010). Energy related environmental impact reduction opportunities in machine design: case study of a laser cutting machine. *International Journal of Sustainable Manufacturing* **2**, 80–98. (DOI: 10.1504/IJSM.2010.031621).

Duflou J.R., J.W. Sutherland, D. Dornfeld, C. Herrmann, J. Jeswiet, S. Kara, M. Hauschild, and K. Kellens (2012). Towards energy and resource efficient manufacturing: A processes and systems approach. *CIRP Annals - Manufacturing Technology* **61**, 587–609. (DOI: 10.1016/j.cirp.2012.05.002).

Dunning J.H. (1981). Explaining the international position of countries towards a dynamic or developmental approach. *Weltwirtshaftliches Archiv*, 30–64.

Dusyk N., T. Berkhout, S. Burch, S. Coleman, and J. Robinson (2009). Transformative energy efficiency and conservation: a sustainable development path approach in British Columbia, Canada. *Energy Efficiency* **2**, 387–400. (DOI: 10.1007/s12053-009-9048-8).

Dyson T. (2006). Population and Development. In: *The Elgar Companion to Development Studies*. Edward Elgar, Cheltenham pp.436–441, (ISBN: 978 1 84376475 5).

Easterlin R.A. (1973). Does Money Buy Happiness? *The Public Interest* **30**, 3–10.

Easterlin R.A. (1995). Will raising the incomes of all increase the happiness of all? *Journal of Economic Behavior & Organization* **27**, 35–47. (DOI: 10.1016/0167-2681(95)00003-B).

Easterlin R.A., L.A. McVey, M. Switek, O. Sawangfa, and J.S. Zweig (2010). The happiness-income paradox revisited. *Proceedings of the National Academy of Sciences* **107**, 22463–22468. (DOI: 10.1073/pnas.1015962107).

Easterly W. (2002). *The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics*. The MIT Press. Available at: http://ideas.repec.org/b/mtp/titles/0262550423.html.

Easterly W. (2009). How the Millennium Development Goals are Unfair to Africa. *World Development* **37**, 26–35. (DOI: 10.1016/j.worlddev.2008.02.009).

Eckersley R. (2004). *The Green State. Rethinking Democracy and Sovereignty*. MIT Press, Masschussets.

Eckersley R. (2012). Moving Forward in the Climate Negotiations: Multilateralism or Minilateralism? *Global Environmental Politics* **12**, 24–42. (DOI: 10.1162/GLEP_a_00107).

Edwards-Jones G., K. Plassmann, E.H. York, B. Hounsome, D.L. Jones, and L. Milà i Canals (2009). Vulnerability of exporting nations to the development of a carbon label in the United Kingdom. *Environmental Science & Policy* **12**, 479–490. (DOI: 10.1016/j.envsci.2008.10.005).

EGTT (2008). *UNFCCC Guidebook on Preparing Technology Transfer Projects for Financing*. Expert Group on Technology Transfer, United Nations Framework Convention on Climate Change, Bonn. Available at: http://unfccc.int/ttclear/jsp/Guidebook.jsp.

Ehrlich P.R., and J. Holdren (1971). Impact of population growth. *Science* **171**, 1212–1217.

Elkington J. (1998). *Cannibals with forks : the triple bottom line of 21st century business*. New Society Publishers, Gabriola Island, BC; Stony Creek, CT, (ISBN: 0865713928 9780865713925).

Den Elzen M.G.J., N. Höhne, B. Brouns, H. Winkler, and H.E. Ott (2007). Differentiation of countries' future commitments in a post-2012 climate regime. *Environmental Science & Policy* **10**, 185–203. (DOI: 10.1016/j.envsci.2006.10.009).

Den Elzen M.G.J., N. Höhne, M.M. Hagemann, J. van Vliet, and D.P. van Vuuren (2010). Sharing developed countries’ post-2012 greenhouse gas emission reductions based on comparable efforts. *Mitigation and Adaptation Strategies for Global Change* **15**, 433–465. (DOI: 10.1007/s11027-010-9227-0).

Den Elzen M.G.J., M. Schaeffer, and P.L. Lucas (2005). Differentiating Future Commitments on the Basis of Countries’ Relative Historical Responsibility for Climate Change: Uncertainties in the “Brazilian Proposal” in the Context of a Policy Implementation. *Climatic Change* **71**, 277–301. (DOI: 10.1007/s10584-005-5382-9).

Epstein G.A. (2005). *Financialization And The World Economy*. Edward Elgar Publishing, 472 pp., (ISBN: 9781843768746).

Erickson P., A. Owen, and E. Dawkins (2012). Low-Greenhouse-Gas Consumption Strategies and Impacts on Developing Countries. *Stockholm Environment Institute Working Papers* **2012-01**. Available at: http://www.sei-international.org/publications?pid=2082.

Etienne C., and A. Asamoa-Baah (2010). *WHO The world health report - health systems financing: the path to universal coverage.* Available at: http://www.cabdirect.org/abstracts/20113115509.html;jsessionid=A44C51F9AD7E7857E3633E1481 27D338.

European Commission (2008). Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan. Available at: http://ec.europa.eu/environment/eussd/escp_en.htm.

Fankhauser S., R.S.J. Tol, and D.W. Pearce (1997). The aggregation of climate change damages: a welfare theoretic approach. *Environmental and Resource Economics* **10**, 249–266.

FAO (2012). *The State of Food Insecurity in the World 2012*. Food and Agriculture Organisation, Rome, Italy.

Farrell J., and P. Klemperer (2007). Chapter 31 Coordination and Lock-In: Competition with Switching Costs and Network Effects. In: *Handbook of Industrial Organization*. Elsevier, pp.1967–2072, (ISBN: 1573-448X). Available at: http://www.sciencedirect.com/science/article/pii/S1573448X06030317.

Fatma Denton, and Thomas Wilbanks (2012). Climate-Resilient Pathways: Adaptation, Mitigation, and Sustainable Development. IPCC WGII AR5 Chapter 20.

Fermann G. (1994). Climate Change, Burden-sharing Criteria, and Competing Conceptions of Responsibility. *International Challenges* **13**, 28–34.

Fine B. (1999). The developmental state is dead - Long live social capital? *Development and Change* **30**, 1–19. (DOI: 10.1111/1467-7660.00105).

Finkbeiner M. (2009). Carbon footprinting—opportunities and threats. *The International Journal of Life Cycle Assessment* **14**, 91–94. (DOI: 10.1007/s11367-009-0064-x).

Finnveden G., M.Z. Hauschild, T. Ekvall, J. Guinée, R. Heijungs, S. Hellweg, A. Koehler, D. Pennington, and S. Suh (2009). Recent developments in Life Cycle Assessment. *Journal of Environmental Management* **91**, 1–21. (DOI: 10.1016/j.jenvman.2009.06.018).

Fischer J., R. Dyball, I. Fazey, C. Gross, S. Dovers, P.R. Ehrlich, R.J. Brulle, C. Christensen, and R.J. Borden (2012). Human behavior and sustainability. *Frontiers in Ecology and the Environment* **10**, 153–160. (DOI: 10.1890/110079).

Fischer J., A.D. Manning, W. Steffen, D.B. Rose, K. Daniell, A. Felton, S. Garnett, B. Gilna, R. Heinsohn, D.B. Lindenmayer, B. MacDonald, F. Mills, B. Newell, J. Reid, L. Robin, K. Sherren, and A. Wade (2007). Mind the sustainability gap. *Trends in Ecology & Evolution* **22**, 621–624. (DOI: 10.1016/j.tree.2007.08.016).

Flavin C., and N. Lenssen (1994). *Powering the future : blueprint for a sustainable electricity industry*. Worldwatch Institute, Washington D.C., (ISBN: 9781878071200).

Fleurbaey M. (2009). Beyond GDP: The quest for a measure of social welfare. *Journal of Economic Literature* **47**, 1029–1075.

Fleurbaey M., and D. Blanchet (2013). *Beyond GDP: measuring welfare and assessing sustainability*. Oxford University Press, Oxford ; New York, (ISBN: 9780199767199).

Flint R.W., and M.J.E. Danner (2001). The nexus of sustainability & social equity: Virginia's Eastern Shore as a local example of global issues. *International Journal of Economic Development*. Available at: http://findarticles.com/p/articles/mi_qa5479/is_2_3/ai_n28892986/?tag=content;col1.

Folke C. (2007). Social–ecological systems and adaptive governance of the commons. *Ecological Research* **22**, 14–15. (DOI: 10.1007/s11284-006-0074-0).

Folke C., S.R. Carpenter, B. Walker, M. Scheffer, T. Chapin, and J. Rockström (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society* **15**, 20.

Folke C., T. Hahn, P. Olsson, and J. Norberg (2005). ADAPTIVE GOVERNANCE OF SOCIAL-ECOLOGICAL SYSTEMS. *Annual Review of Environment and Resources* **30**, 441–473. (DOI: 10.1146/annurev.energy.30.050504.144511).

Folke C., A. Jansson, J. Rockstrom, P. Olsson, S.R. Carpenter, F.S. Chapin, A.-S. Crepin, G. Daily, K. Danell, J. Ebbesson, T. Elmqvist, V. Galaz, F. Moberg, M. Nilsson, H. Osterblom, E. Ostrom, A. Persson, G. Peterson, S. Polasky, W. Steffen, B. Walker, and F. Westley (2011). Reconnecting to the Biosphere. *Ambio* **40**, 719–738. (DOI: 10.1007/s13280-011-0184-y).

Folke C., Å. Jansson, J. Rockström, P. Olsson, S.R. Carpenter, F. Stuart Chapin, A.-S. Crépin, G. Daily, K. Danell, J. Ebbesson, T. Elmqvist, V. Galaz, F. Moberg, M. Nilsson, H. Österblom, E. Ostrom, Å. Persson, G. Peterson, S. Polasky, W. Steffen, B. Walker, and F. Westley (2011). Reconnecting to the Biosphere. *AMBIO: A Journal of the Human Environment* **40**, 719–738. (DOI: 10.1007/s13280-011-0184-y).

Foray D. (1997). The dynamic implications of increasing returns: Technological change and path dependent inefficiency. *International Journal of Industrial Organization* **15**, 733–752. (DOI: 10.1016/S0167-7187(97)00009-X).

Fouquet R. (2010). The slow search for solutions: Lessons from historical energy transitions by sector and service. *Energy Policy* **38**, 6586–6596. (DOI: 10.1016/j.enpol.2010.06.029).

Frantz C.M., and F.S. Mayer (2009). The Emergency of Climate Change: Why Are We Failing to Take Action? *Analyses of Social Issues and Public Policy* **9**, 205–222. (DOI: 10.1111/j.1530-2415.2009.01180.x).

Fujita M., P. Krugman, and A.J. Venables (1999). *The Spatial Economy*. MIT Press, Cambridge, Mass.

Fukuyama F. (2002). Social Capital and Development: The Coming Agenda. *The SAIS Review of International Affairs* **22**, 23–37.

Gallopín G. (2003). *A systems approach to sustainability and sustainable development*. ECLAC Sustainable Development and Human Settletments Division, Santiago Chile, (ISBN: 9789211213980).

Gallopín G.C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change* **16**, 293–303. (DOI: 10.1016/j.gloenvcha.2006.02.004).

Gallup Organisation (2008a). *Public opinion in the European union*. European Commission, Brussels.

Gallup Organisation (2008b). *Attitudes of European citizens towards the environment*. European Commission, Brussels. Available at: http://ec.europa.eu/public_opinion/archives/ebs/ebs_295_en.pdf.

Gamarnikow E., and A. Green (1999). Social Capital and the Educated Citizen. *The School Field* **10**, 103–126.

Gardiner S.M. (2004). Ethics and Global Climate Change. *Ethics* **114**, 555–600. (DOI: 10.1086/382247).

Gardiner S.M. (2006). A Perfect Moral Storm: Climate Change, Intergenerational Ethics and the Problem of Moral Corruption. *Environmental Values* **15**, 397–413.

Gardiner S.M. (2011). Climate Justice. In: *Climate Change and Society*. J.S. Dryzek, R.B. Norgaard, D. Schlosberg, (eds.), Oxford University Press, pp.309–322, .

Gatersleben B., E. White, W. Abrahamse, T. Jackson, and D. Uzzell (2010). Values and sustainable lifestyles. *Architectural Science Review* **53**, 37–50. (DOI: 10.3763/asre.2009.0101).

Geels F. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy* **31**, 1257–1274. (DOI: 10.1016/S0048-7333(02)00062-8).

Geels F.W. (2006). The hygienic transition from cesspools to sewer systems (1840–1930): The dynamics of regime transformation. *Research Policy* **35**, 1069–1082. (DOI: 10.1016/j.respol.2006.06.001).

Geels F.W., and J. Schot (2007). Typology of sociotechnical transition pathways. *Research Policy* **36**, 399–417. (DOI: 10.1016/j.respol.2007.01.003).

German Advisory Council on Global Change (WBGU) (2009). *Solving the climate dilemma: The budget approach special report* (C. Hay and T. Cullen, Trans.). WBGU, Berlin, Germany. Available at: http://www.wbgu.de/en/special-reports/sr-2009-budget-approach/.

Ghersi F., J.-C. Hourcade, and P. Criqui (2003). Viable responses to the equity-responsibility dilemma: a consequentialist view. *Climate Policy* **3**, S115–S133. (DOI: 10.1016/j.clipol.2003.10.011).

Gibbon P., S. Ponte, and E. Lazaro (Eds.) **(2010).** *Global agro-food trade and standards*. Palgrave Macmillan, London.

Giddens A. (2009). *The Politics of Climate Change*. Polity Press, Cambridge.

Gimmon E., and J. Levie (2010). Founder's human capital, external investment, and the survival of new high-technology ventures. *Research Policy* **39**, 1214–1226. (DOI: 10.1016/j.respol.2010.05.017).

Gladwin T.N., J.J. Kennelly, and T.-S. Ause (1995). Shifting paradigms for sustainable development: Implications for management theory and research. *Academy of Management Review* **20**, 874–907.

Goerner S.J., B. Lietaer, and R.E. Ulanowicz (2009). Quantifying economic sustainability: Implications for free-enterprise theory, policy and practice. *Ecological Economics* **69**, 76–81. (DOI: 10.1016/j.ecolecon.2009.07.018).

Gonzalez Miguez J.D., and A. Santhiago de Oliveira (2011). The importance of historical responsibility in the context of the international regime on climate change. In: *Equitable access to sustainable development: Contribution to the body of scientific knowledge*. BASIC expert group, Beijing, Brasilia, Cape Town and Mumbai pp.23–34, .Available at: http://www.erc.uct.ac.za/Basic_Experts_Paper.pdf.

Graham C. (2009). *Happiness around the World: The Paradox of Happy Peasants and Miserable Millionaires*. Oxford University Press, Oxford.

Grasso M. (2010). An ethical approach to climate adaptation finance. *Global Environmental Change* **20**, 74–81. (DOI: 10.1016/j.gloenvcha.2009.10.006).

Griffin P.A., D.H. Lont, and Y. Sun (2012). The Relevance to Investors of Greenhouse Gas Emission Disclosures. *UC Davis Graduate School of Management Research Papers* **11**, 1–58.

De Groot R. (2006). Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. *Landscape and Urban Planning* **75**, 175–186. (DOI: 10.1016/j.landurbplan.2005.02.016).

Grootaert C., and T. van Bastelaer (2002). *The Role of Social Capital in Development: An Empirical Assessment*. Cambridge University Press, 384 pp., (ISBN: 9780521812917).

Group of 7 Heads of State (1979). G7 Economic Summit Declaration, Tokyo, 1979. Available at: http://www.g8.utoronto.ca/summit/1979tokyo/communique.html.

Grubb M. (1989). *The greenhouse effect: negotiating targets*. Royal Institute of International Affairs, 70 pp., (ISBN: 9780905031309).

Grubb M. (1990). The Greenhouse Effect : Negotiating Targets. *International Affairs* **66**, 67–89.

Grubb M.J., and J. Sebenius (1992). Participation, allocation, and adaptability in international tradeable emission permit systems for greenhouse gas control. In: *Climate Change: Designing a Tradeable Permit System*. Organization for Economic Co-operation and Development, Paris, France.

Grübler A., and Y. Fujii (1991). Intergenerational and spatial equity issues of carbon accounts. *Energy for Sustainable Development*, 1397–1416.

Gupta N. (2011). Globalization does lead to change in consumer behavior: An empirical evidence of impact of globalization on changing materialistic values in Indian consumers and its aftereffects. *Asia Pacific Journal of Marketing and Logistics* **23**, 251–269. (DOI: 10.1108/13555851111143204).

Gupta J., and N. van der Grijp (Eds.) **(2010).** *Mainstreaming climate change in development cooperation: theory, practice and implications for the European Union*. Cambridge University Press, Cambridge ; New York, 347 pp., (ISBN: 9780521197618).

Gutowski T.G., M.S. Branham, J.B. Dahmus, A.J. Jones, A. Thiriez, and D.P. Sekulic (2009). Thermodynamic Analysis of Resources Used in Manufacturing Processes. *Environmental Science & Technology* **43**, 1584–1590. (DOI: 10.1021/es8016655).

Ha-Duong M., M.J. Grubb, and J.-C. Hourcade (1997). Influence of socioeconomic inertia and uncertainty on optimal CO2-emission abatement. *Nature* **390**, 270–273. (DOI: 10.1038/36825).

Hall S.M. (2011). Exploring the "ethical everyday": An ethnography of the ethics of family consumption. *Geoforum* **42**, 627–637. (DOI: 10.1016/j.geoforum.2011.06.009).

Hallegate S., G.M. Heal, M. Fay, and D. Treguer (2011). *From growth to green growth -- a framework*. World Bank, Washington, D.C. 39 pp. Available at: http://econ.worldbank.org/external/default/main?pagePK=64165259&piPK=64165421&theSitePK=469372&menuPK=64166093&entityID=000158349_20111104145858.

Hallegatte S., J.-C. Hourcade, and P. Dumas (2007). Why economic dynamics matter in assessing climate change damages: Illustration on extreme events. *Ecological Economics* **62**, 330–340. (DOI: 10.1016/j.ecolecon.2006.06.006).

Halsnaes K., A. Markandya, and P. Shukla (2011). Introduction: Sustainable Development, Energy, and Climate Change. *World Development* **39**, 983–986. (DOI: 10.1016/j.worlddev.2010.01.006).

Hamilton K., and G. Atkinson (2006). *Wealth, welfare and sustainability : advances in measuring sustainable development*. Edward Elgar, Cheltenham, (ISBN: 9781848441750).

Hamilton K., and M. Clemens (1999). Genuine Savings Rates in Developing Countries. *The World Bank Economic Review* **13**, 333 –356. (DOI: 10.1093/wber/13.2.333).

Hanss D., and G. Böhm (2010). Can I make a difference? The role of general and domain-specific self-efficacy in sustainable consumption decisions. *Umweltpsychologie* **14**, 46–74.

Hartzell-Nichols L. (2011). Responsibility for meeting the costs of adaptation. *Wiley Interdisciplinary Reviews: Climate Change* **2**, 687–700. (DOI: 10.1002/wcc.132).

Hauschild (2005). Assessing Environmental Impacts in a Life-Cycle Perspective. *Environmental Science & Technology* **39**, 81A–88A. (DOI: 10.1021/es053190s).

Hauschild M.Z., L.C. Dreyer, and A. Jørgensen (2008). Assessing social impacts in a life cycle perspective—Lessons learned. *CIRP Annals - Manufacturing Technology* **57**, 21–24. (DOI: 10.1016/j.cirp.2008.03.002).

Hauschild M.Z., J. Jeswiet, and L. Alting (2004). Design for Environment — Do We Get the Focus Right? *CIRP Annals - Manufacturing Technology* **53**, 1–4. (DOI: 10.1016/S0007-8506(07)60631-3).

Hayakawa N., Y. Wakazono, T. Kato, Y. Suzuoki, and Y. Kaya (1999). Minimizing Energy Consumption in Industry by Cascade Use of Waste Energy. *IEEE Transactions on Energy Conversion* **14**, 795–801.

Hayes P., and K.R. Smith (Eds.) **(1993).** *The Global Greenhouse Regime: Who Pays? Science, Economics, and North-South Politics in the Climate Change Convention*. Earthscan, Oxford, UK, 288 pp., (ISBN: 9781853831362).

Healy T., and S. Cote (2001). *The Well-Being of Nations: The Role of Human and Social Capital. Education and Skills.* Organisation for Economic Cooperation and Development, 2 rue Andre Pascal, F-75775 Paris Cedex 16, France ($25); Tel: +33 1-45-24-82-00; Web site: http://www.oecd.org; Web site: http://www.oecdwash.org/PUBS/pubshome.htm. Available at: http://www.eric.ed.gov/ERICWebPortal/detail?accno=ED453111.

Herrmann I.T., and M.Z. Hauschild (2009). Effects of globalisation on carbon footprints of products. *CIRP Annals - Manufacturing Technology* **58**, 13–16. (DOI: 10.1016/j.cirp.2009.03.078).

Herrmann C., S. Thiede, S. Kara, and J. Hesselbach (2011). Energy oriented simulation of manufacturing systems – Concept and application. *CIRP Annals - Manufacturing Technology* **60**, 45–48. (DOI: 10.1016/j.cirp.2011.03.127).

Hertwich E.G. (2011). THE LIFE CYCLE ENVIRONMENTAL IMPACTS OF CONSUMPTION. *Economic Systems Research* **23**, 27–47. (DOI: 10.1080/09535314.2010.536905).

Hertwich E.G., and G.P. Peters (2009). Carbon Footprint of Nations: A Global, Trade-Linked Analysis. *Environ. Sci. Technol.* **43**, 6414–6420. (DOI: 10.1021/es803496a).

Heyward C. (2007). Equity and international climate change negotiations: a matter of perspective. *Climate Policy* **7**, 518–534.

Hoffmann M.J. (2011). *Climate Governance at the Crossroads: Experimenting with a Global Response after Kyoto*. Oxford University Press, Oxford.

Höhne N., and K. Blok (2005). Calculating Historical Contributions To Climate Change--Discussing The "Brazilian Proposal". *Climatic Change* **71**, 141–173. (DOI: 10.1007/s10584-005-5929-9).

Höhne N., M.G.J. den Elzen, and M. Weiss (2006). Common but differentiated convergence (CDC): A new conceptual approach to long-term climate policy. *Climate Policy* **6**, 181–199. (DOI: 10.1080/14693062.2006.9685594).

Holling C.S. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecology and Systematics* **4**, 1–23. (DOI: 10.2307/2096802).

Holling C.S. (Ed.) **(1978).** Adaptive environmental assessment and management. , xviii + 377.

Homma T., K. Akimoto, and T. Tomoda (2012). Quantitative evaluation of time-series GHG emissions by sector and region using consumption-based accounting. *Energy Policy* **51**, 816–827. (DOI: 10.1016/j.enpol.2012.09.031).

Hopwood B., M. Mellor, and G. O'Brien (2005). Sustainable development: mapping different approaches. *Sustainable Development* **13**, 38–52. (DOI: 10.1002/sd.244).

Horstmann B. (2011). Operationalizing the Adaptation Fund: challenges in allocating funds to the vulnerable. *Climate Policy* **11**, 1086–1096. (DOI: 10.1080/14693062.2011.579392).

Hufty M. (2011). Investigating Policy Processes: The Governance Analytical Framework (GAF). *Research Sustainable Development: Foundations, Experiences, and Perspectives*, 403–424.

Hulme M. (2009). *Why we disagree about climate change*. Cambridge University Press, Cambridge.

Hulme M., S.J. O'Neill, and S. Dessai (2011). Is Weather Event Attribution Necessary for Adaptation Funding? *Science* **334**, 764–765. (DOI: 10.1126/science.1211740).

Humphreys S. (Ed.) **(2009).** *Human Rights and Climate Change*. Available at: http://www.cambridge.org/gb/knowledge/isbn/item2713745/?site_locale=en_GB.

Huneke M.E. (2005). The face of the un-consumer: An empirical examination of the practice of voluntary simplicity in the United States. *Psychology and Marketing* **22**, 527–550. (DOI: 10.1002/mar.20072).

Intergovernmental Panel on Climate Change (1990). *Climate Change: First Assessment Report*. Cambridge University Press, Cambridge, UK; New York, USA, and Melbourne, Australia.

Intergovernmental Panel on Climate Change (1995). *Climate Change 1995: IPCC Second Assessment*. Cambridge University Press, Cambridge, UK; New York, USA, and Melbourne, Australia.

Intergovernmental Panel on Climate Change (2001). *Climate Change 2001: IPCC Third Assessment Report*. Cambridge University Press, Cambridge, UK. Available at: http://www.grida.no/publications/other/ipcc_tar/.

Intergovernmental Panel on Climate Change (2007). *Climate Change 2007: IPCC Fourth Assessment Report*. Cambridge University Press, Cambridge, UK.

Intergovernmental Panel on Climate Change (2011). *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* (O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. (coordinating lead authors) Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, and C. von Stechow, Eds.). Cambridge University Press, Cambridge, U.K., and New York. Available at: http://srren.ipcc-wg3.de/report.

Intergovernmental Panel on Climate Change (2012a). *Managing the risks of extreme events and disasters to advance climate change adaption*. Cambridge University Press, New York, N.Y, 582 pp., (ISBN: 9781107025066).

Intergovernmental Panel on Climate Change (2012b). *Meeting Report of the Intergovernmental Panel on Climate Change Expert Meeting on Geoengineering [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, C. Field, V. Barros, T.F. Stocker, Q. Dahe, J. Minx, K. Mach, G.-K. Plattner, S. Schlömer, G. Hansen, M. Mastrandrea (eds.)]. IPCC Working Group III Technical Support Unit, Potsdam Institute for Climate Impact Research, Potsdam, Germany, pp. 99.* Potsdam, Germany.

Intergovernmental Panel on Climate Change (2014). *IPCC Fifth Assessment Report, Working Group Two*.

International Energy Agency (2012). *World Energy Outlook 2012*. IEA, Paris, France.

Iyer S. (2006). Human Capital. In: *The Elgar Companion to Development Studies*. Edward Elgar, Cheltenham pp.240–245, (ISBN: 978 1 84376 475 5).

Jabareen Y. (2006). A New Conceptual Framework for Sustainable Development. *Environment, Development and Sustainability* **10**, 179–192. (DOI: 10.1007/s10668-006-9058-z).

Jackson T. (2005a). *Motivating sustainable consumption: A review of evidence on consumer behaviour and behavioural change. A report to the Sustainable Development Research Network*. University of Surrey, Centre for Environmental Strategies, Surrey. Available at: http://www3.surrey.ac.uk/eng/data/staff/rp/JacksonSDRN-review.pdf.

Jackson T. (2005b). Live Better by Consuming Less?: Is There a “Double Dividend” in Sustainable Consumption? *Journal of Industrial Ecology* **9**, 19–36. (DOI: 10.1162/1088198054084734).

Jackson T. (2009). *Prosperity without Growth? – The Transition to a Sustainable Economy*. Sustainable Development Commission, London. Available at: http://www.earthscan.co.uk/ProsperityWithoutGrowth/tabid/102098/Default.aspx.

Jackson A.L.R. (2011). Renewable energy vs. biodiversity: Policy conflicts and the future of nature conservation. *Global Environmental Change* **21**, 1195–1208. (DOI: 10.1016/j.gloenvcha.2011.07.001).

Jacobsson S., and A. Bergek (2011). Innovation system analyses and sustainability transitions: Contributions and suggestions for research. *Environmental Innovation and Societal Transitions* **1**, 41–57. (DOI: 10.1016/j.eist.2011.04.006).

Jacoby H., M. Babiker, S. Paltsev, and J. Reilly (2009). Sharing the burden of GHG reductions. In: *Post-Kyoto international climate policy : implementing architectures for agreement*. J.E. Aldy, R.N. Stavins, (eds.), Cambridge University Press, Cambridge(ISBN: 9780521137850 0521137853 9780521129527 0521129524).

Jaeger C.C., L. Paroussos, D. Mangalagiu, R. Kupers, A. Mandel, and J.D. Tabara (2011). *A New Growth Path for Europe: Generating Prosperity and Jobs in the Low-Carbon Economy (Synthesis Report)*. Postdam, (ISBN: 978-3-941663-09-1).

Jaffe A.B., R.G. Newell, and R.N. Stavins (2005). A tale of two market failures: Technology and environmental policy. *Ecological Economics* **54**, 164–174. (DOI: 10.1016/j.ecolecon.2004.12.027).

Jagers S., and G. Duus-Otterstrom (2008). Dual climate change responsibility: on moral divergences between mitigation and adaptation. *Environmental Politics* **17**, 576–591. (DOI: 10.1080/09644010802193443).

Jagers S.C., and J. Stripple (2003). Climate governance beyond the state. *Global Governance* **9**, 385–399.

Jakob M., and R. Marschinski (2012). Interpreting trade-related CO2 emission transfers. *Nature Climate Change*. (DOI: 10.1038/nclimate1630). Available at: http://www.nature.com.globalproxy.cvt.dk/nclimate/journal/vaop/ncurrent/full/nclimate1630.html.

Jamieson D. (2001). Climate Change and Global Environmental Justice. In: *Changing the Atmosphere: Expert Knowledge and Environmental Governance*. The MIT Press, Cambridge, MA pp.287–308, .

Jamieson D. (2013). Climate change, consequentialism and the road ahead. *Chicago Journal of International Law* **13**.

Janetos A.C., E. Malone, E. Mastrangelo, K. Hardee, and A. de Bremond (2012). Linking climate change and development goals: framing, integrating, and measuring. *Climate and Development* **4**, 141–156. (DOI: 10.1080/17565529.2012.726195).

Jänicke M. (2012). Dynamic governance of clean-energy markets: how technical innovation could accelerate climate policies. *Journal of Cleaner Production* **22**, 50–59. (DOI: 10.1016/j.jclepro.2011.09.006).

Jasanoff S. (2004). *Earthly Politics: Local and Global in Environmental Governance*. MIT Press, 372 pp., (ISBN: 9780262600590).

Jayaraman T., T. Kaniktar, and M. D'Souza (2011). Equitable access to sustainable development: An Indian approach. In: *Equitable access to sustainable development: Contribution to the body of scientific knowledge*. BASIC expert group, Beijing, Brasilia, Cape Town and Mumbai pp.59–77, .Available at: http://www.erc.uct.ac.za/Basic_Experts_Paper.pdf.

Jonas H. (1985). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*. University of Chicago Press, 267 pp., (ISBN: 9780226405971).

Jones C.M., and D.M. Kammen (2011). Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities. *Environ. Sci. Technol.* **45**, 4088–4095. (DOI: 10.1021/es102221h).

Jones B.F., and B.A. Olken (2005). Do Leaders Matter? National Leadership and Growth Since World War II. *The Quarterly Journal of Economics* **120**, 835–864. (DOI: 10.1093/qje/120.3.835).

Kagawa F., and D. Selby (2010). *Education and Climate Change Living and Learning in Interesting Times Introduction* (F. Kagawa and D. Selby, Eds.). Routledge, London, (ISBN: 978-0-203-86639-9).

Kahneman D., and A. Deaton (2010). High income improves evaluation of life but not emotional well-being. *Proceedings of the National Academy of Sciences* **107**, 16489–16493. (DOI: 10.1073/pnas.1011492107).

Kahneman D., E. Diener, and N. Schwarz (2003). *Well-being : the foundations of hedonic psychology*. Russell Sage Foundation, New York, (ISBN: 9780871544230).

Kals E., and J. Maes (2011). *Justice and conflicts*. Springer, New York, (ISBN: 9783642190346).

Kara S., and W. Li (2011). Unit process energy consumption models for material removal processes. *CIRP Annals - Manufacturing Technology* **60**, 37–40. (DOI: 10.1016/j.cirp.2011.03.018).

Kartha S., P. Baer, T. Athanasiou, and E. Kemp-Benedict (2009). The Greenhouse Development Rights framework. *Climate and Development* **1**, 147–165. (DOI: 10.3763/cdev.2009.0010).

Kates R.W. (2001). Sustainability Science. *Science* **292**, 641–642. (DOI: 10.1126/science.1059386).

Kates R.W., W.R. Travis, and T.J. Wilbanks (2012). Transformational adaptation when incremental adaptations to climate change are insufficient. *Proceedings of the National Academy of Sciences* **109**, 7156–7161. (DOI: 10.1073/pnas.1115521109).

Kaya Y. (1990). Impact of carbon dioxide emissions control on GNP growth: Interpretation of proposed scenarios.

Kellstedt P.M., S. Zahran, and A. Vedlitz (2008). Personal Efficacy, the Information Environment, and Attitudes Toward Global Warming and Climate Change in the United States. *Risk Analysis* **28**, 113–126. (DOI: 10.1111/j.1539-6924.2008.01010.x).

Kemp R. (1994). Technology and the transition to environmental sustainability: The problem of technological regime shifts. *Futures* **26**, 1023–1046. (DOI: 10.1016/0016-3287(94)90071-X).

Keyzer M., and L. Wesenbeeck (2007). The Millennium Development Goals, How Realistic are They? *De Economist* **155**, 139–139. (DOI: 10.1007/s10645-006-9039-5).

Khor M. (2011). Risks and uses of the green economy concept in the context of sustainable development, poverty and equity. *South Centre Research Paper*. Available at: http://www.twnside.org.sg/title2/uncsd2012/RP40_GreenEcon_concept_MKJul11.pdf.

Kilbourne W.E. (2010). Facing the Challenge of Sustainability in a Changing World: An Introduction to the Special Issue. *Journal of Macromarketing* **30**, 109 –111. (DOI: 10.1177/0276146710363726).

Kjellén B. (2004). Pathways to the Future: The New Diplomacy for Sustainable Development. *IDS Bulletin* **35**, 107–113. (DOI: 10.1111/j.1759-5436.2004.tb00143.x).

Klinsky S., and H. Dowlatabadi (2009). Conceptualizations of justice in climate policy. *Climate Policy* **9**, 88–108. (DOI: 10.3763/cpol.2008.0583b).

Knox J.H. (2009). Linking Human Rights and Climate Change at the United Nations. *Harvard Environmental Law Review* **33**, 477.

Kolk A., D. Levy, and J. Pinkse (2008). Corporate Responses in an Emerging Climate Regime: The Institutionalization and Commensuration of Carbon Disclosure. *European Accounting Review* **17**, 719–745. (DOI: 10.1080/09638180802489121).

Kooiman J. (2003). *Governing as Governance*. Sage Publications, Inc, London, Thousand Oaks, New Delhi.

Krausmann F., S. Gingrich, N. Eisenmenger, K.-H. Erb, H. Haberl, and M. Fischer-Kowalski (2009a). Growth in global materials use, GDP and population during the 20th century. *Ecological Economics* **68**, 2696–2705. (DOI: 10.1016/j.ecolecon.2009.05.007).

Krausmann F., S. Gingrich, N. Eisenmenger, K.-H. Erb, H. Haberl, and M. Fischer-Kowalski (2009b). Growth in global materials use, GDP and population during the 20th century. *Ecological Economics* **68**, 2696–2705. (DOI: 10.1016/j.ecolecon.2009.05.007).

Krippner G.R. (2005). The financialization of the American economy. *Socio-Economic Review* **3**, 173–208. (DOI: 10.1093/SER/mwi008).

Krugman P.R. (1979). Increasing returns, monopolistic competition, and international trade. *Journal of International Economics* **9**, 469–479. (DOI: 10.1016/0022-1996(79)90017-5).

Kurtz M.J., and S.M. Brooks (2011). Conditioning the "Resource Curse": Globalization, Human Capital, and Growth in Oil-Rich Nations. *Comparative Political Studies* **44**, 747–770. (DOI: 10.1177/0010414011401215).

Kvaløy B., H. Finseraas, and O. Listhaug (2012). The publics' concern for global warming: A cross-national study of 47 countries. *Journal of Peace Research* **49**, 11–22. (DOI: 10.1177/0022343311425841).

Lane M.S. (2012). *Eco-republic: what the ancients can teach us about ethics, virtue, and sustainable living*. Princeton University Press, Princeton, NJ, 245 pp., (ISBN: 9780691151243).

Lange A., A. Löschel, C. Vogt, and A. Ziegler (2010). On the self-interested use of equity in international climate negotiations. *European Economic Review* **54**, 359–375. (DOI: 10.1016/j.euroecorev.2009.08.006).

Lastovicka J.L., L.A. Bettencourt, R.S. Hughner, and R.J. Kuntze (1999). Lifestyle of the Tight and Frugal: Theory and Measurement. *Journal of Consumer Research* **26**, 85–98. (DOI: 10.1086/209552).

Laurent A., S.I. Olsen, and M.Z. Hauschild (2012). Limitations of Carbon Footprint as Indicator of Environmental Sustainability. *Environ. Sci. Technol.* **46**, 4100–4108. (DOI: 10.1021/es204163f).

Lawn P.A. (2003). A theoretical foundation to support the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI), and other related indexes. *Ecological Economics* **44**, 105–118. (DOI: 10.1016/S0921-8009(02)00258-6).

Layard R. (2005). *Happiness: Lessons from a New Science*. Penguin, London.

Layard R., G. Mayraz, and S. Nickell (2008). The marginal utility of income. *Journal of Public Economics* **92**, 1846–1857.

Leadley P., H.M. Pereira, R. Alkemade, J.F. Fernandez-Manjarrés, V. Proença, J.P.W. Scharlemann, and M.J. Walpole (2010). *Biodiversity Scenarios: Projections of 21st Century Change in Biodiversity and Associated Ecosystem Services : a Technical Report for the Global Biodiversity Outlook 3*. UNEP/Earthprint, 136 pp., (ISBN: 9789292252182).

Lebel L., and S. Lorek (2008). Enabling Sustainable Production-Consumption Systems. *Annual Review of Environment and Resources* **33**, 241–275. (DOI: 10.1146/annurev.environ.33.022007.145734).

Lecocq F., and J.-C. Hourcade (2010). Unspoken ethical issues in the climate affair: Insights from a theoretical analysis of negotiation mandates. *Economic Theory* **49**, 445–471. (DOI: 10.1007/s00199-010-0589-z).

Lecocq F., J.-C. Hourcade, and M. Ha Duong (1998). Decision making under uncertainty and inertia constraints: sectoral implications of the when flexibility. *Energy Economics* **20**, 539–555. (DOI: 10.1016/S0140-9883(98)00012-7).

Lecocq F., and Z. Shalizi (2007). Balancing Expenditures on Mitigation of and Adaptation to Climate Change—An Exploration of Issues Relevant to Developing Countries. World Bank.

Lee R. (2011). The Outlook for Population Growth. *Science* **333**, 569–573. (DOI: 10.1126/science.1208859).

Lee K.-H. (2012). Carbon accounting for supply chain management in the automobile industry. *Journal of Cleaner Production*. (DOI: 10.1016/j.jclepro.2012.02.023). Available at: http://www.sciencedirect.com/science/article/pii/S0959652612000996.

Leiserowitz A., R.W. Kates, and T.M. Parris (2005). Do Global Attitudes and Behaviors Support Sustainable Development? By ANTHONY A. LEISEROWITZ, ROBERT W. KATES, AND THOMAS M. PARRIS. *Environment* **47**, 22–38.

Lenzen M., J. Murray, F. Sack, and T. Wiedmann (2007). Shared producer and consumer responsibility — Theory and practice. *Ecological Economics* **61**, 27–42. (DOI: 10.1016/j.ecolecon.2006.05.018).

Lenzen M., and G.M. Peters (2010). How City Dwellers Affect Their Resource Hinterland. *Journal of Industrial Ecology* **14**, 73–90. (DOI: 10.1111/j.1530-9290.2009.00190.x).

Lenzen M., M. Wier, C. Cohen, H. Hayami, S. Pachauri, and R. Schaeffer (2006). A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan. *Energy* **31**, 181–207. (DOI: 10.1016/j.energy.2005.01.009).

Lenzen M., R. Wood, and T. Wiedmann (2010). UNCERTAINTY ANALYSIS FOR MULTI-REGION INPUT–OUTPUT MODELS – A CASE STUDY OF THE UK'S CARBON FOOTPRINT. *Economic Systems Research* **22**, 43–63. (DOI: 10.1080/09535311003661226).

Levin S.A. (2000). *Fragile dominion : complexity and the commons*. Perseus, Cambridge, Mass.; [Oxford], (ISBN: 073820319X 9780738203195 0738201111 9780738201115).

Li Y., and C.N. Hewitt (2008). The effect of trade between China and the UK on national and global carbon dioxide emissions. *Energy Policy* **36**, 1907–1914. (DOI: 10.1016/j.enpol.2008.02.005).

Li Y., and B. Zhang (2008). Development Path of China and India and the Challenges for their Sustainable Growth. *The World Economy* **31**, 1277–1291. (DOI: 10.1111/j.1467-9701.2008.01128.x).

Liebowitz S.J., and S.E. Margolis (1995). Path Dependence, Lock-in, and History. *Journal of Law, Economics, & Organization* **11**, 205–226.

Lohmann L. (2009). Climate as Investment. *Development and Change* **40**, 1063–1083. (DOI: 10.1111/j.1467-7660.2009.01612.x).

Lohmann L. (2010). Uncertainty Markets and Carbon Markets: Variations on Polanyian Themes. *New Political Economy* **15**, 225–254. (DOI: 10.1080/13563460903290946).

Lorenzoni I., S. Nicholson-Cole, and L. Whitmarsh (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Global Environmental Change* **17**, 445–459. (DOI: 10.1016/j.gloenvcha.2007.01.004).

Lovell H., H. Bulkeley, and D. Liverman (2009). Carbon offsetting: sustaining consumption? *Environment and Planning A* **41**, 2357–2379. (DOI: 10.1068/a40345).

Lutz W., and S. KC (2010). Dimensions of global population projections: what do we know about future population trends and structures? *Philosophical Transactions of the Royal Society B-Biological Sciences* **365**, 2779–2791. (DOI: 10.1098/rstb.2010.0133).

MacDonald G., H. Abarbanel, and P. Carruthers (1979). *JASON. Long term impact of atmospheric carbon dioxide on climate. Technical report*. SRI International, Arlington, VA, US. Available at: http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=5829641.

MacKellar F.L., W. Lutz, C. Prinz, and A. Goujon (1995). Population, Households, and CO2 Emissions. *Population and Development Review* **21**, 849. (DOI: 10.2307/2137777).

Manzini E., and C. Vezzoli (2003). *Product-service Systems and Sustainability: Opportunities for Sustainable Solutions*. United Nations Environment Programme, Division of Technology Industry and Economics, Paris. Available at: http://www.unep.fr/scp/design/pdf/pss-imp-7.pdf.

Marginson D., and L. McAulay (2008). Exploring the debate on short-termism: a theoretical and empirical analysis. *Strategic Management Journal* **29**, 273–292. (DOI: 10.1002/smj.657).

Martin P.L. (2011). Global Governance from the Amazon: Leaving Oil Underground in Yasuni National Park, Ecuador. *Global Environmental Politics* **11**, 22–+.

Martinet V. (2011). A characterization of sustainability with indicators. *Journal of Environmental Economics and Management* **61**, 183–197. (DOI: 10.1016/j.jeem.2010.10.002).

Martinet V. (2012). *Economic theory and sustainable development: what can we preserve for future generations?* Routledge, London ; New York, 203 pp., (ISBN: 9780415544771).

Martínez E., F. Sanz, S. Pellegrini, E. Jiménez, and J. Blanco (2009). Life cycle assessment of a multi-megawatt wind turbine. *Renewable Energy* **34**, 667–673. (DOI: 10.1016/j.renene.2008.05.020).

Martinez-Alier J., G. Kallis, S. Veuthey, M. Walter, and L. Temper (2010). Social Metabolism, Ecological Distribution Conflicts, and Valuation Languages Joan Martinez-Alier a, Giorgos Kallis b,∗, Sandra Veuthey a, Mariana Walter a, Leah Temper. *Ecological Economics* **70**, 153–158.

Martínez-Alier J., U. Pascual, F.-D. Vivien, and E. Zaccai (2010). Sustainable de-growth: Mapping the context, criticisms and future prospects of an emergent paradigm. *Ecological Economics* **69**, 1741–1747. (DOI: 10.1016/j.ecolecon.2010.04.017).

Marvel M.R., and G.T. Lumpkin (2007). Technology entrepreneurs' human capital and its effects on innovation radicalness. *Entrepreneurship Theory and Practice* **31**, 807–828. (DOI: 10.1111/j.1540-6520.2007.00209.x).

Maslow A.H. *Motivation and personality*. Harper & Row, New York.

Mazzucato V., and D. Niemeijer (2002). Population growth and the environment in Africa: Local informal institutions, the missing link. *Economic Geography* **78**, 171–193. (DOI: 10.2307/4140786).

McCormick J. (1991). *Reclaiming paradise : the global environmental movement*. Indiana University Press, Bloomington, (ISBN: 9780253206602).

McCright A.M., and R.E. Dunlap (2011). Cool dudes: The denial of climate change among conservative white males in the United States. *Global Environmental Change* **21**, 1163–1172. (DOI: 10.1016/j.gloenvcha.2011.06.003).

McDonald S., C. Oates, M. Thyne, P. Alevizou, and L.-A. McMorland (2009). Comparing sustainable consumption patterns across product sectors. *International Journal of Consumer Studies* **33**, 137–145. (DOI: 10.1111/j.1470-6431.2009.00755.x).

McFadden J.E., T.L. Hiller, and A.J. Tyre (2011). Evaluating the efficacy of adaptive management approaches: Is there a formula for success? *Journal of Environmental Management* **92**, 1354–1359. (DOI: 10.1016/j.jenvman.2010.10.038).

McShane K. (2007). Why Environmental Ethics Shouldn't Give Up on Intrinsic Value. *Environmental Ethics* **29**, 43–61.

Meade J.E. (1967). Population explosion, the standard of living and social conflict. *The Economic Journal* **77**, 233–255.

Meadows D.H., J. Randers, and D. Meadows (2004). *Limits to Growth: The 30-Year Update*. Chelsea Green, (ISBN: 1931498857).

Mehlum H., K. Moene, and R. Torvik (2006). Cursed by resources or institutions? *World Economy* **29**, 1117–1131. (DOI: 10.1111/j.1467-9701.2006.00808.x).

Metz B., M. Berk, M.G.J. den Elzen, B. de Vries, and D.P. van Vuuren (2002). Towards an equitable global climate change regime: compatibility with Article 2 of the Climate change Convention and the link with sustainable development. *Climate Policy* **2**, 211–230.

Meyer A. (2004). Briefing: Contraction and convergence. *Proceedings of the ICE - Engineering Sustainability* **157**, 189–192. (DOI: 10.1680/ensu.2004.157.4.189).

Milanović B., P.H. Lindert, and J.G. Williamson (2007). *Measuring Ancient Inequality*. National Bureau of Economic Research.

Millennium Ecosystem Assessment (2005a). *Ecosystems and human well-being: synthesis*. Island Press, Washington, DC, 137 pp., (ISBN: 1597260401).

Millennium Ecosystem Assessment (2005b). *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, D.C. Available at: http://www.unep.org/maweb/en/Synthesis.aspx.

Mitchell D. (2008). *A Note on Rising Food Prices*. Available at: http://papers.ssrn.com/abstract=1233058.

Mitchell J., and C. Coles (Eds.) **(2011).** *Markets and rural poverty: upgrading in value chains*. Taylor & Francis UK, London.

Mitchell S.M., and C.G. Thies (2012). Resource Curse in Reverse: How Civil Wars Influence Natural Resource Production. *International Interactions* **38**, 218–242. (DOI: 10.1080/03050629.2012.658326).

Moisander J., A. Markkula, and K. Eräranta (2010). Construction of consumer choice in the market: challenges for environmental policy. *International Journal of Consumer Studies* **34**, 73–79. (DOI: 10.1111/j.1470-6431.2009.00821.x).

Mokyr J. (1992). *The Lever of Riches: Technological Creativity and Economic Progress*. Oxford University Press, Oxford.

Mori K., and A. Christodoulou (2012). Review of sustainability indices and indicators: Towards a new City Sustainability Index (CSI). *Environmental Impact Assessment Review* **32**, 94–106. (DOI: 10.1016/j.eiar.2011.06.001).

Moss R.H., J.A. Edmonds, K.A. Hibbard, M.R. Manning, S.K. Rose, D.P. van Vuuren, T.R. Carter, S. Emori, M. Kainuma, T. Kram, G.A. Meehl, J.F.B. Mitchell, N. Nakicenovic, K. Riahi, S.J. Smith, R.J. Stouffer, A.M. Thomson, J.P. Weyant, and T.J. Wilbanks (2010). The next generation of scenarios for climate change research and assessment. *Nature* **463**, 747–756. (DOI: 10.1038/nature08823).

Moulin H. (2003). *Fair division and collective welfare*. MIT Press, Cambridge, Mass., (ISBN: 0262134233 9780262134231 0262633116 9780262633116).

Müller B. (1999). *Justice in Global Warming Negotiations: How to Obtain a Procedurally Fair Compromise*. Oxford Institute for Energy Studies, Oxford, UK. Available at: http://www.oxfordenergy.org/1998/03/justice-in-global-warming-negotiations-how-to-obtain-a-procedurally-fair-compromise/.

Müller B., N. Höhne, and C. Ellermann (2009). Differentiating (historic) responsibilities for climate change. *Climate Policy* **9**, 593–611. (DOI: 10.3763/cpol.2008.0570).

Muradian R., M. Walter, and J. Martinez-Alier (2012). Hegemonic transitions and global shifts in social metabolism: Implications for resource-rich countries. Introduction to the special section. *Global Environmental Change*. (DOI: 10.1016/j.gloenvcha.2012.03.004). Available at: http://www.sciencedirect.com/science/article/pii/S0959378012000283.

Murdiyarso D. (2010). Climate and development - the challenges in delivering the promises: an editorial essay. *Wiley Interdisciplinary Reviews: Climate Change* **1**, 765–769. (DOI: 10.1002/wcc.19).

Nakicenovic N., J. Alcamo, G. Davis, B. de Vries, J. Fenhann, S. Gaffin, K. Gregory, A. Grübler, T.Y. Jung, T. Kram, E.L. La Rovere, L. Michaelis, S. Mori, T. Morita, W. Pepper, H. Pitcher, L. Price, K. Riahi, A. Roehrl, H.-H. Rogner, A. Sankovski, M. Schlesinger, P. Shukla, S. Smith, R. Swart, S. van Rooijen, N. Victor, and Z. Dadi (2000). *Special Report on Emissions Scenarios* (N. Nakicenovic and R. Swart, Eds.). Intergovernmental Panel on Climate Change, The Hague. Available at: http://www.grida.no/publications/other/ipcc_sr/?src=/climate/ipcc/emission.

Nakicenovic N., and R. Swart (Eds.) **(2000).** *Emissions Scenarios*. Cambridge University Press, UK, Cambridge, UK, 570 pp. Available at: http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=0.

National Cancer Institute (NCI) (2011). NCI Thesaurus - Cell Differentiation or Development Pathway - Terms | NCBO BioPortal. Available at: http://bioportal.bioontology.org/ontologies/45400/?p=terms&conceptid=Cell_Differentiation_or_Development_Pathway#details.

Negro S.O., F. Alkemade, and M.P. Hekkert (2012). Why does renewable energy diffuse so slowly? A review of innovation system problems. *Renewable and Sustainable Energy Reviews* **16**, 3836–3846. (DOI: 10.1016/j.rser.2012.03.043).

Nelson R.R., and S.G. Winter (2002). Evolutionary Theorizing in Economics. *The Journal of Economic Perspectives* **16**, 23–46.

Nemet G.F., and D.M. Kammen (2007). US energy research and development: Declining investment, increasing need, and the feasibility of expansion. *Energy Policy* **35**, 746–755. (DOI: 10.1016/j.enpol.2005.12.012).

Neumayer E. (2000). In defence of historical accountability for greenhouse gas emissions. *Ecological Economics* **33**, 185–192. (DOI: 10.1016/S0921-8009(00)00135-X).

Neumayer E. (2010). *Weak versus strong sustainability: exploring the limits of two opposing paradigms*. Edward Elgar, Cheltenham, UK ; Northhampton, MA, 272 pp., (ISBN: 9781848448728).

Newell P., and M. Paterson (2010). *Climate Capitalism. Global Warming and the Transformation of the Global Economy*. Cambridge University Press, Cambridge.

Norenzayan A. (2011). Explaining Human Behavioral Diversity. *Science* **332**, 1041–1042. (DOI: 10.1126/science.1207050).

Norgaard K.M. (2011). *Living in Denial: Climate Change, Emotions, and Everyday Life*. MIT Press, 300 pp., (ISBN: 9780262515856).

Norwegian Ministry of Environment (1994). Symposium: Sustainable consumption, Oslo, 19-20 January 1994. Norwegian Ministry of Environment, Oslo. 1994, .Available at: http://www.regjeringen.no/nb/dokumentarkiv/regjeringen-brundtland-iii/smk/taler-og-artikler-arkivert-individuelt/1994/address-to-symposium-on-sustainable-cons.html?id=558605.

Van Notten P.W.., J. Rotmans, M.B.. van Asselt, and D.S. Rothman (2003). An updated scenario typology. *Futures* **35**, 423–443. (DOI: 10.1016/S0016-3287(02)00090-3).

O'Brien K. (2011). Global environmental change II: From adaptation to deliberate transformation. *Progress in Human Geography* **36**, 667–676. (DOI: 10.1177/0309132511425767).

O'Neill B.C., L.F. MacKellar, and W. Lutz (2001). *Population and Climate Change*. Cambridge University Press, Cambridge.

Oberheitmann A. (2010). A new post-Kyoto climate regime based on per-capita cumulative CO2-emission rights—rationale, architecture and quantitative assessment of the implication for the CO2-emissions from China, India and the Annex-I countries by 2050. *Mitigation and Adaptation Strategies for Global Change* **15**, 137–168. (DOI: 10.1007/s11027-009-9207-4).

Ockwell D.G., R. Haum, A. Mallett, and J. Watson (2010). Intellectual property rights and low carbon technology transfer: Conflicting discourses of diffusion and development. *Global Environmental Change* **20**, 729–738. (DOI: 10.1016/j.gloenvcha.2010.04.009).

OECD (2011). *Towards Green Growth*. OECD Publishing, Paris, 142 pp., (ISBN: 9789264094970). Available at: http://www.oecd.org/document/10/0,3746,en_2649_37465_47983690_1_1_1_37465,00.html.

Oishi S., S. Kesebir, and E. Diener (2011). Income Inequality and Happiness. *Psychlogical Science* **22**, 1095–1100. (DOI: 10.1177/0956797611417262).

Okereke C. (2008). *Global justice and neoliberal environmental governance*. Routledge, London.

Okereke C. (2010). Climate justice and the international regime. *Wiley Interdisciplinary Reviews-Climate Change* **1**, 462–474. (DOI: 10.1002/wcc.52).

Okereke C. (2011). Moral Foundations for Global Environmental and Climate Justice. *Royal Institute of Philosophy Supplements* **69**, 117–135. (DOI: 10.1017/S1358246111000245).

Okereke C., H. Bulkeley, and H. Schroeder (2009). Conceptualizing Climate Governance Beyond the International Regime. *Global Environmental Politics* **9**, 58–+. (DOI: 10.1162/glep.2009.9.1.58).

Okereke C., and K. Dooley (2010). Principles of justice in proposals and policy approaches to avoided deforestation: Towards a post-Kyoto climate agreement. *Global Environmental Change-Human and Policy Dimensions* **20**, 82–95. (DOI: 10.1016/j.gloenvcha.2009.08.004).

Okereke C., and D. McDaniels (2012). To what extent are EU steel companies susceptible to competitive loss due to climate policy? *Energy Policy* **46**, 203–215. (DOI: 10.1016/j.enpol.2012.03.052).

Olsen K.H. (2007). The clean development mechanism's contribution to sustainable development: A review of the literature. *Climatic Change*, 59–73.

Osbaldiston R., and J.P. Schott (2012). Environmental Sustainability and Behavioral Science: Meta-Analysis of Proenvironmental Behavior Experiments. *Environment and Behavior* **44**, 257–299. (DOI: 10.1177/0013916511402673).

Ostrom E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press, 302 pp., (ISBN: 9780521405997).

Ostrom E., J. Burger, C.B. Field, R.B. Norgaard, and D. Policansky (1999). Revisiting the Commons: Local Lessons, Global Challenges. *Science* **284**, 278–282. (DOI: 10.1126/science.284.5412.278).

Paavola J., and W.N. Adger (2006). Fair adaptation to climate change. *Ecological Economics* **56**, 594–609. (DOI: 10.1016/j.ecolecon.2005.03.015).

Page S.E. (2006). Path Dependence. *Quarterly Journal of Political Science* **1**, 87–115. (DOI: 10.1561/100.00000006).

Page E.A. (2008). Distributing the burdens of climate change. *Environmental Politics* **17**, 556–575. (DOI: 10.1080/09644010802193419).

Paillard S., S. Treyer, and B. Dorin (2010). *Agrimonde: Scénarios et défis pour nourrir le monde en 2050*. Editions Quae, 298 pp., (ISBN: 9782759208883).

Palley T. (2007). Financialization: What it is and Why it Matters. *PERI Working Papers*. Available at: http://scholarworks.umass.edu/peri_workingpapers/135.

Pan J., J. Phillips, and Y. Chen (2008). China's balance of emissions embodied in trade: approaches to measurement and allocating international responsibility. *Oxford Review of Economic Policy* **24**, 354–376. (DOI: 10.1093/oxrep/grn016).

Pandey D., M. Agrawal, and J. Pandey (2011). Carbon footprint: current methods of estimation. *Environmental Monitoring and Assessment* **178**, 135–160. (DOI: 10.1007/s10661-010-1678-y).

Parthan B., M. Osterkorn, M. Kennedy, S.J. Hoskyns, M. Bazilian, and P. Monga (2010). Lessons for low-carbon energy transition: Experience from the Renewable Energy and Energy Efficiency Partnership (REEEP). *Energy for Sustainable Development* **14**, 83–93. (DOI: 10.1016/j.esd.2010.04.003).

Paterson M. (2009). Global governance for sustainable capitalism? The political economy of global environmental governance. In: *Governing Sustainability*. Cambridge University Press, Cambridge pp.99–122, (ISBN: 9780521732437).

Pattberg P. (2010). Public-private partnerships in global climate governance. *Wiley Interdisciplinary Reviews-Climate Change* **1**, 279–287. (DOI: 10.1002/wcc.38).

Patzelt H. (2010). CEO human capital, top management teams, and the acquisition of venture capital in new technology ventures: An empirical analysis. *Journal of Engineering and Technology Management* **27**, 131–147. (DOI: 10.1016/j.jengtecman.2010.06.001).

De Paula Gomes M.S., and M.S. Muylaert de Araujo (2011). Artificial cooling of the atmosphere-A discussion on the environmental effects. *Renewable & Sustainable Energy Reviews* **15**, 780–786. (DOI: 10.1016/j.rser.2010.07.045).

Pelling M. (2010). *Adaptation to Climate Change: From Resilience to Transformation*. Taylor & Francis US, 220 pp., (ISBN: 9780415477505).

Pendergast S.M., J.A. Clarke, and G.C. van Kooten (2011). Corruption, Development and the Curse of Natural Resources. *Canadian Journal of Political Science-Revue Canadienne De Science Politique* **44**, 411–437. (DOI: 10.1017/S0008423911000114).

Pepper M., T. Jackson, and D. Uzzell (2009). An examination of the values that motivate socially conscious and frugal consumer behaviours. *International Journal of Consumer Studies* **33**, 126–136. (DOI: 10.1111/j.1470-6431.2009.00753.x).

Pereira H.M., P.W. Leadley, V. Proença, R. Alkemade, J.P.W. Scharlemann, J.F. Fernandez-Manjarrés, M.B. Araújo, P. Balvanera, R. Biggs, W.W.L. Cheung, L. Chini, H.D. Cooper, E.L. Gilman, S. Guénette, G.C. Hurtt, H.P. Huntington, G.M. Mace, T. Oberdorff, C. Revenga, P. Rodrigues, R.J. Scholes, U.R. Sumaila, and M. Walpole (2010). Scenarios for Global Biodiversity in the 21st Century. *Science* **330**, 1496–1501. (DOI: 10.1126/science.1196624).

Peters G.P. (2010). Carbon footprints and embodied carbon at multiple scales. *Current Opinion in Environmental Sustainability* **2**, 245–250. (DOI: 10.1016/j.cosust.2010.05.004).

Peters G.P., S.J. Davis, and R. Andrew (2012). A synthesis of carbon in international trade. *Biogeosciences* **9**, 3247–3276. (DOI: 10.5194/bg-9-3247-2012).

Peters G.P., and E.G. Hertwich (2008). Post-Kyoto greenhouse gas inventories: production versus consumption RID B-1012-2008. *Climatic Change* **86**, 51–66. (DOI: 10.1007/s10584-007-9280-1).

Peters G.P., J.C. Minx, C.L. Weber, and O. Edenhofer (2011). Growth in emission transfers via international trade from 1990 to 2008. *Proceedings of the National Academy of Sciences* **108**, 8903–8908. (DOI: 10.1073/pnas.1006388108).

Peters G.P., C.L. Weber, D. Guan, and K. Hubacek (2007). China's Growing CO2 EmissionsA Race between Increasing Consumption and Efficiency Gains. *Environmental Science & Technology* **41**, 5939–5944. (DOI: 10.1021/es070108f).

Pezzey J.C.V. (2004). One-sided sustainability tests with amenities, and changes in technology, trade and population. *Journal of Environmental Economics and Management* **48**, 613–631. (DOI: 10.1016/j.jeem.2003.10.002).

Pezzey J.C.V., and M. Toman (2002). Progress and problems in the economics of sustainability. In: *International Yearbook of Environmental and Resource Economics 2002/2003*. Edward Elgar Publishing, .

Pickering J., and C. Barry (2012). On the concept of climate debt: its moral and political value. *Critical Review of International Social and Political Philosophy* **15**, 667–685. (DOI: 10.1080/13698230.2012.727311).

Pidgeon N.F., I. Lorenzoni, and W. Poortinga (2008). Climate change or nuclear power - No thanks! A quantitative study of public perceptions and risk framing in Britain. *Global Environmental Change-Human and Policy Dimensions* **18**, 69–85. (DOI: 10.1016/j.gloenvcha.2007.09.005).

Pimentel D., A. Marklein, M.A. Toth, M.N. Karpoff, G.S. Paul, R. McCormack, J. Kyriazis, and T. Krueger (2009). Food Versus Biofuels: Environmental and Economic Costs. *Human Ecology* **37**, 1–12. (DOI: 10.1007/s10745-009-9215-8).

Pimentel D., and M.G. Paoletti (2009). *Developing a 21st Century View of Agriculture and the Environment* (N. Ferry and A.M.R. Gatehouse, Eds.). Cabi Publishing-C a B Int, Wallingford, (ISBN: 978-1-84593-409-5).

Plassmann K., A. Norton, N. Attarzadeh, M.P. Jensen, P. Brenton, and G. Edwards-Jones (2010). Methodological complexities of product carbon footprinting: a sensitivity analysis of key variables in a developing country context. *Environmental Science & Policy* **13**, 393–404. (DOI: 10.1016/j.envsci.2010.03.013).

Plevin R.J., M. O'Hare, A.D. Jones, M.S. Torn, and H.K. Gibbs (2010). Greenhouse Gas Emissions from Biofuels' Indirect Land Use Change Are Uncertain but May Be Much Greater than Previously Estimated. *Environ. Sci. Technol.* **44**, 8015–8021. (DOI: 10.1021/es101946t).

Van der Ploeg F. (2011). Natural Resources: Curse or Blessing? *Journal of Economic Literature* **49**, 366–420. (DOI: 10.1257/jel.49.2.366).

Pogutz S., and V. Micale (2011). Sustainable consumption and production. *Society and Economy* **33**, 29–50. (DOI: 10.1556/SocEc.33.2011.1.5).

Polasky S., S.R. Carpenter, C. Folke, and B. Keeler (2011). Decision-making under great uncertainty: environmental management in an era of global change. *Trends in Ecology & Evolution* **26**, 398–404. (DOI: 10.1016/j.tree.2011.04.007).

Polsky C., and H. Eakin (2011). Global change vulnerability assessments: Definitions, challenges, and opportunities. In: *The Oxford Handbook of Climate Change and Society*. Oxford University Press, (ISBN: 9780199566600).

Pope J., D. Annandale, and A. Morrison-Saunders (2004). Conceptualising sustainability assessment. *Environmental Impact Assessment Review* **24**, 595–616. (DOI: 10.1016/j.eiar.2004.03.001).

Posner E.A. (2007). *Climate Change and International Human Rights Litigation: A Critical Appraisal*. Social Science Research Network, Rochester, NY. Available at: http://papers.ssrn.com/abstract=959748.

Posner E.A., and C.R. Sunstein (2007). Climate Change Justice. *Georgetown Law Journal* **96**, 1565.

Posner E.A., and D. Weisbach (2010). *Climate Change Justice*. Princeton University Press, 231 pp., (ISBN: 9780691137759).

Posner E.A., and D. Weisbach (2012). International Paretianism: A Defense. Available at: http://papers.ssrn.com/abstract=2120650.

Poteete A.R. (2009). Is Development Path Dependent or Political? A Reinterpretation of Mineral-Dependent Development in Botswana. *Journal of Development Studies* **45**, 544–571. (DOI: 10.1080/00220380802265488).

Potts M. (2007). Population and environment in the twenty-first century. *Population and Environment* **28**, 204–211. (DOI: 10.1007/s11111-007-0045-6).

Poumadere M., R. Bertoldo, and J. Samadi (2011). Public perceptions and governance of controversial technologies to tackle climate change: nuclear power, carbon capture and storage, wind, and geoengineering. *Wiley Interdisciplinary Reviews-Climate Change* **2**, 712–727. (DOI: 10.1002/wcc.134).

Pow C.-P. (2011). Living it up: Super-rich enclave and transnational elite urbanism in Singapore. *Geoforum* **42**, 382–393. (DOI: 10.1016/j.geoforum.2011.01.009).

Prescott-Allen R. (1980). *How to save the world : strategy for world conservation*. Barnes and Noble Books, Totowa, N.J., (ISBN: 0389200115 9780389200116).

Ramanathan V., and Y. Xu (2010). The Copenhagen Accord for limiting global warming: Criteria, constraints, and available avenues. *Proceedings of the National Academy of Sciences of the United States of America* **107**, 8055–8062. (DOI: 10.1073/pnas.1002293107).

Rao N., and P. Baer (2012). "Decent Living" Emissions: A Conceptual Framework. *Sustainability* **4**, 656–681. (DOI: 10.3390/su4040656).

Rao K.U., and V.V.N. Kishore (2010). A review of technology diffusion models with special reference to renewable energy technologies. *Renewable and Sustainable Energy Reviews* **14**, 1070–1078. (DOI: 10.1016/j.rser.2009.11.007).

Rasch P.J., P.J. Crutzen, and D.B. Coleman (2008). Exploring the geoengineering of climate using stratospheric sulfate aerosols: The role of particle size. *Geophysical Research Letters* **35**. (DOI: 10.1029/2007GL032179).

Raskin P.D., C. Electris, and R.A. Rosen (2010). The Century Ahead: Searching for Sustainability. *Sustainability* **2**, 2626–2651. (DOI: 10.3390/su2082626).

Rawls J. (2000). *A theory of justice.* Belknap, Cambridge Mass., (ISBN: 9780674000773).

Raymond L.S. (2003). *Private Rights in Public Resources: Equity and Property Allocation in Market-Based Environmental Policy*. Resources for the Future, 268 pp., (ISBN: 9781891853685).

Rayner S. (2010). How to eat an elephant: a bottom-up approach to climate policy. *Climate Policy* **10**, 615–621. (DOI: 10.3763/cpol.2010.0138).

Van Renssen S. (2011). POLICY WATCH: The case for adaptation funding. *Nature Climate Change* **1**, 19–20.

Republic of Korea (2009). *Road to Our Future: Green Growth, National Strategy and the Five-Year Plan (2009-2013)*. Presidential commission on green growth, Seoul. Available at: http://www.greengrowth.go.kr/english/en_information/en_report/userBbs/bbsView.do.

Riisgaard L. (2009). Global Value Chains, Labor Organization and Private Social Standards: Lessons from East African Cut Flower Industries. *World Development* **37**, 326–340. (DOI: 10.1016/j.worlddev.2008.03.003).

Ringius L., A. Torvanger, and A. Underdal (2002). Burden Sharing and Fairness Principles in International Climate Policy. *International Environmental Agreements: Politics, Law and Economics* **2**, 1–22. (DOI: 10.1023/A:1015041613785).

Rist G. (2003). *The History of Development: From Western Origins to Global Faith*. Zed Books, 308 pp., (ISBN: 9781842771815).

Rival L. (2010). Ecuador's Yasuni-ITT Initiative The old and new values of petroleum. *Ecological Economics* **70**, 358–365. (DOI: 10.1016/j.ecolecon.2010.09.007).

Rive N., A. Torvanger, and J.S. Fuglestvedt (2006). Climate agreements based on responsibility for global warming: Periodic updating, policy choices, and regional costs. *Global Environmental Change* **16**, 182–194. (DOI: 10.1016/j.gloenvcha.2006.01.002).

Roberts J.T., and B.C. Parks (2007). *A Climate of Injustice. Global Inequality, North-South Politics, and Climate Policy*. MIT Press, Cambridge Mass., 404 pp.

Robinson J., M. Bradley, P. Busby, D. Connor, A. Murray, B. Sampson, and W. Soper (2006). Climate change and sustainable development: realizing the opportunity. *Ambio* **35**, 2–8.

Rockström J., W. Steffen, K. Noone, A. Persson, F.S. Chapin, E.F. Lambin, T.M. Lenton, M. Scheffer, C. Folke, H.J. Schellnhuber, B. Nykvist, C.A. de Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sorlin, P.K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R.W. Corell, V.J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J.A. Foley (2009a). Planetary Boundaries: Exploring the safe operating space for humanity. *Ecology and Society* **14**.

Rockström J., W. Steffen, K. Noone, A. Persson, F.S. Chapin, E.F. Lambin, T.M. Lenton, M. Scheffer, C. Folke, H.J. Schellnhuber, B. Nykvist, C.A. de Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sorlin, P.K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R.W. Corell, V.J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J.A. Foley (2009b). A safe operating space for humanity. *Nature* **461**, 472–475. (DOI: 10.1038/461472a).

Roemer J., and K. Suzumura (2007). *Intergenerational equity and sustainability*. Palgrave Macmillan, Basingstoke ;New York, (ISBN: 9780230007864).

Rohan M.J. (2000). A Rose by Any Name? The Values Construct. *Personality and Social Psychology Review* **4**, 255–277. (DOI: 10.1207/S15327957PSPR0403_4).

Roitner-Schobesberger B., I. Darnhofer, S. Somsook, and C.R. Vogl (2008). Consumer perceptions of organic foods in Bangkok, Thailand. *Food Policy* **33**, 112–121. (DOI: 10.1016/j.foodpol.2007.09.004).

Romer P.M. (1990). Endogenous Technological Change. *Journal of Political Economy* **98**, S71–S102.

Rose A. (1990). Reducing conflict in global warming policy: The potential of equity as a unifying principle. *Energy Policy* **18**, 927–935. (DOI: 10.1016/0301-4215(90)90127-P).

Rosenau J.N. (1990). *Turbulence in World Politics: A Theory of Change and Continuity*. Princeton University Press, Princeton.

Rudra N., and N.M. Jensen (2011). Globalization and the Politics of Natural Resources. *Comparative Political Studies* **44**, 639–661. (DOI: 10.1177/0010414011401207).

Ruiz-Mallén I., and E. Corbera (2013). Community-Based Conservation and Traditional Ecological Knowledge: Implications for socio-ecological resilience. *Ecology and Society* **forthcoming**.

Sachs, Wolfgang (1999). *Planet Dialectics: Explorations in Environment and Development*. Zed Books Ltd., London, UK and New York, NY, 230 pp., (ISBN: 1 85649 700 3). Available at: http://books.google.com/books?hl=en&lr=&id=0rBPM3qkHncC&oi=fnd&pg=PR8&dq=Sachs,+Wolfgang&ots=Fm8LFgapAl&sig=RVtUCjJ5MbNCePdI5tj9N82ezR4.

Sacks D.W., B. Stevenson, and J. Wolfers (2010). *SUBJECTIVE WELL-BEING, INCOME, ECONOMIC DEVELOPMENT AND GROWTH*. NBER. Available at: http://www.nber.org/papers/w16441.

Sæverud I.A., and J.B. Skjærseth (2007). Oil Companies and Climate Change: Inconsistencies between Strategy Formulation and Implementation? *Global Environmental Politics* **7**, 42–62. (DOI: 10.1162/glep.2007.7.3.42).

Sagar A.D., C. Bremner, and M.J. Grubb (2009). Climate Innovation Centres: A partnership approach to meeting energy and climate challenges. *Natural Resources Forum* **33**, 274–284.

Samaras C., and K. Meisterling (2008). Life Cycle Assessment of Greenhouse Gas Emissions from Plug-in Hybrid Vehicles: Implications for Policy. *Environmental Science & Technology* **42**, 3170–3176. (DOI: 10.1021/es702178s).

Sanne C. (2002). Willing consumers—or locked-in? Policies for a sustainable consumption. *Ecological Economics* **42**, 273–287. (DOI: 10.1016/S0921-8009(02)00086-1).

Sanwal M. (2010). Climate change and global sustainability: The need for a new paradigm for international cooperation. *Climate and Development* **2**, 3–8. (DOI: 10.3763/cdev.2010.0030).

Sanwal M. (2011). Climate change and the Rio +20 summit: A developing country perspective. *Climate and Development* **3**, 89–93. (DOI: 10.1080/17565529.2011.582274).

Sarewitz D. (2011). Does climate change knowledge really matter? *Wiley Interdisciplinary Reviews: Climate Change* **2**, 475–481. (DOI: 10.1002/wcc.126).

Sathaye J., A. Najam, J. Robinson, R. Schaeffer, Y. Sokona, R. Swart, H. Winkler, C. Cocklin, T. Heller, F. Lecocq, J. Llanes-Regueiro, J. Pan, G. Petschel-Held, and S. Rayner (2007). Sustainable development and mitigation. In: *Climate Change 2007 : Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the IPCC*. B. Metz, O.R. Davidson, P.R. Bosh, R. Dave, L.A. Meyer, (eds.), Cambridge University Press, Cambridge (GBR) pp.692–743, .Available at: http://www.brookings.edu/press/Books/2008/climatechangeandforests.aspx.

Schandl H., and J. West (2010). Resource use and resource efficiency in the Asia-Pacific region. *Global Environmental Change-Human and Policy Dimensions* **20**, 636–647. (DOI: 10.1016/j.gloenvcha.2010.06.003).

Scheidel A., and A.H. Sorman (2012). Energy transitions and the global land rush: Ultimate drivers and persistent consequences. *Global Environmental Change*. (DOI: 10.1016/j.gloenvcha.2011.12.005). Available at: http://www.sciencedirect.com/science/article/pii/S0959378011002068.

Schelling T. (1995). Intergenerational discounting. *Energy Policy* **23**, 395–401.

Schelling T. (2006). Global Warming: Intellectual History and Strategic Choices. Resources for the Future, Washington, D.C. 2006, .

Scherbov S., W. Lutz, and W.C. Sanderson (2011). The Uncertain Timing of Reaching 8 Billion, Peak World Population, and Other Demographic Milestones. *Population and Development Review* **37**, 571–+. (DOI: 10.1111/j.1728-4457.2011.00435.x).

Schmidheiny S., and WBSCD (1992). *Changing Course: A Global Business Perspective on Development and the Environment*. MIT Press.

Schmidt-Bleek F. (2008). Factor 10: The future of stuff. *Sustainability: Science, Practice, & Policy* **4**. Available at: http://sspp.proquest.com/archives/vol4iss1/editorial.schmidt-bleek.html.

Schokkaert E. (2009). The capabilities approach. In: *The Handbook of Rational and Social Choice*. P. Anand, P.K. Pattanaik, C. Puppe, (eds.), Oxford University Press, pp.542–566, .

Schopenhauer A. (1819). *Le monde comme volonté et comme représentation (Die Welt als Wille und Vorstellung) trad. A. Bureau, 1966*. Presses Universitaires de France, Paris.

Schrader U., and J. Thøgersen (2011). Putting Sustainable Consumption into Practice. *Journal of Consumer Policy* **34**, 3–8. (DOI: 10.1007/s10603-011-9154-9).

Schultz T.W. (1961). Investment in Human Capital. *The American Economic Review* **51**, 1–17.

Schwartz S.H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. In: *Advances in Experimental Social Psychology*. Academic Press, San Diego(ISBN: 0-12-015225-8).

Schwartz S.H. (1994). Are There Universal Aspects in the Structure and Contents of Human Values? *Journal of Social Issues* **50**, 19–45. (DOI: 10.1111/j.1540-4560.1994.tb01196.x).

Schwartz S.H., and W. Bilsky (1987). Toward a universal psychological structure of human values. *Journal of Personality and Social Psychology* **53**, 550–562. (DOI: 10.1037/0022-3514.53.3.550).

Scott K.N. (2013). International Law in the Anthropocene: Responding to the Geoengineering Challenge. *Michigan Journal of International Law* **35**.

Semenza J.C., D. Hall, D. Wilson, B. Bontempo, D. Sailor, and L. George (2008). Public Perception of Climate Change Voluntary Mitigation and Barriers to Behavior Change. *American Journal of Preventive Medicine* **35**, 479–487.

Sen A. (1997). Editorial: Human Capital and Human Capability. *World Development* **25**, 1959–1961.

Sen A. (2001). *Development as freedom*. Oxford University Press, Oxford; New York, (ISBN: 0192893300 9780192893307).

Sen A.K. (2009). *The idea of justice*. Belknap Press of Harvard University Press, Cambridge, Mass., (ISBN: 9780674036130 0674036131).

Seres S., E. Haites, and K. Murphy (2009). Analysis of technology transfer in CDM projects: An update. *Energy Policy* **37**, 4919–4926. (DOI: 10.1016/j.enpol.2009.06.052).

Shackley S., C. McLachlan, and C. Gough (2005). The public perception of carbon dioxide capture and storage in the UK: results from focus groups and a survey. *Climate Policy* **4**, 377–398.

Shalizi Z., and F. Lecocq (2009). *Climate Change and the Economics of Targeted Mitigation in Sectors with Long-Lived Capital Stock*. World Bank, Washington, D.C. 41 pp. Available at: http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2009/09/23/000158349_20090923161232/Rendered/PDF/WPS5063.pdf.

Shalizi Z., and F. Lecocq (2010). To Mitigate or to Adapt: Is that the Question? Observations on an Appropriate Response to the Climate Change Challenge to Development Strategies. *The World Bank Research Observer* **25**, 295 –321. (DOI: 10.1093/wbro/lkp012).

Sharma A., A. Saxena, M. Sethi, V. Shree, and Varun (2011). Life cycle assessment of buildings: A review. *Renewable and Sustainable Energy Reviews* **15**, 871–875. (DOI: 10.1016/j.rser.2010.09.008).

Shaw D., and T. Newholm (2002). Voluntary simplicity and the ethics of consumption. *Psychology and Marketing* **19**, 167–185. (DOI: 10.1002/mar.10008).

Shrader-Frechette K. (2011). Climate Change, Nuclear Economics, and Conflicts of Interest. *Science and Engineering Ethics* **17**, 75–107. (DOI: 10.1007/s11948-009-9181-y).

Shue H. (1993). Subsistence Emissions and Luxury Emissions. *Law & Policy* **15**, 39–60. (DOI: 10.1111/j.1467-9930.1993.tb00093.x).

Shue H. (1999). Global Environment and International Inequality, Global Environment and International Inequality. *International Affairs, International Affairs* **75**, 531–545. (DOI: 10.1111/1468-2346.00092, 10.1111/1468-2346.00092).

Shui B., and R.C. Harriss (2006). The role of CO2 embodiment in US–China trade. *Energy Policy* **34**, 4063–4068. (DOI: 10.1016/j.enpol.2005.09.010).

Sinden G. (2009). The contribution of PAS 2050 to the evolution of international greenhouse gas emission standards. *The International Journal of Life Cycle Assessment* **14**, 195–203. (DOI: 10.1007/s11367-009-0079-3).

Singer P. (2004). *One World: The Ethics of Globalization*. Yale University Press, 264 pp., (ISBN: 9780300103052).

Smith K.R. (1991). Allocating Responsibility for Global Warming: The Natural Debt Index. *Ambio* **20**, 95–96.

Smith J.B., T. Dickinson, J.D.B. Donahue, I. Burton, E. Haites, R.J.T. Klein, and A. Patwardhan (2011). Development and climate change adaptation funding: coordination and integration. *Climate Policy* **11**, 987–1000. (DOI: 10.1080/14693062.2011.582385).

Smith P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko, M. Howden, T. McAllister, G. Pan, V. Romanenkov, U. Schneider, and S. Towprayoon (2007). Policy and technological constraints to implementation of greenhouse gas mitigation options in agriculture. *Agriculture Ecosystems & Environment* **118**, 6–28. (DOI: 10.1016/j.agee.2006.06.006).

Smith K.R., J. Swisher, and D. Ahuja (1993). Who pays to solve the problem and how much? also Working Paper No. 1991-22, World Bank Environment Department. In: *The Global Greenhouse Regime: Who Pays?* P. Hayes, K.R. Smith, (eds.), Earthscan, Oxford, UK pp.70–98, (ISBN: 9781853831362).

Sneddon C., R.B. Howarth, and R.B. Norgaard (2006). Sustainable development in a post-Brundtland world. *Ecological Economics* **57**, 253–268. (DOI: 10.1016/j.ecolecon.2005.04.013).

Soimakallio S., J. Kiviluoma, and L. Saikku (2011). The complexity and challenges of determining GHG (greenhouse gas) emissions from grid electricity consumption and conservation in LCA (life cycle assessment) – A methodological review. *Energy* **36**, 6705–6713. (DOI: 10.1016/j.energy.2011.10.028).

Sokka L., S. Pakarinen, and M. Melanen (2011). Industrial symbiosis contributing to more sustainable energy use – an example from the forest industry in Kymenlaakso, Finland. *Journal of Cleaner Production* **19**, 285–293. (DOI: 10.1016/j.jclepro.2009.08.014).

Solow R.M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics* **70**, 65–94.

Solow R.M. (2000). Toward a Macroeconomics of the Medium Run. *The Journal of Economic Perspectives* **14**, 151–158.

Soroos M.S. (1997). *The Endangered Atmosphere: Preserving a Global Commons*. Univ of South Carolina Pr, 339 pp., (ISBN: 1570031606).

Speth J.G., and P. Haas (2006). *Global Environmental Governance: Foundations of Contemporary Environmental Studies*. Island Press, 192 pp., (ISBN: 1597260819).

Srinivasan U.T., S.P. Carey, E. Hallstein, P.A.T. Higgins, A.C. Kerr, L.E. Koteen, A.B. Smith, R. Watson, J. Harte, and R.B. Norgaard (2008). The debt of nations and the distribution of ecological impacts from human activities. *Proceedings of the National Academy of Sciences* **105**, 1768 –1773. (DOI: 10.1073/pnas.0709562104).

Starkey R. (2011). Assessing common(s) arguments for an equal per capita allocation. *The Geographical Journal* **177**, 112–126. (DOI: 10.1111/j.1475-4959.2010.00359.x).

Stechemesser K., and E. Guenther (2012). Carbon accounting: a systematic literature review. *Journal of Cleaner Production*. (DOI: 10.1016/j.jclepro.2012.02.021). Available at: http://www.sciencedirect.com/science/article/pii/S0959652612000972.

Steckel J.C., M. Kalkuhl, and R. Marschinski (2010). Should carbon-exporting countries strive for consumption-based accounting in a global cap-and-trade regime? *Climatic Change* **100**, 779–786. (DOI: 10.1007/s10584-010-9825-6).

Steen-Olsen K., J. Weinzettel, G. Cranston, A.E. Ercin, and E.G. Hertwich (2012). Carbon, Land, and Water Footprint Accounts for the European Union: Consumption, Production, and Displacements through International Trade. *Environmental Science & Technology* **46**, 10883–10891. (DOI: 10.1021/es301949t).

Steffen W., J. Grinevald, P. Crutzen, and J. McNeill (2011). The Anthropocene: conceptual and historical perspectives. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* **369**, 842–867. (DOI: 10.1098/rsta.2010.0327).

Stern N.H., and G.B. Treasury (2007). *The economics of climate change: the Stern review*. Cambridge University Press, 713 pp., (ISBN: 9780521700801).

Stevenson H., and J.S. Dryzek (2012). The discursive democratisation of global climate governance. *Environmental Politics* **21**, 189–210. (DOI: 10.1080/09644016.2012.651898).

Stevenson B., and J. Wolfers (2008). Economic growth and subjective well-being: reassessing the Easterlin Paradox. In: *Brookings Papers on Economic Activity: Spring 2008*. Brookings Institution Press, Washington, D.C. pp.1–102, .

Stiglitz J.E. (2002). *Globalization And Its Discontents*. W.W. Norton, New York and London, 282 pp., (ISBN: 0-393-05124-2).

Stiglitz J.E., A. Sen, and J.-P. Fitoussi (2009). *Report by the Commission on the Measurement of Economic Performance and Social Progress*. Paris. 2632–2637 pp. Available at: http://www.stiglitz-sen-fitoussi.fr/documents/rapport_anglais.pdf.

Stoll-Kleemann S., T. O'Riordan, and C.C. Jaeger (2001). The psychology of denial concerning climate mitigation measures: evidence from Swiss focus groups. *Global Environmental Change-Human and Policy Dimensions* **11**, 107–117. (DOI: 10.1016/S0959-3780(00)00061-3).

Stone C. (2004). Common but Differentiated Responsibilities in International Law. *American Journal of International Law* **98**, 276–301.

Suh S., and S. Nakamura (2007). Five years in the area of input-output and hybrid LCA. *The International Journal of Life Cycle Assessment* **12**, 351–352. (DOI: 10.1065/lca2007.08.358).

Sukhdev P., H. Wittmer, C. Schröter-Schlaack, C. Nesshöver, J. Bishop, P. Brink, H. Gundimeda, P. Kumar, and B. Simmons (2010). *The economics of ecosystems and biodiversity: mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB*. TEEB, (ISBN: 3981341031).

Sukla P.R., S. Dhar, and D. Mahapatra (2008). Low-carbon society scenarios for India. *Climate Policy* **8**, 156–176. (DOI: 10.3763/cpol.2007.0498).

Sullivan R., and A. Gouldson (2012). Does voluntary carbon reporting meet investors' needs? *Journal of Cleaner Production*. (DOI: 10.1016/j.jclepro.2012.02.020). Available at: http://www.sciencedirect.com/science/article/pii/S0959652612000960.

Sundarakani B., R. de Souza, M. Goh, S.M. Wagner, and S. Manikandan (2010). Modeling carbon footprints across the supply chain. *International Journal of Production Economics* **128**, 43–50. (DOI: 10.1016/j.ijpe.2010.01.018).

Sutton S.G., and R.C. Tobin (2011). Constraints on community engagement with Great Barrier Reef climate change reduction and mitigation. *Global Environmental Change-Human and Policy Dimensions* **21**, 894–905. (DOI: 10.1016/j.gloenvcha.2011.05.006).

Swart R., J. Robinson, and S. Cohen (2003). Climate change and sustainable development: expanding the options. *Climate Policy* **3**, S19–S40. (DOI: 10.1016/j.clipol.2003.10.010).

Swim J., S. Clayton, T. Doherty, R. Gifford, G. Howard, J. Reser, P. Stern, and E.U. Weber (2009). Psychology and Global Climate Change: Addressing a Multi-faceted Phenomenon and Set of Challenges. Available at: http://www.apa.org/science/about/publications/climate-change.aspx.

Di Tella R., and R. MacCulloch (2010). Happiness Adaption to Income beyond "Basic Needs". In: *International Differences in Well-Being*. E. Diener, J. Helliwell, D.M. Kahneman, (eds.), Oxford University Press, New York.

Terjesen S. (2007). Building a better rat trap: Technological innovation, human capital, and the irula. *Entrepreneurship Theory and Practice* **31**, 953–963. (DOI: 10.1111/j.1540-6520.2007.00204.x).

Thampapillai D.J. (2011). Value of sensitive in-situ environmental assets in energy resource extraction. *Energy Policy* **39**, 7695–7701. (DOI: 10.1016/j.enpol.2011.09.006).

The UK Government Office for Science (2011). *Foresight: Migration and Global Environmental Change (2011) Final Project Report*. London. Available at: http://www.bis.gov.uk/foresight/our-work/projects/published-projects/global-migration/reports-publications.

Thøgersen J. (2002). Promoting green consumer behavior with eco-labels. In: *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*. T. Dietz, P.C. Stern, (eds.), National Academies Press, Washington, D.C. pp.83–104, (ISBN: 9780309084222).

Thøgersen J. (2005). How May Consumer Policy Empower Consumers for Sustainable Lifestyles? *Journal of Consumer Policy* **28**, 143–177. (DOI: 10.1007/s10603-005-2982-8).

Thøgersen J. (2009). Consumer decision-making with regard to organic food products. In: *Traditional Food Production and Rural Sustainable Development: A European Challenge*. M.T. de N. Vaz, P. Nijkamp, J.L. Rastoin, (eds.), Ashgate Publishing, Farnham pp.173–194, (ISBN: 9780754674627).

Thøgersen J. (2010). Country Differences in Sustainable Consumption: The Case of Organic Food. *Journal of Macromarketing* **30**, 171–185. (DOI: 10.1177/0276146710361926).

Thøgersen J., A.-K. Jørgensen, and S. Sandager (2012). Consumer Decision Making Regarding a “Green” Everyday Product. *Psychology and Marketing* **29**, 187–197. (DOI: 10.1002/mar.20514).

Thøgersen J., and Y. Zhou (2012). Chinese consumers’ adoption of a “green” innovation – The case of organic food. *Journal of Marketing Management* **28**, 313–333. (DOI: 10.1080/0267257X.2012.658834).

Thomson W. (2011). Fair Allocation Rules. In: *Handbook of Social Choice and Welfare*. Elsevier, pp.393–506, (ISBN: 9780444508942). Available at: http://linkinghub.elsevier.com/retrieve/pii/S0169721810000213.

Thuiller W. (2007). Biodiversity: Climate change and the ecologist. *Nature* **448**, 550–552. (DOI: 10.1038/448550a).

Tol R.S.J. (1999). The marginal costs of greenhouse gas emissions. *Energy Journal* **20**, 61–81.

Tompkins E.L., and W. Neil Adger (2005). Defining response capacity to enhance climate change policy. *Environmental Science & Policy* **8**, 562–571. (DOI: 10.1016/j.envsci.2005.06.012).

Tonello M. (2006). *Revisiting Stock Market Short-Termism*. Social Science Research Network, Rochester, NY. Available at: http://papers.ssrn.com/abstract=938466.

Truffer B., and L. Coenen (2012). Environmental Innovation and Sustainability Transitions in Regional Studies. *Regional Studies* **46**, 1–21. (DOI: 10.1080/00343404.2012.646164).

Tubi A., I. Fischhendler, and E. Feitelson (2012). The effect of vulnerability on climate change mitigation policies. *Global Environmental Change-Human and Policy Dimensions* **22**, 472–482. (DOI: 10.1016/j.gloenvcha.2012.02.004).

Tukker A., M.J. Cohen, K. Hubacek, and O. Mont (2010a). The Impacts of Household Consumption and Options for Change. *Journal of Industrial Ecology* **14**, 13–30. (DOI: 10.1111/j.1530-9290.2009.00208.x).

Tukker A., M.J. Cohen, K. Hubacek, and O. Mont (2010b). Sustainable Consumption and Production. *Journal of Industrial Ecology* **14**, 1–3. (DOI: 10.1111/j.1530-9290.2009.00214.x).

Tukker A., M.J. Cohen, U. Zoysa, E. Hertwich, P. Hofstetter, A. Inaba, S. Lorek, and E. Stø (2006). The Oslo Declaration on Sustainable Consumption. *Journal of Industrial Ecology* **10**, 9–14. (DOI: 10.1162/108819806775545303).

U.S. National Research Council Committee on Atmospheric Sciences (1966). *Weather and climate modification problems and prospects: Final report of the Panel on Weather and Climate Modification*. National Academy of Sciences, Washington, DC.

Udo V.E., and P.M. Jansson (2009). Bridging the gaps for global sustainable development: A quantitative analysis. *Journal of Environmental Management* **90**, 3700–3707. (DOI: 10.1016/j.jenvman.2008.12.020).

UNCSD (2001). *Indicators of Sustainable Development: Framework and Methodologies*. United Nations Commission on Sustainable Development, New York.

UNEP (1997). *Environment Outlook-1*. UNEP and Oxford University Press, New York and Oxford, UK.

UNEP (2000). *Global Environment Outlook*. UNEP and Earthscan, London.

UNEP (2002). *Global Environment Outlook-3*. UNEP and Earthscan, London and Sterling, VA, US.

UNEP (2011). *Decoupling natural resource use and environmental impacts from economic growth*. United Nations Environment Programme. Available at: http://www.unep.org/resourcepanel/decoupling/files/pdf/Decoupling_Report_English.pdf.

UNEP/Risø Centre on Energy (2011). CDM pipeline overview. Available at: http://cdmpipeline.org.

UNFCCC (2011). *Report of the Global Environment Facility to the Conference of the Parties.* United Nations Framework Convention on Climate Change, Bonn. Available at: http://unfccc.int/cooperation_and_support/financial_mechanism/items/3741.php.

UNIDO (2011). The New Industrial Revolution: making it Sustainable. General Conference: 14th session, 28 November to 2 December 2011. Available at: http://www.unido.org/index.php?id=1001772.

United Nations (1992a). *United Nations Framework Convention on Climate Change*. Rio de Janeiro. Available at: http://unfccc.int.

United Nations (1992b). *Rio Declaration on Environment and Development*. Available at: https://www.google.com/search?q=rio+declaration+1992&ie=utf-8&oe=utf-8&aq=t&rls=org.mozilla:en-US:official&client=firefox-a.

United Nations (1992c). Agenda 21. United Nations Conference on Environment & Development. Available at: http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=52&ArticleID=52&l=en.

United Nations (1997). *Programme for Further Implementation of Agenda 21 and the Commitments to the Rio Declaration principles*.

United Nations (2000). *United Nations Millennium Declaration*. New York. Available at: http://www.un.org/millennium/declaration/ares552e.htm.

United Nations (2002). *Plan of Implementation*. Johannesburg.

United Nations (2011a). Millennium Development Goals Report 2011. United Nations, New York. Available at: http://www.un.org/millenniumgoals/pdf/(2011_E)%20MDG%20Report%202011_Book%20LR.pdf.

United Nations (2011b). *World population prospects, the 2010 revision*. Available at: http://esa.un.org/undp/wpp/index.htm.

United Nations (2012a). *The Future We Want*. Available at: http://uncsd2012.org/thefuturewewant.html.

United Nations (2012b). A 10-year framework of programmes on sustainable consumption and production patterns. A/CONF.216/5. Available at: http://www.unep.org/resourceefficiency/Policy/SCPPoliciesandthe10YFP/The10YearFrameworkProgrammesonSCP/tabid/102563/Default.aspx.

Vanclay J.K., J. Shortiss, S. Aulsebrook, A.M. Gillespie, B.C. Howell, R. Johanni, M.J. Maher, K.M. Mitchell, M.D. Stewart, and J. Yates (2010). Customer Response to Carbon Labelling of Groceries. *Journal of Consumer Policy* **34**, 153–160. (DOI: 10.1007/s10603-010-9140-7).

Vanderheiden S. (2008). *Atmospheric justice: a political theory of climate change*. Oxford University Press, 304 pp., (ISBN: 9780195334609).

Victor D. (1998). The Regulation of Greenhouse Gases: Does Fairness Matter? In: *Fair weather? Equity concerns in climate change*. F.L. Tóth, (ed.), Earthscan, London(ISBN: 1853835579 9781853835575 1853835587 9781853835582).

Victor D.G. (2004). *The Collapse Of The Kyoto Protocol And The Struggle To Slow Global Warming*. Princeton University Press, 219 pp., (ISBN: 9780691120263).

Visschers V.H.M., and M. Siegrist (2012). Fair play in energy policy decisions: Procedural fairness, outcome fairness and acceptance of the decision to rebuild nuclear power plants. *Energy Policy* **46**, 292–300. (DOI: 10.1016/j.enpol.2012.03.062).

Vlek C., and L. Steg (2007). Human behavior and environmental sustainability: Problems, driving forces, and research topics. *Journal of Social Issues* **63**, 1–19. (DOI: 10.1111/j.1540-4560.2007.00493.x).

Wada K., F. Sano, K. Akimoto, and T. Homma (2012). Assessment of Copenhagen pledges with long-term implications. *Energy Economics* **34, Supplement 3**, S481–S486. (DOI: 10.1016/j.eneco.2012.01.001).

Wallquist L., V.H.M. Visschers, and M. Siegrist (2010). Impact of Knowledge and Misconceptions on Benefit and Risk Perception of CCS. *Environmental Science & Technology* **44**, 6557–6562. (DOI: 10.1021/es1005412).

Walters C.J., and C.S. Holling (1990). Large-Scale Management Experiments and Learning by Doing. *Ecology* **71**, 2060–2068. (DOI: 10.2307/1938620).

Wang B. (2010). Can CDM bring technology transfer to China?—An empirical study of technology transfer in China's CDM projects. *Energy Policy* **38**, 2572–2585. (DOI: 10.1016/j.enpol.2009.12.052).

Wang Can, Chen Jining, and Zou Ji (2005). Impact assessment of CO_2 mitigation on China economy based on a CGE model. *Journal of Tsinghua University (Science and Technology)* **12**.

Wang Ke (2008). Technological Change Simulation and Its Application in Climate Change Policy Analysis Based on a CGE Model. Tsinghua University.

Wang S., C. Wang, and J. Jiang (2013). The Role of Intellectual Property in Wind Power Technology Innovation and Transferring: Case Study of China. *Advances in Climate Change Research*.

Wang S., C. Wang, and Y. Xu (2013). *Intellectual Property Rights and Climate Change*. Social Sciences Academic Press.

Weale A. (2009). Governance, government and the pursuit of sustainability. In: *Governing Sustainability*. Cambridge University Press, Cambridge pp.55–75, .

Weber M. (1978). *An Outline of Interpretive Sociology*. University of California Press, Berkeley and Los Angeles, (ISBN: 0520035003).

Weber E.U., and E.J. Johnson (2009). Mindful Judgment and Decision Making. *Annual Review of Psychology* **60**, 53–85. (DOI: 10.1146/annurev.psych.60.110707.163633).

Weber E.U., and E.J. Johnson (2012). Psychology and behavioral economics. Lessons for the design of a green growth strategy. *Policy Research Working Paper, The World Bank*, 1–47.

Wei T., S. Yang, J.C. Moore, P. Shi, X. Cui, Q. Duan, B. Xu, Y. Dai, W. Yuan, X. Wei, Z. Yang, T. Wen, F. Teng, Y. Gao, J. Chou, X. Yan, Z. Wei, Y. Guo, Y. Jiang, X. Gao, K. Wang, X. Zheng, F. Ren, S. Lv, Y. Yu, B. Liu, Y. Luo, W. Li, D. Ji, J. Feng, Q. Wu, H. Cheng, J. He, C. Fu, D. Ye, G. Xu, and W. Dong (2012). Developed and developing world responsibilities for historical climate change and CO2 mitigation. *Proceedings of the National Academy of Sciences* **109**, 12911–12915. (DOI: 10.1073/pnas.1203282109).

Von Weizsäcker E., K. Hargroves, M.H. Smith, C. Desha, and P. Stasinopoulos (2009). *Factor Five: Transforming the Global Economy through 80% Improvements in Resource Productivity*. Earthscan/The Natural Edge Project, London and Sterling, VA, US, (ISBN: 9781844075911).

Von Weizsäcker E., A.B. Lovins, and L.H. Lovins (1997). *Factor Four: Doubling Wealth, Halving Resource Use - A Report to the Club of Rome*. Earthscan, London, (ISBN: 9781864484380).

Welsch H. (1993). A CO2 agreement proposal with flexible quotas. *Energy Policy* **21**, 748–756. (DOI: 10.1016/0301-4215(93)90145-6).

Wenzel H., M.Z. Hauschild, and L. Alting (1997). *Environmental Assessment of Products: Volume 1: Methodology, Tools and Case Studies in Product Development*. Springer, 568 pp., (ISBN: 9780792378594).

Wewerinke M., and V.P. Yu III (2010). *ADDRESSING CLIMATE CHANGE THROUGH SUSTAINABLE DEVELOPMENT AND THE PROMOTION OF HUMAN RIGHTS*. South Centre.

Weyant J.P. (2011). Accelerating the development and diffusion of new energy technologies: Beyond the “valley of death”. *Energy Economics* **33**, 674–682. (DOI: 10.1016/j.eneco.2010.08.008).

Whitmarsh L. (2009). Behavioural responses to climate change: Asymmetry of intentions and impacts. *Journal of Environmental Psychology* **29**, 13–23.

WHO (2012). *Research and development to meet health needs in developing countries: strengthening global financing and coordination. Report of the Consultative Expert Working Group on Research and Development: Financing and Coordination.* World Health Organisation, Geneva.

Wick K., and E. Bulte (2009). The Curse of Natural Resources. In: *Annual Review of Resource Economics*. Annual Reviews, Palo Alto pp.139–155, (ISBN: 978-0-8243-4701-7).

Wiedmann T. (2009). A review of recent multi-region input–output models used for consumption-based emission and resource accounting. *Ecological Economics* **69**, 211–222. (DOI: 10.1016/j.ecolecon.2009.08.026).

Wiedmann T.O., M. Lenzen, and J.R. Barrett (2009). Companies on the Scale. *Journal of Industrial Ecology* **13**, 361–383. (DOI: 10.1111/j.1530-9290.2009.00125.x).

Wiedmann T.O., and J. Minx (2007). *A Definition of "Carbon Footprint"*. ISA (UK) Research and Consulting, London. Available at: www.isa-research.co.uk.

Wilbanks T.J. (2005). Issues in developing a capacity for integrated analysis of mitigation and adaptation. *Environmental Science & Policy* **8**, 541–547. (DOI: 10.1016/j.envsci.2005.06.014).

Williams B.K. (2011). Adaptive management of natural resources—framework and issues. *Journal of Environmental Management* **92**, 1346–1353. (DOI: 10.1016/j.jenvman.2010.10.041).

Williams E.D., C.L. Weber, and T.R. Hawkins (2009). Hybrid Framework for Managing Uncertainty in Life Cycle Inventories. *Journal of Industrial Ecology* **13**, 928–944. (DOI: 10.1111/j.1530-9290.2009.00170.x).

Wilson E.O. (1978). *On Human Nature*. Harvard University Press, 292 pp., (ISBN: 9780674016385).

Winkler H., K. Baumert, O. Blanchard, S. Burch, and J. Robinson (2007a). What factors influence mitigative capacity? *Energy Policy* **35**, 692–703. (DOI: 10.1016/j.enpol.2006.01.009).

Winkler H., K. Baumert, O. Blanchard, S. Burch, and J. Robinson (2007b). What factors influence mitigative capacity? *Energy Policy* **35**, 692–703. (DOI: 10.1016/j.enpol.2006.01.009).

Winkler H., T. Jayaraman, Jiahua Pan, A. Santhiago de Oliveira, Yongsheng Zhang, G. Sant, J.D. Gonzalez Miguez, Thapelo Letete, A. Marquard, and S. Raubenheimer (2011). *Equitable access to sustainable development: Contribution to the body of scientific knowledge*. BASIC expert group, Beijing, Brasilia, Cape Town and Mumbai. Available at: http://www.erc.uct.ac.za/Basic_Experts_Paper.pdf.

Winkler H., T. Letete, and A. Marquard (2011). A South African approach – responsibility, capability and sustainable development. In: *Equitable access to sustainable development: Contribution to the body of scientific knowledge*. BASIC expert group, Beijing, Brasilia, Cape Town and Mumbai pp.78–91, .Available at: http://www.erc.uct.ac.za/Basic_Experts_Paper.pdf.

Wittneben B.B.F., C. Okereke, S.B. Banerjee, and D.L. Levy (2012). Climate Change and the Emergence of New Organizational Landscapes. *Organization Studies* **33**, 1431–1450. (DOI: 10.1177/0170840612464612).

Wolf J., and S.C. Moser (2011). Individual understandings, perceptions, and engagement with climate change: insights from in-depth studies across the world. *Wiley Interdisciplinary Reviews: Climate Change* **2**, 547–569. (DOI: 10.1002/wcc.120).

Wolsink M. (2007). Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. *Energy Policy* **35**, 2692–2704. (DOI: 10.1016/j.enpol.2006.12.002).

Woolcock M. (1998). Social capital and economic development: Toward a theoretical synthesis and policy framework. *Theory and Society* **27**, 151–208. (DOI: 10.1023/A:1006884930135).

Woolcock M., and D. Narayan (2000). Social Capital: Implications for Development Theory, Research, and Policy. *The World Bank Research Observer* **15**, 225–249. (DOI: 10.1093/wbro/15.2.225).

World Bank (2003). *World Development Report 2003: Sustainable Development in a dynamic World*. World Bank, Washington, D.C.

World Bank (2010). *World Development Report 2010: Development and Climate Change*. World Bank, Washington, D.C., 424 pp., (ISBN: 978-0-8213-7987-5). Available at: http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTWDRS/EXTWDR2010/0,,menuPK:5287748~pagePK:64167702~piPK:64167676~theSitePK:5287741,00.html.

World Bank (2011). *The Changing Wealth of Nations. Measuring Sustainable Development in the New Millenium*. World Bank, Washington DC.

World Commission on Environment and Development (WCED) (1987). *Our common future*. Oxford University Press, Oxford.

Worldwatch Institute (2010). *Transforming Cultures: From Consumerism to Sustainability*. The Worldwatch Institute, New York and London.

Yigitcanlar T., and K. Velibeyoglu (2008). Knowledge-Based Urban Development: The Local Economic Development Path of Brisbane, Australia. *Local Economy* **23**, 195–207. (DOI: 10.1080/02690940802197358).

Yohe G. (2001). Mitigative Capacity – the Mirror Image of Adaptive Capacity on the Emissions Side. *Climatic Change* **49**, 247–262. (DOI: 10.1023/A:1010677916703).

Young O.R. (2012). *On Environmental Governance: Sustainability, Efficiency, and Equity*. Paradigm Publishers, 192 pp., (ISBN: 1612051324).

Young O.R. (2013). Does Fairness Matter in International Environmental Governance? Creating an Effective and Equitable Climate Regime. In: *Toward a New Climate Agreement: Conflict, Resolution and Governance*. C. Todd, J. Hovi, D. McEvoy, (eds.),.

Young W., K. Hwang, S. McDonald, and C.J. Oates (2010). Sustainable consumption: green consumer behaviour when purchasing products. *Sustainable Development* **18**, 20–31. (DOI: 10.1002/sd.394).

Yue C., and S. Wang (forthcoming). The National Development Rights Framework Bridging the gap between developed and developing countries.

Yung W.K.C., H.K. Chan, J.H.T. So, D.W.C. Wong, A.C.K. Choi, and T.M. Yue (2011). A life-cycle assessment for eco-redesign of a consumer electronic product. *Journal of Engineering Design* **22**, 69–85. (DOI: 10.1080/09544820902916597).

Zelli F. (2011). The fragmentation of the global climate governance architecture. *Wiley Interdisciplinary Reviews-Climate Change* **2**, 255–270. (DOI: 10.1002/wcc.104).

Zografos C., and J. Martinez-Alier (2009). The politics of landscape value: a case study of wind farm conflict in rural Catalonia. *Environment and Planning A* **41**, 1726–1744. (DOI: 10.1068/a41208).