Available online at www.sciencedirect.com
SCIENCE DIRECT
Climate Policy 3S1 (2003) S19–S40
CLIMATE POLICY
www.climatepolicy.com

Climate change and sustainable development: expanding the options

Rob Swart[a,*], John Robinson[b], Stewart Cohen[c,1]

[a] National Institute for Public Health and the Environment, IPCC Working Group III, RIVM, P.O. Box 1, Bilthoven 3720, BA, The Netherlands
[b] SDRI, 2nd Floor, 1924 West Mall, UBC Vancouver, BC, Canada V6T 1Z2
[c] AIRG, Environment Canada, 2029 West Mall, UBC Vancouver, BC, Canada V6T 1Z2

Abstract

Climate change and sustainable development have been addressed in largely separate circles in both research and policy. Nevertheless, there are strong linkages between the two in both realms. This paper focuses on the scientific linkages and discusses the opportunities they provide for integrated policy development, and the necessity to consider the risk of trade-offs. It is suggested that integration may not only provide new opportunities, but may even be a prerequisite for successfully addressing both issues. Since the feasibility of stabilising greenhouse gas concentrations is dependent on general socio-economic development paths, climate policy responses should be fully placed in the larger context of technological and socio-economic policy development rather than be viewed as an add-on to those broader policies. The arguments are supported by a range of examples for various economic sectors in the areas of both mitigation and adaptation, largely drawn from IPCC's Third Assessment Report.

Keywords: Sustainable development-links to climate policy; Adaptation-links to SRES; Adaptation-mitigation links (and vice versa); Mitigation-links to development paths

1. Introduction

The need to connect the fields of climate change and sustainable development has been increasingly recognized in the climate change literature. The Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC) has suggested that sustainable development may be the most effective way to frame the mitigation question (Banuri et al., 2001) and a crucial dimension of climate change adaptation and impacts (Smit et al., 2001). And the linkage between climate change and broader issues related to population, lifestyles, environment and development is a constant theme in a recent state-of-the-art review of social science literature relevant to climate change (Rayner and Malone, 1998).

* Corresponding author. Tel.: +31-30-2743026; fax: +31-30-2744464.
E-mail addresses: rob.swart@rivm.nl (R. Swart), johnr@sdri.ubc.ca (J. Robinson), scohen@sdri.ubc.ca (S. Cohen).
[1] Opinions expressed herein are not necessarily those of Environment Canada.

1469-3062/$ – see front matter
doi:10.1016/j.clipol.2003.10.010

While the intellectual argument for integration has been strongly made, its realization in the policy realm has been less successful. In the decade that followed the co-production of Agenda 21 (UNCED, 1992) and the United Nations Framework Convention on Climate Change (UNFCCC, 1992) at the Rio Earth Summit in 1992, the spirit of addressing sustainability problems in an integrated fashion faded, and largely parallel agendas were pursued. The sustainable development debate about the implementation of Agenda 21 has basically left the climate change response to the UNFCCC. In the UNFCCC and the associated Kyoto Protocol sustainable development is mentioned,[2] but this has not yet been operationalized. Some parties to the climate negotiations have even seen links between climate change and sustainable development as a threat, because they may draw attention away from the main negotiating issue—considered to be a narrow focus on climate change—and slow progress down.

In earlier papers, several of us have argued for greater integration between climate change and sustainable development (Cohen et al., 1998), and proposed a possible general approach for such integration (Robinson and Herbert, 2001).[3] In this paper, we will discuss some concrete forms of linkage, drawing on the findings of Working Groups II and III of the IPCC. We will suggest that revisiting the linkages between climate change and wider sustainable development priorities is not only providing new opportunities, but may be a necessity to make progress in both areas, both national and internationally.

There are several reasons why, both in science and policy, parallel discourses have followed the initial deliberations. Climate change essentially was framed in the late 1980s by natural scientists as a problem related to the long-term disturbance of the global geo-biochemical cycles and the associated effects on global climatic patterns, modelled in complex Global Circulation Models. As such, climate change was divorced from its social context, and normative aspects have long been ignored (Cohen et al., 1998). And as exemplified by the evolution of the assessments of the IPCC, socio-economic analysis only gradually took on a more important role in climate change research—and this was initially seen almost entirely through the lens of economic analysis at the global level, rather than any of the other social sciences or humanities.[4] The natural science-based establishment of the IPCC by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP, 2002) rather than by a more development-oriented organization contributed to the slow pace of this change. Not only was climate change treated separately from broader sustainability issues, it may have also received disproportional political and scientific attention. This is partly due to the perceived high costs of addressing the problem in the industrialized countries, the economies of which depend on cheap fossil fuels.

---

[2] Example, in the principles of the UNFCCC and in the conditions for projects in the context of the Clean Development Mechanism of the Kyoto Protocol (CDM). The CDM combines climate change mitigation objectives of the industrialized countries with sustainable development goals of developing countries, and as such is an excellent example of the linkages discussed in this paper. It can help bring about more environmentally sound development in participating countries. However, we believe that the potential amount of investments related to the CDM at the level of individual projects in selected countries is insufficient to more widely capture the potential of the linkages.

[3] While we specifically discuss the linkages between climate change and sustainable development in this paper, the same often holds for other issues, such as water scarcity and land degradation, which would also benefit from more extensive linkages with broader development issues.

[4] In fact, the IPCC demonstrates an interesting process of widening the terms of the debate on the so-called "human dimensions" of climate change, from negligible consideration in the First Assessment Report (IPCC, 1990), to an inclusion mainly of economic analysis in the Second Assessment Report (IPCC, 1995), to an attempt at a more inclusive analysis in the Third Assessment Report (TAR) (Banuri et al., 2001). However, this broader treatment in the TAR is confined to only a few chapters and the report as a whole still remains vulnerable to the criticisms contained in Cohen et al. (1998).

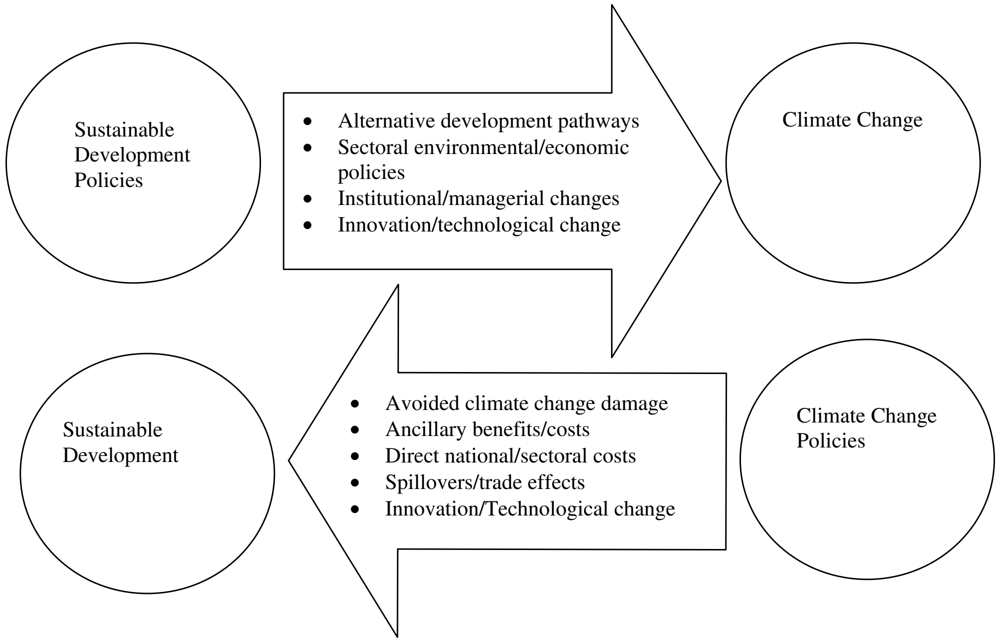

Fig. 1. Linkages between sustainable development, climate change, and policies in these areas.

Sustainable development however has been framed much more through problem-driven social science addressing current economic, social and environmental problems at the local level, explicitly accepting the fact that these problems are inherently value-laden. Cohen et al. (1998) analyse the reasons behind the separation and make recommendations for bringing the two discourses closer together. Differences in conceptual frameworks, definitions, and language are all contributing to the fissure between the two issues. Increasingly, it is recognized that this artificial separation of subjects results in missed chances for synergies and in unrecognised, undesirable trade-offs. This paper therefore focuses on the *linkages* between the two issues and the opportunities these provide for policy, rather than on the *differences*. Policy synergies[5] provide opportunities, and trade-offs can be minimized if the linkages are well understood.

It is well-established that there is not one definition of sustainable development (Robinson, 2002) and different people with different cultural backgrounds and priorities have different definitions.[6] There is general agreement, however, that sustainable development has economic, social and environmental objectives and that development should be made more sustainable for all three dimensions (Munasinghe, 2001). In this context, Fig. 1 provides a framework for exploring the linkages and gives some examples. Climate policies can affect wider sustainable development objectives by:

[5] That is, the effect of climate policy integrated into wider development policies can be greater than the sum of parallel, unrelated policies.

[6] Thompson and Rayner (1998) argue that different cultural discourses about nature and society have strong implications for how climate change issues are perceived and acted upon.

(i) *Reducing climate change damages*: Not only through reducing greenhouse gas (GHG) emissions or enhancing their sinks (mitigation), but also by reducing vulnerability and adapting to climate change; in this way, sustainable development aspirations are less frustrated by negative climatic impacts.
(ii) *Providing ancillary benefits*: Example, in terms of abatement of local air pollution, conserving biological diversity, or enhancing employment.
(iii) *Imposing direct costs associated with mitigation or adaptation measures*: The magnitude of these costs (and sometimes whether they are positive or negative) is dependent on the strictness of the measures and on their implementation.
(iv) *Causing—positive or negative—"spill-over" effects*: That is, measures in one country can have an economic effect on other countries, e.g. a decrease of the oil price as a result of reduced oil demand can negatively affect oil exporting countries, but positively affect oil importing countries; also, trade-effects may result from changes in competitiveness.
(v) *Inducing and spreading technological innovation*: Technologies and practices, induced by climate policies, which abate GHG emissions or reduce vulnerability, are often also more environmentally sound in a more general sense, and would spread across regions after their implementation in the countries committed to reduce GHG emissions.

Equally, wider development policies can affect climate change and the response to climate change by:

(i) *Pursuing alternative development pathways*: GHG emissions may depend as much on underlying socio-economic and technological development paths as on specific climate policies. For example, economic structural changes towards a service economy or behavioural changes associated with sustainable development would likely lead to lower GHG emissions, while avoiding building in flood-prone and other high risk areas would also reduce vulnerability to future climate change.
(ii) *Specific sectoral environmental, social or economic policies, which have climate side effects*: The bio-fuel programme in Brazil, for example, did not have any climate-related objective, but did contribute significantly to climate change mitigation. Nature conservation programmes to protect biodiversity and boost eco-tourism would protect carbon storage as a side effect.
(iii) *Pursuing institutional changes*: For example, the capability to mitigate climate change or adapt to it can also be ameliorated by building or improving institutions to address current socio-economic and environmental problems and by enhancing social capital.[7]
(iv) *Stimulating technological innovation and change*: Technological change can be stimulated in environmentally sound directions for reasons unrelated to climate change, e.g. to reduce dependency on imported fuels, to improve local air pollution or to generate local employment. Development of drought-resistant crop varieties to reduce vulnerability to current climate variability will also reduce vulnerability to future climate change.

These policy linkages are directly related to the linkages between the underlying natural and socio-economic processes in our rapidly changing world. In the next section, we will first discuss some of these process linkages, then turn to the concept of alternative development pathways, and finally address policy linkages in more detail, both in the area of climate change mitigation and adaptation.

[7] Social capital can be broadly defined as the glue that holds society together through the relations between people, or more specifically, in economics, as the ways in which social relationships affect economic outcomes, efficiency and externalities (Olhoff, 2002).

2. Process linkages: a web of connections

Climatic change, its driving forces and its impacts have linkages with all three dimensions of sustainable development: environmental, social and economic. We first discuss some examples of the linkages between climate change and other environmental problems (for more detail see Watson et al., 1998, 2001):

- *Stratospheric ozone depletion*: Climate change and the depletion of stratospheric ozone are linked in two major ways: their causes, and the associated atmospheric chemical and physical processes. Halocarbons such as chlorofluorocarbons (CFCs) and their initial replacements hydrochlorofluorocarbons (HCFCs) have the potential to deplete the ozone layer, but are also GHGs. Hydrofluorocarbons (HFCs), which have been developed as alternatives to CFCs and HCFCs and do not deplete stratospheric ozone, do contribute to global warming. Stratospheric ozone depletion leads to a cooling of the troposphere, thus offsetting climate warming, through decreased downward infrared radiation, and through increased UVB radiation, which enhances the oxidation of methane. Climate change may also change temperature and wind conditions in the stratosphere, enhancing further ozone depletion.
- *Urban and regional air pollution*: There are also two major ways in which climate change is linked to urban air pollution: causes, and chemical and physical processes. The combustion of fossil fuels in cities, e.g. for heating or transportation, not only leads to GHG emissions, it also produces local air pollutants such as particulate matter, sulphur compounds, carbon monoxide, and ozone precursors such as nitrogen oxide and volatile organic compounds (VOCs). Climate change can also affect the chemical processes involved in urban air pollution (through changes in temperature, cloud cover, winds), and the impacts of this pollution on public health. There are also links at the larger regional level. Substances like sulphur dioxide and nitrogen oxide can lead to acid deposition, and at the same time sulphur aerosols have a cooling effect on climate, and nitrogen oxides (with VOCs and carbon monoxide) can affect the ozone levels in the troposphere. Ground level ozone is the third most important GHG.
- *Desertification*, *land degradation and food production*: One of the most urgent environmental problems in several regions is the deterioration of land quality, affecting the production of food and other agricultural crops. Linkages again are diverse. In many regions, such as sub-Saharan Africa, the projected changes in temperature and especially precipitation due to climate change would lead to additional stresses on agricultural productivity. But food production can also be a cause of global warming, e.g. applying nitrogenous fertilisers for intensive agriculture leads to increased emissions of the GHG nitrous oxide.
- *Land-use*, *land-cover change and biodiversity*: Land-use changes, such as the conversion of natural lands to agricultural or urban usage, can lead to loss of biodiversity as well as the release of GHGs into the atmosphere. Conversely, climate change can impact on vulnerable ecosystems, affecting ecosystem composition and biological diversity.
- *Forestry*: Unsustainable forestry practices, leading to deforestation or forest degradation, release CO_2 into the atmosphere. Climatic changes can affect the species distribution and productivity of forest ecosystems, impacting on forestry operations (Gitay et al., 2001).
- *Quantity and quality of water resources*: Climate change can change precipitation patterns, snow and ice cover (including glaciers) and thus affect water supply. Increased temperatures can increase water demand for agriculture and can also affect water quality. Water management is not a major contributor to GHG emissions, although a locally significant exception may be the fossil fuel use associated with the energy needs of some water management activities, such as irrigation. Carbon-free energy supply

is provided by hydropower, but climate change can affect water users (agriculture, industry, urban centres) and aquatic ecosystems (fisheries, etc.), and may also affect the availability of hydropower.

We now turn to examples of linkages between climate change, and socio-economic problems:

- *Poverty*: One of the most disturbing aspects of climate change impacts is that they are projected to fall disproportionally on the poor and increase existing development inequalities (McCarthy et al., 2001). Poverty often coincides with limited technological development, inadequate institutions, unequal access to resources and information, and poor levels of participation in decision-making. Therefore, it is no surprise that the impacts of climate change are projected to affect especially the poor, who are much more vulnerable and have less capacity to adapt to a changing climate. At the same time, the poor contribute to climate change as well, because of the conversion of forests and marginal lands by poor farmers and the usage of inefficient technologies.
- *Economic growth and development*: The magnitude and structure of economic development directly affects GHG emissions. A more service-oriented economy or a society with less consumptive lifestyles would lead to lower GHGs as compared to an economy with an emphasis on the production on energy- and materials-intensive goods. Conversely, the impacts of climate change on agriculture, water supply, or coastal systems can significantly affect economic activity.
- *Health*: Climate change can impact on health in several ways, such as through the influence on the incidence of vector-borne diseases, through heat waves, increased weather variability, and deterioration of local air quality. Health as such does not contribute to climate change.
- *Security*: Climate change can also have linkages with security issues. Climate change impacts can exacerbate environmental problems such as water shortage, which can be among the important drivers of regional political tensions and conflicts. Projected reductions in Arctic sea ice could affect Arctic security by making high latitude waterways more accessible for longer periods. Overdependence on fossil fuel resources (the most important source of GHGs), concentrated in a limited and politically unstable region (such as oil in the Middle East), has proven to be a source of conflict. Military activities on the other hand also contribute to GHG emissions.
- *Access to environmentally sound technologies*: One factor playing a role in constraining economic development in developing countries is the limited access to modern technologies. Concerns about local environmental pollution may lead to enhanced development and transfer of environmentally sound technologies, with beneficial side-effects both in the areas of climate change mitigation and adaptation.

In addition to these direct influences in specific areas, it is important to recognize a more integrated set of concerns related to *human well-being*, *consumption and social organization*. For example, a key finding of recent social science research on energy and social systems is that the social, institutional and technological dimensions of energy-using behaviour are intertwined in complex ways and cannot meaningfully be separated (Shove et al., 1998) This suggests a need to go beyond thinking of unidirectional effects of climate change on sustainable development, or vice versa, and beginning to see both of them as part of a complex system of interactions, ranging from concrete issues of technological choice and innovation, to questions of institutional design and management, through to more abstract questions related to identity, agency, control and power. It is difficult, for example, simply to change the technological, or the behavioural, aspects of energy use, since these are both part of larger embedded socio-psychological and institutional practices. This conclusion suggests the need to tie both the climate change and sustainable development issues into the broader agendas, and findings, of the social sciences and humanities.

The question is, how can we turn the identification and understanding of the linkages suggested here into actions needed to respond to climate change and make development more sustainable at the same time? In the next two sections of this paper, we discuss two approaches to this question. First we discuss the concept of alternative development pathways, recognising that the world's development is influenced by myriads of decisions made by individual human beings. Next, we more specifically consider how policies, which integrate climate change and broader development concerns, can address these concerns simultaneously.

3. The importance of alternative development pathways

Surprisingly, the recognition that the general development path of society is a determinant of GHG emissions at least as important as explicit climate policy is a recent one (Metz et al., 2001). One reason for this is that usually only one reference or business-as-usual scenario has been used as the basis for the analysis of the technological potential of GHG mitigation options and their economic implications. Although in 1992 the IPCC had recommended that mitigation analyses use the full range of baseline emissions scenarios that had been developed (Leggett et al., 1992), the majority of analysts continued to use one preferred case, often the IS92a scenario. Consistent with Shackley and Wynne's arguments regarding the tendency for each group of scientists to want to minimize input uncertainty while concentrating on the uncertainty resulting from their analysis (i.e. proliferating output uncertainty) most analysts used single baseline scenarios as a basis for multiple mitigation scenarios or runs (Shackley and Wynne, 1995).[8] In addition to this, scenarios such as those from the 1992 IPCC assessment (Leggett et al., 1992), although they covered a wide range of plausible futures, were not presented as a range of possible future societal development pathways influenced by human choice. Rather, they were proposed as a set of scenarios based on autonomous high, medium or low developments of key driving forces such as demographics, economic growth, and technology development. This approach does not illuminate the exploration of alternative development pathways and is instead conducive to selecting a middle case as the most likely one.

However, the new set of IPCC baseline emissions scenarios prepared for the Special Report on Emissions Scenarios (SRES, Nakicenovic and Swart, 2000; see also Box 1), were generated on the basis of explicitly different packages of socio-economic and technological conditions. That analysis concluded that not only different socio-economic futures can have similar GHG emissions (amongst other factors as a result of human choices), but also that similar futures in terms of economic and demographic development can have very different GHG emissions because of choices in the area of technology development

[8] In fact, the IPCC as a whole represents a very interesting case of this tendency. If we follow the logical flow around the four quadrants of the integrated assessment framework used in the TAR Synthesis Report (socio-economic development paths ->emissions and concentrations ->climate change ->impacts on human and natural systems, Watson et al., 2001), the logic of Shackley and Wynne's argument becomes clear. If each quadrant generates multiple configurations for each input scenario to that quadrant, then the whole system speedily becomes unmanageably complex. In such a situation, analysts at each stage naturally prefer to have single baseline scenarios to work with, and the inevitable tendency of their work is to want to emphasize the uncertainty associated with a range of outputs for their quadrant. One of the challenges implicitly raised by the TAR is the need to grapple with the problem of proliferating scenarios at all stages of the integrated assessment cycle.

Box 1. The emissions scenarios of the IPCC special report on emissions scenarios (SRES).

A1: The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2: The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1: The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2: The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol. Fig. 2 shows the CO_2 emissions associated with these scenarios and the different gaps to achieve stabilisation of CO_2 concentrations at different levels. Ranges depict different outcomes for different models used.

Source: Nakicenovic and Swart (2000) and Metz et al., 2001.

and consumption patterns. In other words, independent of climate policy, development pathways do matter for greenhouse emissions. Choices made in the key energy sector are particularly important. While reserves of conventional oil and gas resources are expected to decrease in the course of the century, they can either be replaced or supplemented by coal or unconventional oil and gas resources with higher GHG emissions, or by alternative non-fossil energy resources. These developments will determine if, and at

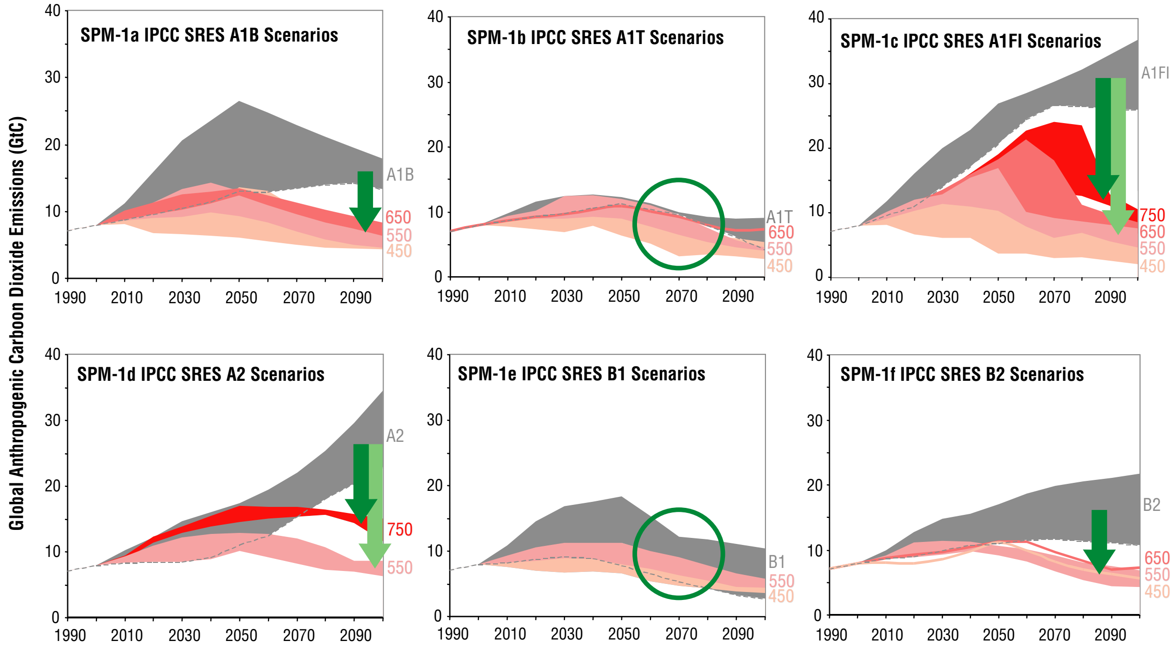

Fig. 2. CO_2 emissions for SRES reference scenarios and for stabilisation of CO_2 concentrations at various levels (Source; adapted from Metz et al. (2001)).

what level, CO_2 concentrations can be stabilised (Metz et al., 2001). But also other sectors play a role that should not be forgotten. Improvements in agricultural yields, dietary changes that influence meat production, cattle population, and in turn, grassland cover in combination with demographic changes can lead in some of the SRES scenarios to a considerable "greening" of the planet, without climate change concerns taken into account (Nakicenovic and Swart, 2000).

The gap between the SRES baseline CO_2 emissions scenarios and the CO_2 emissions profiles associated with stabilisation of the CO_2 concentration at various levels differs very much between the scenarios. In a scenario in which the world would address local and regional sustainability concerns (B1) or in a world in which technological advances in the area of renewable energy resources would be very rapid and shared globally, independent of sustainability concerns (A1T), the additional CO_2 emissions reductions to stabilise CO_2 concentrations at 550 ppm would be relatively small (Fig. 2 , circles in the middle two panels). Interestingly, in these scenarios low environmental pressure is combined with a narrowing of the income gap between developing and developed countries. These results are consistent with a review of more qualitative futures studies conducted for the TAR, which suggested that sustainable development futures tended to share a mix of characteristics, including low GHG emissions (Morita et al., 2001). On the other hand, in a scenario in which technological development would be slow (A2) or concentrated on the development of new fossil fuel resources (A1FI), there would be a huge gap to be bridged to achieve similar levels of CO_2 stabilisation, implying very high costs if at all feasible (Fig. 2, arrows in the top right and bottom left panel, respectively, indicate gaps to be closed to achieve stabilization at 550 and 750 ppm).

A critical aspect of the SRES emission scenarios is that none are intended to include any climate policy measures in addition to those already in place in the late 1990s. The scenarios therefore suggest that a

Table 1
SRES scenarios and proposed rating of vulnerability

SRES scenario	Projected climate impacts[a]	Projected adaptive capacity[b]	Future vulnerability compared to present
A1FI	+ + +	+ +	More vulnerable
A1B	+ +	+ +	About the same
A1T	+ +	+ +	About the same
A2	+ + +	+	Much more vulnerable
B1	+	+ + +	Less vulnerable
B2	+ +	+ +	About the same

[a] + + +: high adverse impacts; + +: intermediate climate impacts; +: low climate impacts.
[b] + + +: large adaptive capacity; + +: moderate adaptive capacity; +: low adaptive capacity.

very wide range of future emissions is possible, depending primarily on the underlying technological and socio-economic development pathway described in the scenario. This implies that choices regarding the achievement of sustainable development pathways are critically important for achieving low emission futures. Climate policies required to achieve stabilisation of greenhouse concentrations with a low emissions baseline would be much smaller in scope and much easier and cheaper to implement, as illustrated for the SRES scenarios in Fig. 2.

A similar argument gained strength in the area of impacts and adaptation: similar climatic futures can have very different socio-economic impacts due to different vulnerability/resilience of communities or economic sectors, and different climatic futures can have very similar socio-economic impacts because of similar, limited vulnerability. Again, the nature of the development path may be at least as important for adaptation and vulnerability reduction as policies specifically targeting adaptation or vulnerability reduction.[9] Unfortunately, SRES scenarios have not included vulnerability aspects within their storylines. Also, the coarse level of detail (six world regions) makes the usage of the scenarios for place-based analysis of impacts and adaptation difficult: additional assumptions are needed while downscaling the scenarios. It is also relevant to note that the SRES scenarios are all relatively optimistic in terms of income development, reflecting the lack of quantified "negative" developments in the literature. More pessimistic assumptions in terms of income developments would provide an even bleaker picture of adaptation options. The Kyoto Protocol itself contains no goals or targets for vulnerability reduction (though the recent Marrakech Accords, agreed to in 2001 at the seventh Conference of the Parties (COP-7) to the UNFCCC, does include the establishment of an adaptation fund), and it has been challenging to reach consensus on vulnerability reduction objectives for specific regions and countries. However, the IPCC TAR does consider the implications of warming on several indicators (e.g. risks to unique and threatened systems, risks of extreme climatic events, distribution of impacts, etc.) that suggest a relationship between magnitude of warming, GHG stabilization levels, and significance of impacts (Watson et al., 2001).

Going a step further, we therefore propose a qualitative assessment of the link between the climate impacts associated with the SRES scenarios, the projected adaptive capacity and the vulnerability of societal systems (Table 1), which illustrates how a development path could affect adaptation and vulnerability as well as emissions. In development paths addressing local and regional sustainability issues such as SRES B1, there would be an emphasis on the development of human and social capital, and appropriate

[9] The adaptive capacity of natural systems is largely independent of socio-economic developments.

technologies in order to reduce vulnerability to current climate variability, which would also better prepare communities to adapt to future climatic changes. In a scenario in which economic development would be slow and inequitable, population growth high, and technological change less rapid (e.g. SRES A2), the vulnerability would be high.

The table assumes that vulnerability is increased by larger climate impacts and decreased by higher levels of development. Given the uncertain nature of this table, we recognize that some readers may not share our views on these rankings. Our main point, however, is that development paths should be assessed on their adaptation/vulnerability aspects, as well as their emissions tendencies.

4. Mitigation: capturing the co-benefits and minimising trade-offs

If there are such close linkages between climate change and other environmental and socio-economic problems both in the area of causes and impacts, it seems obvious that policies should take these into account. When problems have similar causes, addressing these causes would have multiple benefits. When problems have similar impacts, reducing the vulnerability to these impacts would also have multiple benefits. At the same time, undesirable effects on yet more problems (trade-offs) would have to be considered as well. It is to such policy implications that we now turn, first to mitigation, then, in the following section, to adaptation.

As already noted above, climate mitigation policies can have important ancillary benefits, although there are examples of ancillary costs as well. Conversely, broader development policies can have important implications for GHG sources or sinks. If we would integrate these policies with the objective of simultaneously pursuing both climate change mitigation and broader development objectives, we may call these ancillary benefits co-benefits, acknowledging that both types of objectives are not qualitatively different in importance (Fig. 3). Even in a situation in which countries explicitly want to abate GHG emissions, e.g. because they have ratified the Kyoto Protocol, they are likely to design policies that simultaneously address other issues, not least because the policies would have to be acceptable to stakeholders who have priorities other than climate change. Developing countries do not yet have any obligations to control GHGs, but could pursue policies to address more pressing concerns, which would also limit GHG emissions. For projects eligible for the CDM of the Protocol, the joint objectives are already embedded in the Protocol, which stipulates that the projects should contribute to sustainable development in the host country, while GHG emissions control would be the main objective of the donor country. Unfortunately, these different objectives for host and donor country are likely to lead to differing priorities when projects have to be selected (Markandya and Halsnaes, 2002).

To illustrate the points made above, we give below some selected examples of options, which would combine climate change mitigation with broader development objectives for some important economic sectors. Most of them are drawn from the TAR (Metz et al., 2001).

4.1. Energy and industry

- *Advanced energy efficient technology*: Maybe the most important option to combine climate change mitigation with other societal objectives is the accelerated introduction of energy efficient technologies. Hundreds of options are available for all economic sectors, and many of them can be adopted at a net profit (Moomaw et al., 2001). Efficient technologies lead to less dependence on (often imported)

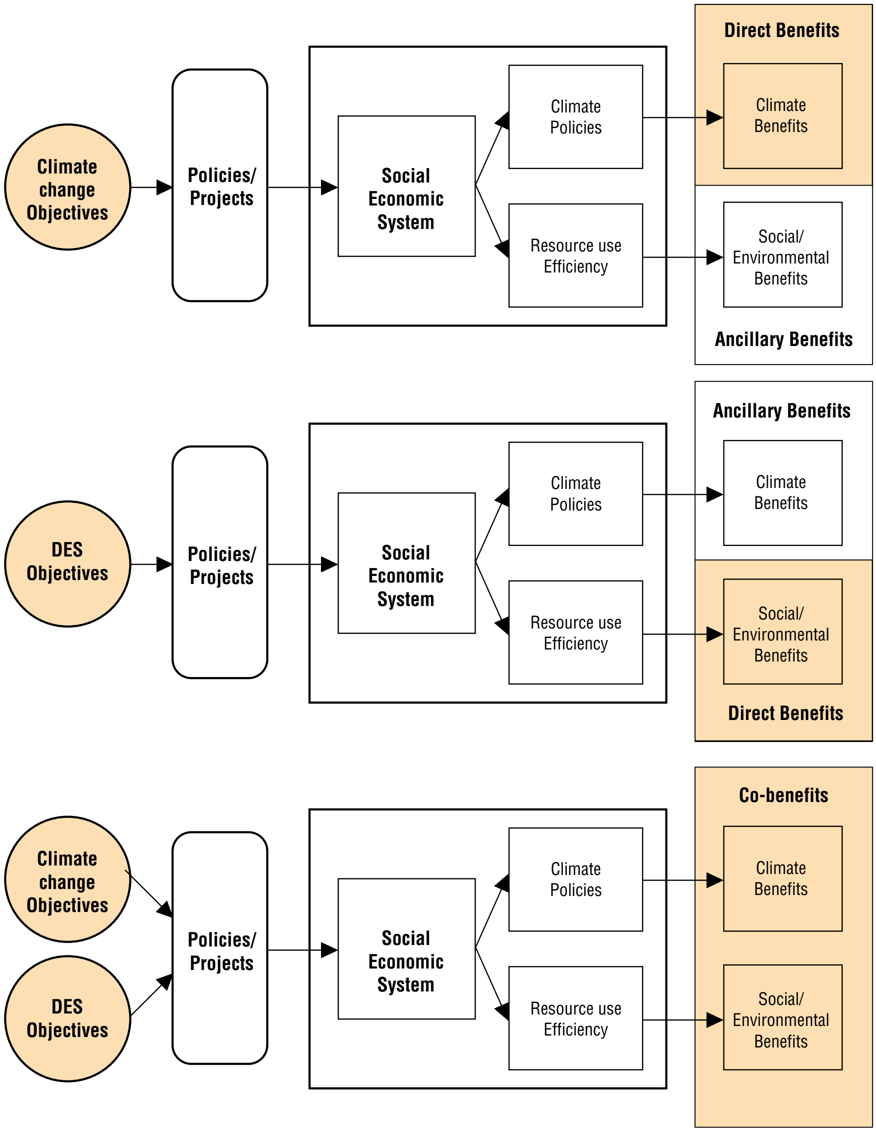

Fig. 3. A framework for co-benefits (Source: Hourcade et al., 2001).

expensive fuels, lower energy costs to the economy, slower resource depletion, less pollution, and, if properly introduced, enhanced skills.

- *Renewable energy technologies*: While not all renewable energy technologies may yet be cost effective in all situations, in many cases there are reasons to introduce renewable energy (such as wind energy, biofuels, solar boilers and solar photovoltaics, and small-scale hydropower in areas without grid electricity) independent of climate change considerations. Reasons can include the reduction of local air pollution, reduced dependence on imported fossil fuels, reduced negative environmental impacts of (coal) mining operations, or boosting local entrepeneurship and employment.

- *Behavioural changes*: Behavioural changes leading to lower energy consumption do not necessarily affect the quality of life. There are many options in households as well as in industry to reduce energy consumption just by conserving energy, such as turning down heating and cooling in unoccupied spaces, switching off equipment to reduce stand-by losses, or eating more local fresh produce rather than imported food. These changes are combined in complex ways with institutional arrangements, social conventions and norms, and identity (Shove et al., 1998). It is not likely that they can be changed in isolation but may be better conceived as part of a more holistic process of social change associated with sustainable development pathways.

4.2. Urban development and mobility

- *Low-emissions vehicles*: New technologies have the potential to significantly reduce energy consumption by cars, including new engine and vehicle design, lower weights, and better maintenance practices (Moomaw et al., 2001). Efficient hybrid cars have just entered the market, and vehicles running on alternative fuel types are rapidly being developed, notably fuel-cell driven cars.
- *Modal split*: In transport, the private automobile has acquired a dominant position for commuting and recreational travel in industrialised countries, and is rapidly gaining a similar status in developing countries as these get more affluent. However, strategies to promote other modes of transport can have multiple benefits unrelated to GHG mitigation. They include public health (in the case of bicycle traffic), reduction of traffic congestion, abatement of local air pollution, noise reduction, reduction of car accidents, and less road damage (Barker et al., 2001). Alternatively, communication technology can reduce the need for transport in many situations.
- *Urban design*: In the coming 50 years, it is expected that up to 3 billion people will be added to the world's population. Virtually all of these new world citizens will live in cities, creating what has been called the "urban tsunami" (Harcourt, 1999). Innovative design of urban areas can reduce GHG emissions and simultaneously avoid many other problems (Robinson, 2002). These include improving the linkages between urban public transport and residential areas, accessibility of jobs and shops, compact urban planning, and integrated, efficient building design. Such measures can significantly improve the quality of life in urban areas by making them safer and cleaner.

4.3. Food and fibre

- *Forestry*: Forestry mitigation projects such as reforestation and avoiding deforestation can contribute to conservation of biological diversity, watershed protection, creation of jobs, enhanced access to forest products, and access to new technologies. Plantation forests usually have lower biodiversity than natural forests, but can reduce the pressure on these forests (Kauppi et al., 2001). Nevertheless, the wider implications of such activities need to be carefully considered to avoid negative consequences, notably for biodiversity, indigenous people, and other local vulnerable communities.
- *Biofuel production*: Countries around the world have been producing biomass for fuel for quite some time, and many both developed and developing countries are currently considering wider usage of modern biofuels. Reasons for this include the rapid development of advanced biomass technology, in some developed countries freeing up of existing agricultural lands, in developing countries factors such as the suitable climate and the desire to decrease dependency on imported oil. While GHG emissions associated with biofuel combustion are lower than those from fossil fuels, climate change is usually not

the most important reason to pursue such policies. To avoid trade-offs, conflicts with food production, soil nutrient depletion, water availability and biodiversity should be considered (Moomaw et al., 2001).

- *Sustainable agriculture*: There are various agricultural practices that can reduce GHG emissions as a side-effect. Examples include increasing the efficiency of nitrogen fertiliser application, decreasing emissions of nitrous oxide, soil quality enhancement through modified tillage practices, sequestering soil carbon, and decreased dependency of livestock husbandry on external input of energy and chemicals.

We note that the examples given above fall into two categories: some represent mainly technological solutions, others involve changes in economic structure, societal organisation, or individual behaviour. The former has been characterised as "dematerialisation" of the economy: decoupling material resource consumption (and associated environmental impacts such as GHG emissions) from economic growth and human well-being. In developing countries, dematerialisation may lead to a slowing down of environmental pressures, but generally not reduce them in absolute terms, because in these regions it is imperative to meet the material needs of the population by rapid growth. In developed countries, dematerialisation may reduce environmental pressure per unit of activity, but this is unlikely to be sufficient to lead to absolute decreases great enough to balance the legitimate increasing pressure on the world's environmental resources by the developing countries. Therefore, a second type of change will be needed in combination with the dematerialisation "wedge". A combination of economic structural changes, lifestyle modifications, changes in societal organization and possible human values has been called the "resocialization" wedge (Robinson and Tinker, 1998). This type of change more explicitly takes into account the social aspects of sustainable development. Identifying opportunities for options to mitigate climate change and simultaneously address a wider set of development objectives thus has to take these two types of options into account.

There are important differences between developing and developed countries. Most developed countries are more concerned about the risks of climate change. Not having the same high-priority survival problems as developing countries, they have more resources to address the problem, and as a consequence many have adopted specific commitments. Climate change policy makers in these countries can not only incorporate broader concerns in their specific climate policy development, but also can help to integrate them into broader socio-economic development strategies.[10] It is likely that decisions on which policies are to be preferred and how they can be implemented are dependent on the weighing of the various objectives, and introducing broader development objectives into climate policy or the other way around can change the ranking of available options.

In developing countries, the main concern is with today's problems, there are usually no specialised climate policy makers, and the issue is to incorporate climate change mitigation in development policy in a way that does not reduce the effectiveness in achieving primary objectives. Often, weak institutional structures constrain communication about climate change and development issues between different government departments, and between government and the private sector. Again, the relative weight of policy objectives would determine which policy would be the best one to choose. At the project level, different weights will lead to very different ranking of projects. In some circumstances, this may lead to problems: for projects in the context of the CDM, the ranking of projects from the perspective of the host country,

[10] Developed countries often have an institutional network allowing regular interactions between different branches of the policy-making bodies.

emphasising a broader set of local social, economic and environmental goals (including vulnerability reduction), is likely to be very different from the perspective of the donor country, which would favour projects which would rank high because of their cost-effectiveness in reaching GHG emissions reduction targets (Markandya and Halsnaes, 2002). It should also be noted that the opportunities to become involved in the Kyoto Protocol (through the CDM, or through participation in the Protocol's Funds) vary significantly between developing countries because of differences in institutional capacity but also because of different priorities afforded to clean development, vulnerability reduction or other issues. Where the opportunities offered by the Kyoto Protocol are seen as attractive, climate change becomes more important for national policy makers.

Another issue that has to be taken into account is the possibility of spillovers from changes in developed countries on developing countries. For example, structural economic changes in developed countries by reducing dependency on heavy industries may lead to a shift of these industries to developing countries, with both positive (employment, income generation) and negative implications (environmental pressures).

5. Adaptation: capturing the co-benefits and minimising trade-offs

According to the IPCC TAR, inclusion of climatic risks in the design and implementation of national and international development initiatives can promote equity and development which is more sustainable, while reducing vulnerability to climate change (McCarthy et al., 2001). Policies specifically aimed at reducing vulnerability to climate change can also be more effective if other development objectives are included. Similar to mitigation, in developed countries concerns about climate impacts may already lead to investment decisions which have climate concerns as an important if not dominant design factor, for example, taking account of sea-level rise in the design of offshore oil platforms, or the construction of coastal defence systems. In developing countries, the emphasis will be on addressing current priority problems, in which climate change can be considered as one of the considerations. Taking climate change into account implies a difference in weighing different criteria and hence is likely to influence the priority ranking and implementation characteristics of policies. Below, we give a number of examples for different sectors vulnerable to climate change. Again, most examples are drawn from the TAR (McCarthy et al., 2001).

5.1. Marine and coastal zone management

- *Reducing coastal vulnerability*: Population and economic development is increasingly concentrated in coastal, often low-lying areas, which are often prone to flooding under conditions of extreme weather events. Maintenance or improvement of coastal defence systems by institution building; avoiding investments in flood-prone zones; managed retreat and flood insurance; improving natural coastal protection systems, such as coral reefs, mangroves and other coastal wetlands; and disaster preparedness and prevention programmes are all examples of strategies that would not only decrease vulnerability to current weather variability, but also increase preparedness to sea level rise and other potential impacts of climate change in coastal lands (McLean et al., 2001).
- *Sustainable fisheries*: Fisheries around the world are being threatened by overexploitation and thus by unsustainable management of marine resources. Recent experiences with conflicts over fish have shown that adaptation can be difficult when a resource is exploited by multiple competing users who possess

incomplete information about the resource. If incentives to cooperate are disrupted by the impacts of climate variation, dysfunctional breakdown in management rather than efficient adaptation may occur. This illustrates the importance of monitoring and archiving to the promotion of climate change adaptation. Improved fishery management can include improved collection and sharing of information, modified fishing industry practices, protection of spawning areas and habitats, all contributing to harvests that remain within sustainable production levels. Climate change is expected to change the distribution and abundance of marine animals and a sound and sustainable fishery industry now will reduce its vulnerability to future climate change impacts (McLean et al., 2001).

- *Protection of coral reefs*: Coral reefs are among the richest and at the same time most threatened ecosystems in the world. They are particularly sensitive to increased water temperatures, but their health is also threatened by marine water pollution, fishing practices, exploitation as building materials, and intensive tourism activities (McLean et al., 2001). Decreasing these stresses will not only help conserve these valuable ecosystems today, but also increase their resilience against the impacts of climate change.

5.2. Land-use, agriculture and water management

- *Developing drought resistant varieties*: The development and application of drought-resistant crop varieties in order to address vulnerability to recurring drought situations will also help reduce vulnerability to future, changing drought occurrences. In general, transfer of appropriate technologies to boost agricultural production in a sustainable fashion can reduce vulnerability, but there could be costs associated with learning about and gaining experience with different crops, or if irrigation becomes necessary but not readily available. Investing in local institutional capacity should accompany transfers of new technology (Gitay et al., 2001).
- *Improving fresh water management*: All important types of water problems (having too little, too much and too dirty water) can be exacerbated by climate change. Reducing the growth of water demand by promoting efficient water use, and reducing the vulnerability to the current hydrological variability, e.g. through appropriate storage and supply facilities, can also reduce vulnerability to future changes in hydrology due to changes in precipitation and evaporation.
- *Protecting vulnerable ecosystems*: Protecting vulnerable ecosystems to external stresses, which already may lead to their degradation, can enhance their resilience in view of climate change. Establishing connected protected systems rather than fragmented areas is often useful for current species movements, but could also facilitate future redistribution or migration in case the climate shifts.

5.3. Public health

- *Improving public health infrastructure*: Investments in public health training programmes, disease surveillance, sanitation systems, disease vector control, immunizations, resources to respond to disease outbreaks and resources to diagnose and treat disease would promote health in general, regardless of the effects of climate change, and would reduce the population's vulnerability to the health impacts of future climate change (McMichael et al., 2001).
- *Improving access to adequate food and water*: The nutritional status of the population as a function of accessibility to local food supplies is an important determinant of health. Improving this status also makes people less vulnerable to the potential negative health impacts of climate change, such as increased exposure to vector-borne diseases, temperature extremes and deterioration of air quality.

- *Health education*: Better education can make people better aware of health risks and improve the general health status, again with a positive side-effect of enhancing resilience to the possible health impacts of climate change.

Although adaptation may be considered as a ‘no regrets’ action, there are many reasons why some regions and economies are already quite vulnerable to climate variations, and have relatively low adaptive capacity to a challenge like climate change. Having the ability to adapt to change is not the same as actually adapting to change. The tools often are not used for a variety of reasons. For example, many options are available to enhance water supply or reduce water demand, but each has a set of economic, environmental and political advantages and disadvantages. Increased drought tolerance could involve controversial genetic engineering of crops. Inter-basin transfers at a large scale could have considerable environmental and social implications. Restrictions on floodplain development pose major political problems at local/regional scales. Increased storage capacity is expensive and requires land that may already be occupied. These and other options may also have side effects on other water users, including fisheries (Arnell et al., 2001). Consequently, adaptation choices would have implications for regional development, and for achieving sustainability.

6. Discussion and recommendations

Climate change has probably been the subject of the most extensive scientific research and policy assessment programme ever undertaken. The reports of the IPCC and many national assessments by scientific academies suggest that there is a great deal of scientific consensus about various aspects of climate change, notably about the physical aspects of global warming, but also about the availability of low-cost, even sometimes profitable, measures that would reduce GHG emissions and the vulnerability to climate impacts. Nevertheless, the international climate change policy community appears to be in a perpetual state of deadlock. Notwithstanding the serious risks of climate change, which have, by now, been accepted by practically all countries, no international legal agreement (e.g. the Kyoto Protocol) has yet entered into force due to lack of sufficient political will. Even if the Protocol enters into force after ratification by the Russian Federation, monitoring and verification of its implementation is likely to be difficult and subject to controversy. The framing of climate change as a scientific, primarily environmental, problem with large spatial and temporal scales, with add-on social and economic dimensions (i.e. treating these aspects as ancillary dimensions of the climate change problem), may be one of the reasons for this lack of meaningful progress. Developing a dialogue between climate change and sustainable development, involving all relevant stakeholders, might represent a promising way to effectively broaden the framing of the problem beyond the merely environmental dimension, connect the science to policy, widen the negotiating space, and break the deadlock.

Cohen et al. (1998), in their earlier paper on climate change and sustainable development, extensively evaluate the historical reasons behind the disconnect in science and policy between the climate change and sustainable development discourses, and provide recommendations for bringing the two closer together. With respect to climate change, they call for the acceptance of science as a social process, in which values do play a role. With respect to sustainable development, they recommend to strive for greater analytical and intellectual rigour to advance the concept and put it into practice. In this way, these two areas can learn from each other. Finally, they recommend pursuing participatory methodologies of integrated assessment, involving relevant stakeholders and going well beyond the limitations of integrated assessment modelling.

Now, 5 years later, we think that these recommendations are still urgent as the IPCC plans its Fourth Assessment Report (AR4). In its Third Assessment Report, the IPCC started to fill the "sustainable development gap" of the Second Assessment Report by explicitly recognizing the importance of the linkages between climate change and sustainability, by proposing a conceptual framework for analysing them, and by discussing the concepts of adaptive and mitigative capacity to capture the social, institutional and economic dimensions of the climate change response in a broader development context. It can be expected that the current IPCC debate on these issues will stimulate a wider and more intensive research effort with results that can be included in the AR4.[11] Hopefully, in an attempt to more fully explore the synergies and trade-offs between climate change and sustainable development, the IPCC can expand the expert community involved in its assessment, for example by more actively reaching out to the expertise embodied in the social sciences and humanities, the private sector and environmental and development NGOs.

We propose two avenues which can be taken to pursue this. First, rather than one all-encompassing assessment, this may be achieved much more effectively by a series of more focused assessments, targeting particular crucial sectors or regions (e.g. more so-called Special Reports, co-produced by the IPCC and other institutions, including private sector and NGO expertise). While we think that the SRES scenarios are appropriate as a wide-ranged basis for analysis of global and regional climate change and associated impacts for the AR4, a parallel assessment of alternative development pathways at the sectoral and regional level would provide excellent opportunities to explore the possible implications of the generic SRES worlds for mitigation and adaptation. Recognizing the uneven coverage of local scale climate impacts literature, especially in developing countries, such an assessment would complement impacts studies with an increased emphasis on reducing vulnerability and options for sustainable development, for different places in the world and in consultation with stakeholders. Such regional and sectoral assessments should transcend the current narrow emphasis on short-term local or sectoral goals, but explicitly stimulate those involved at regional and sectoral levels to reflect on these goals in a broader development perspective and a global setting. More long-term, innovative solutions beyond short-term technological fixes, which make sense in the local circumstances, should be considered.

Second, in addition to this regional and sectoral focus (in Special Reports, and/or in the AR4 chapter structure), we identify a need for an integrated assessment of the cross-cutting issues between the three Working Groups, in a concerted effort in parallel to the development of the three Working Group volumes. This assessment would be centred around the bottom right hand quadrant of the framework of the TAR, the socio-economic development paths, and the links with the other three quadrants, noting that the current three Working Groups are primarily associated with these other quadrants. Since the creation of a fourth Working Group to address this need is politically unlikely at this stage, an alternative approach would be to create a cross-cutting group of authors from the three Working Groups who would develop such an integrated assessment of the linkages between sustainable development and climate change. This is reminiscent of the development of the Synthesis Report during the TAR process, with two important

[11] In this connection the publication in 1998 of a state-of-the-art review on climate change and social science (Rayner and Malone, 1998) is of landmark importance. These four volumes represent a very important complement to the TAR, and go a long way toward beginning to rectify the somewhat one-sided representation of social and human issues in the IPCC process. Hopefully the AR4 can build in this momentum and create a much more integrated treatment of the human and natural aspects of climate change and sustainable development.

differences. First, the author team would be specifically selected to include expertise in this area, broadening the coverage of relevant literature. Second, rather than synthesizing the findings of the three Working Groups at the later stages of the process, the group would work in parallel with the three Working Groups, cross-fertilizing all four AR4 products from the start of the drafting process.

Gradually, this may help shift the framing of the climate problem from a merely scientific, environmental issue to a real-world societal problem with social and economic dimensions that are at least as relevant as the environmental aspects. While contributing to the policy-relevance of its assessment, this does not have to lead to policy-prescription, something that is not in the IPCC's mandate. In order to forge an effective link between global climate change and local sustainable development, the assessment of climate change, climate change impacts, adaptation, and mitigation options has to go down to the regional, and preferably local, level. In this paper, we do not primarily discuss what divorces the two problems, but focus on what binds them together and draw conclusions as to what the implications of the linkages can be for policy development in both areas. It is well-established that climate change is linked to other environmental issues at global (e.g. stratospheric ozone depletion), regional (e.g. photochemical smog, acid deposition, desertification) and local scales (e.g. urban air pollution, local water scarcity). These linkages are the focus of an increasing amount of research activities. Less is known about the linkages between climate change and local social and economic conditions and problems. Although this is an emerging field of inquiry, obvious linkages can already be identified and policies with joint gains can be explored. How these linkages can be exploited to make development more sustainable is approached from two angles in this paper.

First, it is recognized that GHGs, and thus human-induced global warming, are determined as much by general development pathways as by specific climate mitigation policies. The same applies to society's capacity to adapt to climate change and its associated vulnerability, which are as much influenced by the development path as by specific adaptation policies. These development pathways are the result of myriads of individual decisions and are strongly dependent on prevailing value systems. Bifurcations resulting from large-scale policy decisions, e.g. in the area of energy supply, can close off options for the future. Thus it is important to begin to think of future options in a more holistic way than that suggested by a focus on individual energy supply or demand technologies or adaptation measures. Important concepts in this connection are those of technological "regimes" and "landscapes".[12] Climate change policy measures will take place in the context of a suite of existing policies, institutional arrangements, social norms and cultural values. How such policies will interact with these factors, including even the possibility of developing the policies in the first place, will depend on the interaction of these contextual factors (Shove et al., 1998). For example, the success of energy efficiency policies may be strongly constrained by institutional barriers such as the well-known problem of split incentives between renters and landlords, or by social norms governing automobile-owning behaviour. The critical point is the need to situate climate policy responses fully in the larger context of technological and socio-economic policy development rather than view them as an add-on to those policies.[13]

[12] A technological regime is the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems—all of them embedded in institutions and infrastructures. Regimes are intermediaries between specific innovations as these are conceived, developed and introduced, and overall socio-technical landscapes (Rip and Kemp, 1998).

[13] Although theoretically not challenged, integration of climate change and sustainable development appears difficult in reality. Notwithstanding recurring discussion, in 2001 no agreement could be reached by IPCC delegations upon the development of even a low-profile Technical Paper—based on existing IPCC documents—on the linkages between climate change and sustainable development.

Second, the recognition of the linkages, and thus the potential for synergies and trade-offs, is the basis for an inventory of concrete policy options, which capitalise on the synergies and minimise the trade-offs. These policy options are a mere reflection of the way in which the alternative development pathways mentioned above are shaped. The paper gives a number of examples, in the area of mitigation for a number of economic sectors (energy and industry; urban development and mobility; food and fibre) and for adaptation for a number of sensitive systems (marine and coastal zones; land-use, agriculture and water management; and public health), without the illusion of being comprehensive. Other papers in this volume present concrete examples of the linkages discussed here. The examples illustrate that policies are seldom developed for merely one reason, even if they may be initiated for addressing one particular problem. For climate change policies, this means that other, wider development issues should be taken into account in the design head-on. For evaluating and developing social and economic policies, climate change mitigation and adaptation should be considered. Doing this, the weighing of criteria will change and consequently the relative priorities and design characteristics of policies as well.

So far, we have discussed mitigation on the one hand, and adaptation and reducing vulnerability on the other, as largely separate issues. For some policy options, this separation may be acceptable, because, for example, they very specifically relate to only reduction of GHG emissions in a particular industry, or only to improvement of coastal defence to specifically reduce vulnerability to future climate change. Generalising this distinction however implies the risk that mitigation and adaptation are considered as activities competing for the same limited resources ("a dollar spent on adaptation cannot be spent on mitigation"). However, many of the underlying societal conditions determining both adaptive and mitigative capacity cannot easily be separated: building human and social capital for example will enhance both mitigative and adaptive capacity, and in general will contribute to wider sustainable development objectives AND climate change response. For these reasons, Robinson and Herbert (2000) argue that it would be helpful to begin to think of mitigation and adaptation in a more integrated way, where climate change measures are seen as parts of a larger response of societies to global change, including a wide range of environmental, socio-economic and technological challenges. This is consistent with the arguments presented here about the central importance of the underlying socio-economic development pathways and technological regimes.

Both approaches discussed here—thinking through the characteristics and consequences of alternative development pathways, and evaluation of specific mitigation and adaptation policies integrated into general development policies—have one important element in common. In order to be effective, they do require engaging the key stakeholders including the general public in the debate, and as partners in assessments where the opportunities present themselves (Abaza and Baranzini, 2002). This will help to build political constituencies and market acceptance for the collective policy and investment decisions required to address climate change and make development more sustainable (Robinson, 2002).

We conclude by returning to our initial concern regarding the need to connect the fields of climate change and sustainable development. There are two basic questions. First, could climate change affect the outcomes of future development paths? Second, could development choices affect future GHG emissions and vulnerabilities to climate? In our view, the answer to both questions is yes. We hope that by presenting arguments for integration of climate change and sustainable development research and alternatives for response, we can accelerate the process towards a more unified and equitable approach to global environmental and economic stewardship.

References

Abaza, H., Baranzini, A. (Eds.), Implementing Sustainable Development: Integrated Assessment and Participatory Decision-Making Processes. Edward Elgar Publishing Ltd., London, 2002.

Arnell, N., Liu, C., Compagnucci, R., da Cunha, L., Hanaki, K., Howe, C., Mailu, G., Shiklomanov, I., Stakhiv, E., 2001. Hydrology and water resources. In: McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., White, K. (Eds.), Climate Change 2001: Impacts, Vulnerability and Adaptations. Cambridge University Press, Cambridge, United Kingdom.

Banuri, T., Weyant, J., Akumu, G., Najam, A., Pinguelli Rosa, L., Rayner, S., Sachs, W., Sharma, R., Yohe, G., 2001. In: Metz, et al. (Eds.), Setting the Stage: Climate Change and Sustainable Development.

Barker, T., Srivastava, L., Al-Moneef, M., Bernstein, L., Criqui, P., Davis, D., Lennon, S., Li, J., Torres Martinez, J., Mori, S., 2001. In: Metz, et al. (Eds.), Sector Costs and Ancillary Benefits of Mitigation.

Cohen, S., Demeritt, J., Robinson, J., Rothman, D., 1998. Climate change and sustainable development: towards dialogue. Global Environ. Change 8 (4), 341–371.

Gitay, H., Brown, S., Easterling, W., Jallow, B., Antle, J., Apps, M., Beamish, R., Chapin, T., Cramer, W., Frangi, J., Laine, J., Lin, E., Magnuson, J., Noble, I., Price, J., Prowse, T., Root, T., Schulze, E., Sirotenko, O., Sohngen, B., Soussana, J., 2001. In: McCarthy, et al. (Eds.), Ecosystems and Their Goods and Services.

Harcourt, M., 1999. The urban Tsunami—A role for Canadian planners. Plan Canada 39 (5), 12–13.

Hourcade, J.-C., Shukla, P., Cifuentes, L., Davis, D., Edmonds, J., Fisher, B., Fortin, E., Golub, A., Hohmeyer, O., Krupnick, A., Kverndokk, S., Loulou, R., Richels, R., Segenovic, H., Yamaji, K., 2001. In: Metz, et al. (Eds.), Global, Regional, and National Costs and Ancillary Benefits of Mitigation.

Kauppi, P., Sedjo, R., Apps, M., Cerri, C., Fujimori, T., Janzen, H., Krankina, O., Makundi, W., Marland, G., Masera, O., Nabuurs, G.-J., Razali, W., Ravindranath, N.H., 2001. In: Metz, et al. (Eds.), Technological and Economic Potential of Options to Enhance, Maintain, and Manage Biological Carbon Reservoirs and Geo-Engineering.

Leggett, J., Pepper, W.J., Swart, R.J., 1992. Emissions scenarios for the IPCC: an update. In: Houghton, J.T., Callander, B.A., Varney, S.K. (Eds.), Climate Change 1992. The Supplementary Report to the IPCC Scientific Assessment. Cambridge University Press, Cambridge, UK, New York, NY, USA, pp. 71–95.

Markandya, A., Halsnaes, K. (Eds.), Climate Change and Sustainable Development. Earthscan Publications, United Kingdom, 2002.

McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., White, K. (Eds.), Climate Change 2001: Impacts, Vulnerability and Adaptation, Cambridge University Press, Cambridge, United Kingdom, 2001.

McLean, R.F., Tsyban, A., Burkett, V., Burkett, V., Codignotto, J.O., Forbes, D.L., Mimura, N., Beamish, R.J., Ittekkot, V., 2002. In: McCarthy, et al. (Eds.), Coastal Zones and Marine Ecosystems.

McMichael, A., Githeko, A., Akhtar, R., Carcavallo, R., Gubler, D., Haines, A., Kovats, R.S., Martens, P., Patz, J., Sasaki, A., 2001. In: McCarthy, et al. (Eds.), Human Health.

Metz, B., Davidson, O., Swart, R., Pan, J. (Eds.), Climate Change 2001: Mitigation. Cambridge University Press, Cambridge, United Kingdom, 2001.

Morita, T., Robinson, J., Adegbulugbe, A., Alcamo, J., Herbert, D., Lebre La Rovere, E., Nakicenovic, N., Pitcher, H., Raskin, P., Riahi, K., Sankovski, A., Sokolov, V., de Vries, B., Zhou, D., 2001. In: Metz, et al. (Eds.), Greenhouse Gas Emission Mitigation Scenarios and Implications.

Moomaw, W.R., Moreira, J.R., Blok, K., Greene, D.L., Gregory, K., Jaszay, T., Kashiwagi, T., Levine, M., McFarland, M., Prasad, N.S., Price, L., Rogner, H.-H., Ralph S., Zhou, F., Zhou, P., 2001. In: Metz, et al. (Eds.), Technological and Economic Potential of Greenhouse Gas Emissions Reduction.

Munasinghe, M., 2001. The sustainomics transdisciplinary metaframework for making development more sustainable. Int. J. Sustainable Develop. 5, 1–2.

Nakicenovic, N., Swart, R.J. (Eds.), IPCC Special Report on Emissions Scenarios. Cambridge University Press, Cambridge, United Kingdom, 2000.

Olhoff, A., 2002. Assessing social capital aspects of climate change projects. In: Markandya, A., Halsnaes, K. (Eds.), Climate Change and Sustainable Development, Earthscan Publications, United Kingdom.

Rayner, S., Malone, E. (Eds.), Human Choice and Climate Change. Battelle Press, Columbus, 1998.

Rip, A., Kemp, R., 1998. Technological Change. In: Rayner, S., Malone, E. (Eds.), Human Choice and Climate Change, Battelle Press, Columbus, OH, pp. 327–399.

Robinson, J., 2002. In: Chesworth, W., Moss, M., Thomas, V. (Eds.), Squaring the Circle? On the Very Idea of Sustainable Development. Sustainable Development: Mandate or Mantra? The Kenneth Hammond Lectures on Environment, Energy and Resources—2001 Series. Faculty of Environmental Studies, University of Guelph, Guelph.

Robinson, J., Tinker, J., 1998. In: Schnurr, J., Holtz, S. (Eds.), Reconciling Ecological, Economic and Social Imperatives. The Cornerstone of Development—Integrating Environmental, Social & Economic Policies. International Development Research Centre, Ottawa.

Robinson, J., Herbert, D., 2000. Integrating Climate change and Sustainable Development. Climate Change and Its Linkages with Development, Equity, and Sustainability, Colombo, Sri Lanka, Intergovernmental Panel on Climate Change.

Robinson, J., Herbert, D., 2001. Integrating climate change and sustainable development. Int. J. Global Environ. Iss. 1 (2), 130–148.

Shackley, S., Wynne, B., 1995. Integrating knowledge for climate change: pyramids, nets and uncertainties. Global Environ. Change 5 (3), 113–126.

Shove, E., Lutzenhiser, L., Guy, S., Hackett, B., Wilhite, H., 1998. Energy and Social Systems. In: Rayner, S., Malone, E. (Eds.), Human Choice and Climate Change, Battelle Press, Columbus, OH, pp. 271–329.

Smit, B., Pilifosova, O., Burton, I., Challenger, B., Huq, S., Klein, R.J.T., Yohe, G., 2001. In: McCarthy, et al. (Eds.), Adaptation to Climate Change in the Context of Sustainable Development and Equity.

Thompson, M., Rayner, S., 1998. Cultural discourses. In: Rayner, S., Malone, E. (Eds.), Human Choice and Climate Change, vol. 1. The Societal Framework. Battelle Press, Columbus, OH, pp. 265–343.

UNEP, 2002. Global Environmental Outlook 3. Earthscan, London, United Kingdom.

UNCED, 1992. Agenda 21. United Nations, New York, United States.

UNFCCC, 1992. The United Nations Framework Convention on Climate Change, A/AC.237/18, 9 May.

Watson, R.T., Dixon, J.A., Hamburg, S.P., Janetos, A.C., Moss, R.H., 1998. Protecting Our Planet Securing Our Future Linkages Among Global Environmental Issues and Human Needs. Worldbank, Washington, United States.

Watson, R., Albritton, D., Barker, T., Bashmakov, I., Canziani, O., Christ, R., Cubasch, U., Davidson, O., Gitay, H., Griggs, D., Houghton, J., House, J., Kundzewicz, Z., Lal, M., Leary, N., Magadza, C., McCarthy, J., Mitchell, J., Moreira, J., Munasinghe, M., Noble, I., Pachauri, R., Pittock, B., Prather, M., Richels, R., Robinson, J., Sathaye, J., Schneider, S., Scholes, R., Stocker, T., Sundararaman, N., Swart, R., Taniguchi, T., Zhou, D., 2001. Climate Change 2001: Synthesis Report. Cambridge University Press, London.