Development and climate - exploring an integrated approach

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1. Introduction

The distribution of wealth amongst the global population makes that development has a totally different connotation in the richer and poorer parts of the world. To the South, pressing day-to-day problems, such as poverty eradication, clean drinking water, food security and access to energy are of the highest priority. Against this background, for developing countries international environmental policies, and more specifically the climate issue, are not only of secondary importance, but often even perceived as a possible threat to development.

The challenges for development are enormous. World-wide, 1.3 billion people in developing countries have to live on less than $1 a day, lacking the resources for obtaining adequate food, clean water, access to energy resources, safe shelter and healthy living conditions. Two billion people are without access to electricity. Among the UN Millennium Goals are eradication of extreme poverty and hunger by 50% in 2015 and ensuring environmental sustainability.

Since the signing of the United Nations Framework Convention (UNFCCC) in Rio de Janeiro in 1992, climate change has received increasing international attention. This process is driven mostly by environmental concerns from the North. In contrast, in many developing countries climate change is considered a remote issue and climate change is seen as a problem caused by the North, that should be solved by the North. At the same time is it generally recognised that controlling the risks of climate change would require global co-operation in limiting greenhouse gas emissions and in adapting to some inevitable further change of the climate. The main concern of developing countries is that such global co-operation would have negative effects on their development. Climate change adaptation and mitigation in the South therefore should be approached in a way that it contributes to development and not interferes with it.

Scientific analysis shows that developing countries are especially vulnerable to climate change impacts and may already be victims of changing climate and weather related disasters. Climate change is thus a threat to development in the South. The challenge is therefore to identify and implement strategies that realise development goals, but also address climate change. Climate change needs to be seen as part of the larger challenge of sustainable development. Both mitigation and adaptation measures fit into this.

This report presents some exploratory research of RIVM's climate and global sustainability group on an alternative approach to the challenges brought on by the climate change problem. In this approach, development is placed before climate change, reversing existing frameworks. This so-called 'Development First' approach emerged from the recognition that many efforts undertaken within developing countries as part of sound development initiatives are also beneficial from a climate perspective. This opens up the possibility of incorporating climate change (and other environmental) policies in development strategies and programmes that are vitally important to developing countries' decision-makers. The idea is that development would be "climate safe", in the sense that countries develop in such a way that they become less vulnerable to climate change impacts. And that development would be "climate friendly", implying an economy with low greenhouse gas emissions. Such nationally recognised development strategies that enable dealing with climate change in an integrated way might pave the way towards international co-operation that would be needed to effectively deal with global climate change. New strategies to realise this have to be explored further.

This report explores in a preliminary way what it would take to meet development goals in a climate friendly and climate safe way, thus making progress towards a sustainable future. After the introduction, this report first briefly discusses the relations between development, climate change and sustainable development and explores the 'Development First' approach. It then shows that there are different ways to realise development goals within climate constraints. After these introductory chapters, the approach is elaborated for two high priority development issues, food security and energy supply and access. The second half of the paper presents four country examples to illustrate the approach further.

2. Linkages between development and climate change

Development is shaped by people, priorities, aspirations, circumstances, resources and politics within society. Development is a multi-dimensional transformation process of society in which related societal goals are to be realised over a longer period of time. At the same time it is clear that development processes at the national level are heavily influenced by international policies (such as programmes of the World Bank and IMF), trade barriers on the world market, international (environmental) treaties and priorities of international donor agencies (Thomas and Sokona, 2002).

Poverty reduction, economic development (including the internal distribution of wealth within a country) and environment are interconnected in a fundamental way. Without economic development no poverty reduction. Without poverty reduction the poor remain vulnerable for changes in environmental resources, such as water, agriculture, forests and fisheries. The development process in many developing countries will be, or is already influenced by the impacts of climate change, especially through extreme weather events damaging infrastructure and climate variability affecting agriculture and water (IPCC, 2001). These impacts are aggravated because widespread poverty in developing countries considerably limits their adaptive capabilities. Some examples are:

- damages in coastal areas as a direct result of sea level rise, especially in poor areas which are already vulnerable to today's extreme weather events
- negative impacts on agricultural productivity in regions where farmers are already struggling to earn a living, notably arid and semi-arid areas;
- expansion of the distribution of vector-borne diseases such as malaria, with serious health and social implications;
- differences in regional and local impacts of climate change will exacerbate inequities between societal groups and regions;
- more frequent disasters caused by extreme weather events (for example in floods and land slides).

The capability of developing countries to adapt and mitigate will largely depend on the country's overall capacities to develop: to perform functions, to solve problems and set and achieve objectives (Fuduka-Parr et al., 2002). It often is suggested that climate change mitigation (or adaptation) measures for developing countries would be too expensive or incompatible with development priorities. However, this paper will explore the idea that there are various ways to combine the objectives of (sustainable) development and climate change.

The challenge is to integrate the long-term dimensions of avoiding and adapting to climate change in the development agenda, to allow countries to contribute to, rather than obstruct, local and national development.

There are not only linkages between climate change and sustainable development at the level of the problems and options, but also at the level of the policies developed and implemented to address them. One thing these policies have in common is that they all reflect the prevailing social capacity (Olhoff, 2002). *Figure 1* shows sustainable development and climate change policies that are directly connected. Applying such policies will allow developing countries to develop in a sustainable way and become less vulnerable to the impacts of climate change. Environmentally sound programmes are often developed and implemented for reasons other than climate change, but as a side effect reduce vulnerability or greenhouse gas (GHG) emissions. Some examples:

- reducing fossil fuel consumption, e.g. by introducing clean and efficient fossil-fuel based engines, or shifting to non-fossil energy sources, also contributes to the abatement of urban and regional air pollution;
- agro-forestry projects protect soils, sequester carbon and provide employment opportunities for local farmers;
- coastal zone management activities can not only protect against the impacts of sea level rise, but also strengthen the capacity of local communities to deal with extreme events due to the current climate variability;
- the development of drought resistant crops reduces farmers' vulnerability to current climate variability as well as future changes;
- on the longer term, climate change mitigation reduces climate change impacts, enhancing opportunities for sustainable development.

These examples, of which some will be further elaborated in the country studies in this report, illustrate the potential for synergies between development and climate change response. But there are also examples of negative links, or trade-offs. Large hydropower plants can lower GHG emissions, but can affect the livelihoods of local communities and destroy valuable ecosystems. Decreased consumption of fossil fuels such as oil can reduce dependency of countries on imported fuels, but can have negative economic consequences for fossil fuel exporting countries.

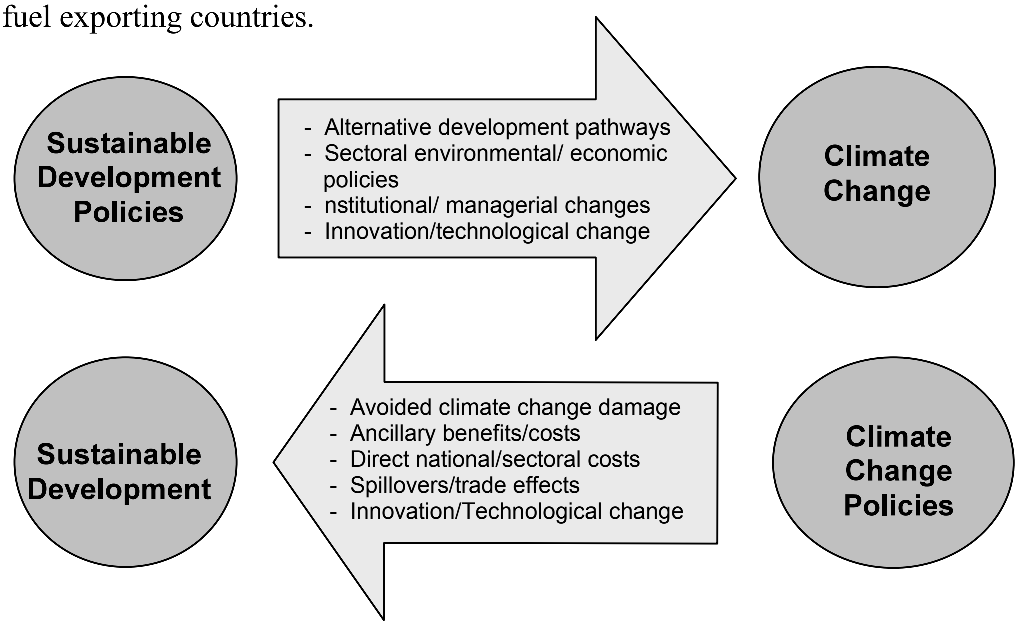

Figure 1 Linkages between sustainable development, climate change, and policies in these areas (Swart, Robinson and Cohen, 2002)

3. Towards a strategic approach starting from development priorities

In many developing countries, energy efficiency and renewable energy initiatives and other climate favouring activities emerge as side-benefits of sound development programmes. Some examples are given in the previous section. They have in common that they are all undertaken without any reference to climate change mitigation or adaptation, but have substantially reduced the growth rates of greenhouse gas emissions (Halsnaes and Olhoff, 2002) or reduce the vulnerability of the population to climate variability.

Although within the larger set of economic and social development priorities climate change is of less importance to many developing countries, the observations above suggest that it might be possible to build climate (and other environmental) policies upon development priorities that are vitally important to developing countries. The point of departure of this integrated approach (and this paper) is development, hence 'Development First'.

The approach is country-specific, it acknowledges each country's specific situation as development is mainly shaped within the country. The challenge is to identify, elaborate and implement national strategies and projects that meet development objectives and, at the same time, help controlling climate change. Case studies show that this is indeed possible, illustrating three major points (see for instance Beg et al., 2002; Biaggini (ed), 2000; Halsnaess and Olhoff, 2002; Goldemberg and Reid (eds.), 1999):

- developing countries already undertake efforts in adaptation and mitigation;
- there are possibilities of de-linking economic growth and fossil energy consumption;
- synergies exist between development policies and climate change objectives to reduce the vulnerability of society and to develop towards a low emission economy.

These positive linkages give hope that a world-wide effort to control climate change is possible. However, progress with synergetic measures dealing with development and climate change is generally still slow. Is has to be realised that from a climate protection perspective timing is crucial, in order to avoid unacceptable climate change (see *Box 1*). This means that the positive linkages between development policies and addressing climate change have to be reinforced.

Box 1
Keeping our options open: the importance of timing

Apart from the inertia in the climate system, there is also inertia in human systems. Many human system components have turnover rates in the order of 20-40 years, such as power plants, industrial complexes and means of transportation, while most infrastructures (e.g. road and railways) have even much longer lifetimes. Development in developing countries will involve many capital investment decisions that will affect GHG emission trajectories for many decades. Thus, time is a crucial element in shifting development pathways in a sustainable direction. Development, when focussing on social and economic issues, may result in an increase in pollution after which more environmental friendly pathways can be taken. If the world wants to keep open the option of avoiding unacceptable climate change, the global GHG emissions have to peak within the next decades in order to limit a global temperature increase to about 2 degrees by the end of the century. But with such temperature increase climate impacts will be experienced in most developing countries.
(See Berk et al., 2002).

International policies and the global economic context of development are important as well. International policies, both environmental and non-environmental, can support as well as hinder national development strategies. The challenge is to identify incentives in global or regional economic and environmental regimes (trade, economic restructuring, technology development, energy, protection of forests, the climate change convention, etc.) that support developing countries to include climate considerations in their development strategies.

4. Development paths: the IPCC SRES scenarios

There are different ways for countries to realise development goals. Some development paths are cleaner than others, resulting in less emissions. Some paths lead to low vulnerability, others not. The main point is that the direction of development matters a lot for the effectiveness of dealing with climate change.

To explore this further, it is helpful to consider various possible directions in which the world may evolve over the coming decades. This can be done using scenarios. Scenarios have been developed to explore possible future ways of development and their consequences for greenhouse gas emissions (IPCC, 2000). These scenarios combine two dimensions: the level of globalisation and the prevailing value orientation (materialistic versus sustainability oriented); there are no climate policies included. These scenarios provide insights in possible trajectories to futures in which development priorities may or may not be realised and to what extent climate change is further evolving. *Table 1* describes these scenarios in more detail, both for the general assumptions and the energy and food system.

The scenarios illustrate that the direction of development matters for realising other goals such as climate protection. *Figure 2* shows the global CO_2-emission trajectories that result from the different scenarios, compared to a stabilisation profile that is often considered sufficiently stringent to avoid large scale climate impacts (450 ppmv CO_2). The scenarios thus show that the way and direction in which the world develops is probably at least as important for future greenhouse gas emissions, as the implementation of climate policies. In an A2 world the policy effort needed to realise the stabilisation profile would be much larger than in a B1 world.

There is not one definition of sustainable development. So, in terms of the IPCC scenarios, it is important to acknowledge that different trajectories may lead to what a particular country would consider sustainable, provided greenhouse gas emissions are sufficiently reduced to stabilise greenhouse gas concentrations in the atmosphere at relatively low levels. In other words, as indicated in *Figure 2*, in an A1 world or B2 world it would be possible to stabilise CO2 concentrations at a level of 450 ppmv, effectively dealing with the climate dimension of sustainability. The other dimensions (income distribution, poverty, food security, etc.) will determine whether overall development is sustainable. *Table 2* shows the performance of different scenarios. It is clear that both A1 and B1 are doing well in realising development priorities, if greenhouse gases are controlled sufficiently. However, the table also shows that only the B1 scenario results in a combined realisation of development and climate goals that go a long way towards low level GHG concentration stabilisation without specific climate policy. This implies that in the other worlds a much larger effort will be needed to realise development and environmental sustainability and climate targets at the same time.

Table 1 Characterisation of the four global scenario story lines (IPCC, 2000)

Scenario assumptions			
A1	**B1**	**A2**	**B2**
Stabilizing population (9 billion in 2050)	Stabilizing population (9 billion in 2050)	Growing population (13.5 billion in 2100); slowdown in fertility decline with lower income	Growing population (10.5 billion in 2100); in some regions slowdown in fertility decline with lower income
Globalization, very high-growth high-tech	Globalization, high-growth high-tech	Focus on regional [cultural] identity; environment low-priority	Focus on regional [cultural] identity; local/regional environment high-priority; non-effective in global environmental issues
Orientation on profits and [technological] opportunities Convergence in regional income and rapid diffusion of technology; no trade barriers	Orientation on non-material quality of life aspects. Convergence in income and rapid diffusion of resource-efficient technology	No convergence in regional income and slow diffusion of technology; trade barriers. In some regions poor functioning markets and institutions	Orientation on non-material quality of life aspects. Varied regional economic and technology developments
Energy system			
Decline in energy-intensity due to innovations and high capital turnover rate	Strong focus on energy efficiency and sufficiency, service economy.	Low rate of energy efficiency innovations, due to trade barriers and capital scarcity	Focus on energy efficiency and sufficiency, service economy.
Preference for clean fuels and fast depletion cause fossil fuel prices to rise. This enables efficiency and zero-carbon options to penetrate, accelerated by learning-by-doing	Large preference for clean fuels and depletion cause fossil fuel prices to rise. This further accelerates efficiency and zero-carbon options to penetrate, accelerated by learning-by-doing	Coal use rises in many regions: seen as cheapest available fuel as oil and gas become more expensive/ unavailable. Initially capital-intensive zero-carbon options penetrate in most regions only slowly	Preference for clean fuels and depletion cause fossil fuel prices to rise in some regions, inducing efficiency and zero-carbon options to penetrate, accelerated by learning-by-doing
Food system			
Fast increase in the volume of trade in food and feed	Fast increase in the volume of trade in food and feed	Moderate increase in the volume of trade in food and feed	Moderate increase in the volume of trade in food and feed
Fast increase in food and livestock productivity	Fast increase in food and livestock productivity with high efficiency of fertilizer use	Slow increase in crop and livestock productivity	Moderate increase in food and livestock productivity
Fast increase in per capita consumption of livestock products as a result of GDP increase	Per capita consumption of livestock products is 10% lower than in A1 scenario in 2050 and 20% lower than in A1 in 2100	Slow increase in per capita consumption of livestock products as a result of GDP increase	Moderate increase in per capita consumption of livestock products as a result of GDP increase

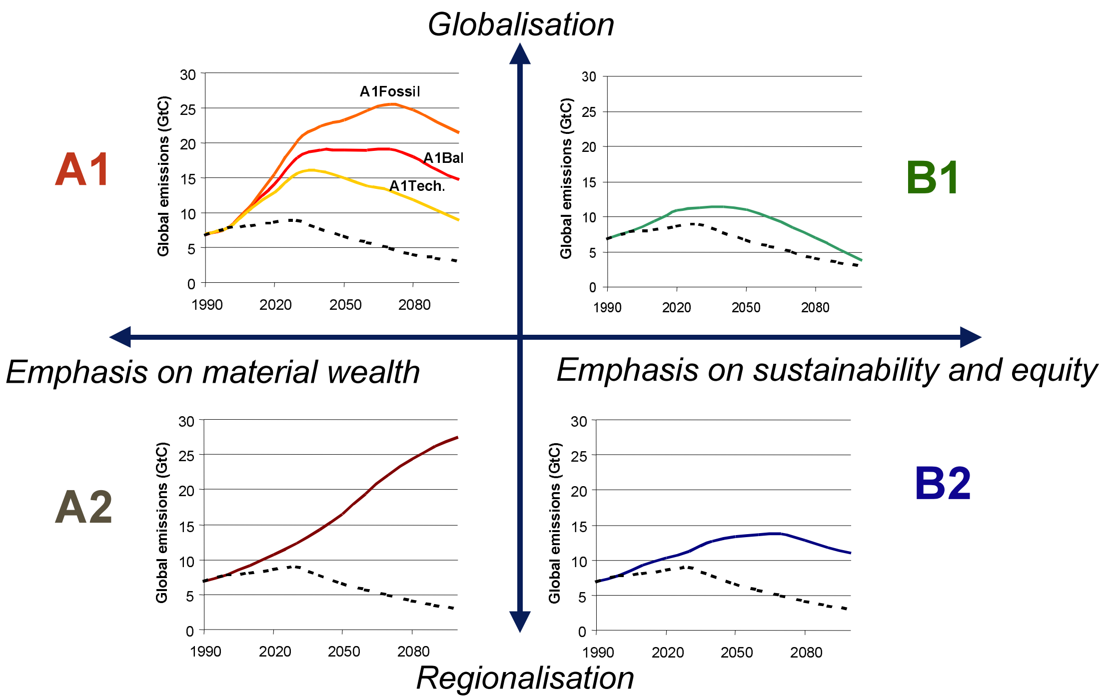

Figure 2 Global CO_2 emission trajectories for the different IPCC-SRES scenarios compared to a 450 stabilisation emission profile (dotted line: based on RIVM FAIR model) (Den Elzen et al., 2001)

The way the world evolves in the different scenario's not only influences the magnitude of the task of bringing emissions back to low levels, but also the preferred (technological) solutions and policy instruments for doing that. For instance, large scale technological fixes such as carbon removal and storage or high tech energy supply systems would fit in a world characterised by strong globalisation and a materialistic attitude. But in a strong regional orientation and emphasis on environmental and social values, consumption patterns, energy efficiency and local sustainable solutions might be preferable. The nature of the development paths furthermore influences social capabilities, and therefore is strongly influencing the adaptive and mitigative capabilities of society (Olhoff, 2002; Swart, Cohen and Robinson, 2002.).

Table 2 Development priorities, environmental sustainability and climate change

Indicator for sustainability	**1990**	**A1B 2050**	**A2 2050**	**B1 2050**	**B2 2050**
Poverty eradication	Low	High	Low	Very high	Medium
Reduction of income gaps between countries	Low	High	Low	Very high	Medium
Access to energy	Low	High	Low/ Medium	Very high	Medium/ High
Avoiding health impacts	Medium	High	Low	Very high	High
Technology diffusion	Low	Very high	Low	High	Medium
Food security	Medium	High	Low/ Medium	High	Medium/ High
Environmental sustainability		Low	Very low	High	Medium
GHG emissions		Very high	High	Low	Medium
Projected climate change		High	High	Low	Medium
Projected vulnerability (incl. adaptive capacity)		High	Very high	Low	Medium

5. Food security and climate change

Development and food security
With growing populations and some 75% of the world's poorest people still living in rural areas where their well-being depends mainly on agricultural development, agriculture plays a central role in exploring pathways of sustainable development. Food security exists when every person, at any time, has physical and economic access to sufficient, safe and nutritious food to meet dietary needs and food preferences for an active and healthy life. Acknowledging the multi-dimensional character of food security, sustainable development pathways for food production in developing countries need to be identified.

Agriculture plays a central role in the economy of most developing countries. Finding a safe and responsible way to feed the growing population will remain a priority for developing countries. This is inextricably linked with environmental management, including reducing long- and short-term vulnerability, aiming at protecting the natural resource base from overexploitation. The main cause of food insecurity is poverty. Those people without minimum and regular income are the most vulnerable to local food shortages caused by either natural factors (droughts) or human factors (conflict, policies). Attacking poverty is the most effective and long lasting solution to ensure food security. While at the farm level food security is strongly linked to production, this link is less strong at regional and national level. The larger the scale, the more important market mechanisms become.

Enhancing food security
Enhancing food production will be crucial for feeding the projected world population of eight billion people by 2030. Area expansion and increasing productivity per unit of land are the two main options in increasing food production. Up to the 1940s, area expansion was the main instrument for developed countries for keeping food production in pace with the increasing population. Later, an increase in yield (production per area) through improved varieties and changes in management became more important. Besides the positive effect of lifting production, both options also have their down side. The first may result in irreversible land degradation, whereas the latter requires input intensification that may result in increased emissions to water resources and the atmosphere. For developing countries, the practice of expanding the agriculture area into, mainly marginal, areas has only recently started to fade out. A related problem is that prime agricultural land is lost as a direct result of urbanisation, further increasing the pressure on the remainder of the land.

In most projections to enhance food production in developing countries, area expansion is of minor importance compared to yield increase. The second half of the 20th century saw enormous improvements in agricultural production. Yields of major food crops such as rice, maize and wheat tripled over this period. This science-based agriculture not only increased yields, but it also resulted in a slowing down of the rate of conversion of natural and fragile areas into agricultural land. Key to this success was the combination of improved varieties, improved technologies and soil and crop management. However, this green revolution bypassed poor farmers because obtaining seeds and fertilisers was beyond their reach. High yielding varieties require more care and input of mainly nutrients and water, and consequently a good understanding of the agro-ecosystem. The negative environmental impacts of high input agriculture are indisputable: soil degradation and excessive use of agro-chemicals such as pesticides and herbicides resulting in groundwater pollution. Loss of soil fertility resulting from shorter fallows and poor land management was among the first signs that the newly introduced agricultural systems caused problems and were undermining the natural resource base. The boundaries and impacts of agricultural development on the environment, but also on social and economic structures became clear. Sustainable development pathways have to put greater emphasis on farm management in its social context.

Food security and dealing with climate change

Possible effects of climate change on crop productivity revealed a diverse picture for developed and developing countries. Where some areas and crops, mainly in the Northern hemisphere may benefit from changes in environmental conditions, other regions especially in the South are pushed towards lower and less stable yields. Thus, climate change may affect agriculture in developing countries in a different way than in the North, exacerbating existing differences in production conditions *(see Box 2)*.

The most vulnerable groups, the rural poor, will be hardest hit by climate change. Coping with the current situation is already a major struggle for them, requiring capacity to adapt. The impacts of climate change, climate variability and extremes on agriculture and water resources will in the long run determine the constraints for sustainable development pathways for many regions. Addressing current climate variability by co-ordinating policies and responses to climate related crisis (such as drought), will reduce short-term vulnerability and at the same time will start a learning process to adapt to changes in climate variability and to long-term climate change.

It is clear that climate is not the only factor that needs to be considered when enhancing or maintaining food security. Livelihood strategies of farmers are not only based on environmental constraints, but also take into account cultural, social, economic, institutional, and political factors. Again, it will be of key importance to target the broad range of adaptive strategies and options to specific vulnerable socio-economic groups and regions. In the case of agriculture, adaptation to short-term climatic risks has a long tradition of disciplinary analysis and practical experience. In fact, this experience provides a good starting point for long-term climate change adaptation. Some examples from the inexhaustible list of adaptation strategies, mainly related to on farm activities, are given below:

Enhancing and maintaining production

- adapt species and production systems via selection and breeding
- adjustments of planting dates, densities
- choice in fields (top, slope, valley)
- fertilisation rates (type, timing + dose)
- irrigation applications (method, timing + dose)
- integrated pest management

Increase reliability of food supply

- early warning systems/yield forecasting
- encourage farmers to avoid mono-culture
- upgrade food storage and distribution system
- conserve soil moisture and nutrients

Most of these strategies are, either directly or indirectly, linked to climate. Without question, access to and use of climate knowledge is particularly important in areas with erratic rainfall patterns such as semi-arid regions. Responding to today's climate variability will help to prepare for future climatic conditions. The successful implementation of these farm level strategies is also determined by policies developed at the regional, national and even global level.

Box 2
Impacts of climate change on crops

Climate variables are the main drivers of crop growth; changes in these variables will directly impact agricultural production. Most crop production systems are temperature and water limited, and will therefore be affected by climate change.

Temperature
High temperatures may hamper crop development or render regions unsuitable for certain crops. Clearly regions with temperatures already near the upper tolerance level will be pushed towards poorer growing conditions. Agriculture in most developing countries will be hardest hit. Higher temperature will also mean crops will mature faster lowering potential yields. The IPCC (2001) concluded that in the tropics with even a small increase in temperature yields would decrease. Semi-arid and arid areas are particularly vulnerable to changes in temperature and rainfall. Shifts in agro-ecological zones will, in some regions, require dramatic changes in production systems.

Water availability
Climate change will have an effect on crop production via changes in water availability. Variability in food supply will also be affected by inter-annual and inter-seasonal variability in rainfall. This already has a distinct impact on regional and national food supplies. In semi-arid and arid regions drought is the most common factor responsible for harvest failures, but also situations with excessive water may reduce yield levels. Water will become a scarce commodity in large parts of the world. Agriculture as a main consumer of water will have to compete with urban and industrial uses. Higher temperatures will result in a higher evaporative demand, increased CO_2 concentrations may partly compensate this. Water related stress, both as result of excess and shortage of water, will reduce crop yields. Whether an increase in water demand for irrigated agriculture can be met is not only a function of rainfall, but will increasingly depend on competition between agriculture, urban centres and industry.

6. Energy poverty and clean energy for development

Energy for development
Development is literally fuelled by energy: energy widens the range of options for development and achieving the needs of individuals and society. Increasing consumption of energy is associated with advanced economies, as well as with longer life expectancies, higher levels of education and other indicators of social development. Lack of electricity usually means inadequate illumination and few labour saving appliances, as well as limited telecommunications and possibilities for commercial enterprise. Greater access can enable people to enjoy both short-term and self-reinforcing, long-term advances in their quality of life (UNDP, 2000b). Energy intensity of all countries grow at low levels of per capita income, but ultimately begins to decline at higher income levels (Goldemberg and Reid, 1999).
The energy dimension of poverty, energy poverty, is defined as the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe, and environmentally benign energy services to support economic and human development (UNDP, 2000a).

Consequences of energy poverty

The current energy system is not sufficiently reliable or affordable to support widespread economic development. Currently, one third of the world's population, 2 billion people, rely completely on traditional energy sources and are not able to take advantage of the opportunities made possible by modern forms of energy. The consequences of energy poverty are enormous. The productivity of one-third of the world's people is compromised by lack of access to commercial energy, and perhaps another third suffer economic hardship and insecurity due to unreliable energy supplies (UNDP, 2000b). It affects for instance women and children who are spending up to 6 hours a day to gather traditional fuels (UNDP, 2000a). This not only consumes productive hours, it also leads to health problems because of the weight they have to carry and due to in-door house pollution (cooking, heating). It can also lead to increased illiteracy among girls, because girls are more likely to spend 5 hours a day on gathering wood or other traditional energy sources, and therefore lose time to spend at school (UNDP, 2000b). Other consequences are the economic burden because of the unreliable energy sources, threat to human development and social stability, health problems at community and regional levels, environmental impacts and finally climate change impacts (UNDP, 2000a). *Table 3* provides an overview of energy related options to address social issues.

Table 3 Energy related options to address social issues (UNDP, 2000b; p. 9)

Social challenge	Energy linkage and interventions
Alleviating poverty in developing countries	- Improve health and increase productivity by providing universal access to adequate energy services, particularly for cooking, lighting, and transport, through affordable, high quality, safe and environmentally acceptable energy carriers and energy devices. - Make commercial energy available to increase income-generating opportunities.
Increasing opportunities for women	- Encourage the use of improved stoves and liquid or gaseous fuels to reduce indoor air pollution and improve women's health. - Support the use of affordable commercial energy to minimise arduous and time-consuming physical labour at home and at work. - Use women's managerial and entrepreneurial skills to develop, run and profit from decentralised energy systems.
Speeding the demographic transition (to low mortality and low fertility	- Reduce child mortality by introducing cleaner fuels and cooking devices and providing safe, potable water. - Use energy initiatives to shift the relative benefits and costs of fertility. For example adequate energy services can reduce the need for children's physical labour for household chores. - Influence attitudes about family size and opportunities for women through communications made accessible through modern energy carriers.
Mitigating the problems associated with rapid urbanisation	- Reduce the 'push' factor in rural-urban migration by improving the energy services in rural areas. - Exploit the advantages of high density settlements through land-planning - Provide universal access to affordable multi-modal transport services and public transportation. Take advantage of new technologies to avoid energy-intensive, environmentally unsound development paths.

Health impacts of energy consumption

In many rapidly expanding urban and industrial zones in developing countries, air pollution as a consequence of energy use is an increasing environmental problem. Each year, levels of air pollutants in these cities are often two to eight times above the recommended World Health Organisation maximum guideline health levels (WHO, 1995). The 3 billion people expected to live in cities by the first quarter of the 21st century face a growing environmental risk. Environmental threats can be particularly damaging to the rapidly increasing number of people at risk from poor living conditions, inadequate health care and malnutrition (UN, 1995; WRI, 1996). According to UN Population Fund, air pollution in general causes the death of 2.7-3 million people every year from which 90% in the developing world (UN, 2001). Outdoor pollution harms more than 1.1 billion people and kills about 0.5 million a year, mostly in cities from which 30 percent situated in developing countries. Children in developing countries are most vulnerable to air pollution. More than 80 percent of all deaths in developing countries attributable to air pollution-induced lung infections are among children under five (WRI, 1999). Next to outdoor pollution, indoor pollution (both in urban and in rural areas) through the use of (polluting) fuels for heating and cooking is an even bigger source of health effects in developing countries. Concentrations of indoors particulate matter are often found at levels 10 to 20 times higher than the WHO guidelines. Estimates suggest that 2.5 million people world-wide die annually from exposure of solid indoor fuels (WHO, 1997) from which 98 percent in developing countries (UN, 2001).

Perspectives for co-benefits on health and climate change

The local (urban) air pollution problems are the first of the environmental problems that usually get on the agenda in developing countries, basically as a health problem. The main source of this air pollution is the use of fossil energy or traditional in industries, households and traffic. These activities that contribute to local air pollution also contribute to climate change through emissions of greenhouse gasses. Components like tropospheric ozone and various types of aerosols have next to their health impact also an impact on climate change. Adopting policies to reduce (health) risks from air pollution will also contribute to mitigation of greenhouse gases.

There are various options available for energy production and use by transport, industry and households that can solve local air pollution problems and, at the same time, can mitigate the climate change problem:

- improving efficiency of energy production (conversion), supply and energy use (industry, transport, houses, offices, etc)
- fuel switch to less carbon intensive energy carriers (e.g. from coal to gas)
- use of renewable energy (biomass, solar, wind, hydro)
- 'clean fossil': fossil fuel use combined with end-of-pipe measures: flue gas desulphurisation, dust removal, catalytic converters, etc.) and carbon capture and underground storage.

A scenario study on energy-related CO_2 emission reduction from a climate perspective and the beneficial impacts on health, used particulate matter (PM) as an indicator for air pollution associated with health effects from fossil fuel use (Working Group on Public Health and Fossil-Fuel Combustion, 1997). Two scenarios were used (see *Figure 3*). Firstly a business-as-usual scenario with no additional environmental policies and secondly a scenario with climate policy. The latter scenario involves a
reduction by developed countries of energy-related CO_2 emissions to 15% below 1990 levels by 2010 and a decrease by developing countries of their emissions to 10% below the levels of the scenario without additional policies. Both scenarios assume that total energy use and efficiencies in the developing countries will continue to meet the demands of economic growth. Adaptation of the climate policy could avoid at least 700,000 premature deaths annually by 2020 from reduced particulate matter concentrations. The cumulative savings of lives could be up to 8 million globally, with 6.3 million in developing countries.

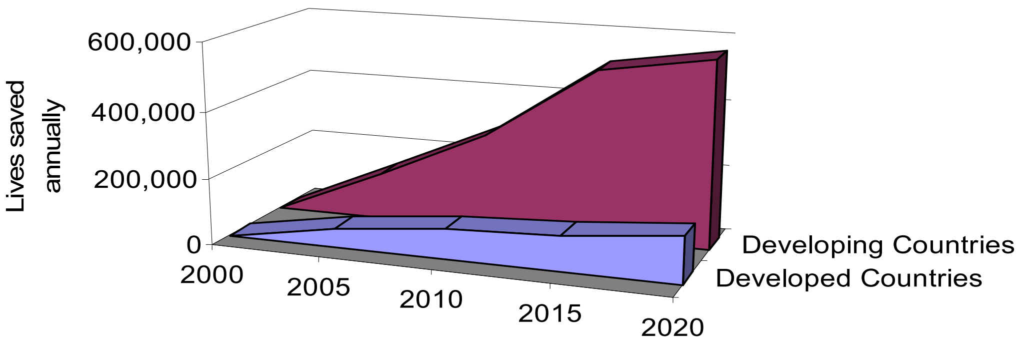

Figure 3 Lives potentially saved annually from reductions in air pollution from fossil fuels (source: Working Group on Public Health Fossil Fuel Combustion (1997)).

Future energy use

Because developing countries very much need modern energy supply to fuel their desired economical expansion, it is critical to find ways to expand energy services to support development, while simultaneously addressing the health and environmental impacts. Projections of future global energy use show a large increase in energy demand in developing countries (IEA, 2002). Since many developing countries do not have a large scale energy infrastructure present yet, a large part of it will have to be constructed in the coming years to meet the growing energy demand. This creates a big opportunity to satisfy the need for energy with a (more) sustainable energy infrastructure.

It is important to make a distinction between rural energy and energy for the urban population. In the countryside providing energy services to the two billion people lacking this access poses a major challenge. Investment- and transport costs are high, while people can only afford limited energy costs. But at the same time it also offers enormous opportunities for improving the well being of these people. In addition, large amounts of new production capacity will be installed in urban and industrial areas. It is important to note that increased energy efficiency is especially important to save extra capital investment in new production capacity.

7. Country studies

This chapter presents four different type of case studies from three countries and one region: Sub Saharan West Africa, Brazil, South Africa and China. The section on Sub Saharan West Africa looks at food security. It is shown that by reducing the vulnerability of the food production for short-term climate variability while increasing their food security, countries can also increase their resilience against long-term climate change. The Brazil case elaborates the ethanol programme, a climate friendly programme set up in the 1970s for development reasons. At a time when the interest in biomass as a renewable energy source is rapidly increasing world-wide, this programme is struggling now to survive in the liberalising energy markets. For South Africa, a country highly dependent on coal, an evaluation is made of how the country can provide all its citizens with access to modern energy and at the same time also realise stringent climate targets. Different alternative energy options are compared from a development perspective. The China case study explores the consequences of different development pathways in terms of their energy consequences.

Together, the cases show possible synergies and the very different circumstances and opportunities at the national and regional level that need to be accommodated in strategies for development in a climate safe and climate friendly direction. To summarise the differences in countries further in *Table 4*, the 4 case study countries are compared for two widely accepted indexes. The first, the Human Development Index (HDI) gives an indication of a country's average development level as composite of well-being (represented by life expectancy), education level (percentage of the population being literate and income (GNP per capita expressed in purchasing power parity). The HDI of China and South Africa are quite similar though there are some remarkable differences in the underlying components (e.g. life expectancy in China is over 70 years while the population in South Africa only has a life expectancy of 53 years. When looking at the GNP within Brazil and South Africa, it should be noted that the distribution of wealth is very skewed. The Human Poverty Index (HPI) represents the percentage of the population living in various states of poverty.

Table 4 Human Development Index and Human Poverty Index for the four case study countries (UNDP, 2000; data 1998)

	HDI components			**HDI**	**HPI**
	Life expectancy (yrs)	Literacy(%)	GNP (ppp$)	Value	Value (%)
Brazil	67.0	84.5	6625	0.747	15.6
China	70.1	82.8	3105	0.706	19.0
South Africa	53.2	84.6	8488	0.697	20.2
Senegal	52.7	35.5	1307	0.416	47.9

7.1 The case of food security in Sub-Saharan West Africa

Development goals for Sub-Saharan West Africa
Fragile areas with erratic rainfall and low soil fertility characterise the Sahelian zone in Sub Saharan Africa. Countries in this regions, such as Mali and Burkina Faso rank amongst the poorest in the world. A primary concern for these countries is to be in a situation where they could choose their own pattern of development. This would mean to steer away from short-term economic goals that lean heavily on unsustainable practices (Denton et al., 2001). In total over 260 million people live in the region, of which many in poverty. Between 60 and 90% of the economically active population is active in agriculture. Around 30% of the GDP is derived from agriculture (35-50% of private expenditures are for food), whereas industry accounts for approximately 20%. Poverty reduction is the main development goal for the region, a goal that is closely linked to halting land degradation (desertification). Another key concern is stability in the region, some countries experienced serious political unrest which might affect development in the whole region.

The economic base of the region is poorly developed, shown by the high dependency on agriculture. This also affects other important factors needed for development, such as technology, education and health. This situation however is not new; the droughts in the 1970s clearly revealed how vulnerable the region is. Local structures were unable to adapt to the rapidly changing conditions and aid programs were necessary to avoid a large-scale disaster. At the same time, the region has shown to be resilient enough to prevent the worst forecasts that were made in the mid-1970s, early 1980s.

Ensuring food security in Sub-Saharan West Africa
The region aims at a high degree of self-sufficiency in food production without further expansion of the agricultural area. This ambitious goal will be difficult to meet, considering the fact that the forecasts for Sub-Saharan Africa and Sub-Saharan West Africa in terms of food security are not positive. The nutrient poor soils and erratic rainfall patterns are responsible for extremely low production levels in this part of the world. This hostile environment may worsen over the coming years. Urbanisation is expected to continue, not only as result from the high (2.5-3%) annual population increase, but also brought on as a result of migration. The rural to urban migration is also partly caused by an increased pressure by changes in local climate. Changes in rainfall distribution will aggravate and lead to additional stress on agricultural production in these areas. Tensions between pastoralists and farming will increase, as competition over scarce water and land resources will grow. Land is central to social, economic and ecological issues in the region; legal issues related to ownership and use of land so far have not been in favour of the pastoralists.

Food aid, mainly cereals, has been a structural phenomenon in Sahelian countries since the famine of 1973-'74. Part of cereal imports comprises food aid, but in most years aid only covers a minor part of all food needs. However, food aid may become a structural phenomenon, as development assistance has already become a structural phenomenon in most areas, with official development aid ranging between 8 and 25% of Gross National Income.

Food security strategies that also prepare for climate change
It is evident that a sustainable future rests upon the resources and decisions of today. At the same time, it is true that the current situation is rooted in past experiences. Climate variability in combination with other factors has shaped Sub-Saharan West Africa. Climate change will affect the region by further desertification and desiccation. In particular the agricultural sector is highly vulnerable since a major part of the regions' water-resources are used for agricultural purposes. However, practices based on past experiences may no longer be adequate to deal with present challenges, posed not only by climate change, but also by other factors such as demographic changes. Sustainable development will depend on adequate and timely adaptation to new and changing conditions.

In regions with low and erratic production levels, risk management in terms of working with rather than against climate variability is crucial in ensuring reliable food supplies at the local level. Strongly linked to the issue of productivity, it includes food storage and also early warning systems using advanced technologies such as remote sensing and modelling. Crop varieties adapted to harsh environmental conditions are crucial, and can make the difference between success and failure. Special attention to water-related stress and varieties that require a short growing season is needed. Essential in all initiatives in this region aiming at increasing productivity is furthermore the use of fertilisers. Without addressing the soil fertility, crop and farm level adaptation strategies will not be sustainable in the long term.

Some of the most successful and promising alternatives or combined production strategies aiming at increasing yield levels, that also prepare for climate change include for semi-arid regions:

- a more efficient use of a variety of geographical niches
- limiting the fallow period and - to achieve that in a sustainable way - maintaining or improving nutrient stocks by adding manure, fertilizer, compost, or by including crops in a rotation (i.e. legumes, that add nutrients to the system), etc.

- improving soil and water management, including application of soil and water conservation measures; the scope for such practices partly depends on long-term security of access to these improved lands, and this often depends on indigenous, religious and/or state-defined land, water and other natural resource rights
- adopting crops and varieties with higher or more secure yields; and by improving access to 'improved' seeds of these crops and varieties
- developing irrigation facilities, either using river water, canal or piped water or groundwater reserves; this may also increase the cropping intensity, i.e. the number of crops grown within a year
- investing labour and care in food crop cultivation.

Agricultural commodities, that have provided the opportunity to increase purchasing power and entitlement for at least part of the recent period, have been cotton (for the sub-humid zone), groundnuts (for the semi-arid zone), charcoal and meat. The scope for these practices depends on the price developments at the regional and the world market. Another strategy to survive problematic times is based on investing in various types of assets during favourable periods and selling in bad times. These assets can come in the form of gold, jewellery; animals, bank savings, land, houses or household utensils, or in the form of productive capital (for example agricultural inputs, agricultural and non-agricultural machinery). Social security arrangements are among the lasts options to achieve food security. This can either be done directly, in the form of social care or in the form of food aid, or indirectly in the form of income support, for which food can be bought (pensions, social security payments, bank or trader's/moneylender's credit).

Development pathways
The agricultural sector is restructuring, both because of changing environmental conditions, and in response to increasing urbanisation. Increased demand for food provides opportunities for farmers to provide the growing population with cereals, cotton, vegetables, meat, milk and charcoal.

Acknowledging climate variability in policy programmes and research, and addressing agricultural production from a risk management perceptive rather than managing the average, is necessary to assist farmers and planners. Droughts should be recognised as part of the highly variable climate, rather than treating them as natural disasters. Management practices and policies should be adapted to capture this concept. Drought management or adaptive management geared to the prevailing climate variations, including droughts, should be the main focus to decrease the vulnerability of the agricultural sector.
Initiatives to provide farmers with climatic information as a basis for priority setting and flexible management decisions need to be improved. Early warning systems, similar to those as already in place in Mali, need improvement to provide tailor- made advice to local farmers. Strategies aimed at increasing production per hectare include, in addition to no further destruction of natural vegetation, the rehabilitation of degraded land. Organic matter will not only improve soil fertility but also capture carbon dioxide. Increasing soil fertility, using organic as well as inorganic fertiliser will also improve the water holding capacity of the soil and help stabilising production levels.

To deal with the problems in the region, including food security, it is also suggested (Denton et al., 2001) that regional co-operation, with a view to eventual economic integration, may be the optimal approach to development in West Africa, and addressing issues such as climate change. In West Africa the West African Economic and Monetary Union (UEMOA) was created in 1994 to realise this. The re-conceptualisation of development as a region-wide challenge reveals considerable potential to bring about desired change. A wide range of future options can be envisaged for the UEMOA, but it requires fundamental changes in policy-making in the region. Many of the options to prepare for long term climate change as described in this section apply on this regional level and can be made more efficient and more effective through regional co-operation.

7.2 Brazil and the case of the ethanol programme

Brazilian development goals
Brazil is the fifth largest country in the world. The Brazilian population was around 170 million people in the year 2000 and the population growth, while decreasing, averaged an annual 1.64% over the last decade. Despite its vast surface, the country is very urbanised as 81% of the total population lives in cities.
Recent Brazilian governmental development goals are to maintain financial and economic stability, to address the social and regional inequalities, to create jobs and to provide electricity in rural areas by promoting the use of renewable and/or decentralised energy. The electricity programme aims at realising social, economic and agricultural development in these areas, in particular by starting activities locally, which can also help reduce migration to urban cities. This will help reduce social inequalities and indirectly contribute to reducing violence in urban cities.

Energy needed for development
With a growing population and economy, an energy-intensive industry and improved access to electricity and transport, the demand for energy is increasing in Brazil. Fossil fuel consumption has been increasing as a result of low prices of fossil fuel in the international market and the deregulation of the Brazilian energy market. To meet such growing demand for energy, the energy production has to increase. An overview of the development of the Brazilian energy supply profile by source is given below (*Figure 4*).

Since the 1980s hydropower and oil contributed most to the increase in the Brazilian primary energy production. Recent data on biomass, which includes the ethanol programme, the use of sugarcane bagasse for steam generation and the use of charcoal in the steel industry, show that biomass production has almost stabilised in absolute terms and decreased in relative terms. Also the usage of hydropower is decreasing. In 1990, hydropower stations generated around 95% of the country's electricity. However, the high up-front costs of hydroelectric power plants, notably in a context of economic uncertainty, lack of financing and environmental concerns, make these relatively less attractive and the investments in natural gas-fired plants become relatively more attractive (Schaeffer et al, 2000). This caused delay in hydropower development and the construction of new plants has stopped.

As part of a reform programme redefining (and reducing) the role of the state in the economy, also an institutional reform of the energy sector is being undertaken. This reform has focused on reducing the cost of energy production by introducing competition (via privatisation) and by reducing subsidies (including those for the ethanol programme). Partly as a result of the reform, the primary energy matrix is changing, as more Bolivian natural gas is used for electricity generation in the Southeast since the 1990s. The use of gas is expected to increase from 2% in 1999 to 12% of the energy matrix in 2010. Therefore, the share of renewable energy in the energy matrix is decreasing.

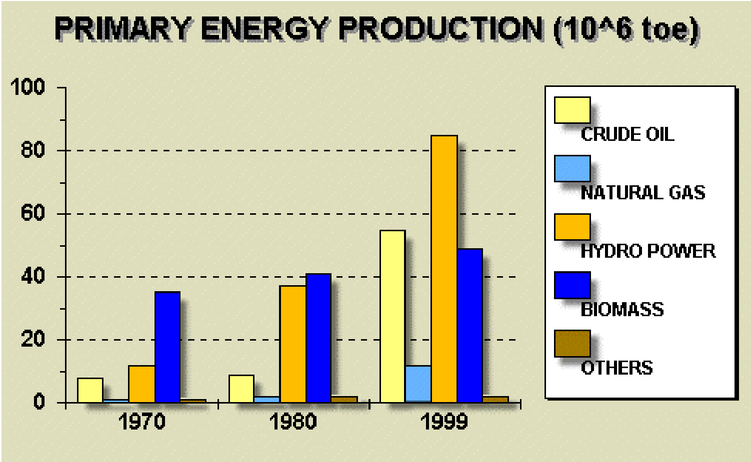

Figure 4 Brazilian primary energy production (Source: www.mme.gov.br/sen/dadhist/Sinop-I.HTM)

As a result of the leading role of renewable energy sources such as hydropower, fuel wood and sugar cane-based products in the energy sector, Brazil has low levels of GHG emissions. In 1997, the Brazilian per capita emissions were 1.81 tCO_2/inhabitant, half the world average (4 tCO_2/inhab). The expected short-term developments in the primary energy matrix mentioned above seem unfavourable for a minimisation of CO_2 emissions. If trends continue, CO_2 emission from the energy system are bound to overtake emissions from deforestation in the long run, despite the fact that the potential for renewable energy production is largely untapped. In some scenarios, CO_2 emission from the combustion of fossil fuels range from 150 to 198 MtC per year in 2010 and 210 to 413 MtC per year in 2025. However, the use of renewable energy, notably for the poorest regions, and the efficient use of energy could allow energy consumption growth without emissions increase in the same rate.

Box 3

Deforestation in the Amazon and biomass production

Land use change (deforestation, abandonment, logging and forest fires) is the major source of carbon emissions in Brazil. Estimates of its contribution vary between 150-350 million tons of carbon per year (Costa, 2002b). Until the 1980s, the main reason for deforestation in the Amazon region was the expansion of the economic frontier towards this region promoted by the government. This included development of the transport infrastructure, settlement programme, incentives to agriculture and financing of large-scale projects such as the Tucurui hydropower plant and the Carajas Iron Ore Project. These policies resulted in a migration flux (mainly from the Northeast region) into the Amazon, which was further enhanced by the 1983 economic crisis (when jobs no longer could be found in the Southeast region). This flow had negative social and environmental impacts for the Amazon region, such as substantially decreasing soil fertility as soon as the forest was cleared. Because of this, much land lies abandoned in the Amazon. Reducing the pace of Amazon deforestation has become a major objective of the Brazilian government, mainly for social but also for environmental reasons. The trend has indeed been curbed. Deforestation dynamics have changed over time. Today, cattle ranching, timber selling and land speculation plays a role in the deforestation in the Amazon region. The recent Amazon deforestation occurred mainly in the so-called deforestation belt (in the states of Mato Grosso, Para and Rondonia), in the southeastern Amazon. It has been suggested to re-use degraded land for agro-forestry, for biomass production for energy and industry purposes and for people to settle in these areas (Costa, 2002a). Programmes such as the ethanol programme may contribute to stopping the deforestation of the Amazon. But this link, however important, will not be elaborated further here.

Biomass use in Brazil: the ethanol programme

One of the unique features of the Brazilian energy system is its large existing share of biomass use. The roots of this large use of biomass lie in the government programmes for the promotion of alternative domestic energy sources, launched to raise the country's energy self-sufficiency during and after the oil crisis in the 1970s. An important programme was the Brazilian ethanol Programme, which also offered farmers a solution to fluctuating sugar prices in the international market. Using bagasse (a residual product from sugar cane processing, widely used for steam production in the sugar mills and distilleries) and alcohol (produced from sugar cane and used as fuel for cars and blended with gasoline) reduced the need to import crude oil and petroleum. The Ethanol Programme was the result of both political and economic considerations and turned out to be a very effective strategy in avoiding CO_2 emissions and producing global environmental benefits. The policies leading to this programme seem to be a historic example of successful implementation of development in a sustainable way. Other biomass options also have large potentials or are already implemented in different parts of Brazil, but will not be discussed further.

<u>The history of the ethanol programme</u>

The success of the ethanol programme was helped by several factors.

- the provision of economic incentives to agro-industrial enterprises willing to produce ethanol. Between 1980-1985 they were offered low interest rates which represented 29% of the total investment needed to reach present installed capacity;
- Petrobras, the public oil company, could centralise fuel distribution and purchased guaranteed amounts of ethanol from producers;
- the low cost of ethanol for automobiles. Steps were taken to make ethanol attractive to consumers by selling it for 59% of the price of petrol. This was possible because the government set the gasoline price at a value approximately double the USA gasoline price. In addition, the Brazilian gasohol consists of gasoline mixed with 24-26% ethanol.

As a result, in the 1980s, ethanol-car sales accounted for 96% of the automobile market in Brazil. However, at the end of the 1980s, the first ethanol crisis occurred, when sugar prices in the international market increased and sugar cane producers decided to produce sugar instead of alcohol. At the same time, the international oil prices were decreasing and the domestic oil and gas production were increasing following the discovery of important Brazilian off-shore resources (La Rovere, 2001). In this context, it was difficult to maintain the high subsidies and thus the energy policy adopted by the government in the 1990s led to a reduction of the role of biomass in the energy sector. As a result, in 2001, ethanol-car sales represented only 1.3% of the automobile market. Today, ethanol sells for 80-85% of the price of petrol. To preserve this ratio, while simultaneously guaranteeing a sufficient remuneration to ethanol producers, a cross subsidy from the sales of conventional fuels is implemented.

<u>Employment, land use, costs and gains to society</u>

Current employment in the sugarcane-alcohol sector is one million direct jobs in rural areas, 300,000 more indirect/industrial jobs in 350 private industrial units and 50,000 sugarcane growers (also private). Investment needed for the creation of jobs in the sugar/alcohol industry is lower than in other industrial sectors. The total land area covered by sugarcane plantations is approximately 4.2 million hectares (of which 60% in the Southeast and the rest in the Northwest and Northeast region). That represents only 7.5% of the area used for all crops or 0.4% of the Brazilian territory. In some sugarcane areas, crop rotation has led to an increase in food production, notably beans and peanuts. By-products of ethanol, such as hydrolysed bagasse and dry yeast, are used in feed for cattle, chicken and pork. Competition for land to be used for either food production, exports crops or energy crops is not significant (Moreira and Goldemberg). Production costs of sugar in Brazil are low (under US$ 200/ton). Therefore, it can compete well in the (volatile) international market. Sugarcane provides farmers with high revenues per hectare planted. If sugar production becomes less attractive due to reduced prices in the international market - which often occurs - it may become more profitable to shift production partially to alcohol.

The ethanol programme represented the most successful effort in the development of renewable resources for the substitution of petroleum products, whether blended with petrol or as a single fuel for ethanol-fuelled vehicles. It is the largest programme of commercial biomass utilisation for energy production in the world. Positive effects of this programme are:

- the creation of jobs in rural areas;
- supporting the rural and agricultural development and contributing to the country's economic stability;
- increasing food production (through crop rotation);
- exchanging dollar debt in an efficient way (by national currency subsidies that are paid by the liquid fossil fuel users);
- development of engines and modified engines for the ethanol-petrol mixture;
- reduction of urban pollution;
- reducing greenhouse gas emissions;
- the programme led to a general interest in renewable energy.

The expansion of the ethanol programme depends on providing incentives for its use in Brazil. Possibilities exist to expand the use of ethanol, in Brazil, by more pure ethanol powered automobiles and by mixing ethanol into diesel. The Northeast sugarcane production could help develop local agriculture. It has also been suggested to export biomass or ethanol to industrialised countries where it could be used as a renewable energy source.

Conclusion

In the liberalising energy market in Brazil, (new) actors have a role to play in incorporating development goals and environmental concerns into the restructuring of the energy sector. This role should be better investigated. The Brazilian priorities are in the social and economical areas. Current reforms in the power sector aim foremost at reducing costs by introducing competition in electricity generation. The main goal of the government is economic stability and the reduction of inequality. The privatisation programme is intended to allow the government to dedicate more resources to development goals. These reforms will greatly influence how power demand is met and the emissions that result. However, in general, the restructuring of the energy sector has contributed to an increase in the carbon content of the Brazilian development path and may imply a major barrier to the incorporation of climate change concerns into development strategies. The use of renewable energy contributes to the Brazilian development goals by diversifying the energy matrix and notably fostering social, technological and economic development in the poorest regions of the country. Brazil has shown ways of finding its own solutions to meet development concerns while at the same time reducing greenhouse gas emissions. There are besides the ethanol programme also other programmes in Brazil that, although not developed specifically for the purpose of reducing global warming, nevertheless result in a considerable reduction of greenhouse gas emissions. These climate-friendly (sustainable) policies are presently endangered. Therefore, (inter)national incentives that could promote renewable energy in the short/medium and long term should receive more attention in policy making.

7.3 South Africa: Providing energy for development and protecting the climate: can South Africa combine these goals?

South African development goals

The main development goals of South Africa are to fulfil basic human needs for all, and simultaneously reduce the gap between the rich and poor and disadvantaged. After the ending of the apartheid policies and the start of the new government in 1994, new priorities were set. The interests of the black South African majority have found representation through new social and economic policies, particularly in the Reconstruction and Development Program as advocated by the government. This new strategy resulted in policies seeking to stimulate economic growth, create employment and create access to key services like housing, water, sanitation, transport, telecommunications, energy services and land reform (Winkler et al., 2002).

Energy needed for development

Energy in sub-Saharan Africa (SSA) is still dominated by traditional fuel use, particularly for cooking. Dependence on firewood and charcoal as cooking fuels varies from 40-90% for the around 700 million people in SSA. Even compared to other parts of the developing world, African energy systems are exceptionally over-depended on low quality energy and lack of access to modern energy (Davidson, 2001). Another characteristic that marks out Africa's position is that the per capita energy consumption is low compared to the world average. It is evident that this low energy use is a handicap. On the other hand, Africa is a continent with rich, diverse and un-exploited renewable and non-renewable resources (Davidson, 2001).

Energy can play a very important role in resolving poverty in Africa. However, South Africa has a quite exceptional and dominant position in the energy production in Africa. South Africa's economy differs from the other economies in Africa. One example of this are the large energy related companies in South Africa. These companies are comparable to companies from the developed world, but on a residential level poverty is linked similarly to energy like in the other African countries. Because of their exceptional position, these companies dominate the energy policy-making of South Africa. The most striking example is Eskom. This South African electricity utility produces about 40 percent of all electricity generated in Africa about 80% of the electricity in the Southern African region.

Another difference with other African countries is that South Africa has the highest GHG-emissions in Africa (about 8.22 tons of CO_2 per capita per year). World-wide South Africans rank in the top twenty of per capita CO_2 emissions related to energy (Gupta et al., 2001), which is exceptionally high for a developing country. Without policies to reduce these emissions, they are expected to grow with 3 percent annually for the next 20 years (Doppegieter, 2001). The high emissions from electricity generation are a result of the high share of coal used to generate electricity. The South African electricity mix consists of 91 % coal, 8 % nuclear, and 1 % hydro (Pretorius Prozi et al., 2002)[1]. *Figure 5* shows the primary and secondary energy used in South Africa, where biomass represents mostly traditional - mainly unsustainable - biomass like wood, which puts a pressure on the natural woodlands (UN, 2002). Traditional biomass forms the main energy source in the rural domestic sector (White paper, 1998).

[1] The percentages differ among different sources, because relatively more electricity is generated by coal fired power stations than its percentage of installed capacity

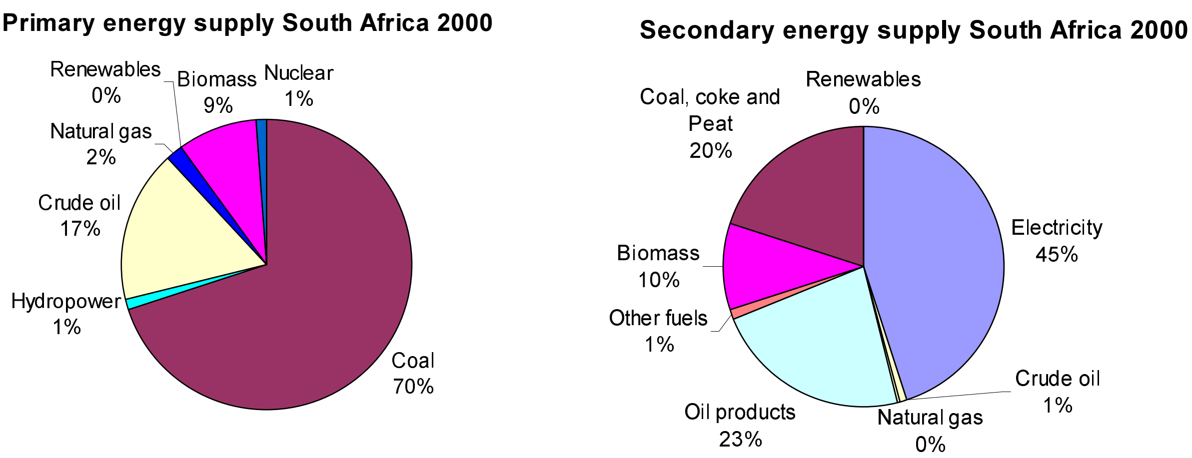

Figure 5 South Africa's primary and secondary energy supply of South Africa in 2000 (preliminary energy outlook, (ERI, 2001))[2]

Just over 50 percent of the population of South Africa lives in urban areas, and of these people, seven to eight million live in informal settlements. Of this urban population, 5.2 million people (about 12 percent) do not own houses, but live in informal dwellings/ shacks/ townships (Doppegieter, 2000). According to the Ministry of Energy, 67% of the South African population has access to electricity, an increase compared to the 40% at the beginning of the 1990s. Despite these enormous improvements, there are still areas where 80% of the households are without power (Matsau, 2000). Therefore one of the major development goals of the new government was to provide electricity to households. Other important energy development goals and policies as stated in the Energy White Paper (1998) are:

- increase access to affordable energy services,
- improve energy governance,
- stimulate economic development,
- manage energy-related environmental and health impacts; and
- secure supply through diversity .

The process of implementation of this White Paper is one of the most influential factors of the national energy policies (Doppegieter et al., 2000). Climate change policies are not yet seen as a priority, although the South African government is paying attention to the consequences of global climate change policies, mainly because they might affect South Africa's carbon intensive industries and exports.

Because of the importance of electricity for development, and the large extent it contributes to CO_2 emissions, the challenge is to improve the access, affordability and supply of electricity without increasing the emissions. *Figure 6* gives an overview of sustainable energy development indicators that are relevant in the South African situation and that are relevant when considering different options for the electricity mix. These indicators will be used to evaluate future electricity generation alternatives.

[2] Secondary energy use is defined as the amount of energy consumed by the end-user and does not include the energy lost in the production and delivery of energy products. Primary energy use, in contrast, is the sum of all energy consumed, including losses at various stages of energy upgrading and processing (Image-team, 2001).

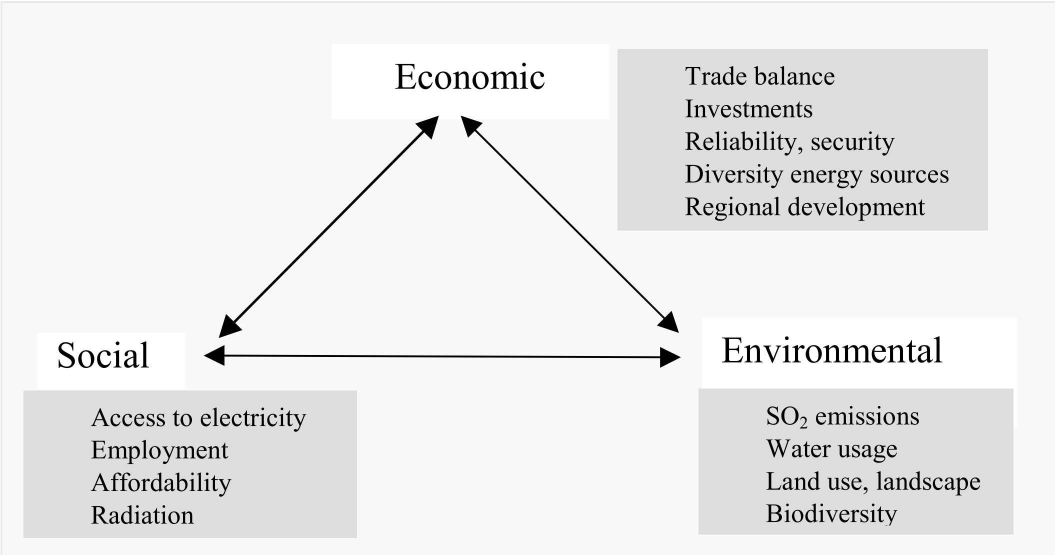

Figure 6 Sustainable energy development criteria to evaluate a switch in electricity mix in South Africa

Evaluation of options for providing electricity for everybody and meet stringent climate targets

Currently, South Africa mainly depends on its coal resources. It is not likely that this dominant position of coal will change significantly in the near future. The usage of coal for electricity generation has resulted in relatively low electricity prices for industry. Another reason why South Africa is not likely to change its dependency on coal without incentives is the large coal resources it still has. Estimates range between 850 and 12290 EJ (Howells, 2000 and IEP, 2002), which is more than sufficient for the coming century (in 2000, about 4 EJ was used (IEP, 2002)). However, there are technologies and alternative electricity sources that can reduce South Africa's GHG emissions in the future and that might still fulfil South Africa's development priorities. These include: increased usage of the solar and wind capacity, increased share of nuclear in the electricity mix, biofuel power stations, import of hydropower from surrounding countries, increased efficiency on demand and supply side and finally CO_2 capture and storage. Gas-fired power stations can also contribute to lower GHG emissions, but these are not included in this evaluation, because Southern African reserves of gas will mainly be used for the replacement of the coal-to-liquid process and are furthermore too small to provide a large part of the electricity production in the long term. Import from outside the region for electricity regeneration is not evaluated as an option in this research.

An evaluation of these different routes towards an electricity system that contributes to a considerable decrease of greenhouse gas emissions on the basis of the indicators as defined above, shows the following results.

The alternative energy strategy that for the short-term fits best in a sustainable development for South Africa is Demand Side Management (DSM) and efficiency increase in supply side. This is basically a no-regret strategy that helps to decrease demand and the need for new production capacity. As a result of the restructuring process, this strategy is currently adopted by Eskom. In this way Eskom tries to avoid large investment in new production capacity as investment costs in increased efficiency and DSM are relatively low (Africa, 2001). It is, however, questionable whether it will be an effective strategy in the long term to give producers the lead in reduction strategies.

Also solar and wind energy are an attractive short-term option from a sustainable development perspective: they are renewable and have little or no emissions. Although the costs are currently much higher that the average electricity prices, it is competing with the cost prices in rural areas. The solar and wind route, however, has one characteristic that might become inconsistent with the development goals: reliability. Especially when used off grid, in decentralised systems Therefore, solar and wind energy are mainly options to diversify the electricity mix, and increase access in rural areas, but only to a limited extent. It is important to note that solar and wind will become more cost effective in the long-term, because their technological development is still making rapid progress (Image-team, 2001).

An additional strategy on the medium-term to optimise the efficient usage of energy sources is co-operation within the Southern African region. This requires a well functioning Southern African Development Community (SADC). A Southern African Power Pool is being established, with almost all SADC countries participating. Although the grid connections are not yet large enough to play a huge role, the opportunities for further co-operation are considerable. According to a study by Greaber et al. (2000) from a purely financial perspective, regional co-operation strictly utilising the least financial cost expansion options in the SADC region would result in savings of $2 to 4 billion (approximately 40% lower investment costs and 60% lower operational costs). This alternative demands an increase in collaboration and trade within SADC and may have a positive effect on stability and development in the region. Despite a willingness for regional co-operation within SADC, regional conflicts, economic problems, environmental problems and disasters such as floods play a major role in current and future policies and still form an important barrier for co-operation (Gupta et al., 2001). These problems may affect the growth of new investments for joint projects. Another obstacle may be the lack of historical relationships with the surrounding countries of South Africa due to its isolation during the years of apartheid, and the current dominant economic position of South Africa, which raises concerns in the region.

An alternative source of energy that can benefit from enhanced co-operation within SADC, is hydropower. Hydropower can be imported from other Southern African countries. Besides potentials in Angola, Mozambique, Zambia and Zimbabwe, the Democratic Republic of Congo has the highest technical potential of about 100,000 MW, which is about twice the electricity currently consumed in the region Southern Africa (Howells, 2000). From a development perspective it should be noted though that the electricity generated by the coal fired power stations in South Africa is cheaper than electricity generated from hydropower, when the costs of externalities are excluded (Greaber et al., 2000). This forms a barrier to a transition towards hydropower. Increased possibilities to trade electricity – improved regional grids - will probably not only open up possibilities to import electricity production from hydropower to South Africa, but also for increasing exports of coal fired power from South Africa to other countries. From a climate change perspective this might be a cause of concern. Another reason for concern are the possible negative impacts of large-scale hydropower.

For the longer term, capture and storage CO_2 from coal fired power plants could become an affordable and reliable alternative. From a development perspective, the evaluation of CO_2 capture is mixed. Two disadvantages are that this option does not fit within goals of the current government of diversifying the energy sources and does not add to the electricity production; it is an end-of-pipe solution that costs energy. The advantage, on the other hand, is that South Africa can still use its large coal resources with, besides costs savings, the additional benefit of keeping the large employment in the coal sector. Therefore, it should be underlined that with CO_2 capture and storage, coal still can be used, even in a future world that puts a high price on carbon emissions. In evaluations of electricity generation options that lower emissions, the complete package of coal-fired power stations and CO_2 capture and storage should be considered. It then is a competitive option compared to other alternatives.

The potential to cultivate biomass in South Africa may not be very large: the Department of Minerals and Energy doubts *"whether biomass is a viable option for South Africa, considering our climatic conditions and agricultural potential"* (DME, 2000). However, there is a potential in the northern part of the Southern African region. According to an IPCC study, the biomass potential of all the SADC-countries is about 5.000 PJ/year (IPCC, 2001). If South Africa is going to use and produce biomass, it is more likely that biomass will replace fossil fuels for transport, than that it will be used for electricity production, since South Africa does not have large resources of liquid fuels itself. Compared to the other alternative energy sources, biomass possibly conflicts with sustainable development objectives like sustainable water use, land use and preservation of biodiversity, depending on the source of biomass.

Nuclear energy scores badly for affordability of the electricity prices, which is mainly caused by the fact that the learning rates for nuclear are expected to be lower than for the other CO_2-reduction options (Image-team, 2001). Also with a carbon tax, nuclear power will remain one of the most expensive options on the long-term. Nuclear energy will therefore be a less attractive option, as long as the costs of electricity production will stay important. Furthermore, there is the problem of nuclear waste. There is however continuous political interest in nuclear technology in South Africa.

Conclusions: alternative energy development pathways with positive consequences for climate change

Returning to the central question of this section: "Providing energy for development and protecting the climate: can South Africa combine these goals?" This evaluation suggests the answer is yes. Although some alternatives evaluated do not fulfil all energy development goals set by the South African government, improving energy efficiency and demand side management measures fit well within almost all sustainable development strategies. However, efficiency improvement and demand side management will not be able to lower GHG emissions sufficiently to contribute to significant global emission reductions. Solar and wind will be an interesting option to connect households in rural areas, where grid expansion is too expensive, but are probably less suitable to become a large part of the electricity mix. For the longer-term CO_2 capture and storage might be an interesting technology to realise a further decrease in emissions. With increased climate change policies, it may be an attractive solution for South Africa to be able to remain reliant on their coal resources. Medium-term alternatives as biofuels for electricity production and nuclear energy might conflict with some of the sustainable development goals, depending on political priorities. However, most of these options require incentives from both inside and outside the country.

7.4 China: Different development trajectories for China – strong differences in energy use and emissions

Chinese development goals

China is the world's most populous country with a population of over 1.2 billion people. Developing the economy and improving the living standard are the number one goals both on the short and the long term set out by the Chinese government. At same time, sustainable development is recognised as an important issue. Agenda 21 for China, as announced by the Chinese government in 1994, explicitly states that '*Taking the path of sustainable development is a choice China must make in order to ensure its future development in the next century. Because China is a developing country, the goal of increasing social productivity, enhancing overall national strength and improving people's quality of life can not be realised without giving primacy…. At the same time, it will be necessary to conserve natural resources and to improve the environment, so that the country will see long-term, stable development'.* Since 1994, Agenda 21's objectives have been incorporated into other policy plans, including the successive Five-Year plans. Other objectives include reducing the large differences in wealth between various areas (especially the rural areas and the regions in the west of the country), and hence reducing poverty and controlling population growth.

Energy needed for development
China's per capita energy consumption is currently equal to only one sixth of OECD countries. Development of the provision of energy services to stimulate economic growth is seen as an important priority by the Chinese government. In particular, rural areas are short of commercial energy supply. Firewood and traditional biomass still dominate many rural areas. The very high share of coal use in China creates both urban and regional air pollution. Many of China's cities rank high on the list of cities in the world that suffer from severe urban air pollution, creating serious health effects. Two important trends characterise China's energy use over the last two decades: energy intensity has fallen dramatically (by around 4% per year), and it primary energy consumption has more than doubled (Zhang, 2001). Environmental pollution, including greenhouse gas emissions, has increased at a similar rate. At same time, its per capita emission is significantly lower than that of OECD countries, China emits about 10% of the global carbon dioxide emissions compared to its share of 20% of the global population

In this case study, we have explored a number of different development pathways in China in terms of their development and environmental consequences. The analysis shows that trends in China's energy future will have considerable consequences not only for China but also for the global environment. We have used a set of recently developed storyline-based scenarios that are based on the IPCC scenarios described in section 4 of this report (Van Vuuren et al., 2002).

Alternative development pathways
There are two fundamental axes in terms of directions of development that could be crucial to China's energy future. One of them is the question whether the country will continue to pursue its current policies to open up its economy to international influences (the so-called 'open-door policy'). Or whether the country will revert back to using domestic resources for its development (as it has done during most of its history). The second axis is whether environmental concerns will have a prominent role within development policies or whether they will play second fiddle. In this section, we will discuss three possible scenarios that describe fundamentally different directions of development and its consequences for the Chinese energy system. All of these scenarios could be regarded as scenarios that aim to achieve the development goals of China discussed above. Our analysis will show that the choices for development made now, may result in very different pathways for the future – each with their own characteristics, challenges and environmental impacts. The resulting energy demand and energy mix of these scenarios is given in *Figure 7*.

An 'open' China in a globalised world

The first scenario (that corresponds with the A1b scenario in section 4) is a case of rapid economic development both in China and the rest of the world, spurred by continuing globalisation. It is assumed that China will continue to pursue its open-door policies, thus enabling strong technology development. In this scenario, by the end of the 21st century, China will almost have reached the income level of the OECD countries – i.e. in line with the countries objective to improve the living standard of its population. The population growth path in China would follow the current expectations of the planning commission – in which population will reach a level of around 1.6 billion by 2050 and then decrease to around 1.5 billion in 2100. As globalisation allows for rapid spread of technologies, renewable energy and other clean energy technologies will become available on a large scale.

In this scenario, the demand for energy will increase rapidly as a result of economic growth and an orientation towards material-intensive lifestyles. Energy demand will grow particularly fast in transport, strengthening the challenge to develop solutions for congestion and transport-related environmental problems. In final energy use, traditional biofuels and coal, will rapidly lose market shares while electricity and natural gas, with their grid-character, wide applicability and local cleanliness, rapidly gain market shares. In the electricity sector, coal-fired power plants will continue to dominate as a result of the strong competitive position of coal in China. Increases in the use of nuclear power and hydropower will be substantial – but both energy sources still will only cover 5-10% of total primary inputs in 2050.

An important feature of this scenario is that China will increasingly depend on international energy resources due to the relative shortage of energy resources and the open markets. By the middle of this century, more than 20% of the domestic demand will have to be met by imported energy. Investments in energy will also increase gradually; they will reach about US$ 200 billion in 2020 and increase to US$ 520 billion in 2050 and US$ 1660 billion in 2100. It will clearly be a challenge for China to be able to realise these investment rates – certainly in the first part of the century.

China geared to solving regional environmental problems

The basic consideration in this scenario (that corresponds with the B2 scenario in section 4) for China is that economic development will utilise domestic resources so as to maintain equity for the future. Shortages of food and water, air pollution and the like are recognised as serious problems and make environmental sustainability a key priority. The growth of the population is assumed to be the same as in the previous scenario. The second scenario assumes a slightly lower economic growth with limited trade and technology transfer among world regions. The energy system will to a larger extent rely on domestic resources, while technological progress will be lower for both energy production and end use because of limited trade and transfer.

As the main energy resource of China is coal, the strong focus to preserve local environmental resources will require the development in this scenario of clean coal technologies. In addition, energy efficiency will be important to prevent demand for oil and natural gas growing too fast. An important difference, therefore, between this scenario and the previous one is the energy demand, which, by the end of the century, will be about 50% lower. Regarding the structure of primary energy demand by energy carrier, the share of natural gas, modern biomass, solar and wind energy will increase. However, China will also depend on domestic energy resources, which means that coal will continue to be the most important energy source in China. In this scenario, investment in energy will be smaller than in the previous scenario, but the ratio of energy investment to GDP will follow the same trend.

Internationally sustainable development

This scenario describes a world dominated by high levels of environmental and social consciousness and successful global co-operation (it corresponds with the B1 scenario in section 4). Economic development will be slightly slower and there will be a much stronger trend towards a service economy. An important difference with the previous scenarios is that China will not adopt the current energy and material-intensive lifestyles of the Western world, but opt for a less material, but service-oriented lifestyle. Western countries will also move in this direction. This scenario will witness a rapid improvement in efficiency. The result is a decline in energy intensity of 40% compared to the 'globalised world scenario'. The 2100 energy consumption of 70 GJ per capita is very low compared to the current OECD average of 150 GJ, but comparable to the OECD average in 2100. Based on its efficiency, this energy consumed will be able to facilitate a much higher level of welfare. As a result of assumed environmental consciousness, coal use will decline and more environmentally friendly fuels such as natural gas and modern biofuels will gain market shares. The extensive use of solar and wind power also means that technology development with regard to these sources will be swift, enabling further penetration of these renewables.

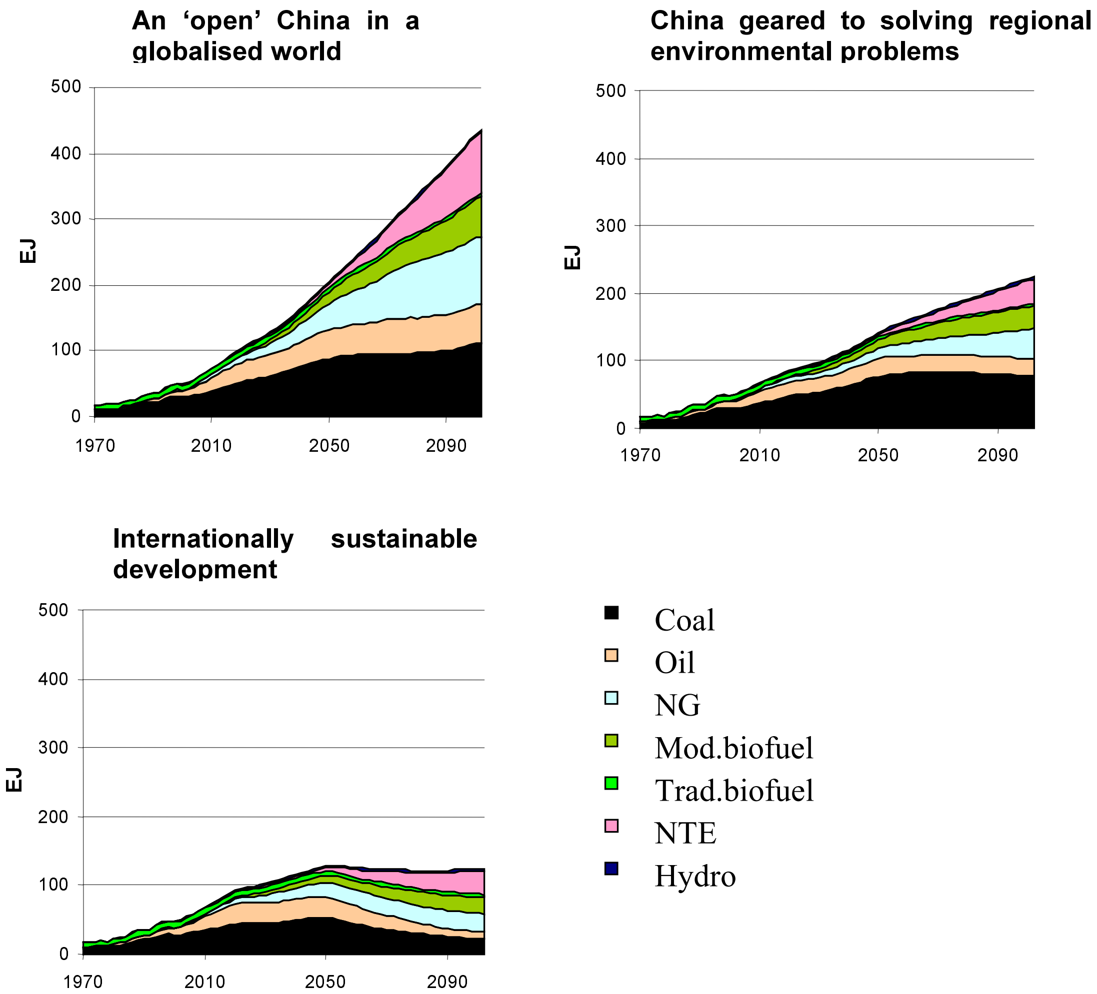

Figure 7 Primary energy use following the three scenario (based on RIVM-TIMER model)

Clear differences in environmental impacts of alternative development pathways
It is already indicated that increasing the amount of energy services and at the same time also controlling urban and regional air pollution to avoid health problems to improve the quality of life, is a major development challenge facing China. Reductions of CO_2 are a co-benefit of such policies. *Figure 9* summarises the discussed scenarios in terms of three important characteristics: energy use per capita, carbon emissions per unit of energy use (carbon factor), and carbon dioxide and sulphur dioxide emissions. In the 'globalised world' scenario, emissions reach a level close to the current global emissions as a result of a strong increase in energy use. Carbon emissions per unit of emissions actually decline, with non-fossil based fuels gaining a significant market share in the second part of the century. The 'domestic orientation' scenario results in carbon dioxide emissions that are about a factor 2 lower than in 'globalised world', thanks to its lower energy use. In fact, the relative share of coal in the former is higher than in latter (reflected in a higher carbon factor). Finally, the 'international sustainability' scenario sees emissions doubling in the first half of the century – but subsequently declining to slightly above the present level in the second half. This decline compared to 'globalised world' is caused both by low energy use per capita (efficiency and structural change) and major changes in the energy supply.

The current level of sulfur emissions in China (around 18 Tg SO_2) contributes to both regional air pollution (in particular, acidification) and urban air pollution, resulting in direct and severe public health problems. In all scenarios, we have assumed that the Chinese government will intensify its effort to reduce sulfur emissions. However, the level of effort paid is different – and, obviously, so is the energy mix. On the right part of *Figure 8* we have plotted the carbon emissions of the scenarios against the sulfur emissions. The main differences between the scenarios are caused by the high level of environmental protection in 'international sustainability' and 'regional orientation' and the less strict protection levels in 'globalised world'. In addition, however, we can see that sulfur emissions are also a function of the changes in energy mix. In other words, lower carbon emissions coincide with lower sulfur emissions. The international sustainability scenario in particular benefits from this.

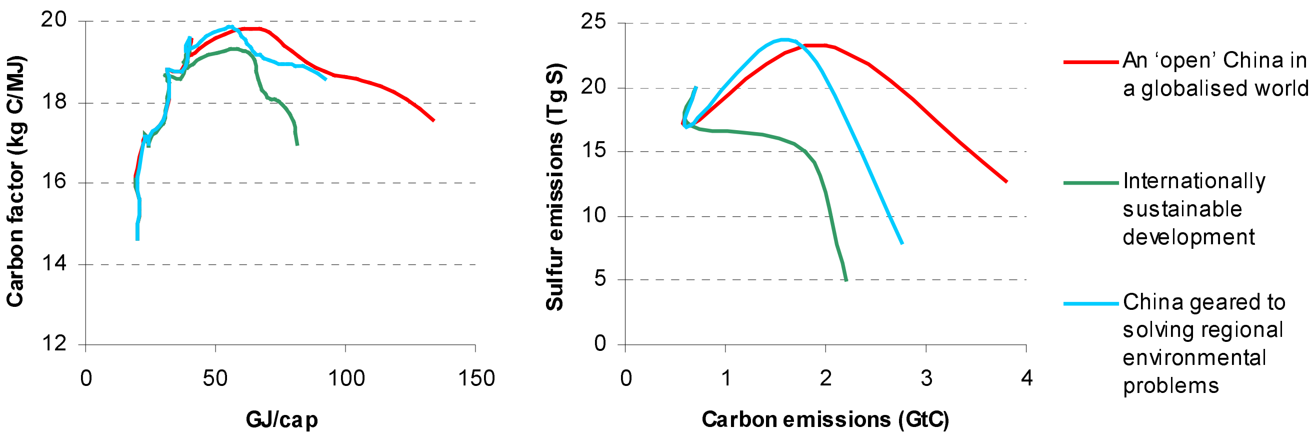

Figure 8 Trajectory of energy use (GJ per capita) and carbon factor (tC/GJ) (left) and CO_2 emissions vs. sulphur emissions (right) in the three scenarios (based on RIVM-TIMER model)

The scenario analyses indicate that different current decisions in China regarding its development trajectories can results in strong differences in emissions. The analysis also shows that an orientation on environmental sustainability can not only reduce urban and local air pollution (and thus improve public health), but also results in lower carbon emissions.

It should also be noted that in all three scenarios, the increase of emissions will be largest in electric power generation and industrial production. The high growth in electricity demand and the competitive position of Chinese coal in this sector will make electricity generation the fastest growing and, from 2015 onwards, largest carbon emitting activity. In the residential and services sector, a phase-out of traditional fuels and, especially in urban regions, of coal can be expected.

We also have explored additional options that would result in exactly the same energy services as provided in the baseline scenario with the highest energy demand. This time, however, we used different energy technologies (an analysis comparable to the one described in the case study for South Africa). We have summarised this analysis in *Box 4*. It suggests that there is a large potential for emissions pathways with lower environmental impacts but the same energy services with additional costs that are low compared to international standards. Not all options will be equally attractive and feasible across the various scenarios. In the first decades, a strengthening of energy conservation policies will be the most beneficial and cost-effective option. However, energy efficiency improvements are often confronted with institutional and financial barriers, especially in rapid growth periods in low-income countries.

Box 4

The same energy services – lower emissions

Several additional options – providing the same energy services, but with lower emissions – have been evaluated in terms of impacts on investments, user costs, fuel import costs and emissions. A large potential is discovered to mitigate local air pollution and carbon dioxide emissions in China, e.g. in the form of energy efficiency improvement (with large co-benefits) and measures in the electricity sector. Combining all these options, it appears to be possible to reduce carbon dioxide emissions compared to the baseline scenarios by 50% with only limited additional costs. Under both baselines, coal is expected to remain a dominant fuel in electricity generation. There are several specific measures to reduce GHG emissions in the electric power sector. First of all, introduction of efficient coal use techniques and an accelerated substitution away from coal to natural gas (with concomitant rise in gas imports) can be key options in the electricity sector (*see also Zhang 1998).* Accelerated expansion of hydropower has only a marginal reduction potential – some 2% by 2050. Other non-fossil fuels, such as nuclear, wind and solar energy, can be important to reduce carbon dioxide emissions further, particularly on the longer term. However, in view of the strong competitive position of coal, these fuels can only play an important role if they are supported by a lasting policy-guided effort (e.g. renewable energy obligation targets or carbon taxes). In all cases, the required investment fluxes may pose the largest challenge, not only for national policies but also for international collaboration.

The analyses also show important trade-offs between the different options in terms of investments, increase of user costs, impacts on the balance of trade and emissions. For instance, policies that rely on a fuel switch from coal to oil might be cheap in terms of required investments but increase the costs of fuel imports.

The analysis has shown the clear relationship between different development trajectories and environmental impacts. The different pathways all meet some of the development goals of China, such as improvement of the living standard and an increase in the per capita provision of energy services. There are also clear trade-offs between the scenarios, in terms of investments and imports of fuels. In terms of controlling emissions of sulphur dioxide (to control the impacts of urban air pollution on public health), clearly one of the development goals, the international sustainability scenarios scores best. This also results in much lower carbon dioxide emissions. As indicated before, sustainable development is already recognized as an important factor in China's development, for both the short and long term. This means that additional policies, such as more energy efficiency and clean energy utilisation, including natural gas, and non-fossil based energy, could well match the targets described in the national plans.

8. Conclusions and discussion

The case studies presented in this paper demonstrate that synergies between development and climate are already captured today. Many countries have strategies in the energy and agriculture sectors that reduce GHG emissions and reduce vulnerability to climatic changes independent of climate change considerations. These strategies could be further enhanced. Unfortunately, some of these initiatives are at the moment under threat, like the Brazilian ethanol programme. The case studies also show that that pursuing joint goals of development and climate change concerns brings in new actors, compared to those that are already involved in the climate change debate. These actors need to be engaged in policy making. It will be important to include also less powerful voices in this process to ensure for instance the bottom-up approaches necessary for effective poverty reduction.

Furthermore it is clear from the case studies that different countries have different development priorities, and countries also have different characteristics as to climate change. The differences between countries leads to the suggestion that it might be useful to further differentiate the developing countries in a development and climate framework. Some countries may contribute little to global warming because they already rely on clean energy sources, but may be vulnerable to the impacts of climate change. Examples of this are the small island states and some of the poorest low-lying countries. For these countries, development strategies could focus on vulnerability reduction and adaptation options. Other countries may be less vulnerable to climatic changes but may be or may become significant emitters of GHGs. For these countries development strategies would focus on achieving low emissions economies. Such countries can play a key role by integrating clean and efficient energy strategies in their development plans, with considerable benefits unrelated to climate change. Developing climate friendly will be most important to the larger countries in the South such as India, China, South Africa, Brazil, Mexico, South Korea and Argentina.

However, implementation of alternative strategies for development is only likely to happen when international policies will provide incentives to enable countries to implement them. When looking at the four cases presented in this paper, examples can be given on what is needed in these countries to support development in a climate friendly and a climate safe direction. These strategies can be enhanced by international policies, which are currently not very effective. In this paper, lessons for international policies have been largely left aside. Some possible directions for creating the right incentives are:

- Sustainable development policies and measures at national level, such as for instance sector-transition strategies, land use policies, and technology development and transfer programmes ensuring the development of endogenous capacity, have the potential to support environmental regimes, including the UN Framework Convention on Climate Change, the Convention on Combating Desertification (CCD), the Convention on Biodiversity (CBD) and regional water agreements;

- Also international regimes such as WTO, Official Development Assistance as implemented through international development banks and the OECD Export crediting agreement can help implement (sustainable) development and climate change policies and measures.
- Important areas for further discussion are how to make use of synergies between different regimes, how international co-ordination could be achieved and how to keep such regimes manageable.

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