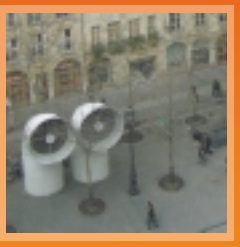
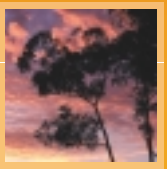
United Nations Framework Convention on Climate Change

The First Ten Years





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The First Ten Years

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United Nations Framework Convention on Climate Change

The First Ten Years

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Message of the Secretary-General of the United Nations

Mr. Kofi A. Annan on the 10th Anniversary of the Entry into Force of the United Nations Framework Convention On Climate Change

21 March 2004

Ten years is not long in the history of a problem whose scale is measured in centuries. Nevertheless, significant progress has been achieved in the decade since the United Nations Framework Convention on Climate Change entered into force.

The issue of climate change has been placed firmly on local, national and international agendas, in the forefront of public and media scrutiny, and in the strategies of a growing number of businesses. Institutions and processes have been put in place to enable the world's governments to take action, to coordinate those steps, and to measure the results. Annual meetings of the states that are Parties to the Convention – now numbering 189 – draw thousands of participants from governments, business, civil society and international organizations.

The Convention has also served as an important market signal, helping new technologies to emerge. For example, the use of wind energy is increasing, industrial processes are being made more efficient, hybrid vehicles are finding their way into the marketplace, and investments in breakthrough technologies involving hydrogen use and carbon capture are on the rise. The Convention's financial mechanism has also channeled almost $10 billion to climate change projects in poor countries, which are the most vulnerable to the impacts of the phenomenon.

The Convention's goal of returning the greenhouse gas emissions of industrialized countries to their 1990 levels by the year 2000 was achieved for those countries as a whole. However, for most individual countries, emissions of greenhouse gases are now increasing. Atmospheric concentrations of carbon dioxide, a key measure of long-term success, have increased about 5 per cent in the past decade. All countries must carry out more intensive efforts to limit future emissions, with developed countries taking a clear lead. There is also a need for more concerted action to adapt to climate change, since some of its effects are by now inevitable and, indeed, we may already be seeing – in the increased incidence of drought, floods and extreme weather events that many regions are experiencing – some of the devastation that lies ahead.

This anniversary is also a moment to reiterate strong support for the Convention's Kyoto Protocol. The Protocol's lack of entry into force remains a major hurdle to effective global action. I call again on those countries that have not yet ratified the Protocol to do so, and show that they are truly committed to shouldering their global responsibilities.

The global fight against climate change is a vast undertaking that will require sustained global citizenship and vision for decades to come. The international community should take pride in what it has done thus far to respond to this challenge. But only if these efforts are truly re-energized will we place our societies on more secure footing, and avert the calamities that the world's best science tells us lie ahead if we continue on our present course.

Foreword

Everybody has heard about climate change. Some people believe it is real, others do not. We are convinced that climate change is imminent if not already with us. And we are not alone – 189 countries are Parties to the United Nations Convention on Climate Change (UNFCCC). This almost universal participation demonstrates that countries around the world do take this global threat seriously, that they are concerned, and that they act accordingly.

In just 10 years since the entry into force of the UNFCCC, debate on the climate change problem, or global warming as it is more popularly known, has moved from scientific journals to the front pages of the world's leading newspapers, and has even inspired cinema directors. This problem concerns everyone. No one is exempt.

Many people, institutions and organizations contributed to the global effort to understand climate change and mitigate its effects. It is not possible to list them all. Some, however, deserve a special mention: the first Chair of the Intergovernmental Negotiating Committee on Climate Change that developed the text of the Convention, the late Mr. Jean Ripert, and his successor Ambassador Raúl Estrada Oyuela who also brought difficult negotiations on the Kyoto Protocol to a successful resolution; chairs of the Intergovernmental Panel on Climate Change Dr. Bert Bolin, Dr. Robert T. Watson and Dr. Rajendra K. Pachauri; former Secretary-General of the World Meteorological Organization Professor Godwin O.P. Obasi; Executive Directors of the United Nations Environment Programme Dr. Mostafa K. Tolba, Ms. Elisabeth Dowdeswell and Dr. Klaus Töpfer; and last but not least my predecessor, the first Executive Secretary of the UNFCCC Mr. Michael Zammit Cutajar.

National governments provided valuable and tangible support to the complex and complicated negotiations. Germany, Switzerland, Japan, Argentina, Netherlands, Morocco, India and Italy hosted Conferences of the Parties or presided over them; representatives of Zimbabwe, Poland and Hungary also served as Presidents of the Conferences of the Parties.

A team in the UNFCCC secretariat, led by Mr. Vitaly Matsarski, prepared this publication on the occasion of the tenth anniversary of the entry into force of the Convention. Scientific insights on how serious the threat of human-induced climate change is, have guided national governments, businesses and the public at large into national and international action. The picture given here of what has been done in the past decade to combat climate change and mitigate its adverse effects, is far from being comprehensive; much more is being done than this short publication can present. Our goal was to tell the reader about some steps that have been taken on a complex and long road towards achieving the ultimate objective of the Convention – preventing dangerous human interference with the climate system.

Happy reading!

Joke Waller-Hunter
Executive Secretary
United Nations Framework Convention
on Climate Change
September 2004

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Executive Summary

The world has taken major strides towards meeting the challenge of climate change – moving on from scientific analysis, to public concern, to developing and implementing an international Convention. There is, however, still a long way to go: first, in achieving a better understanding of the global climate system; second, in taking decisive and early action to reduce greenhouse gas emissions; third in ensuring a broad public support for both mitigation and adaptation efforts. For even if emissions merely continue at their present rate, atmospheric concentrations of the greenhouse gases will increase for centuries ahead – leading to a rise in global mean temperatures. There is an urgent need to rise to the challenge – to reduce emissions in order to stabilize concentrations.

The United Nations Framework Convention on Climate Change, which entered into force in March 1994, was a crucial step in this direction – aiming to reduce emissions of greenhouse gases, including the most important of them, carbon dioxide. Although global in scope, it differentiated commitments of its Parties depending on their respective capabilities, economic structures and resource bases.

This publication broadly describes progress achieved in combating climate change since 1994 and presents some of the wide range of actions, policies and approaches as reported in national communications from Parties to the Convention. Much more has and is being done, in particular by non-governmental organizations, businesses and the civil society than could be reflected here.

"Climate change" means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

(Article 1.2)

Assessing the scale of the problem

One of the most important steps towards the Convention was the establishment in 1988 of the Intergovernmental Panel on Climate Change (IPCC). The Panel has since issued a series of reports, the third of which in 2001 noted that over the past 200 years the concentration of carbon dioxide in the atmosphere had increased from 280 to 368 parts per million and, while emphasizing the inevitable uncertainty involved, the Panel, based on various scenarios, estimated that due to human activities by 2100 concentrations can be in the range between 540 and 970 parts per million. As a result, between 1990 and 2050 global mean temperatures could increase by between 0.8 and 2.6 degrees Celsius and by 2100 – between 1.4 and 5.8 degrees Celsius. In addition the Panel anticipated changes in levels of precipitation during the 21st century, both increases and decreases, in the range of 5% to 20%. The Panel also provided an evidence that most of the warming observed in the last 50 years can be attributed to human activity. Greater and more abrupt climatic variations may occur in the future with increased frequency and magnitude of extreme weather events, such as hurricanes and droughts.

The Panel concluded, however, that the net effects on the global economy were initially likely to be small: depending on the country, they would result in an increase or a decrease in gross domestic product of 1% or 2%, though as warming increased, the impacts were expected to become increasingly negative. The IPCC assessed the potential cumulative costs of climate change mitigation: in the developed countries by 2010 these could result in reductions in GDP of between 0.1% and 2.0%. Despite remaining uncertainties associated with the magnitude of climate change, its impacts and mitigation costs, the IPCC has sent a clear message that the risks are high enough to justify an urgent policy action.

Recent emissions trends

The bulk of information on the emission trends comes from the national communications and greenhouse gas inventories. These show that for the developed countries as a whole over the period 1990–2001 annual emissions fell by 1.2 billion tons of carbon dioxide equivalent – 6.6% – exceeding the aim of the Convention to return emissions to the 1990 level by the end of the 20th century. However this was largely due to a 39.7% fall in emissions in the countries with economies in transition, as a result of economic contraction, which more than offset a 7.5% rise in the highly industrialized countries. There was also striking variations between countries – from a reduction of 60% to an increase of 40%. There was also a significant growth in emissions from developing countries: between 1990 and 2000, energy-related carbon dioxide emissions increased in many of them.

The predominant greenhouse gas remains carbon dioxide, which in the developed countries was responsible in 2001 for 81% of emissions – together with 6% from nitrous oxide, 10% from methane and 3% from fluorocarbons. For carbon dioxide the main source was fuel combustion; for nitrous oxide it was agriculture; while for methane the main sources were emissions associated with extraction and transport of fossil fuels, agriculture and waste management. During the 1990s emissions appear to have fallen in most sectors, particularly in energy and industrial processes, though they rose significantly for transportation. There were additional emissions from international aviation and shipping and while those from shipping have remained almost stable those from aviation have been climbing steadily.

The key question is whether economic growth itself is becoming more climate friendly. Between 1990 and 2000, 'emissions intensity' fell for the world as a whole in that emissions were growing more slowly than GDP. However, not all of this was due to climate-specific actions or a shift from carbon-based production; a substantial proportion reflected structural change away from industry and manufacturing and towards service industries which tend to use less energy.

Combating climate change

To slow or reverse greenhouse gas emissions all governments need to develop and implement policies to combat climate change. In the early years these policies tended to be rather fragmented; now they are becoming more coherent and linked to sustainable development. The overall aims are to achieve production that is less carbon-intensive and to increase the use of alternative sources of energy, while boosting energy efficiency – in industry, in buildings, in transportation and appliances. Fiscal measures were among the most widely used in developed countries, often combined with financial incentives such as grants and preferential loan rates and tariffs.

Although most developed countries are now committed to combating climate change they do not want to reduce international competitiveness so have tried to ensure that some new measures, particularly for energy-intensive industries, are introduced mostly on a voluntary basis – though there can still be sanctions for non-compliance. As well as using fiscal and financial measures, some governments have also introduced national systems to allow companies to trade emissions allowances. Local governments, cities and municipalities often have their own climate change programmes. Many businesses introduce "win-win" practices, which increase profitability and at the same reduce emissions of greenhouse gases.

Many developing countries too have been trying to integrate climate-friendly approaches into their sustainable development strategies while striving to achieve the overriding goal of poverty eradication. For this, however, they need to rely to some extent on external assistance – bilateral and multilateral. Bilateral aid from the OECD countries for climate change over the period 1998–2000 averaged $2.7 billion per year. The most significant multilateral source has been the Global Environment Facility which over the period 1995–2003 allocated for climate change activities about $1.25 billion and leveraged $6.2 billion in other funding.

The promise of technology

Significant reduction in emissions in the longer term will rely to a large extent on the deployment of new and more efficient technologies. In fact progress has been faster than expected – as with combined heat and power, hybrid engine cars or fuel cell technology. The IPCC has estimated that technological improvements could some time between 2010 and 2020 reduce greenhouse gas emissions to levels below those in the year 2000.

A very broad spectrum of technological options is available worldwide – from wind-turbine generators to underground storage of captured carbon dioxide. All countries should be able to benefit from international cooperation – which is currently evident in hydrogen and fuel cell technologies, for example, as well as in fusion energy and carbon sequestration. Developing countries, with fewer resources and facilities, will have to rely more on technology transfer – an important issue which receives due attention from Parties to the Convention.

Strategies for adaptation

As well as planning to mitigate future climate changes the world also needs to adapt to such phenomena as rises in mean temperature, shifts in the seasons, and an increasing frequency of extreme weather events. The question now is not 'whether to adapt?', but 'how to adapt?'.

Thus far, however, most adaptation activity has been limited to carrying out impact assessments. The research started with global models to construct a range of possible long-term scenarios. Although these scenarios were not sufficiently detailed at the regional or national level, they were instrumental in identifying the key impacts of climate change, as well as options and priorities for adaptation. Recently, researchers have turned also to second-generation assessments that are 'vulnerability-based' – looking at current climate variability and the ways in which people are actually adapting. This approach also includes risk assessment along with the more refined climate change scenarios which allow to consider what will happen in the future, given changes in both the natural and the socio-economic environments. The process has now moved one step further: adaptation is more and more being taken into account in development plans, programmes and actions.

Raising public awareness

All these strategies for both mitigation and adaptation will depend critically on public support. Much of the credit for raising public awareness of climate change must go to NGOs – who have worked closely with concerned scientists at both national and international levels. But governments too, both central and local, have become keen to increase public understanding and participation, and as governments adopt new climate-related measures, and as manufacturers advertise more climate-friendly products, public perceptions are expected to evolve from an abstract concern to a lived experience.

The Kyoto Protocol

The Convention laid the groundwork for concerted international action, which in 1997 led to the adoption of the Kyoto Protocol containing legally binding quantitative time-bound targets for developed countries. Actions towards achieving these targets will contribute to modifying longer-term trends in anthropogenic emissions. The Kyoto Protocol is designed to ensure proper monitoring and verification of its implementation, including stringent and elaborate reporting, review and compliance procedures.

Recognizing that relying on domestic measures alone to meet the targets could be onerous, the Kyoto Protocol offers considerable flexibility through three mechanisms. Two are project based. One is the Clean Development Mechanism (CDM), instituted in 2001, through which industrialized countries can finance mitigation projects in developing countries contributing to their sustainable development. Credits received from such projects can be used to meet commitments under the Kyoto Protocol. The second one is joint implementation (JI) through which industrialized countries acquire emissions credits by financially supporting projects in other industrialized countries. The third Kyoto mechanism is emissions trading – allowing countries that expect their emissions to be above the target to buy unused quotas from other countries. Some Parties to the Convention

which ratified the Protocol are already developing their own trading systems. The EU will launch its system on 1 January 2005. A Kyoto-based system will thus be running in a significant number of countries very soon, involving the private sector and creating a market for the new commodity – carbon.

The Kyoto Protocol, already ratified by 124 countries, will enter into force once it is ratified by the Russian Federation. It now holds the key to unlocking this international instrument after the announcement by the United States that it does not intend to be party to this treaty.

The clock is ticking

Dealing with climate change requires an approach that is vigorous and determined, but also flexible and adaptable, allowing each country to progress at a pace that suits its own national circumstances. Measures taken so far lay the foundation for what is needed to fully meet the ultimate objective of the Convention – to achieve stabilization of greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system.

Most countries do indeed now treat climate change as a serious threat – and are addressing it in a more comprehensive and integrated fashion. The challenge of future negotiations will be to find a combination of approaches that reassures all countries that the others are doing their share, while preserving their right to protect their divergent national interests. The outcome of these negotiations may need to provide a large degree of flexibility and certainty (within possible limits) on implementation costs while assuring countries potentially affected by climate change or by impacts of response measures that steps are being taken to mitigate these consequences. The ultimate objective of the Convention is attainable. But the clock is ticking.

Chapter 1

The path to the Convention

The world has taken major strides towards meeting the challenge of climate change – moving on from scientific analysis, to public concern, to the signing of an international Convention. This was a critical achievement. Even if emissions of greenhouse gases merely continue at their present rate, atmospheric concentration will increase for centuries ahead – leading to a rise in global mean temperatures. The world has to act now, not just to stabilize emissions but to cut them. The United Nations Framework Convention on Climate Change is an essential first step in that direction.

The Parties to this Convention, Determined to protect the climate system for present and future generations...

(Preamble to the UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC) is rooted in the scientific findings of the 1960s and 1970s. Scientists had concluded that increasing concentrations of carbon dioxide, which were partly the result of human or 'anthropogenic' activities, were warming the global atmosphere through their additional contribution to the natural 'greenhouse effect'. Some also blamed the increase in concentrations of carbon dioxide and other greenhouse gases for a greater frequency and severity of extreme weather events, such as droughts and heat waves.

By the mid-1980s, governments decided that this complex issue needed to be addressed impartially by an independent body and in 1988 established the Intergovernmental Panel on Climate Change (IPCC). Under the auspices of the World Meteorological Organization and the United Nations Environment Programme, the IPCC was to assess the magnitude and timing of these changes, estimate their potential environmental and socio-economic impacts and present realistic strategies for response. The United Nations General Assembly endorsed the establishment of the IPCC and urged the global community to give this issue a high priority.

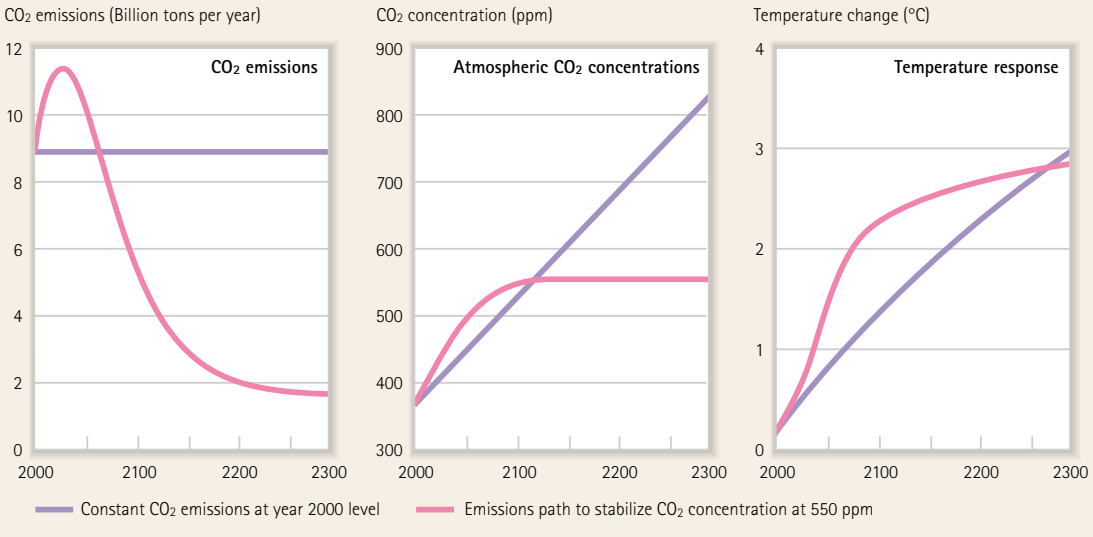
Because climate change embraces so many subjects the panel would need to draw upon a wide range of experts from many disciplines – not only climate scientists but also biologists, economists, sociologists, health scientists, and others. The IPCC would not, however, engage in research itself; rather it would synthesize the available peer-reviewed scientific data. Nor would it propose its own prescriptions; it would simply provide governments with policy-relevant information.

Box 1.1 Relationship between emissions, concentrations and global temperatures.

Changes in global climate are determined by complex processes, both natural and anthropogenic. **Emissions** of greenhouse gases increase their **concentrations** in the atmosphere, which in turn leads to **changes in global temperature.**

As figure below illustrates, the global climate system needs time to react to lower emission levels. This is an important factor for the consideration of possible pathways to the stabilization of greenhouse gas concentrations in the atmosphere.

Impact of stabilizing emissions versus stabilizing concentrations of CO_2



Source: IPCC, 2001

The First Assessment Report

The IPCC presented its First Assessment Report in 1990. Reflecting the views of hundreds of experts, the report concluded that anthropogenic activities and the resulting emissions were substantially increasing atmospheric concentrations of greenhouse gases – more than half of the total being carbon dioxide. This would enhance the natural greenhouse effect and further warm the surface of the Earth: if no action were taken, global mean temperatures would, during the next century, rise by an unprecedented 0.3 degrees Celsius per decade. This in turn would melt some of the polar ice caps and raise the level of the seas: by 2030, this could result in a rise in mean sea level of 20 centimetres, and by the end of the 21st century of up to 65 centimetres.

The report emphasized that this was a long-term and persistent issue – that even if emissions did not increase but simply continued at their present rate the concentration of greenhouse gases would rise for centuries ahead. To actually halt this process would require something more dramatic: stabilizing the concentrations of long-lived gases at their present level, would require emissions to be reduced by over 60%.

Governments could scarcely ignore such a stark warning and realized that they would need to tackle this issue through a legally binding instrument. In December 1989, the UN General Assembly mandated governments to make the necessary preparations and in December 1990 established a single negotiating process – the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change.

Negotiating the Convention

Negotiations proved difficult. At the outset there was no single view on what the Convention should look like or what should be its ultimate objective. Moreover, the subject was very complex, touching on many economic interests and aspects of human activity. Many argued that the Convention would have to focus on the use of energy since the carbon dioxide being released into the atmosphere was mostly the result of burning fossil fuels. However, it would also need to encompass many other sectors including transport, industry, agriculture and forestry. It was also likely to be contentious – requiring drastic and unpopular measures that could radically affect economic and social activities all over the world.

Inevitably there were many different points of view, particularly between developing and developed countries. The developing countries, insisting on their right to development were reluctant to make commitments to reduce or limit greenhouse gas emissions that might jeopardize economic growth. Climate change, they argued was a problem that had been caused mainly by the developed countries who had the corresponding responsibility to solve it within their own territories. If measures were needed in

The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology…

(Article 4.7)

The ultimate objective of this Convention ...is to achieve... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

(Article 2)

"Greenhouse gases" means those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation.

(Article 1.5)

poorer countries the wealthier countries could pay for these too. Within the group of developing countries there were divergent views on how to deal with climate change. At one end of the spectrum were small island states that were threatened with the loss of much of their land as a result of rising sea levels; at the other were oil producers who were concerned that measures to reduce the consumption of fossil fuels would damage their economies.

For their part, the developed countries accepted that they would have to take the prime responsibility and said they were prepared to take measures to reduce their emissions. They also agreed that they would need to support the efforts of the developing countries, but they argued against establishing a new financial mechanism, believing that the Global Environment Facility, established in 1991, could serve the purpose.

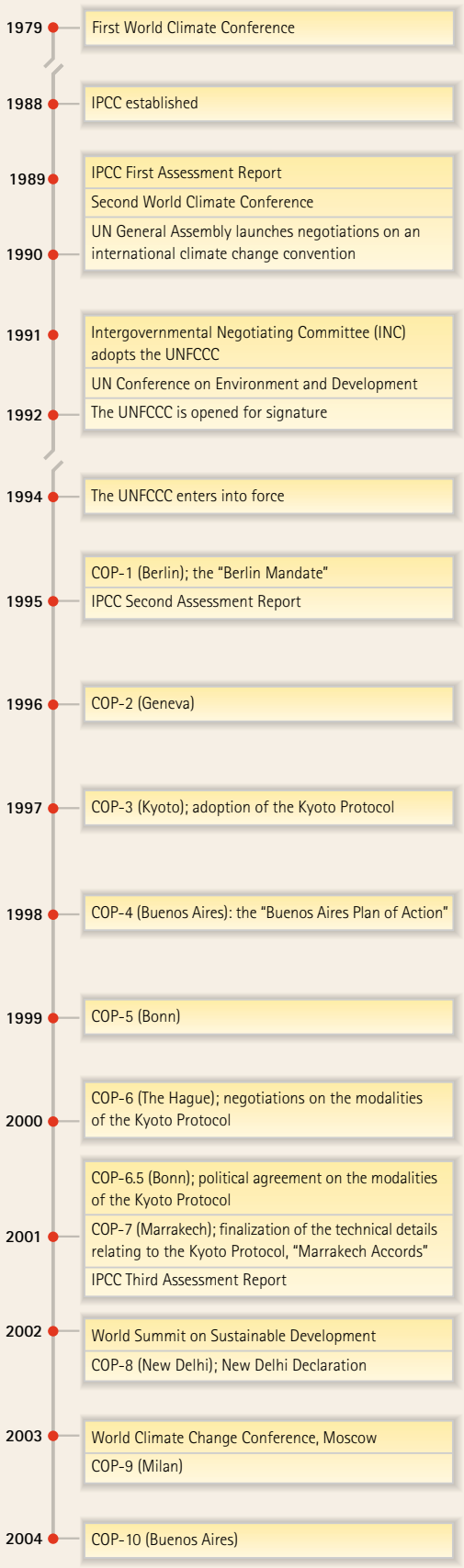
Given the complexity of the issues, widely divergent views, and the tight deadline, it soon became clear that the Convention would be unable to set quantitative targets. Instead, recognizing both the common and the differentiated responsibilities of both developed and developing countries, the best that could be achieved was a limited 'framework' text that would set the stage for a broad range of subsequent activities.

The Convention was finally adopted on 9 May 1992. It was opened for signature the following month at the Earth Summit in Rio de Janeiro where it was signed by 154 states and the European Community. On 21 March 1994, 90 days after receiving its fiftieth ratification, the Convention entered into force. At the time of writing, 189 countries were Parties to it. This year, 2004, marks the tenth anniversary of the Convention.

The Convention covers greenhouse gases not controlled by the Montreal Protocol on ozone-depleting substances. At present, Parties are mostly concerned with the following greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorinated hydrocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6). These are not the only gases that contribute to global climate change, but they are the most important ones. Perfluorinated hydrocarbons and hydrofluorocarbons are the substitutes for chlorofluorocarbons which, under the 1987 Montreal Protocol, are being phased out in order to protect the stratospheric ozone layer.

Although all six contribute to global warming some have a more powerful greenhouse effect than others. Over a 100 year period, a ton of methane, for example, can make the same contribution to the man-made greenhouse effect as 21 tons of carbon dioxide and a ton of hydrofluorocarbons can be equivalent to many thousands of tons of carbon dioxide. For the preparation of greenhouse gas inventories a system has therefore been developed so that emissions can be expressed on a comparable basis in terms of their global warming potential – as tons of carbon dioxide equivalent.

Box 1.2 Major milestones in the climate change process



Carbon dioxide is the primary contributor to climate change since it is produced in such large volumes by burning fossil fuel (around 6.5 billion tons of carbon are added to the atmosphere annually), and in most countries it dominates their greenhouse gas emissions. But the other gases, though produced in smaller volumes, also need to be carefully controlled given their greater global warming potential.

The differentiated responsibilities of countries

The responsibility for achieving the objectives of the Convention is shared among the 189 Parties. But they have different commitments according to their levels of economic development. The classification of countries, with corresponding responsibilities, is reflected in their listing in the Convention's annexes.

Annex I Parties – These are mostly the developed countries, of which there are currently 41, including the European Community which is a Party in its own right. Annex I countries were aiming to return their emissions by 2000 to 1990 levels. They also have to make regular reports on their implementation of the Convention – in particular, on the policies and measures they are taking and the impacts that these are having on emission trends, as well as on the amount of greenhouse gases released into the atmosphere.

Annex II Parties – These are an Annex I subset – the 24 highly developed countries. In addition to reducing their own emissions they are also required to financially and otherwise support the efforts of the developing countries.

Countries with economies in transition (EITs) – There are 14 of them. These are mostly countries of Eastern and Central Europe and the former Soviet Union, eight of whom are now members of the European Union. They are listed in Annex I, but they do not have the additional obligations of the Annex II Parties.

Non-Annex I Parties – All Parties that are not included in either Annex. They are mostly developing countries. Like all Parties to the Convention they have general commitments to respond to climate change but they have fewer specific obligations and should also be able to rely on external support. They are also required to provide a general description of steps take or envisaged to implement the Convention and estimate emissions of greenhouse gases.

The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.

(Article 3.1)

The path to the Convention

All Parties meet annually in the Conference of the Parties (COP) – This is the supreme body which reviews the implementation of the Convention and takes appropriate decisions. It is supported by two main subsidiary bodies that are also open to all Parties. They meet twice a year and do the bulk of the technical work:

The Subsidiary Body for Scientific and Technological Advice (SBSTA) – This provides advice to the Conference of the Parties on matters of science, technology and methodology.

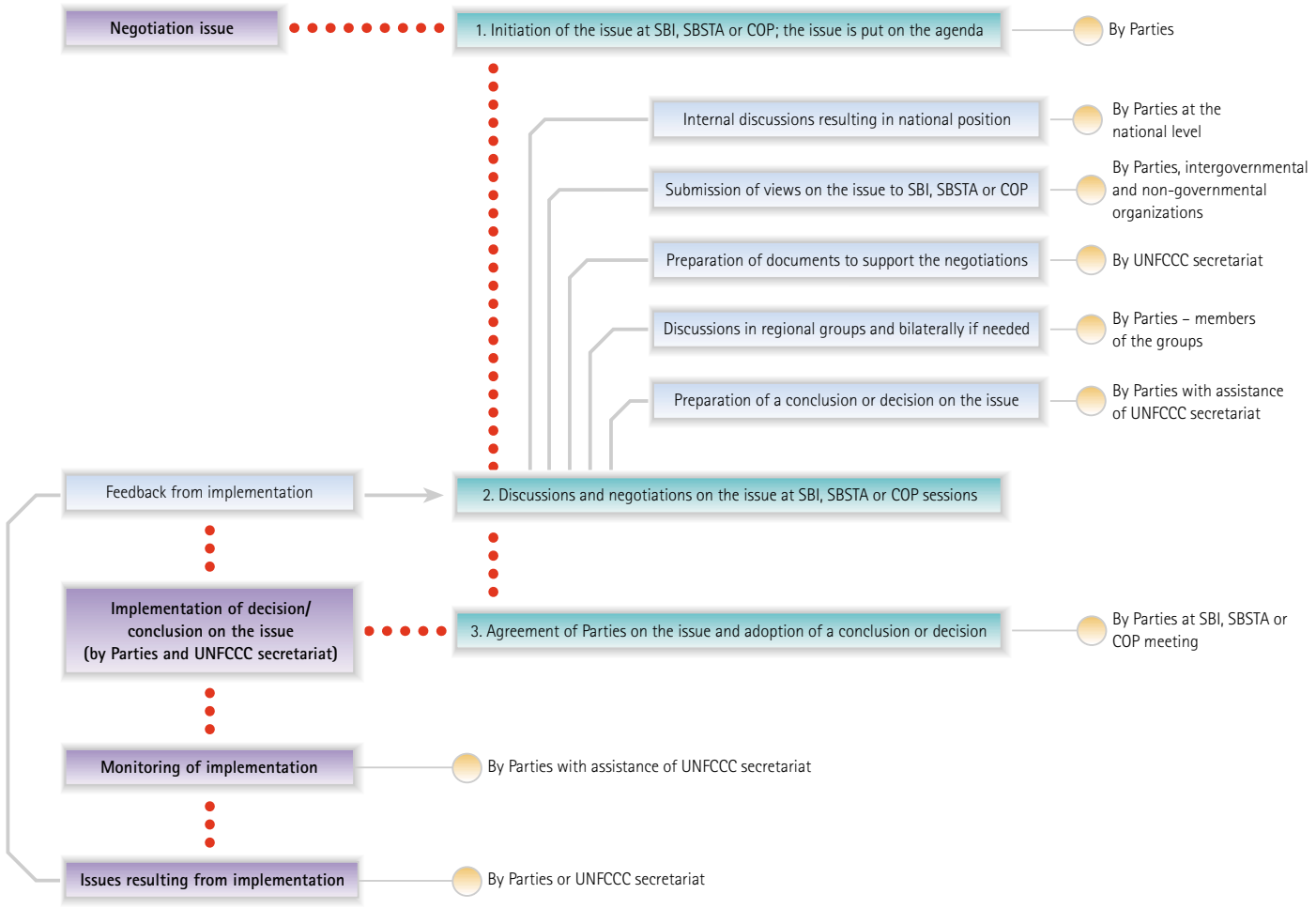
The Subsidiary Body for Implementation (SBI) – This deals with all implementation-related matters, including national communications as well as financial and administrative matters.

There are also other constituted bodies that will be introduced later in this report. The overall decision-making process is illustrated in Figure 1.1.

The first Conference of the Parties took place in Germany in March-April 1995. Here the delegates adopted the 'Berlin mandate' – requiring Parties to enter into negotiations for reducing emissions through quantitative targets and timelines. This bore fruit in Japan in December 1997 at the third Conference of the Parties which added to the Convention the first additional agreement, or Protocol.

The Kyoto Protocol stated that during the first commitment period, 2008–12, developed countries would have to reduce their emissions to at least 5% below their 1990 levels. The Protocol has not yet come into force – it will do so when it has been ratified by 55 countries, providing this includes enough countries to encompass 55% of the carbon dioxide emissions of the Annex I countries. It is already ratified by 124 countries and will enter into force once the Russian Federation or the United States of America submit their ratifications. The United States announced in 2001 that it does not intend to do so.

Figure 1.1 Decision making process for UNFCCC bodies



Climate change is a complex subject, encompassing a huge and varied body of information – scientific, social, economic and political, so this publication can present only a small fraction of the available knowledge. It gathers data from a variety of organizations, notably UN bodies and agencies as well as non-governmental organizations, but it takes most of its information from reports from Parties to the United Nations Framework Convention on Climate Change.

In the chapters that follow, the publication looks at recent emissions trends and prospects and then sets the stage for future policies by considering how climate change concerns fit in with strategies for sustainable development. After this it considers ways of both combating climate change and adapting to it – along with the likely technological developments and the ways of ensuring greater public involvement. Finally it explains the significance of the Kyoto Protocol and what this implies for the next generation of climate change policies.

Chapter 2

Recent trends and glimpses of the future

Decades of research have indicated the extent of climate change and the rise in global mean temperature, but have illuminated only a small corner of a vast and complex subject. Nevertheless, information on the current situation has now started to flow – and reports from the developed countries indicate that as a group they met their commitments under the Convention for 2000. Developing countries too have presented reports, but will need much more assistance if they are to achieve and monitor their progress effectively.

All Parties... shall:
... Develop, periodically update, publish and make available to the Conference of the Parties... national inventories of anthropogenic emissions by sources and removals by sinks...
(Article 4.1.a)

Coming to terms with the diversity of the information and the interactions between scientific, economic, social and political issues make this one of the most difficult policy areas for governments, for businesses and for civil society.

The IPCC's First Assessment Report in 1990 had addressed some of the urgent questions. But it left many others unresolved. The world's scientists still had only a limited understanding of some of the key factors in climate change – such as the sources and sinks of greenhouse gases, and the nature of the interaction between clouds, oceans and polar ice sheets. They found it difficult therefore to make firm predictions about climate changes – especially about their timing, magnitudes and regional impact. Nor in their first report did the panel say much about strategies for response.

The Second Assessment Report 1995 went into greater detail. The panel confirmed the main findings of the first report and stated that "the balance of evidence suggests that there a discernible human influence on global climate". Indeed it pointed out that the process is already well underway: since the late 19th century global mean temperature has increased by 0.5 degrees Celsius.

The second report also indicated the impact that this would have on the environment – disturbing delicate balances both within and between ecosystems. Temperature rise would, for example, make conditions in deserts more extreme: hotter, though not significantly wetter. It would also affect the growth and regeneration of forests. But climate change would also have a profound impact on human populations. People all over the world would see differences in ground and surface water supplies with significant effects on irrigation schemes, for example, as well as on hydropower generation, navigation, in-stream ecosystems and water-based recreation. Their health would also be affected by patterns of disease

and many would be more exposed to extreme climatic events that could lead to significant loss of life.

The Report emphasized, however, that there were still many uncertainties and gaps in knowledge and understanding. Scientists know that the climate is changing but they can find it hard to distinguish signals of human influence from the 'background noise' of natural variability. So although it is difficult to be sure of the extent of human responsibility it is clear that human beings have added a major new stress.

The Report also looked at ways of responding to climate change. This would involve 'mitigation' – by reducing emissions, for example, or by absorbing them in sinks, such as forests, or by storing or 'sequestering' them. It would also imply adaptation – changing patterns of crop production, for example, or even moving human settlements. It argued for a flexible approach: rather than aiming for a policy for the next hundred years the global community should devise a strategy that is currently acceptable and adjust it over time in the light of new information.

The degree of acceptability will be strongly influenced by potential economic costs. If countries are to reduce emissions below 1990 levels they could affect their economic growth. Nevertheless there are a number of policies that developed countries could adopt to minimize the cost. Developing countries too have a range of opportunities for reducing greenhouse gas emissions. Indeed, said the report, most countries had many 'no-regrets' opportunities – options whose benefits, such as reduced energy costs and reduced pollution, are greater than their costs, even without taking into account their merits for climate change.

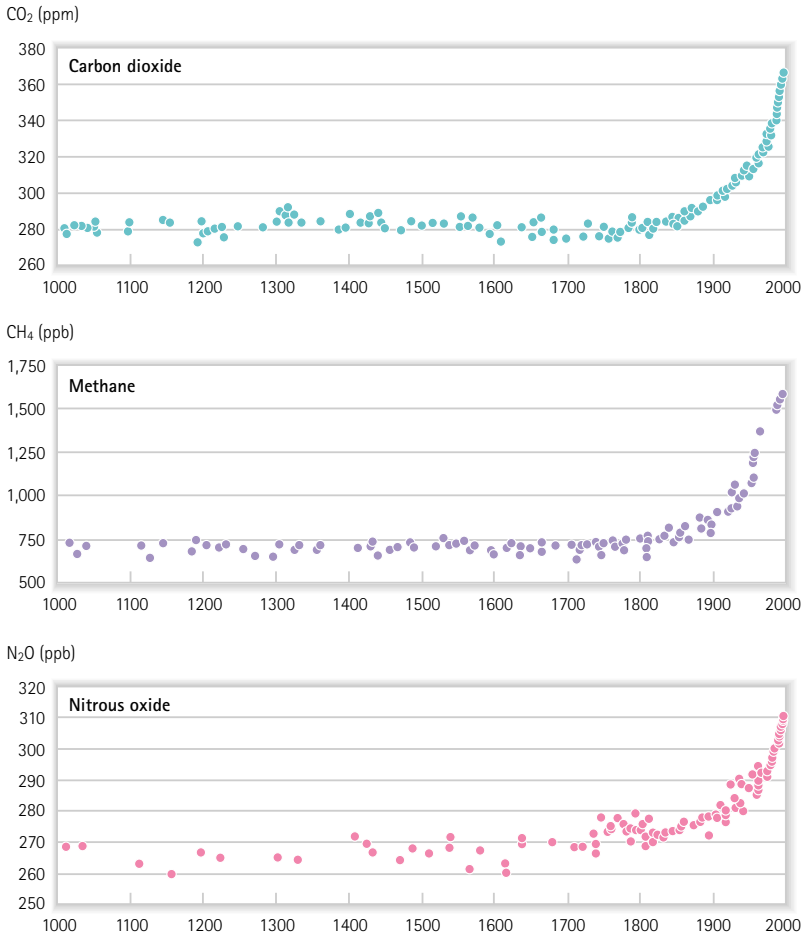
Nevertheless faced with the uncertainties and potential long-term economic damage from climate change, all countries should take precautionary measures and other actions beyond 'no regrets'. The Second Assessment Report concluded that international action was urgently needed and that it would need to be wide ranging, but that it should be possible to deal with climate change without a serious impact on economic development. It thus helped provide the scientific background for the negotiations that led to the Kyoto Protocol.

The Third Assessment Report

The most recent assessment report was published in 2001. Again, this moved forward the understanding of scientific issues related to climate change. But it also attempted to answer other questions related to specific concentrations of gases. What, for example, would be the global warming effects of various levels of greenhouse gases and what would be the resulting economic damage? And would it actually be feasible to stabilize greenhouse gases at any given concentration, and if so what would this cost?

The report responded first with historic information on climate change, noting that in the past 200 years the concentration of carbon dioxide had increased from 280 to 368 parts per million – that is to 368 molecules of carbon dioxide for every one million molecules in the air, with similar rises for methane and nitrous oxide (Figure 2.1). Then it made new projections of future concentrations of greenhouse gases based on different assumptions – demographic, social, economic and technological. For the year 2100 these produced results ranging from 540 to 970 parts per million. It also suggested resulting temperature increases: between 1990 and 2050 these ranged from 0.8 to 2.6 degrees Celsius and by 2100 – between 1.4 and 5.8 degrees Celsius. In addition during the 21st century there would be changes in levels of precipitation, both increases and decreases, in the range of 5% to 20%, along with greater and more abrupt climatic variations.

Figure 2.1 Human influence on the atmosphere during the industrial era



Source: IPCC, 2001

The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. ...Lack of full scientific certainty should not be used as a reason for postponing... measures...

(Article 3.3)

Figure 2.2 Reasons for concern about global warming

The bars show the range of potential impacts along different dimensions of concern, given a range of changes in global mean temperature.

I – Risks to unique and threatened ecosystems

II – Risks from extreme climatic events

III – Distribution of impacts

IV – Aggregate impacts

V – Risks from future large-scale discontinuities

Source: IPCC, 2001

The report also listed a series of 'reasons for concern' which are illustrated in Figure 2.2.

Although the Third Assessment Report did not fully remove scientific uncertainties associated with the magnitude and scale of climate change it somewhat reduced those uncertainties, thus creating a solid foundation for further action.

The cost of climate change

Estimating the costs of these changes given different emission scenarios would, however, be very difficult. This is partly because of uncertainties in the climatic variables themselves, but also because it is hard to apply a monetary value to changes in ecological systems, for example, or to human health. The costs will also be distributed very unevenly: the countries likely to be affected most are those in low latitudes, the majority of which are developing countries.

Global warming is still at an early stage, so at this point the aggregate net effects on the global economy are likely to be quite small. Depending on the country, they would result in an increase or a decrease in gross domestic product of one or two percent. But as warming increases, the impacts are expected to become increasingly negative – with the potential for large-scale and irreversible changes in the Earth's systems.

The report also assessed investigations of what the measures needed to mitigate climate change would cost. Again there is a wide range of uncertainty. For the developed countries by 2010 the estimates of reductions in GDP range from 0.1% to 2.0%. For non-Annex I oil-producing countries the knock-on effects could include losses of between 13% and 25% of projected oil revenues. The report also pointed out that while much could be done in the early years by taking some of the more obvious measures, mitigation would become steadily more expensive when these opportunities had been exhausted. However against all these costs, it is also important to consider the potential benefits of avoiding climate change – environmental, social and economic.

The report concluded that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities". But it also underlined the need for further scientific assessment of a very complex set of issues to provide a sound scientific basis for national and international decision making.

The Parties shall: ...Support international and intergovernmental efforts to strengthen systematic observation and national scientific and technical research...

(Article 5.b)

The need for systematic observations

These assessments will require long-term, high-quality observations examining the history of the Earth's system and its current situation, as well as the extent of variability. These can be space-based or surface-based and encompass a broad range of environmental measurements. Climatologists can gain a good deal of useful information from routine weather observations which, if collected over a long period of time, can help describe a region's climatology. At the same time they can also make other more precise and continuous observations of weather systems designed specifically to assess long-term changes; in some cases these can extend the climate record back for millennia. Many other disciplines can also carry out research investigation that contribute to an understanding of climate change, such as those designed to elucidate chemical, biological or radiative processes.

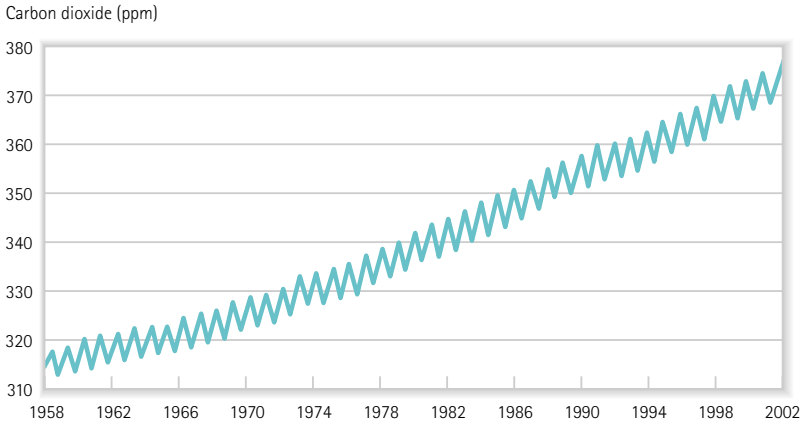
Some of these observations can be made from space. Equipment on satellites measure a wide range of variables, including solar output, the Earth's

radiation budget, vegetation cover, the biomass productivity of the oceans, levels of atmospheric ozone, levels of stratospheric water vapour and aerosols, and the distribution of greenhouse gases. They can also provide information on sea levels, ocean surface conditions, winds, weather and tropical precipitation. Satellite observations have the advantage of ensuring global coverage – over the oceans and sparsely populated areas such as deserts, mountains and forests. They can also cover the north and south polar regions, and the mid and upper troposphere and stratosphere. Space-based observations are not sufficient on their own, however, and need to be supplemented with in-situ land and sea measurements – to provide information on biodiversity, for example, groundwater levels, carbon sequestration, surface temperature, winds, and subsurface ocean temperatures, as well as on the emission and discharge of pollutants.

In the case of carbon dioxide the longest continuous record has been produced by Dr. Charles Keeling. He started his measurements in Mauna Loa in Hawaii in 1958. At that point the average atmospheric concentration of carbon dioxide was around 315 parts per million (ppm). By 2002 the level had risen to more than 370 ppm – one-third higher than in the pre-industrial era. When plotted, the data follow an oscillating line known as the 'Keeling Curve' (Figure 2.3).

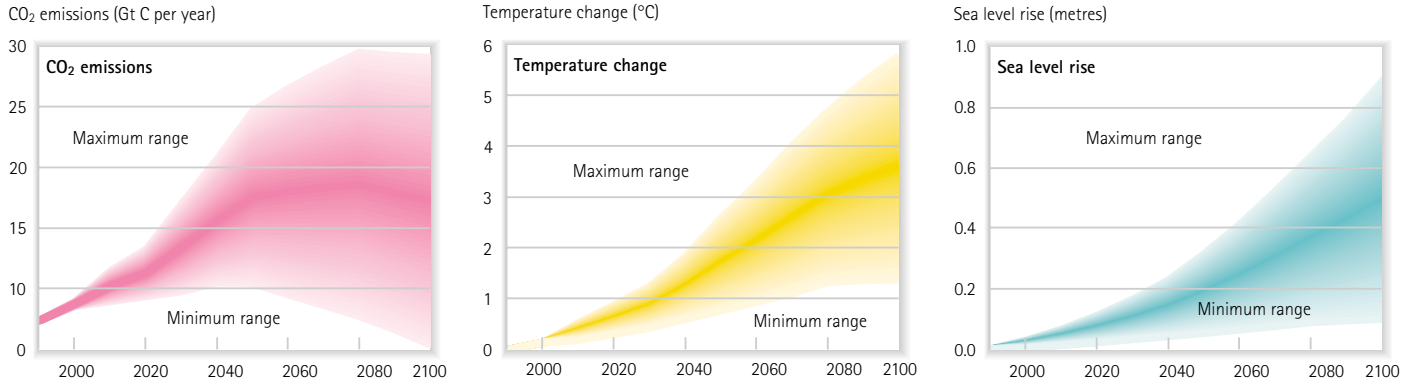
Much of today's monitoring is stimulated and encouraged by the World Meteorological Organization and the Global Climate Observing System, a body established in 1992 by a group of international organizations. This has a number of components: the Global Ocean Observing System; the World Hydrological Cycle Observing System; and the Global Terrestrial Observing System, which monitors and records ground data, including glaciers, permafrost and carbon flux phenomena. In addition there is the Global Observing System, which monitors the atmosphere, and Global Atmospheric Watch which covers the atmosphere's chemical composition. These measurements are carried out all over the world: by 2001 there were 989 observation sites.

Figure 2.3 The Keeling curve of atmospheric carbon dioxide from Mauna Loa, Hawaii



Source: Scripps Institution of Oceanography, University of California

Figure 2.4 Projected effects of emissions on temperature and sea levels



Source: IPCC, 2001

"Climate system" means the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions.

(Article 1.3)

Note: 'OECD' consists of all OECD members in 1990; 'Countries in transition' consist of countries in economic transition of Eastern and Central Europe, and the newly independent states of the former Soviet Union; 'Asia' includes developing countries of Asia and the Pacific region.

Models of climate change

The information collected by those systems has multiple uses. The data can, for example, be fed into models that can assist in predicting the impact of greenhouse gases on climate change and also help increase our understanding of the impact of climate change on natural systems and on human activity. Models of a system as complex as the global climate cannot, of course, offer accurate predictions, but do at least reduce levels of uncertainty. The models can also generate scenarios that can be used to present many of the crucial issues to a wide variety of people, ranging from academia and the research community to decision makers, students and the general public.

These models have already been used to offer a range of projections, the most recent of which were presented in 2000 in the Special Report on Emission Scenarios from the Intergovernmental Panel on Climate Change (Figure 2.4). These suggest that global emissions will increase at least until the middle of the 21st century after which, if the world takes action now, emissions could start to fall.

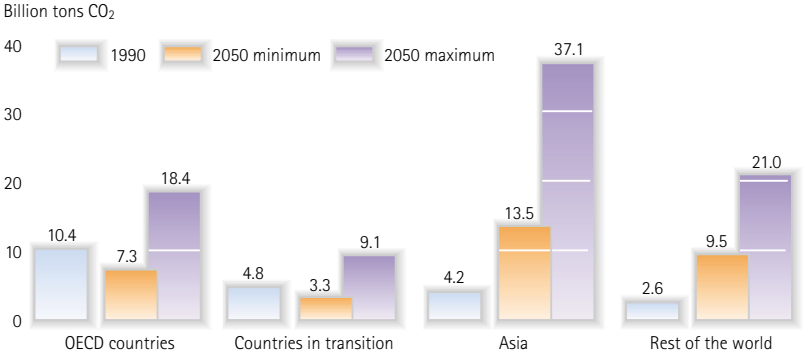
Policy makers today will necessarily be taking decisions based on incomplete information. In these circumstances and given the catastrophic implications of the worst-case scenarios – and the costs of adapting to them in the future – they should therefore take precautionary measures. Today's policy makers will never see the results. Only our children and grandchildren will live to experience the consequences of decisions taken today, or tomorrow, or the day after tomorrow.

Policy makers will also need to take climate change into account when making long-term economic plans. They would need to consider infrastructure such as bridges, dams, roads and railways that can last one hundred years or more and may need to be designed to accommodate climatic variations. But the implications permeate throughout national economies as planners in each sector take into account the potential effects of climate change.

Striving for more accurate data

If governments and the international community are to take the most appropriate action on climate change they will need to base their decisions on data that are

Figure 2.5 Actual and projected carbon dioxide emissions by region



Box 2.1 Some regions emit far more greenhouse gases than others

Although all countries need to take action to combat climate change their circumstances can be very different. This is illustrated in Table 2.3. Per capita emissions in North America, for example, are more than twice those in Europe.

Comparisons of carbon dioxide emissions to GDP are also revealing. The ratio of carbon dioxide emissions to GDP is more than twice as high in the Middle East than in other regions of the developing world – reflecting the abundance of oil in this region.

accurate, consistent and internationally comparable. Since 1994 governments have therefore invested significant time and resources into the preparation, collection and validation of data on greenhouse gas emissions, and the Conference of the Parties has made determined efforts to improve the quality and consistency of the data and has prepared guidelines for reporting.

Most Annex I countries presented their first inventories of greenhouse gases in 1996, the second year of the Convention. Although the information was incomplete, aggregating this data enabled estimates to be made of total emissions for these countries for 1990, which was to serve as the base year, and also made it possible to establish the first emissions trends. Their reports identified the most important gases – indicating that carbon dioxide accounted for 80% of the total and in addition they showed where these emissions were coming from: for carbon dioxide the main source was fuel consumption followed by industrial processes; for methane it was 'fugitive emissions' (emissions leaking out during coal mining or extracting and transporting oil and gas rather than emerging from chimneys or vents) followed by those from livestock and waste; for nitrous oxide it was emissions from agricultural soils followed by those from industrial processes.

Developing countries were also required to report, but for them the requirements were less stringent. They had to provide data on the three main gases for one year only – 1990 or 1994 – and although they had to follow the same guidelines they were not obliged to use a particular version of them. They were however, also encouraged to improve the quality of their data.

In 1999, building on the experience of several years of reporting, the Conference of the Parties in Bonn adopted a new series of guidelines that paved the way for more rigorous and internationally supervised reporting for developed countries. These covered annual greenhouse gas inventories, the preparation of national communications, and the technical review of inventories (Box 2.2).

Meanwhile, over the period 1997–99, 11 developing countries, fulfilling their reporting requirements under the Convention, had also submitted their initial communications (Table 2.1). These covered emissions by gas and by sector – demonstrating how much progress these countries had made in establishing inventory teams, in improving their capacity to evaluate emissions and in generating the first sets of original national data.

Nevertheless these reports also showed that developing countries faced a number of reporting problems, notably the lack of high-quality data and the difficulty of ensuring continuity and stability in the preparation of national inventories. It was also evident that developing countries would need significant external assistance. Ten of the eleven countries had received technical and financial support from the Global Environment Facility and its implementing agencies or through additional multilateral and bilateral programmes, such as the United States Country Studies Program.

The Conference of the Parties has made efforts to improve the quality of data from developing countries. In 1999 it established a consultative group of experts which made recommendations to the Conference of the Parties in New Delhi in 2002.

Box 2.2 Annex I countries – Reporting on emissions of greenhouse gases and on the technical review of their inventories

The Conference of the Parties in Bonn in 1999 took two crucial decisions on the preparation and submission of data by the Annex I Parties –on reporting guidelines for national greenhouse gas inventories and on guidelines for the technical review of inventories.

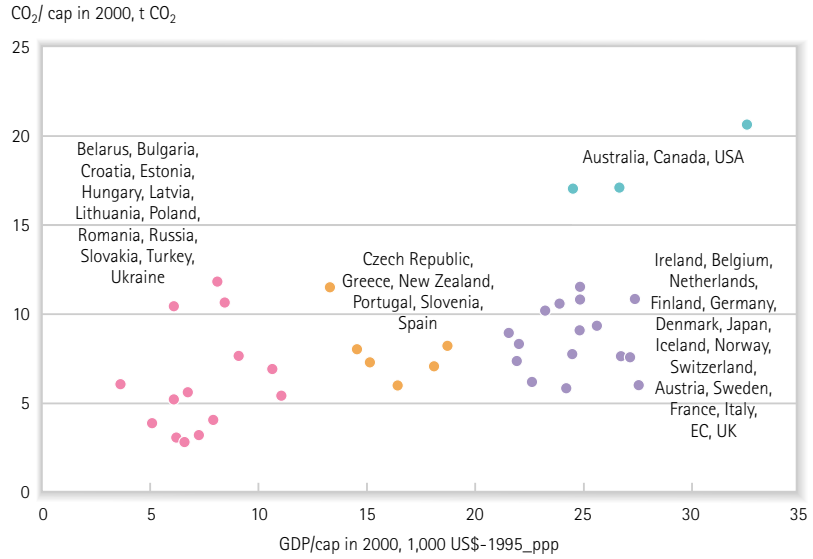
All Annex I Parties were required to report an inventory annually, using the 'Common Reporting Format' which specifies, for example, standardized tables for submitting inventory information. The reviews were also strengthened and had to be conducted under the collective responsibility of a team of experts nominated by Parties and coordinated by the UNFCCC secretariat. For the two-year trial period (2000–01) the new review procedures were voluntary but from 2003 they became mandatory.

These changes offered opportunities to considerably improve the quality and reliability of inventory data. They also ensured that national data would be continuously monitored by international teams of experts representing both developed and developing countries.

Table 2.1 Data available from non-Annex I countries on greenhouse gas emissions, 1999

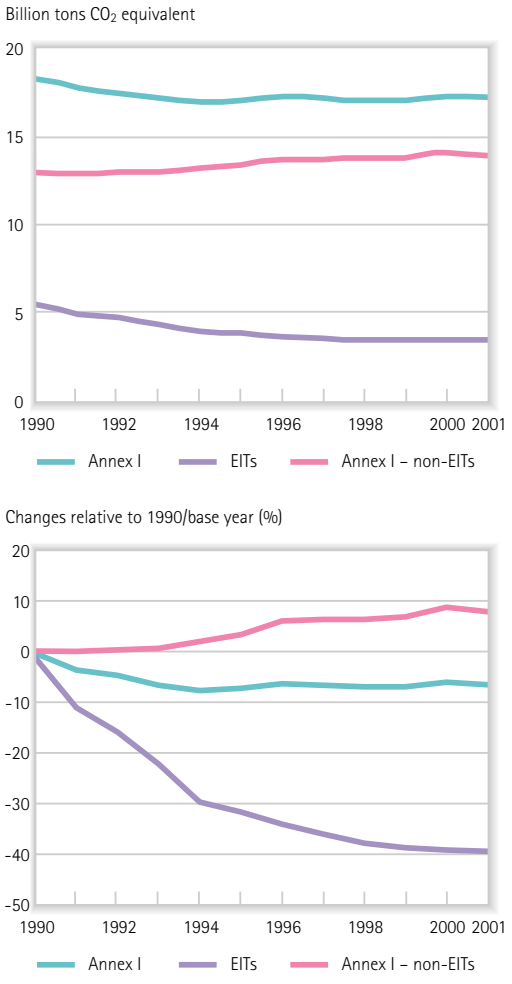
Number of communications from non-Annex I parties:	11
Communications that included greenhouse gas inventories	10
Years covered in the inventories: 3 Parties: 1990	3 Parties: 1994
	1 Party: 1995
	3 Parties: 1990 and 1994

Figure 2.6 Annex I countries: comparing per capita emissions and per capita GDP, 2000



Source: National Communications, IEA

Figure 2.7 Greenhouse gas emissions by Annex I Parties to the Convention, 1990–2001



Note: Emissions are the sum of CO_2, CH_4, N_2O, HFCs, PFCs and SF_6; excluding CO_2 removals by land use change and forestry.

The Conference used these as the basis for a revised set of guidelines for non-Annex I Parties and also recommended that the group continue its work.

Recent emissions trends in Annex I countries

Over the period 2001–03 the Annex I countries submitted their annual greenhouse gas inventories – with a noticeable improvement in quality, mainly because technical review procedures had been strengthened (Box 2.2). In 2001–02 most of them also submitted their third national communications on the implementation of the Convention. Combining these two sources of information thus made it possible not just to present data on greenhouse gas emission trends but also to analyse them and gain some understanding of the forces that were driving them.

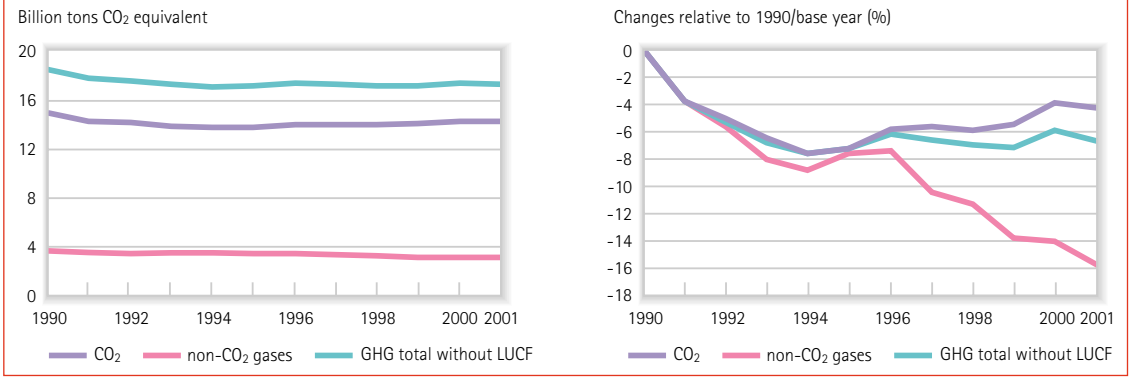
The latest data show first that there are still substantial differences in the per capita levels of emissions between different Annex I countries. This is illustrated in Figure 2.6. To some degree, per capita emissions rise with GDP per capita – though at these higher levels of GDP the correlation is relatively weak and many of the richer Annex I countries have lower emissions than those that are less wealthy such as the EIT countries. The differences can reflect, for example, the extent to which countries use renewables or nuclear power, or their requirements for heating or air conditioning or their different transport systems. Another important factor is the balance in the economy between manufacturing and services since the service sectors tends to make less use of fossil fuels.

For these countries as a whole, as Figure 2.7 illustrates, emissions fell by 1.2 billion tons of carbon dioxide equivalent – 6.6%. They have therefore as a group exceeded the aim established in Article 4.2 (b) of the Convention which was by 2000 to have returned emissions to their 1990 levels. However this was largely due to a 39.7% fall in emissions in the EIT countries which more than offset the 7.5% rise in emissions from the highly industrialized countries.

These reductions were achieved across the range of greenhouse gases. In absolute terms the reduction by the Annex I countries in carbon dioxide emissions was roughly the same as that for the reductions in all the other gases taken together, though in percentage terms the reduction in carbon dioxide emissions was smaller (Figure 2.8).

Although the most significant overall contrast in performance is between the highly developed countries and the economies in transition, there are also striking differences between individual countries

Figure 2.8 Greenhouse gas emissions by Annex I countries, 1990–2001



Note: Emissions are the sum of CO_2, CH_4, N_2O, HFCs, PFCs and SF_6; excluding CO_2 removals by land use change and forestry (LUCF).

Source: National Communications, IEA

within these groups. This is illustrated in Figure 2.9 which shows that changes in emissions varied from a reduction of 60% in Latvia at one extreme to an increase of 40% in Monaco at the other.

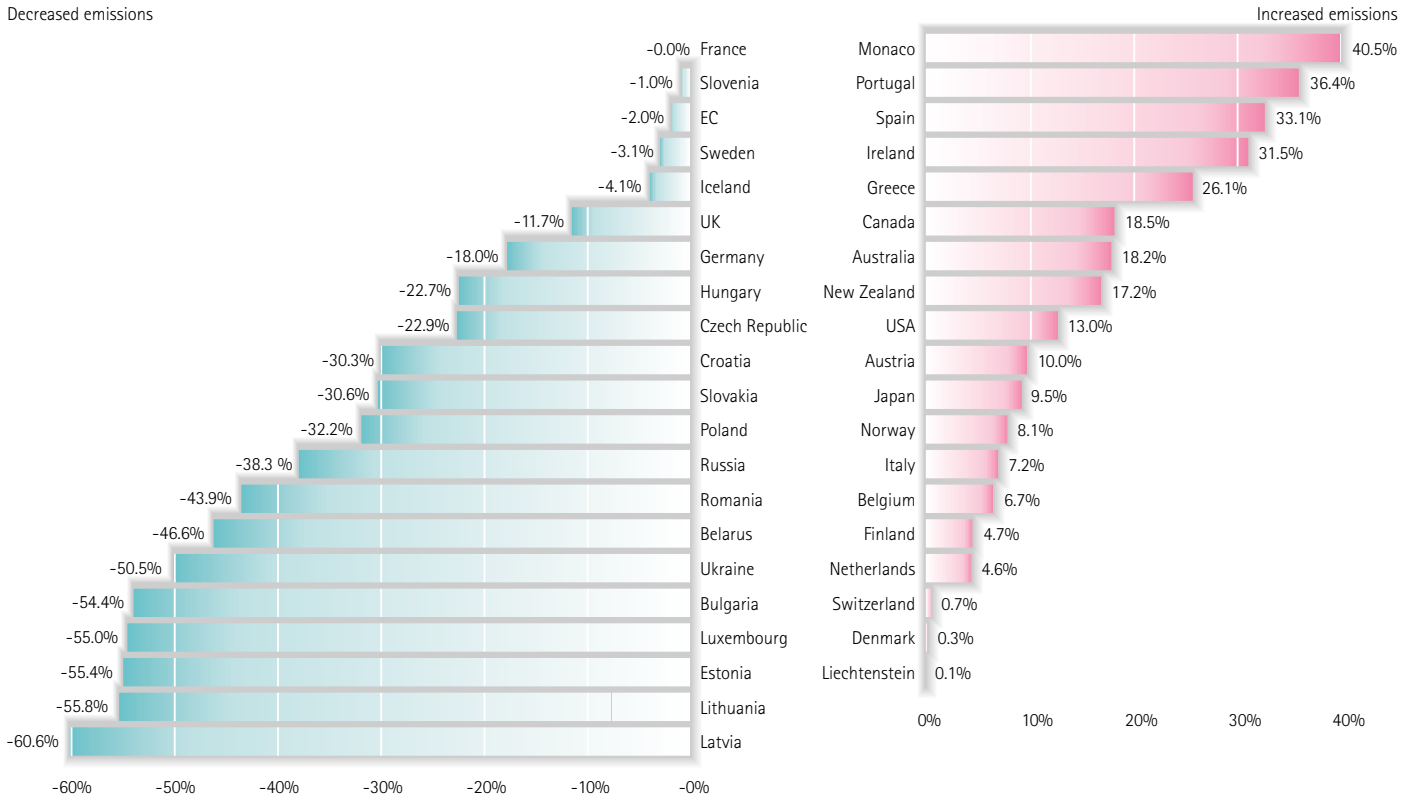
These differences partly reflect different national circumstances. Economic growth, for example, has been much faster in some countries than others, and this can be associated with rises in emissions: in fact over this period the economies of many EIT countries actually shrank. Other underlying factors include rates of population growth and patterns of energy supply and use.

However the differences also partly reflect the extent to which these countries have taken steps to reduce emissions. These involve direct efforts to mitigate emissions as well as policies that work indirectly: some countries have, for example, liberalized their energy supply industries with the result that coal, a major source of carbon dioxide, has been substituted with gas. Reductions in emissions in, for example, Germany and the United Kingdom manifest successes of such policies.

The latest data also confirm that the predominant greenhouse gas is carbon dioxide,

Source: National Communications, IEA

Figure 2.9 Changes in greenhouse gas emissions by Annex I Parties, 1990–2001



Note: Emissions exclude removals by land use change and forestry.

Figure 2.10 Profile of emissions by Annex I countries, by gas and by sector, 2001

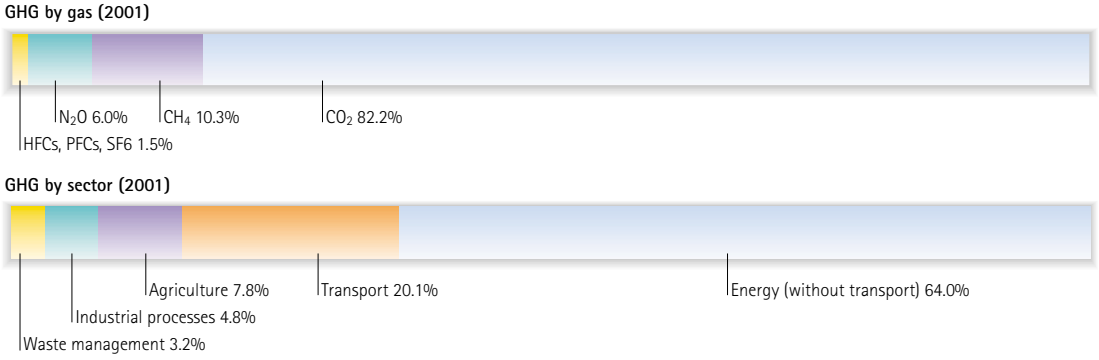
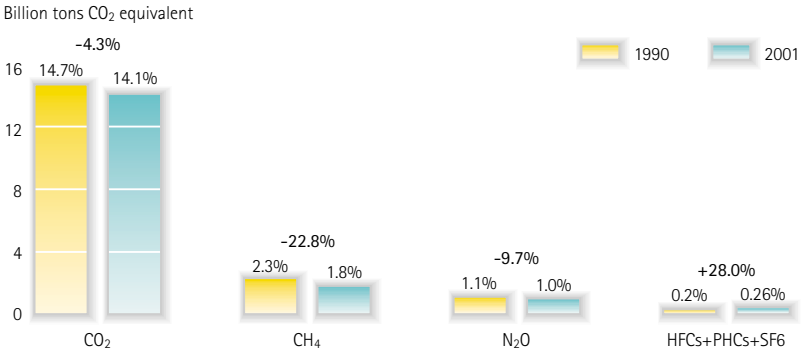


Figure 2.11 Changes in emissions of individual greenhouse gases in Annex I countries, 1990–2001



Note: Data gaps for some countries were filled by extrapolation or interpolation. Emissions exclude removals by land use change and forestry.

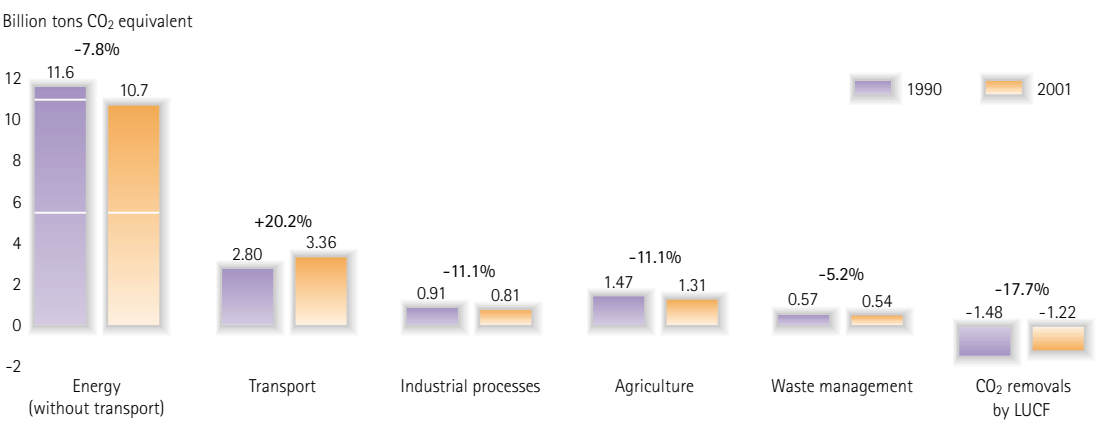
so performance on carbon dioxide largely determines the overall trend. However, methane and nitrous oxide still represent a sizeable share so reductions in emissions of these gases also make an important contribution (Figure 2.10). These data also confirm where the greenhouse gases were coming from (Figure 2.11). In the case of carbon dioxide the main source was fuel combustion which accounted for 95% of emissions; for methane the main sources were fugitive emissions and agriculture, both of which accounted for around one-third of the total; for nitrous oxide the dominant source was agriculture, mostly from agricultural soils which were responsible for around 70% of emissions.

During the 1990s emissions fell in most sectors, particularly in energy, though with the important exception of transportation (Figure 2.12).

In addition to emissions from the main sectors – energy, transport, industrial processes, agriculture and waste management, there are also emissions from international aviation and shipping (also referred to as 'international bunker fuels'). These are reported separately; they are not included in national greenhouse gas inventories totals. In absolute terms they remain relatively small – about 2.5% of the total from Annex I countries. But as Figure 2.13 indicates, while emissions from shipping have remained fairly stable those from aviation have been climbing steadily – and represent a serious challenge for the future.

For the Annex I countries the past decade has thus seen both positive and negative developments.

Figure 2.12 Changes in emissions of greenhouse gases by Annex I countries, by sector 1990–2001



Note: Data gaps for some countries were filled by extrapolation or interpolation. Only 29 Parties that provided land use change and forestry data for 2001 calculated it as a sum. In particular, Australia, Belarus, Japan, Russian Federation and Ukraine are not included. Interpolation and extrapolation were not used for land use change and forestry.

On the positive side they have, as a group, succeeded in bringing their emissions below the 1990 level as envisaged in the Convention and thus to some extent managed to decouple greenhouse gas emissions from economic growth. This is illustrated in Figure 2.14 for the period 1990–2001. While the economies of this group of countries grew by 22.6% their emissions fell by 6.6%. Moreover this progress was quite widely shared: around half managed to stabilize or decrease their emissions and, with the notable exception of transport, they made progress across most sectors.

Nevertheless, much of this success has actually reflected economic failure since it took place over a period of steep economic decline in the countries with economies in transition. Subsequently, many of the EIT countries' economies have revived with the attendant risk of increased emissions. In some of these countries, however, economy started to grow in mid-1990s, while emissions remained stable, e.g. Hungary, or even continued to decline, e.g. Poland. This reflects profound structural changes in economy and significant improvements in energy efficiency.

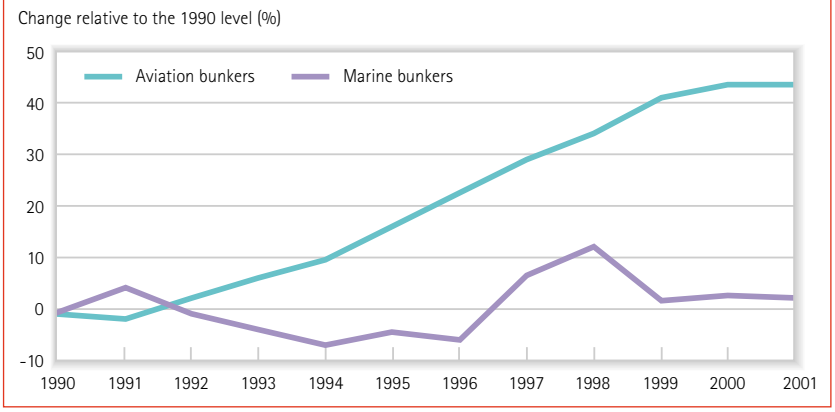
Emissions intensity of economies

The key question is whether in these and other countries economic growth itself is becoming more climate friendly. One way of examining this is to compare the rate of growth in emissions with the rate of growth for GDP; if emissions are growing more slowly than GDP then growth is becoming less 'emissions intensive'. This is illustrated in Figure 2.15 which shows that this is indeed the case, both for the world as a whole, and for the two main groups of countries: as GDP increased between 1990 and 2000, emissions intensity declined. Not all of this has been due to a shift away from carbon-based production or to an increase in energy efficiency. A substantial proportion will simply reflect the continuing long-term structural change away from industry and manufacturing and towards service industries which generally tend to burn less fossil fuel. It is difficult to distinguish one cause from another but it is at least evident that economies are overall becoming less emissions intensive.

Figure 2.16 offers a slightly different perspective, showing how emissions intensity of different groups of countries changed between 1990 and 2000 as per capita emissions increased or decreased. All these groups of countries saw a reduction in emissions intensity. Generally this was also accompanied by a decline in per capita emissions – large for the EIT countries, but smaller for the Annex I countries as a whole.

Figure 2.17 presents emissions of carbon dioxide per capita and per unit of GDP in 2001 for the world based on the data of the International Energy Agency.

Figure 2.13 Greenhouse gas emissions from international aviation and shipping, 1990–2001



Note: Emissions are those for carbon dioxide, methane and nitrous oxide. For some countries interpolations or extrapolations were used to fill data gaps.

Note: GDP and population data are from the International Energy Agency database. The GDP data are based on purchasing power parities. Greenhouse gas data are from UNFCCC.

Figure 2.14 Comparison of changes in emissions, populations and GDP for Annex I countries, 1990–2001

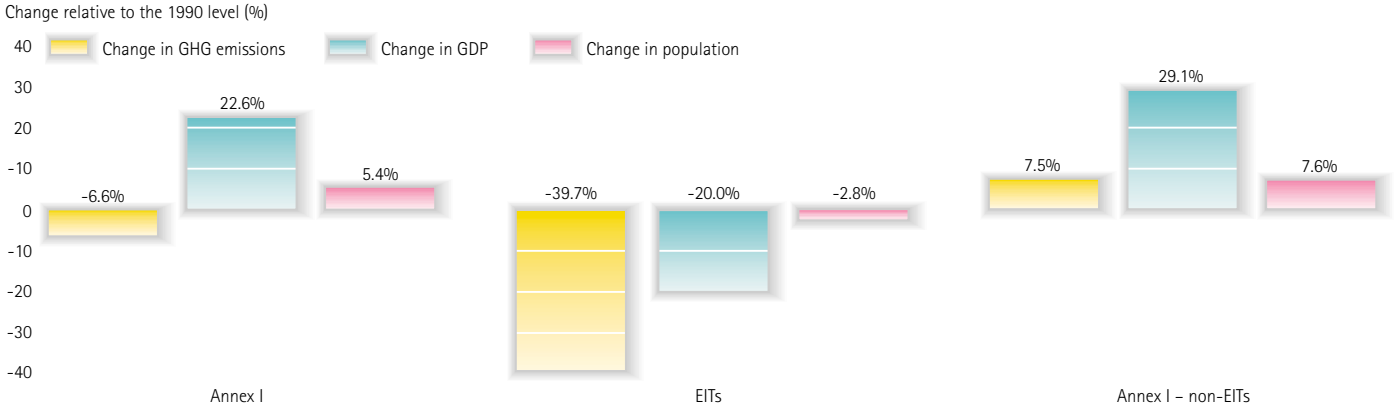


Figure 2.15 Changes in emissions intensity of economies, 1990–2000

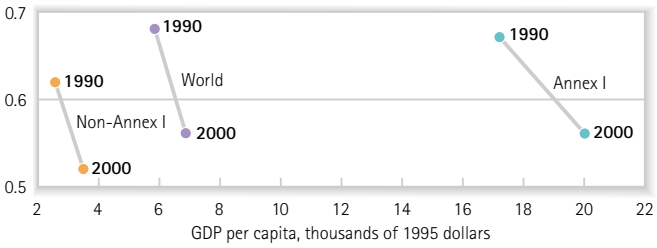
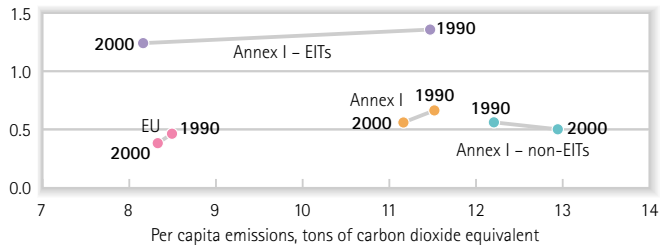


Figure 2.16 Annex I countries: reductions in emissions intensity as overall emissions rose or fell, 1990–2000

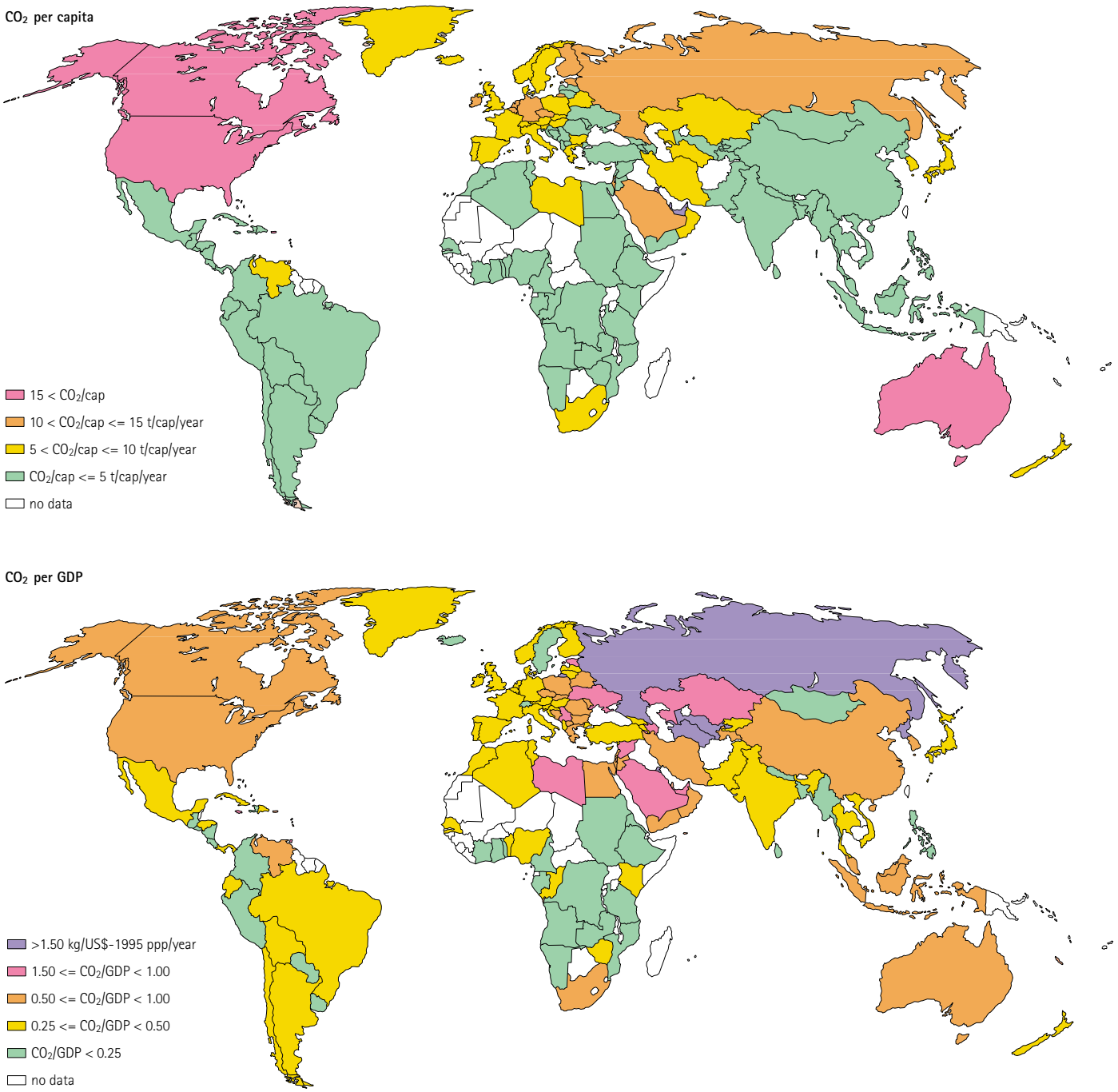


To ensure that their policies are based on reliable information, most countries are determined to improve their national systems for collecting, evaluating and reporting greenhouse gas data. A summary of the typical procedures is given in figure 2.18.

Recent emissions trends in non-Annex I countries

Some developing countries are taking steps to mitigate climate change, though often have done so indirectly through other policies. By carrying out market reforms and economic restructuring, for example, they have ensured that energy prices better reflect true costs, leading to a reduction in waste. And by promoting more broadly based and secure sources of energy they have boosted energy efficiency and reduced the use of carbon-intensive fossil fuels. Similarly, efforts to sustain forests in order to protect water supplies and agricultural land have also had benefits of increasing carbon sequestration. Rapid economic growth is accompanied by increases in energy-related carbon dioxide emissions. Between 1990 and 2000, energy-related carbon dioxide emissions grew in developing countries that held a noticeable share of world emissions (IEA 2003). In Indonesia these emissions increased by 101%, in the Republic of Korea by 86%, in India by 69% and in Brazil by 57%. Only in three of these countries was growth in emissions relatively slow: in South Africa 17%; Venezuela 22%; and China 33%.

Figure 2.17 World emissions of carbon dioxide per capita and per unit of GDP

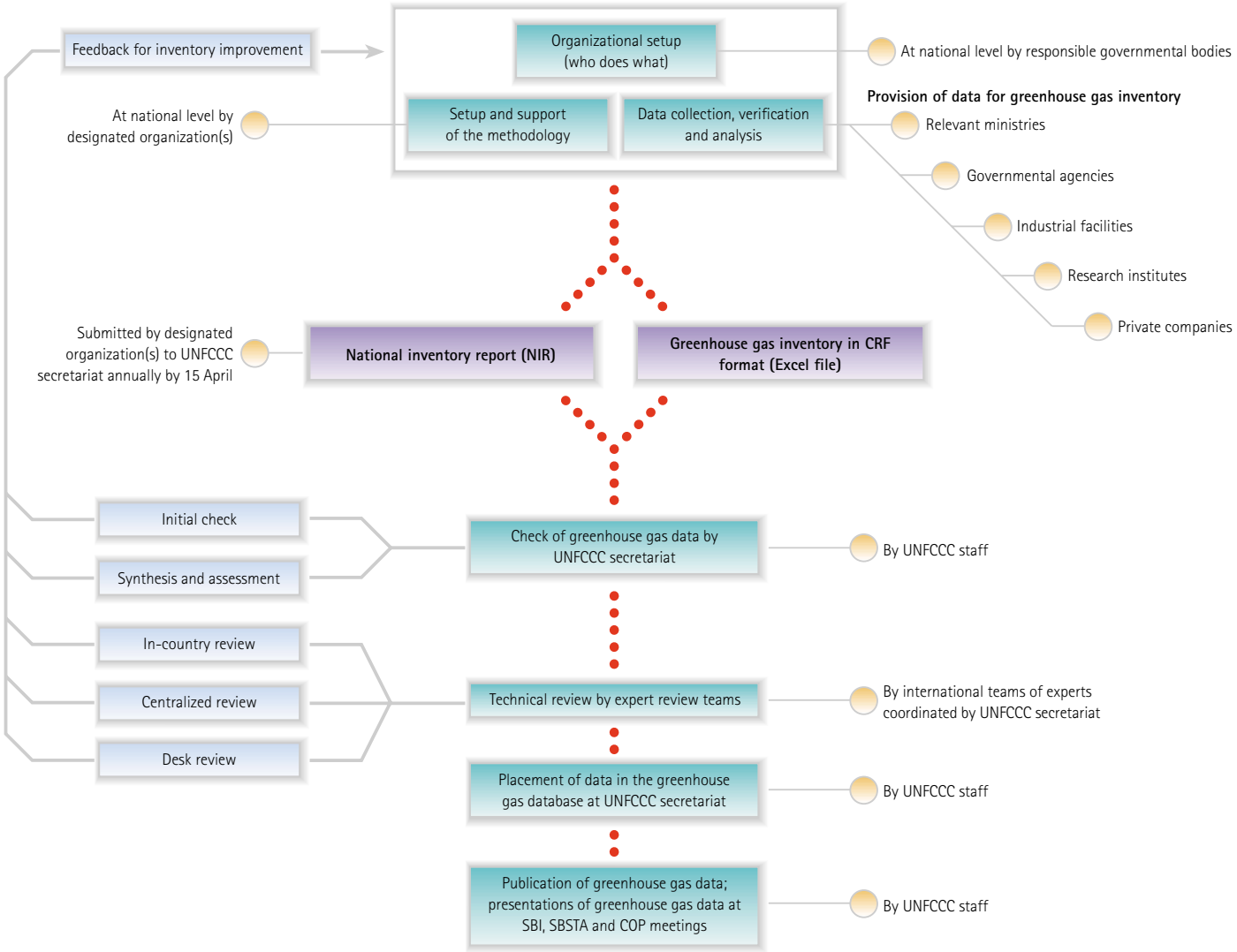


Source: IEA, 2003

China too has seen emissions grow, if fairly slowly. China occupies an important position: even though the growth in emissions has been smaller, given the country's size its absolute emissions are substantial – amounting in 2000 to three billion tons of carbon dioxide equivalent. Nevertheless China has been making determined efforts to increase energy efficiency. Indeed, over some periods China has seen its emissions drop, as between 1998 and 1999 when they fell by 4%. This will have been due partly to a reduction in output linked to the Asian financial crisis but the Government has also undertaken radical reforms in the energy sector with a strong focus on energy efficiency and conservation. As a result in the 1990s China's energy use efficiency doubled.

China and other developing countries have a number of options for improving energy efficiency and conservation. These include cogeneration. In

Figure 2.18 Typical procedure for the preparation, support and review of national greenhouse gas inventories by Annex I countries



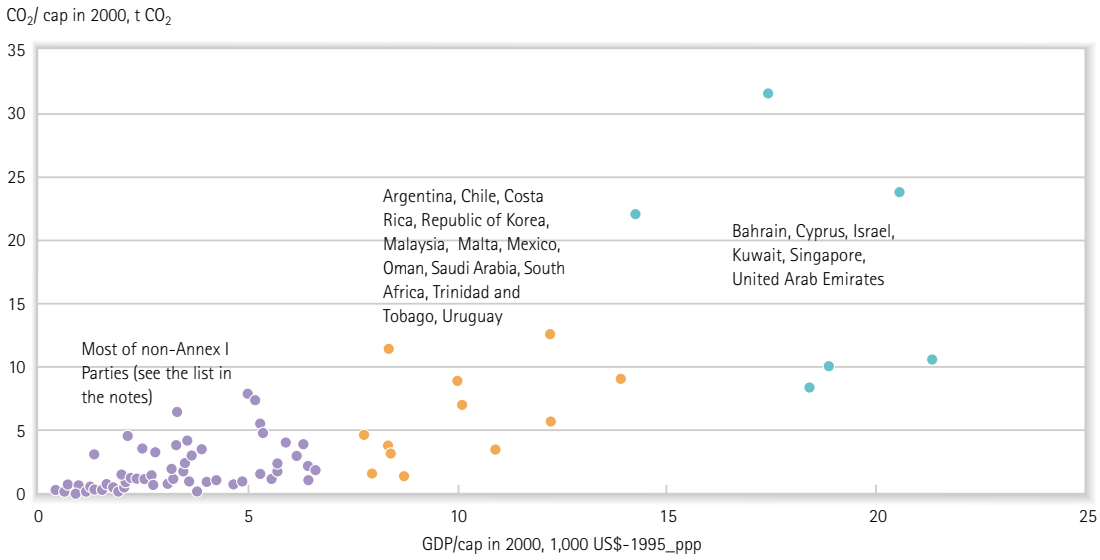
the case of gas turbines, for example, this means not just using the turbine to generate electricity but also collecting and using energy from the heat exhaust. Countries can also improve the efficiency of their thermal electricity generation, their hot water supply systems and their appliances, and they can try to reduce losses in electricity transmission and distribution.

Many countries, including Ghana, Lesotho, Morocco, Senegal and Tunisia, are also turning to alternative energy sources – responding to the increasing demand for electricity, especially in the rural areas, by exploring solar, wind and hydro power. In Tunisia over the period 2001–20 the use of solar and wind power is expected to save 4.5 million tons of oil equivalent and avoid the production of 12.6 million tons of carbon dioxide.

As economies develop and industrialize, historically they have made greater use of energy, including fossil fuels. This is illustrated in Figure 2.19 for the non-Annex I countries in 2000. Those with the lower per capita GDPs also tend to have lower per capita emissions. Most fall into the low per capita GDP cluster, while at the other end of the scale are countries that are either highly developed, or benefit from the exploitation of significant reserves of fossil fuels.

Developing countries have also made progress in reporting. Between 1999 and 2003 the number of non-Annex I countries that had presented national inventories of greenhouse gas data increased from 10 to 111, of which 83 gave complete coverage by gas and by sector (Table 2.2). Some have even turned their attention to their second communications: by

Figure 2.19 Per capita emissions of non-Annex I countries compared with per capita GDP, 2000



2003 Republic of Korea and Mexico had already presented these while Argentina, Costa Rica and Uruguay were working on their submissions.

Reporting was particularly encouraging from the least developed countries (LDCs). Because of their difficulties in collecting and analysing information they are not required to submit their initial communications within a specific period. Nevertheless 35 of the 48 LDCs that are Parties to the Convention had submitted their national communications by mid-2004 – a clear demonstration of their commitment.

There are distinctive reporting challenges for the larger developing countries. They have to cover a huge diversity of national circumstances – not just geographic and climatic, but also economic, institutional and social. Even so, national communications that incorporate greenhouse gas inventories have been submitted by many of these countries – including Algeria, Argentina, Egypt, India, Indonesia, the Islamic Republic of Iran, Kazakhstan, Mexico, Mongolia, Nigeria, South Africa and Sudan. They are likely to be followed in 2004 by Brazil and China.

Table 2.2 Data available from non-Annex I countries

Initial communications submitted:	112
Initial communications in preparation:	16
Second communications submitted:	2
Second communications in preparation:	3
Years covered in inventories:	One year – 77 countries (mostly 1990 or 1994) Two years – 12 countries (mostly 1990 and one other year) More than two years – 22 countries more than two years (One reporting country provided no inventory data)
Gases and sectors covered in the inventories:	Full coverage by gas[a] and sector[b] – 83 Parties Full coverage by gas, incomplete coverage by sector – 26 countries Incomplete coverage by gas and sector – 2 countries

Notes: [a] Full coverage by gas means that carbon dioxide, methane and nitrous oxide emissions have been estimated; the emissions of fluorinated gases are not considered here because the reporting on these gases is not mandatory and the presentation of these emissions varied greatly by country.

[b] Full coverage by sector means that emissions have been estimated from the following sectors: energy, transport, industry, agriculture, waste management and land use change and forestry.

Notes:

1. GDP is expressed in purchasing power parity dollars at 1995 values.

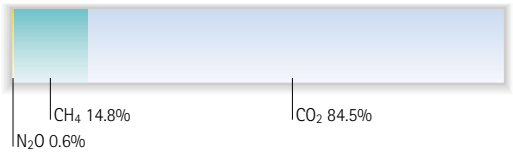
2. Qatar is not shown, as its per capita emissions are so high as to fall outside the scale of this chart – 60 tons per capita).

3. The following countries are included: Albania, Algeria, Angola, Armenia, Azerbaijan, Bangladesh, Benin, Bolivia, Bosnia and Herzegovina, Brazil, Cameroon, Ethiopia, Gabon, Georgia, Ghana, Guatemala, Haiti, Honduras, India, Indonesia, Iran, Jamaica, Jordan, Kazakhstan, China, Colombia, Congo, Côte d'Ivoire, Cuba, Democratic People's Republic of Korea, Democratic Republic of the Congo, Dominican Republic, Ecuador, Egypt, El Salvador, Eritrea, Kenya, Kyrgyzstan, Lebanon, Libyan Arab Jamahiriya, Macedonia (The former Yugoslav Republic of), Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Nigeria, Pakistan, Panama, Paraguay, Peru, Philippines, Republic of Moldova, Senegal, Serbia and Montenegro, Sri Lanka, Sudan, Syrian Arab Republic, Tajikistan, Thailand, Togo, Tunisia, Turkmenistan, United Republic of Tanzania, Uzbekistan, Venezuela, Viet Nam, Yemen, Zambia, Zimbabwe; and the average value for all non-Annex I Parties.

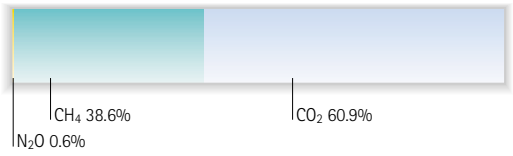
Figure 2.20 Examples of reporting by non-Annex I countries

a) Emission profiles by gas

Nauru (1994)

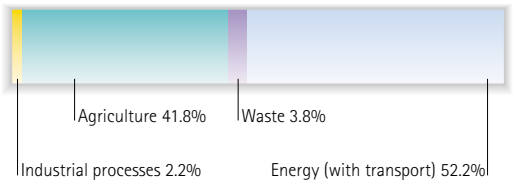


Jordan (1994)

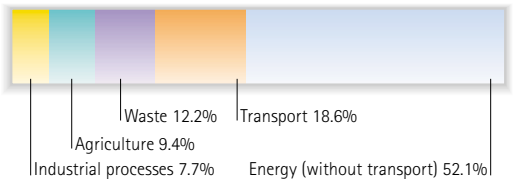


b) Emission profiles by sector

Greenhouse gas by sector for Ghana (1994)

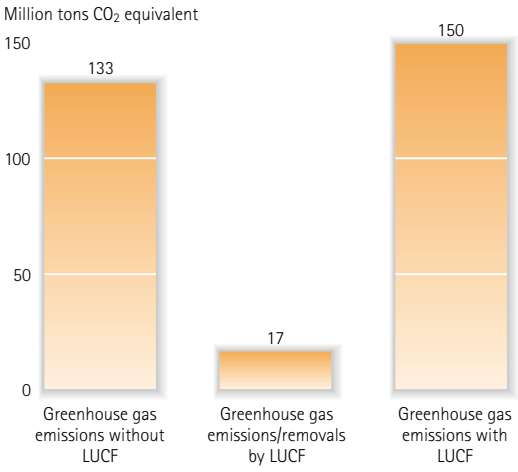


Greenhouse gas by sector for Mexico (1998)

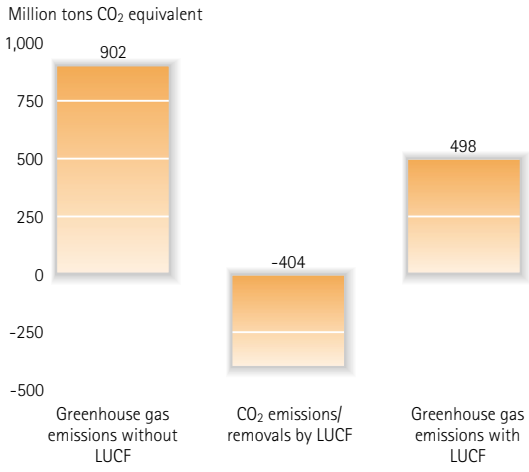


c) Greenhouse gas removals by land use change and forestry

GHG emissions with and without LUCF in Colombia (1994)

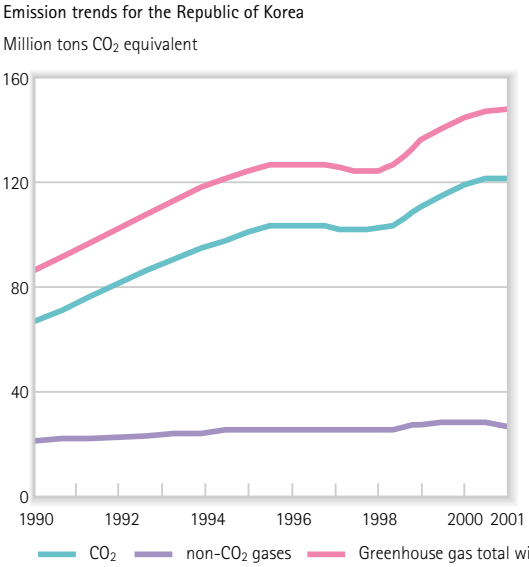


GHG emissions with and without LUCF in Indonesia (1994)

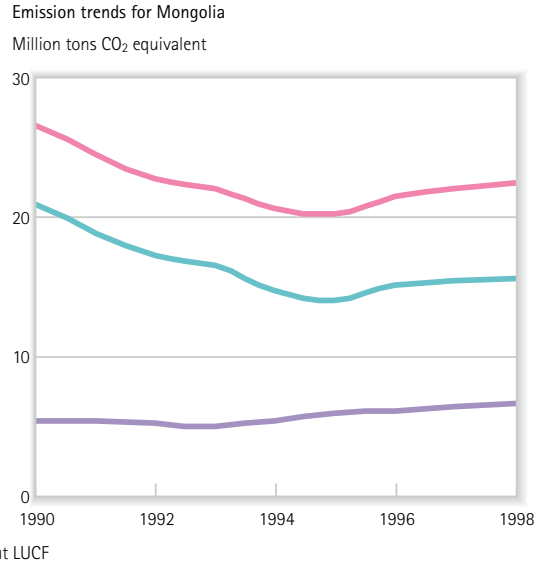


d) Emission trends

Emission trends for the Republic of Korea



Emission trends for Mongolia



Box 2.3 Non-Annex I Parties – Revised guidelines for national communications

The eighth Conference of the Parties in New Delhi in 2002 adopted revised guidelines for national communications from non-Annex I Parties. These guidelines are more explicit, for example, when it comes to national greenhouse gas inventories. They require countries to report on both numerical data and the methodologies they have applied and encourage them to include the inventory sectoral tables and IPCC worksheets, in both electronic format and hard copy. The guidelines also suggest appropriate reporting years: countries making their initial communications should present inventories for 1990 or 1994, while those making their second national communications should provide data for 2000 – although least developed countries may, at their discretion, provide estimates for other years.

In the preparation of national greenhouse gas inventories the non-Annex I Parties should use the 'Revised 1996 IPCC guidelines' and are also encouraged to apply IPCC's 'Good practice guidance and uncertainty management in national GHG inventories' – and should include an analysis of key sources along with estimates of uncertainties.

Countries should provide estimates on a gas-by-gas basis for carbon dioxide, methane and nitrous oxide, though they are also encouraged to provide information on fluorinated gases as well as on precursor gases such as carbon monoxide, non-methane volatile compounds, and other oxides of nitrogen. They can also include other gases not controlled by the Montreal Protocol, such as oxides of sulphur. They should report on emissions from international aviation and marine transport as separate items.

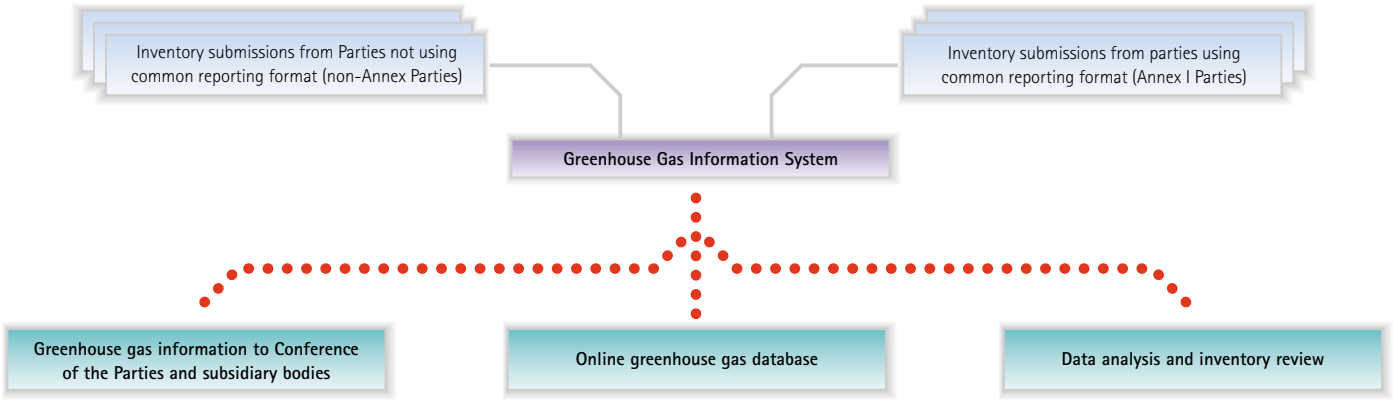
The initial national communications from non-Annex I countries included national greenhouse gas inventories, making it possible to build up a much more complete picture of emissions across the world. They indicated many similarities between countries but also differences as illustrated in Figure 2.20a to Figure 2.20d. This was evident, for example, in the profile of gases: thus in Jordan methane plays a much more important role than it does in Nauru (Figure 2.20a). There were also differences in emission origins: in Ghana, for example, agriculture is a much more significant source of greenhouse gases than it is in Mexico (Figure 2.20d).

These national communications also provided valuable information on land use change and forestry – a crucial issue in developing countries where forests often play a central role both in economic development and in sustaining the environment. Many of the national communications contained detailed estimates of both emissions and removals. In Colombia, for example, data demonstrate net emissions of greenhouse gases while in Indonesia net removals (Figure 2.20c).

Although the UNFCCC guidelines only require non-Annex I countries to report emissions for one year, 34 countries presented data for two or more years, some with a time series sufficiently complete to indicate a general trend – steadily upwards in the Republic of Korea, for example, but more variable in Mongolia (Figure 2.20c).

Despite their successes, it should also be emphasized that many developing countries still face considerable reporting challenges. They often find it difficult to maintain stable national teams of experts and to sustain the collection and reporting of information on energy balances, for example, or to make estimates of site-specific emission factors. Then they may struggle to apply the often complex

Figure 2.21 The Greenhouse Gas Information System



methodologies required for the preparation of inventories (Box 2.3). In addition they may have limited opportunities to exchange information with other countries and gain access to regional and international sources of data. In these circumstances many developing countries will therefore continue to rely on external financial and technical support.

Data online – the Greenhouse Gas Information System

To manage and integrate the increasingly large and regular flows of data, the UNFCCC secretariat has developed a Greenhouse Gas Information System that serves as the basis for the provision of information to the Conference of the Parties and for various types of data analysis (Figure 2.21). This system, which now

Table 2.3 Key macroeconomic and greenhouse gas indicators, 2001

	GDP per capita ($PPP '000s)	Total primary energy supply, tons per capita	Carbon dioxide emissions (tons per capita)	Ratio of carbon dioxide emissions to GDP	Average population growth rate 1990–2000 (%/year)	Average GDP growth rate 1990–2000 (%/year)
World total	6.9	1.7	3.9	0.56	1.4	3.1
Africa	2.1	0.6	0.9	0.42	2.5	2.3
Asia[a]	3.2	0.7	1.6	0.51	1.5	7.0
Latin America	6.2	1.1	2.0	0.32	1.6	3.1
Middle East	6.0	2.3	6.2	1.04	2.4	3.5
OECD countries of Europe[b]	18.7	3.4	7.6	0.41	0.5	2.2
OECD countries of North America[c]	25.5	6.4	15.8	0.62	1.2	3.2
Non-OECD Europe[d]	5.3	3.0	7.2	1.36	0.0	–4.0
Annex I Parties	20.0	4.7	11.1	0.56	0.4	2.0
Annex I – non-EIT Parties	25.9	5.5	12.8	0.50	0.6	2.5
European Union	22.2	3.9	8.5	0.38	0.3	2.1
EIT Parties	6.9	3.4	8.3	1.20	–0.2	–2.6
Non-Annex I Parties	3.6	0.9	1.9	0.52	1.7	5.0

Note: The data are from the International Energy Agency and correspond to its regional definitions; CO_2 emissions are from fuel combustion only.

[a] Including China.

[b] Includes Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

[c] Includes Canada, Mexico and the United States of America.

[d] Includes Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, Gibraltar, Former Yugoslav Republic of Macedonia (FYROM), Malta, Romania, Slovenia and Serbia/Montenegro; and Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan.

contains detailed inventory information for more than 140 Parties at different levels of aggregation, is updated twice a year and is continuously supported and enhanced to ensure that it offers reliable data suitable for a wide range of analyses. It is also accessible to the public via a special web site: http://ghg.unfccc.int where it can be searched by Party, sector, gas and year.

Gaps and barriers

In its first ten years, the Convention has thus given the global community the opportunity to engage more deeply with climate change – to gain a greater understanding of the issues and build up a more complete picture through scientific investigations as well as through national communications – though there are still large areas of uncertainty and information gaps. The increasing flows of data into the Greenhouse Gas Information System are an encouraging sign of commitment to the Convention but for many issues accurate, consistent and internationally comparable information that is essential for sound policy making is still lacking. The situation is particularly challenging for the developing countries. The difficulties they face in addressing climate change, and the support they need, are the subject of the following chapter.

Chapter 3

Integrating climate change in sustainable development

For centuries economic growth has relied on industrial activities that burn fossil fuels. It has become increasingly clear, however, that such growth is unsustainable, not least because it is leading to global warming, so the world needs to switch to more sustainable forms of development. For the developed countries this will generally mean attacking climate change directly – in particular changing their patterns of energy use. For developing countries the overriding priority remains economic development. While working towards achieving this goal, many of them strive to establish climate-friendly patterns of sustainable development. This will mean building up the institutions and the capacity needed to address the many complex issues involved – for which developing countries should be able to rely on support from the richer countries through bilateral and multilateral assistance. The challenge for both developed and developing countries is to create conditions under which decent living standard could be provided for all people at minimum environmental cost, while the global economy is still running on fossil fuels.

...economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties.

(Article 4.7)

The Parties have a right to, and should, promote sustainable development.

(Article 3.4)

It is no accident that the Convention on climate change was signed at the UN Conference on Environment and Development. This legal instrument, as well as the other two conventions negotiated in parallel with the UNFCCC – on biodiversity and combating desertification and drought – were conceived as a means of integrating environmental concerns into the fabric of global development.

The best-known definition of sustainable development was given by the World Commission on Environment and Development which defined it as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. This implies a complex balance – sustaining the economic growth that is essential for poverty reduction while using natural resources in a prudent fashion. It also means ensuring greater equity both within and between societies and generations – achieving a stable relationship between human activities and the natural world that does not diminish the prospects for future generations to enjoy a quality of life at least as good as our own. This task will be difficult but by no means impossible. The same kind of creativity and drive that powered the industrial revolution is also constantly creating new technologies that could permit continued economic growth without provoking unacceptable global warming.

The world now has an opportunity to take the right path. The wrong choices now could not only exclude millions of people from the fruits of economic development but also cause them to suffer from the side effects of other people's growth – and cause some of the greatest damage in the poorest countries.

A few decades ago the main issue appeared to be that economic growth was unsustainable because the world was likely to run out of fossil fuels. Now that problem seems more remote: many

countries still have ample reserves of coal and are discovering new deposits of oil and gas every year. The more immediate danger is that burning most of these deposits in the next hundred years will release so much carbon dioxide into the atmosphere that it will significantly change the global climate and alter the way our civilization functions. To avoid this, the world needs to produce the same amount of goods and services by using fewer resources – sustaining and improving levels of consumption while avoiding environmental degradation.

The only option is to share both the risks and the responsibilities as widely as possible – through extensive international cooperation and widespread participation at all levels of society, national, regional and local. These cooperative efforts cannot, however, consider climate change in isolation; they need to embed climate change within overall strategies for sustainable development. When people have this broader vision and can see how different policies interact they will be in a better position to make difficult policy choices. The general framework for these policies has been provided through a series of international meetings, most recently the 2002 World Summit on Sustainable Development (Box 3.1).

All countries now need to integrate concerns for climate change within their sustainable development strategies. Among the developed countries the European Union took the lead in 2002 with a Sustainable Development Strategy that aims to limit the increase in global temperature to less than 2 degrees Celsius above pre-industrial levels – through taxing energy and the use of environmental resources, for example, and by removing subsidies for fossil fuel. Individual members of the EU have similar strategies: in 2000 Belgium, for example, adopted a Federal Plan for Sustainable Development that established a framework for renewed political action on climate change.

Other developed countries have also ensured that climate change issues are integrated into broader frameworks of sustainable development. Canada, for example, pursues its goals through a single Sustainable Development Technology Fund and New Zealand integrates climate change into sustainable development strategies not just at the national level but even more so at the regional and local levels through Agenda 21 activities.

EIT countries have made some progress in this direction. Over the years, they have improved their capacity in greenhouse gas inventories and other activities relating to the preparation of national communications. But they need further assistance – for the development, analysis and implementation of policies and measures, and for emissions trading and registries. Recognizing this, Parties have therefore adopted a capacity-building framework that identifies the scope of the necessary activities.

The situation for developing countries is different since under the Convention the non-Annex I countries are not required to take on quantitative emission reduction targets. They do of course undertake many activities related to climate-change but these are essentially driven by their commitment to sustainable development. Thus most are promoting energy efficiency, new fuels and greater use of renewable energy, along with better waste management and more sustainable forms of transportation, agriculture and forestry.

This also means that many have been taking measures to reduce emissions – on the grounds that these in themselves will promote sustainable development. Thus, controlling industrial emissions can also reduce pollution and increase technological efficiency, while shifting passengers and freight from private to public transport will also ease road congestion. Similarly switching to other forms of energy can offer more secure public power supplies. At the same time, undertaking climate change mitigation projects can generate useful sources of employment.

Box 3.1 The international framework for sustainable development

Policies for sustainable development have usually been based on the conceptual framework provided by the World Commission on Environment and Development, the 'Brundtland Commission'. This was later operationalized at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 and reflected in the Rio Declaration, in Agenda 21, and in the two conventions that were brought to signature at this conference: the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change – which offered practical ways forward but also put the onus on governments to publish and implement appropriate national strategies.

Further impetus came from the World Summit on Sustainable Development held in Johannesburg in 2002 where many countries strengthened existing policies or initiated new ones. The Summit adopted the Johannesburg Declaration whose Plan of Implementation included measures particularly relevant for climate change. The Declaration urged countries to improve efficiency and sustainability in the use of resources and production processes and to reduce resource degradation, pollution and waste. It called on action from all countries, but said that developed countries should take the lead not just by taking action at home but also by mobilizing financial resources for developing countries and by helping them through programmes of technical assistance and capacity building.

Boosting the capacity for sustainable development in developing countries

The developed countries already have the institutions to address these issues or have the resources to launch new ones. In developing countries one of the main limitations on these activities is the shortage of financial and human resources. An essential component of sustainable development must therefore be capacity building – strengthening national institutions and human capacity so that they can better analyse existing vulnerabilities and problems and take the necessary action.

Building human capacity in developing countries was supported through various bilateral and multilateral channels. For example, the United States Country Studies Programme provided assistance to 55 countries for training of 3,000 analysts on greenhouse gas inventory and vulnerability assessments, whereas Japan provided training to 209 experts from 42 countries. The enabling activity project of the Global Environment Facility supported training of experts on national communications in developing countries.

In the past most developing countries handled issues such as erosion, flooding, land degradation and meteorology through myriad national agencies. In recent years, however, a number have created specialist institutions. Thus, as a result of the preparatory work for the 1992 Earth Summit and the creation of UNFCCC a number of countries established climate change bodies. Brazil was one of the forerunners – founding a Climate Change Advisory Unit within the Ministry of Science and Technology. Others created environment ministries that would later assume key roles in the climate change process. In Ghana, for example, the Ministry of Environment is the focal point for the country's UNFCCC activities and also hosts a National Committee on Climate Change that is mandated to contribute to a reduction in greenhouse gases and an increase in carbon sinks. Other countries have taken a variety of approaches: in Belize, Botswana and the Solomon Islands the focal point charged with meeting obligations under the Convention is the Department of Meteorological Services.

Institutional arrangements also tend to evolve depending on local circumstances. In the larger countries this will require sophisticated systems of coordination. In India, for example, the preparation of the national communication has involved more

Box 3.2 The institutional framework in Brazil

In 1991, during the preparation of the climate Convention prior to the Rio Conference, Brazil's Federal Government established a Climate Change Advisory Unit within the Ministry of Science and Technology (MCT). MCT provides technical support to the Climate Change Focal Point and coordinates the execution of national activities carried out under the Convention. The Brazilian Space Agency provides additional technical support and is a member of the Brazilian delegation. However, general coordination of Brazilian position at the Convention is the responsibility of the Ministry of Foreign Affairs (MRE) through its Environment Division.

In 1999, the Federal Government created an Inter-Ministerial Commission on Climate Change, and in August 2000 the Government also established a Brazilian Climate Change Forum. Chaired by the president of the Republic, this brings together all the climate change stakeholders, including government institutions, the private sector, the scientific community and NGOs.

The business community has also been active. Many have been involved through the Brazilian section of the World Business Council for Sustainable Development. The Industry Federations in the states of São Paulo and Rio de Janeiro have, for example, organized meetings to increase awareness within the private sector about climate change issues, including the Clean Development Mechanism (CDM). Furthermore, environmental finance consulting firms such as EcoSecurities have started to identify and design CDM project proposals and are looking for potential investors abroad.

The scientific community is also playing a major role. MCT is currently preparing Brazil's first National Communication in conjunction with a network of more than 20 scientific institutions. Brazil also encourages participation from NGOs and the Brazilian delegation at UNFCCC meetings has a representative from the NGO Forum. One of the most prominent NGOs is the Brazilian Foundation for Sustainable Development which works closely with different branches of industry on developing forestry schemes that could serve as carbon sinks. Some NGOs, including Winrock International, are also very active in promoting renewables in remote areas and have recently launched a Brazilian Network of NGOs for Renewable Energy, RENOVE. Finally, a number of NGOs working on forest management in the Amazon are interested in using the CDM.

than one hundred institutions and several hundred experts. And given the breadth of issues covered by climate change even the coordination function may have to be dispersed among different government departments depending on the task in hand. Thus in Brazil the general coordination of the country's position at the Convention is managed by the Environment Division of the Ministry of Foreign Affairs, while national execution is coordinated by climate-change focal points. Other assignments, such as the Clean Development Mechanism are handled by an inter-ministerial commission (Box 3.2).

Dealing with climate change is not however the sole responsibility of central government. Many developing countries are now seeing greater involvement from other stakeholders, including local governments, industry federations, scientific institutions and NGOs. In some cases they have participated through membership of national advisory bodies, which in Botswana, for example, is the National Committee on Climate Change, while others have participated through international networks such as Cities for Climate Protection or the World Business Council for Sustainable Development. Individual enterprises can also make direct contact with other bodies overseas: environmental consulting firms in a number of developing countries have started to prepare Clean Development Mechanism projects and are looking for potential investors from abroad.

Despite these encouraging signs, many countries have yet to build a sound institutional framework. A number have yet even to report on their institutional arrangements or have pointed out that their systems are weak. In its national communication Morocco, for example, stresses that it needs to strengthen institutions dealing with vulnerability and adaptation, databases and systematic observation. Albania points out that responsibility for environmental monitoring is still dispersed across several government departments – which results in significant overlaps and inconsistencies. Kenya too concludes that its climate change institutions are constrained at all levels by inadequate capacity and weaknesses in linkages and networking.

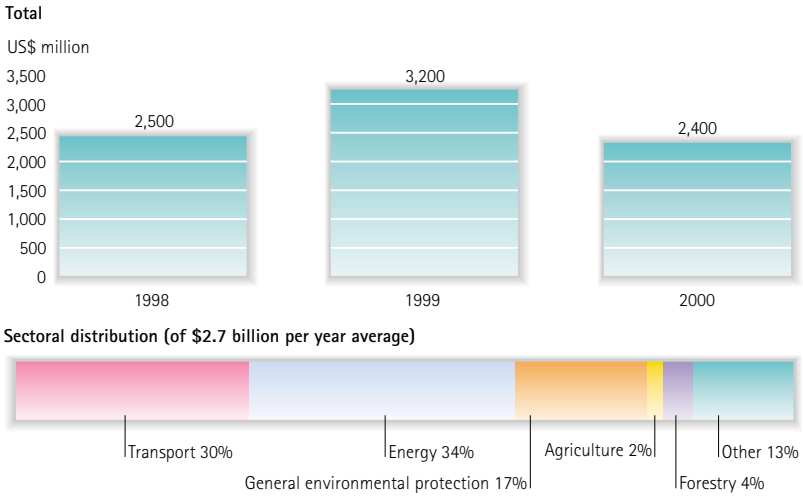
The problems identified by individual countries have been confirmed by the Consultative Group of Experts on National Communications from non-Annex I Parties which also recommends institutional strengthening in the area of vulnerability and adaptation assessment.

Funding climate change activities through official development assistance

The Convention stipulates that the developed countries should assist developing countries in their efforts to mitigate climate change. One of the most importance channels for this is official development assistance (ODA) both bilateral and multilateral. This may not have seemed a very promising option since overall ODA seemed to be in decline during the 1990s – dropping by 10% between 1990 and 2000. Since then, however there has been a modest revival: flows increased by 7% in 2002 and by a further 4% in 2003.

How much of this has been in support of climate change? The Development Assistance Committee of the OECD has analyzed the data provided over the period 1998–2000 through its Creditor Reporting System to see how much aid was channelled in support of the three Rio Conventions – including the Convention on Climate Change.

Figure 3.1 Bilateral assistance for climate change activities, 1998–2000



Source: OECD, 2002

Bilateral assistance

In the case of bilateral aid, the DAC estimates that total funding for climate change over this period was $8.1 billion – $2.5 billion in 1998, $3.2 billion in 1999, and $2.4 billion in 2000 – averaging $2.7 billion per year (Figure 3.1). This represented 5,124 individual projects. The regions receiving the largest amount of bilateral financial resources were Africa and Asia and the Pacific which between then received more than 60%. The bulk of these activities were in energy, transport, agriculture, forestry and general environmental protection.

Another way of estimating bilateral commitments to climate change activities is through the national communications of the Annex II countries. The results for the period 1997–99 are shown in Figure 3.2. Again this shows the main sector over this period to be energy – aimed at the improvement of energy efficiency, planning and management, and utilization of renewable energy sources, as well as energy planning and market reform. Projects in the forestry sector included those to improve forest management, create protected areas and increase afforestation. Those for agriculture were directed towards, among other things, sustainable land use, soil management and protection against desertification.

In their national communications, some countries detailed their bilateral activities at length. France described the 'French Fund for the Global Environment', the Netherlands reported on its 'Climate Change Studies Assistance Programme', while Germany explained its 'Protecting the future through climate protection' initiative, and Canada its 'Climate Change Action Fund'. The United States had three major bilateral initiatives: the 'US Initiative on Joint Implementation', the 'US Country Studies Program' and the 'Climate Change Initiative'. The European Union indicated numerous programmes of bilateral cooperation across a wide range of sectors in countries that joined the EU in 2004. Other Parties, including Japan, Netherlands, Norway, and Switzerland, provided detailed information on their Joint Implementation projects.

Most of these projects were aimed at mitigation, while recently a smaller proportion were directed at adapting to the adverse effects of climate change (Figure 3.3). However, some Parties pointed out that it was difficult to single out a climate change project's adaptation component, and others indicated

Source: National communications of Annex II countries

Figure 3.2 Bilateral assistance for climate change activities, 1997–99

that most projects aimed at promoting sustainable development can contribute indirectly to adaptation, for example through enhancing the adaptive capacity of people and institutions.

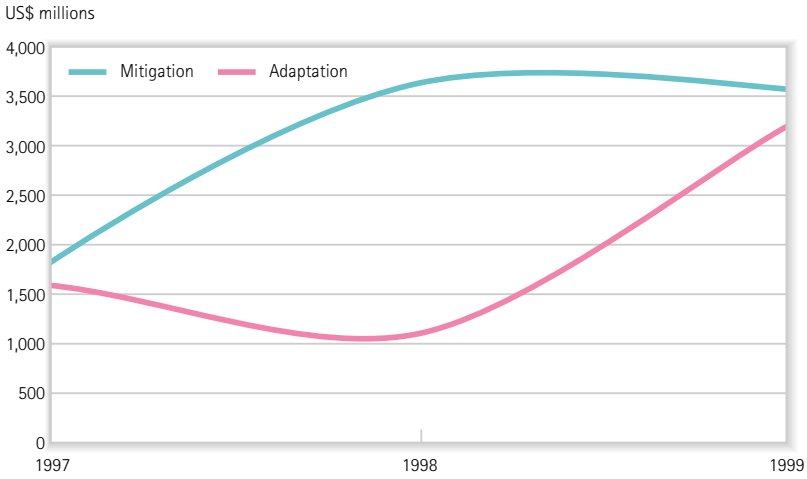
Multilateral flows – the Global Environment Facility

Donors also support climate change activities in developing countries through multilateral programmes, of which the most significant is the Global Environment Facility (GEF). In 1995 the GEF, responding to guidance from the Conference of the Parties, developed the appropriate framework and since then it has helped finance both enabling activities and greenhouse gas mitigation projects across the developing world.

Originally the GEF's greenhouse gas mitigation programmes, which matched country-driven project opportunities and priorities, were in three operational areas: energy efficiency and conservation; renewable energy; and the promotion of low greenhouse gas energy technologies (Box 3.3). Over the period 1995–97 the GEF financed 27 of these projects: 10 in energy efficiency and conservation with grants of more than $86 million; 14 in renewable energy with grants of $132 million; and three in the area of low greenhouse gas energy technologies with grants of $94 million ($312 million in total). Additionally the GEF financed 5 projects of short-term response measures amounting to $21 million. On top of this, the GEF leveraged over $1.3 billion as co-financing. Over the same period, the GEF also provided funds for enabling activities – at national, regional and global levels: grants totalled $35 million and covered 55 projects to support capacity building as well as the preparation of initial national communications in more than 90 countries.

Subsequently the GEF added a fourth operational area – the development of sustainable transport. Over the period 1998–2001 it made grants for 86 projects in all four areas worth in total $573 million: 35 in energy efficiency and conservation worth $181 million; 38 in renewable energy worth $252 million; 5 in low greenhouse gas energy technologies worth around $100 million; and 8 in sustainable transport worth $40 million. In addition there were 11 projects for short-term response measures worth $46 million. Another $32 million was spent on 119 enabling activity projects for the preparation of national communications and capacity building activities. Over this period the GEF also leveraged around $3.2 billion in co-financing.

Figure 3.3 The evolution of bilateral aid to support mitigation and adaptation, 1997–99



In the period from 2002–2003 the GEF funded 18, 26 and 3 projects in energy efficiency and conservation, renewable energy and sustainable transport respectively at a total cost of nearly $295 million. About $5 million more was spent on three national and regional short-term response measure projects. Additionally it leveraged $1.7 billion in co-financing for these projects. In the same period, the GEF financed 67 enabling activities projects for the preparation of national communications and capacity building worth about $26.5 million.

Overall, over the period from 1995–2003 the GEF allocated about $1.25 billion for 179 greenhouse

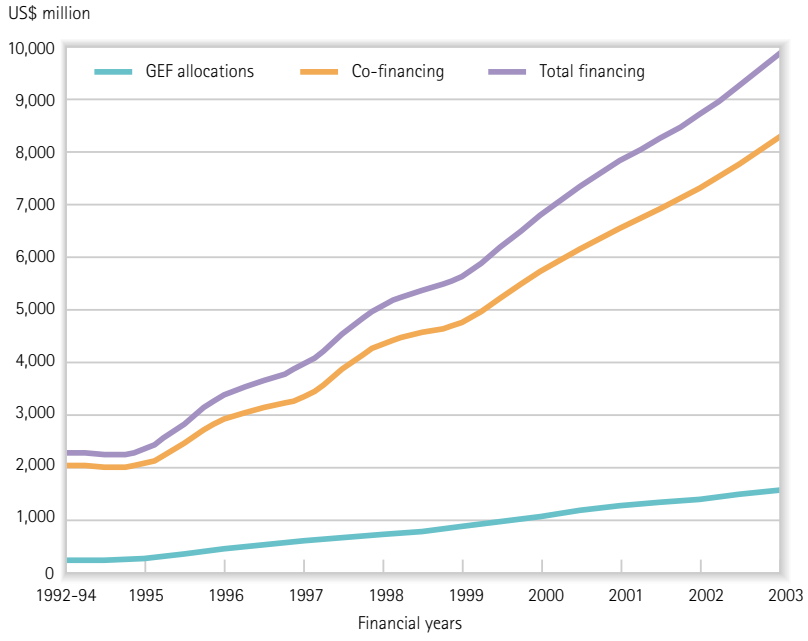
Box 3.3 Examples of energy-related projects supported by the Global Environment Facility

In some countries, GEF-supported projects have directly or indirectly resulted in policy changes – mainly through setting up national codes and standards and developing specialized regulations. In Zimbabwe, for example, one project led to the development of a national programme for installing solar photovoltaic systems. Similarly in Mexico a lighting project led to the development of national quality standards for high-efficiency lights.

Following a GEF-funded project in Thailand, a utility company collaborated with the Thai Consumer Protection Agency in getting mandatory labelling on refrigerators. In China too an energy efficiency project has led to national standards for refrigerators. In Senegal, an energy efficiency project led to the development of building codes.

As a result of GEF-funded projects, some countries have also developed power-purchase agreements for private power supply systems. Jordan, for example, has a biogas power project – Reduction of Methane Emissions and Utilization of Municipal Waste for Energy in Amman – which has been negotiating a power-purchase agreement with the national utility.

Figure 3.4 The Global Environment Facility – cumulative funding for climate change activities, 1992–2003

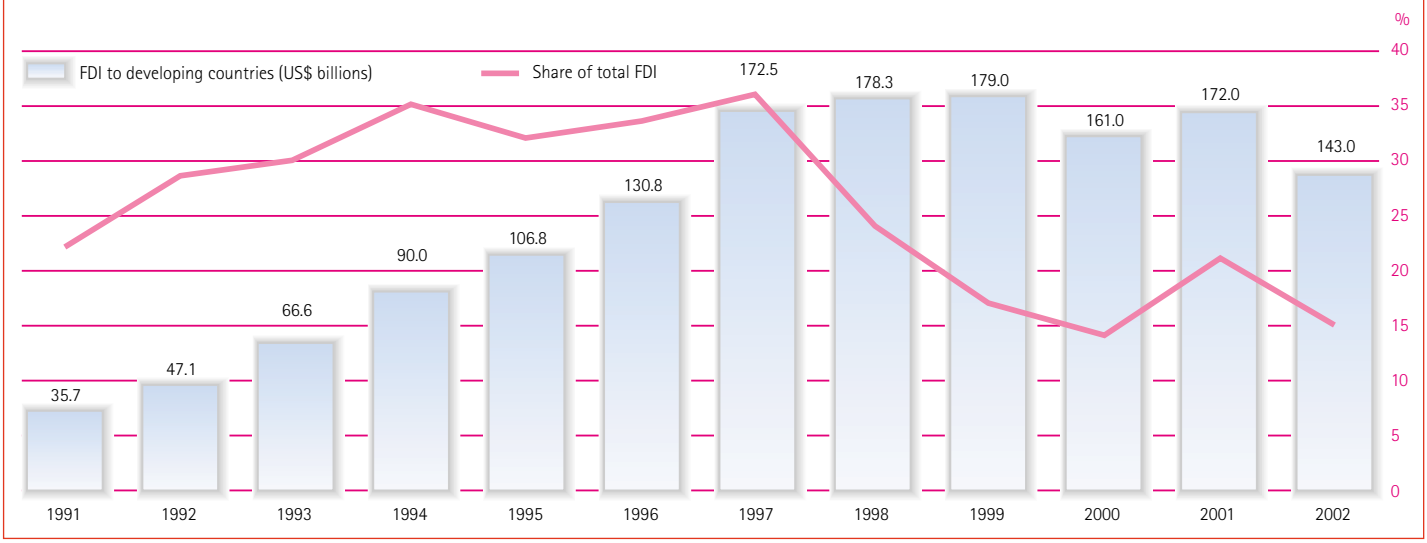


gas mitigation projects. Over this period, it also financed 241 enabling activity projects, worth approximately $94 million, for capacity building and the preparation of national communications. Within this period the GEF was able to leverage a total amount of about $6.2 billion in co-financing. Cumulative funding since 1992 is indicated in Figure 3.4.

Foreign direct investment

The richer countries can also support climate change activities through foreign direct investment. FDI flows to developing countries rose through the 1990s, peaking in $184 billion in 1999 – 2.4% of their combined GDP. Since then it has fallen back, to $143 billion in 2002 (Figure 3.5). These flows tend to be concentrated in a few countries: in 2002 East Asia and the Pacific received around 40% (Table 3.1). However the degree of concentration has been falling: in 1999 the top ten developing country recipients of FDI received 79% of the flows, while in 2002 they received 70%.

Figure 3.5 Foreign direct investment in developing countries, 1991–2002



Source: World Bank, Global Development Finance 2003 and 2002

Table 3.1 Net inward FDI flows to developing countries, 1999–2002 ($ billions)

	1999	2000	2001	2002
East Asia and Pacific	49	44	49	57
Europe and Central Asia	28	29	30	29
Latin America and the Caribbean	88	76	69	42
Middle East and North Africa	3	3	6	3
South Asia	3	3	4	
Sub-Saharan Africa	8	6	14	7
Total	**179**	**161**	**172**	**143**

It is not known, however, how much of this FDI involves technology transfer or other related activities that help the recipient countries reduce greenhouse gas emissions or adapt to climate change. It should also be noted that some FDI will certainly add to the problems – if logging companies, for example, invest in deforestation in rainforests, or if automobile companies build more factories to meet the growing demand for private transportation.

Nevertheless a number of Annex II countries try to ensure that the effects are positive. In their third national communications Canada and Japan, for example, described government activities to involve the private sector in projects and programmes relating to the transfer of technologies that will help developing country Parties to mitigate or adapt to climate change. The United States also described its assistance provided to the private sector, as well as a number of public–private partnership activities that help address climate change in developing countries and EIT counties. Other countries also described policies or programmes relating to the private sector. The German Government, for example, used targeted loans to help small and medium-sized German companies introduce new technologies into developing countries. The Netherlands, among other initiatives, presented the concept of 'green certificates' which companies investing in green projects overseas can use to claim tax exemptions.

A shared responsibility

If they are to bequeath a viable climate to succeeding generations, all countries will need to establish a long-tern basis for sustainable development – to protect the Earth's rich resources, to conserve irreplaceable species, and to generate sustainable livelihoods for all the world's people. The Convention laid down the foundation for these policies by both developing and developed countries, recognizing their common but differentiated responsibilities and respective capabilities. Although the most immediate responsibility for cutting greenhouse gas emissions lies with the richer and more industrialized countries, the developing countries too need to establish climate-friendly patterns of sustainable development for which they should also be able to rely on bilateral and multilateral assistance. Almost all countries have now established the basis for such policies and taken at least some action to combat climate change. Their progress is explored in the next chapter.

Chapter 4

Combating climate change

Since climate change is such a complex issue with ramifications for almost every aspect of human life, the measures taken to combat the problem are likely to be equally diverse. In addition to stimulating voluntary action, governments have a variety of options – fiscal, economic and regulatory – through which they can encourage patterns of production and consumption that can minimize emissions of greenhouse gases. At first their policies tended to be rather fragmented; now they are becoming more coherent and integrated.

…policies and measures will demonstrate that developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions…

(Article 4.2.a)

Even as the Convention was coming into force many developed countries were already taking action to combat climate change. Generally they did so primarily for economic motives – as they tried to improve energy efficiency. Their initial activities could thus be considered as 'no-regrets' measures whose benefits exceeded their costs even without taking into account their merits for climate change.

A number of governments had, for example, saved money by cutting subsidies to energy and agriculture – measures that also helped reduce emissions of carbon dioxide from the energy sector and emissions of methane and nitrous oxide from agriculture. Some developed countries had also deregulated and liberalized their energy markets to sharpen competition and make energy production and distribution more efficient – which also had beneficial effects for climate change. The effects of such policies were even more dramatic in the EIT countries whose radical economic restructuring in the initial years triggered a sudden collapse in output and a corresponding fall in emissions of greenhouse gases.

Counting the costs

But what criteria should apply when measures to combat climate change do imply immediate costs – either in terms of financial or human resources, or of lost opportunities for rapid economic growth? In economic terms it should in principle be possible to calculate an optimum course of action – balancing the costs of cutting greenhouse gas emissions against the costs of damage to the climate; in other words, taking action up to the point where the extra cost of the last policy was equal to the benefit of the damage avoided. Unfortunately, this is not always achievable in practice. While it is usually possible to work out the costs of mitigation policies – for example the extra manpower and materials needed to comply with new regulations – it is far more difficult to assign a monetary value to the environmental damage avoided. A further complicating factor is that these costs do not normally appear on the same balance sheet: the costs of mitigation policies are not usually borne by the same people, or even by the same generation, as those who will take the brunt of the impact of climate change.

Estimating the costs of damage caused to the planet by a ton of carbon dioxide or its equivalent also requires a good understanding of the relationship between emissions and global warming and the ability to predict all consequent impacts. Moreover it involves assigning a monetary value to many things for which there is no market. What, for example, is the cost of diminished human potential, or the loss of the polar ice cap, or of fragile ecosystems? In the face of these scientific, economic

and social uncertainties governments have to adopt the precautionary approach – taking action to avoid the worst-case scenarios.

Fragmented policies

Governments have certainly taken longer to devise and implement coherent policies that address climate change directly. In some cases this was not just for financial reasons but because they had to resolve complex institutional issues. In some federal systems, for example, the central government has only limited control over use of natural resources, or the implementation of energy or transport policies. As a result central governments could only allocate funding after they had negotiated with provincial or state governments – a time-consuming process.

However, even when policies were finally agreed they were often quite fragmented and lacked sanctions in the event of non-compliance. In the early years of the Convention progress was thus relatively slow and emissions continued to grow, particularly in those developed countries outside Europe that had not changed much their use of energy and where energy prices were low.

By the end of the 1990s, the trend was somewhat more positive: Belgium, Japan and the Netherlands, for example, had slowed down their growth in emissions, and by 2000 a number of countries – for example Austria, Italy, and New Zealand – had brought their emissions down to only slightly above their 1990 levels. Meanwhile other countries, in particular Germany, Denmark, France, the UK, Sweden, Switzerland and the European Community as a whole, had successfully reduced their emissions to below their 1990s levels. Some of this success was due to slower economic growth at the beginning of the 1990s and milder winters, which would have cut their use of energy, but they could also claim credit for introducing some effective climate change policies.

An integrated approach

By the turn of the century policies for the developed countries had also become more coherent – largely as a result of the Kyoto Protocol which encouraged a more integrated approach (Box 4.1). Some of the key components of this new approach were:

Building a policy portfolio – Obtaining maximum gains in mitigation requires a wide range of complementary instruments. In the case of energy, for example, this could include combining carbon dioxide taxes and new policies to implement emissions trading with policies to promote public transport, while at the same time devising a mix of preferential tariffs, grants and tax exemptions to promote renewables. The mix of policies within the portfolio will depend on national circumstances, though the balance tends to be similar across groups of countries – as across European compared with developed countries outside Europe.

Wider participation – This integrated approach works best when it is based on extensive consultation and

Box 4.1 Major objectives of climate change policies of Annex I countries

Though the circumstance of Annex I countries may be different they generally have similar overall objectives of their policies on climate change.

Energy

- Economically efficient supply and use of energy
- Diversification of energy sources leading to enhanced security of supply
- Protection of the environment, in particular the management of air quality
- Energy sector reform to increase economic efficiency by introducing more private sector participation, more competition in supply and distribution, and increased consumer choice over energy suppliers
- Efficient use of resources, including energy resources, through green tax reform
- Climate change mitigation through emissions trading

Transport

- Sustainable development
- Air-quality management
- Congestion management
- Energy security

Industrial processes

- Reduction of gases emitted as by-products
- Improved efficiency
- Minimization of the use and emission of fluorinated gases

Agriculture

- Improved environmental performance such as preventing pollution of underground waters
- Greater sustainability through, among other things, improved food quality, rural development, organic farming and land-use planning

Land-use change and forestry

- Protection and sustainable management of forests
- Conservation of biodiversity, wildlife, soil and water
- Afforestation and reforestation to increase sink capacity

Waste

- Reducing the impact of waste on air, soil and underground waters
- Recycling and minimizing waste

collaboration – between central, local and regional governments and also includes other major stakeholders and targeted groups.

Phased introduction of policies – A number of countries, including Denmark, Japan, the Netherlands, New Zealand, Switzerland and the United Kingdom have defined their policies in roughly two groups: initial and "reserve". If towards the end of the Kyoto commitment period the initial policies do not appear to be working sufficiently rapidly to achieve the target then the reserve policies will be brought into play. For example, countries that have introduced energy and carbon dioxide taxes as initial measures could strengthen these during the secondary phase. The Netherlands is holding in reserve policies for carbon dioxide capture and sequestration that it can deploy if the country is not on track to meet the Kyoto targets. The European Union has also identified carbon dioxide capture and sequestration as a possibility under the second phase of the EU Climate Plan.

More comprehensive coverage – Most countries have moved on from an initial concentration on carbon dioxide emissions from the energy sector to a more comprehensive approach that deals with six greenhouse gases and addresses all sources of emissions, as well as the potential for removals by sinks. Indeed businesses have often been keen to deal with other gases, for which there are technological alternatives whose use could bring not just environmental but also economic gains.

Specific policies for climate change – In the past, climate change mitigation has often been a side effect of other policies, or a 'co-benefit'. Nowadays, however, countries are also more likely to adopt policies that have climate change as their primary objective. The prime examples are of course emissions trading schemes, which are already in place in some European countries and as of 2005 will cover the European Community as a whole. These schemes, triggered by the Kyoto Protocol, are expected to

Box 4.2 Co-benefits and ancillary benefits of climate change measures

Until recently, most policies and measures in developed countries were still primarily implemented for objectives other than climate change. With some exceptions, climate change mitigation was a side effect of other policies. Or it could have been a 'co-benefit' which implies that this outcome was also one of the original policy drivers. Fuel-switching from coal to gas, for example, has co-benefits in the form of reduced greenhouse gas emissions combined with improvements in air quality with the attendant health benefits.

Ancillary benefits of climate change policies, on the other hand, are those that are not prime objectives of the policy yet can still be very welcome. In some cases, the magnitude of the ancillary benefits could be comparable with the cost of the implementation of mitigation measures, thus reducing the overall economic cost of mitigation. These benefits include those from reduced traffic congestion, job creation and cleaner air and water:

Switzerland – The implementation of the core programme for climate change 'Energy 2000' is also expected to result in extra investment opportunities of SwF 4.4 billion ($3.6 billion) and added employment opportunities of 40,000 person-years.

Netherlands – The Government has identified potential improvements in energy efficiency that will not only save 19,000 Gg CO_2 emissions but also bring substantial financial benefits since the value of the energy saved will outweigh the costs.

Norway – Reducing emissions of perfluorocarbons from the aluminium industry has brought production and economic efficiency gains, and hence enhanced the competitiveness of the industry.

United Kingdom – The Government's Plan of Action estimates that over the next six years it will not only cut emissions of carbon dioxide by 12 million tons but also save more than £3 billion ($5.5 billion) in energy costs as well as create new jobs.

United States – Tree planting on non-industrial, private forestland and marginal agricultural land has increased sequestration of carbon dioxide while bringing environmental benefits such as improvements in wildlife habitats, soil conservation, water quality and opportunities for recreation.

become an effective way of implementing the Convention irrespective of the entry into force of the Protocol. Another example is the introduction of carbon dioxide taxes and systems for trading in green certificates between energy producers.

An appreciation of ancillary benefits – Even specific climate change measures can bring other important ancillary benefits. Some of these will also be environmental – improving the quality of local air and water and reducing transboundary pollution. But there can also be employment gains: the European Union, for example, expects that by 2010 the renewable energy sector will produce around half a million jobs.

Combining mitigation and adaptation – Although most countries put most emphasis on mitigation they also include elements of adaptation – especially in sectors such as land use change and forestry where success in mitigation may depend on enhancing the adaptive capacity of different systems.

Criteria for policy choice

When it comes to selecting policies each country has its own criteria. The primary ones are environmental effectiveness and cost-effectiveness – even in countries with circumstances as different as Australia and Iceland. But as governments acquire a fuller understanding of the implications of policies, and the many potential costs and benefits, they have to take account of many other factors. Thus, they will consider the impact on communities and individuals, judging how their policies will affect human health and welfare, as well as the effects on income distribution, equity and social inclusion. They will also have a range of economic considerations including employment generation and business prospects as well as the opportunities to promote technological development and innovation. Last but not least there are political considerations: governments always have to take into account public attitudes and behaviour and the acceptability of policies to many groups of stakeholders.

Even if countries have similar criteria they can still define and apply these in different ways. When measuring cost-effectiveness, for example, they can have their own methods for assessing economic, social and welfare costs or for estimating shadow costs and prices. As a result it is often difficult to compare costs across countries – even for something as fundamental as the cost per ton of greenhouse gas emissions saved.

In implementing their climate change policies they have been using a wider variety of instruments. These include:

- Economic and fiscal instruments
- Market instruments, such as emissions trading
- Voluntary and negotiated agreements
- Regulations and standards
- Information, education and public awareness
- Research and development

The most important instruments are still economic and fiscal. However the mix and balance of instruments varies from country to country. The instruments can also vary from sector to sector: thus in the waste sector regulations are more prevalent, while energy use in industrial processes is more likely to be governed by voluntary agreements, though the pattern is changing in Europe where one of the principal instruments within industry in future is likely to be emissions trading.

Economic and fiscal instruments

These form the main body of instruments and include different types of tax on carbon dioxide emissions and on the use of energy, financial incentives such as grants and preferential loan rates, preferential tariffs, and various types of tax relief.

From the outset the most common instruments have been taxes on energy use and carbon dioxide emissions. Many countries that introduced energy and carbon dioxide taxes in the early 1990s have steadily increased the tax rates – or extended their coverage. In 2001, Sweden for example raised its carbon dioxide tax. In 2003, Finland raised its energy tax, after increasing its carbon dioxide tax to €17.2 per ton CO_2 in the 1990s.

Norway also extended the coverage of its taxes on the offshore oil and gas industries – though in response to low oil prices in 1998–99 it reduced the tax rate to NKr315 (or $35).

A number of countries, including Denmark, France, Germany, Sweden and the UK, are moving towards 'green taxation' thus shifting the tax base away from labour and income towards physical items such as energy, minerals and pollution. In some cases, however, they have cancelled or suspended these taxes after significant increases in the world oil and gas prices.

In 2000 Estonia, for example, introduced a charge on carbon dioxide emissions from those power plants that used fossil fuels and had a capacity greater than 50 MW. In 2001 the United Kingdom introduced a 'climate change levy' – a tax on energy use by businesses and the public sector. Some countries, such as New Zealand, are also considering such taxes as part of their package of measures under the Kyoto Protocol. Switzerland, following the rejection of a proposal to introduce an energy tax in a referendum in 2000, intends to put the issue to the vote again.

While applying these taxes, governments have also been careful to avoid tax rates that would make their industries uncompetitive on world markets. The United Kingdom applies its climate change levy on energy-intensive industries at only 20% of the standard rate if these industries conclude negotiated agreements. Sweden similarly has reduced its carbon dioxide tax on fuel to 35% of the standard rate – for all manufacturing industry as well as agriculture, forestry and aquaculture. Sweden has also reduced the rate to less than 10% of the standard rate for businesses whose tax payments exceed 0.8% of gross sales, and for some energy-intensive industries – cement, lime and glass production – it has capped tax payments at 1.2% of gross sales.

To enhance the climate change impact of taxes it is also possible to 'recycle' the revenue to the same industries. Thus the United Kingdom redirects some of the climate change levy to the newly established Carbon Trust which encourages climate-friendly technologies and best practices. Denmark has also redirected a share of the tax revenue to subsidies for energy efficiency projects – setting aside DKr1.8 billion (€242 million) for such subsidies in 1996–2000, with a noticeable effect on emission levels.

A number of countries have also used fiscal measures to promote renewables – using preferential tax rates and allowing accelerated depreciation on capital invested. Canada for example, has encouraged manufacturing, processing and mining companies to invest in renewable energy supply and energy efficiency measures by allowing these investments to be written off against tax on all sources of income. Most of the European countries that have introduced a tax on electricity consumption have in place refund schemes for electricity produced from renewable energy.

Box 4.3 Effects and cost-effectiveness of carbon dioxide taxes

Carbon taxes are not generally applied to all sectors in a uniform manner, as this could reduce the competitiveness of some sectors, particularly energy-intensive industry. In Sweden, for example industry pays the taxes at reduced or zero rates. The United Kingdom has used this asymmetric approach to enhance the cost-effectiveness of the Climate Change Levy by allowing companies increased flexibility: they can join negotiated agreements and qualify for reduced tax rates and, as an alternative to reducing emissions, they can buy permits from the emissions trading scheme. However, the climate change levy is an energy tax, applied on the energy content per kW of electricity, rather than on the carbon content of the fuel, so the effect on emissions is not proportional to the effect on energy consumption.

Denmark applies the carbon tax to all energy users, although fuel used for electricity generation is exempt, and in order to protect the competitiveness of energy-intensive industries the tax package differentiates between heavy and light industrial processes. The carbon tax, which was phased in gradually between 1996 and 2000, is linked to a tax rebate system for industries that agree to reduce greenhouse gas emissions voluntarily. The difference between the tax rate in industries with and without voluntary agreement grew considerably between 1996 and 2001, though has remained constant thereafter. In 1999 an evaluation of the tax suggested that by 2005 emission would be reduced by 3.8% of the previously projected amount, corresponding to 2.3 million tons. Half of this reduction was expected to come from the tax itself and the other half from subsidies and voluntary agreements.

In Norway research suggests that, excluding offshore oil and gas, the tax has reduced emissions by between 1.5% and 4%. Another study focussing on the offshore carbon dioxide tax concluded that this had encouraged companies to identify and implement technological improvements that would have been cost-effective even without the incentive of reducing their tax bills.

Subsidies and grants

The introduction of carbon taxes has been complemented by reductions in subsidies. Many countries have been reforming their energy sectors, aiming

to boost economic efficiency – by increasing private-sector participation, by heightening competition in energy supply and distribution, and by giving consumers greater choice in their energy suppliers. As part of these reforms they have also been reducing subsidies for the production or consumption of energy, particularly those using fossil fuels.

In the developed countries these reforms and reductions in subsidies have resulted in a shrinking coal industry. In France, for example, the 200-year-old coal industry finally closed in 2004 by which time the price of indigenous coal had risen to seven times higher than that mined in the United States. In the UK coal is presently produced at a very limited scale. At present only Germany, Spain and Turkey continue to subsidise their coal industries, and even then at very low levels. The European Union has proposed that member states phase out all fuel subsidies by 2010.

In addition, most of the highly developed countries have reduced or eliminated electricity subsidies. Sweden, for example, has transferred subsidies from electrical heating to district heating schemes, especially those based on renewables. France subsidizes electricity for consumers only in its overseas territories where production costs are higher, though to avoid making alternative energy sources uncompetitive it also subsidizes solar water heaters.

Many EIT countries including Bulgaria, Croatia, the Czech Republic, Poland and Slovakia have also phased out subsidies and as a result their energy prices are therefore now much closer to the real costs of production – stimulating a range of measures for energy conservation. Some however have retained cross subsidies, charging higher prices for industrial energy use and using the revenue to subsidize lower prices for residential consumers.

Other options include grants to support new activities and technologies. A number of countries including Belgium, Germany, Hungary and Switzerland have also introduced 'green' tariffs, which guarantee to pay higher prices for energy from renewable sources for over a decade.

Combinations of economic incentives

In practice governments address climate change through a combination of economic measures, fiscal and financial. They have used these in:

Combined heat and power – Electricity generation produces heat as a by-product, but this is often discarded. Combined heat and power (CHP) systems channel this extra heat instead to useful purposes such as district heating schemes. The European Union aims to boost the share of CHP systems within the electricity market from 10% in 2000 to 18% in 2010. Denmark has already had considerable success: by 2000 the country was using CHP for 58% of household space heating and 55% of electricity. This was achieved by encouraging district heating companies to convert heat-only boilers to CHP with the help of production subsidies, power purchase obligations and guaranteed premium buy-back rates. France too has offered various incentives – exempting CHP schemes from a tax on natural gas and heavy fuel oil (though only for low-sulphur oil) and supplementing this with reduced rates of business tax and accelerated depreciation on CHP investments. Bulgaria has also encouraged state-owned enterprises to invest in CHP, and Slovakia has used subsidies and other forms of financial assistance to improve the efficiency of district heating schemes.

Renewable energy – Many companies use a combination of economic and fiscal measures to promote renewables. Australia, for example offers grants to support promising technologies, or to promote strategic industrial development, through training, quality control facilities and renewable resource mapping. Germany

Box 4.4 Voluntary agreements in the Netherlands

The Netherlands has now had voluntary agreements for more than a decade – with encouraging results. An assessment for the period 1989–2000 estimates that these agreements have increased energy savings from 1.3% to 2.2% per year. Companies that join long-term sectoral agreements have these measures integrated into their environmental permit-setting process. Companies that choose not to join the long-term agreements, on the other hand, are obliged by the authorities to undertake every energy-saving measure that has an internal rate of return on investment of at least 15% after tax.

Although these agreements have typically been agreed with central government, the Netherlands recently allocated additional funds to support the role of local authorities in the environmental permit-setting process.

These agreements do not apply to companies in energy-intensive sectors. Instead these companies have to commit themselves to being among the world's most energy-efficient businesses in their sector.

supported the rapid increase of its renewable energy market through a complex system of direct subsidies, low interest loans and financial incentives, that are combined with a priority access to the grid and guaranteed buy-back rates. Spain supported the development of its renewable power industry through incentive programme and direct economic benefits. This allowed Spain to boost its capacity of renewable energy and, in particular wind capacity. In 2000 it ranked third in the world after the United States and Germany in wind-generated electricity.

Energy efficiency in industry – Most countries, including Australia, Belgium, the Netherlands and the UK, promote energy efficiency through direct financial incentives including grants, subsidies, tax relief and accelerated depreciation.

Energy efficiency in buildings – A number of countries have offered incentives to encourage energy efficiency in both new and existing buildings. These can take the form of grants, as in Hungary, or low-cost loans or preferential tax treatment. For this and other purposes Denmark and the United Kingdom have created 'Energy Saving Trusts'. These are government-funded but independent bodies that can offer advice and make grants for energy efficiency programmes. Another option for the building industry is the use of energy service companies (ESCOs) – businesses that finance energy-efficiency investments, usually over a payback period of less than eight years. In Austria, for example, ESCOs have successfully financed energy-efficiency improvements in public sector buildings in return for a share of the financial savings. ECSOs are also common in the United States where by 2000 there were more than 80 companies which that year completed projects worth around $2 billion.

Energy efficiency in transport – In this case the aim is to divert both passengers and freight to less polluting forms of transport. Passengers are encouraged to move to public transport by investment in bus, tram and railways. In some countries there are also fiscal incentives: Belgium and Sweden, for example, offer tax exemptions for public transport commuter tickets and car pooling expenditures. In London, many people are now using public transport following the introduction of 'congestion charges' for driving in the centre of the city. These and other actions have been supplemented by information campaigns and also the promotion of cycling and walking. To divert freight away from road transport many countries, such as France and Spain have invested heavily in rail services while Austria, Germany and Slovenia have introduced mileage-based tolls on trucks, and Sweden has imposed differentiated charges for goods travelling by air or by ship. For both passenger and freight traffic it seems that the best option is a mixture of both 'push' and 'pull' policies to encourage a modal shift in long-distance transport. In addition there are efforts to reduce the carbon content of transport fuels: some countries are encouraging both private and commercial vehicles to convert to biofuels, including 'biodiesel'. Canada and Italy offer allowances for the use of liquefied petroleum gas; Canada also offers excise tax exemption for ethanol and methanol. The Czech Republic and France offer tax and other incentives for the use of alternative fuels.

Energy efficiency in appliances – Most countries now offer incentives to consumers to use more efficient appliances. In the Netherlands, for example, customers are entitled to a partial rebate on the purchase price of the most efficient appliances as well as on window insulation and household energy systems that are based on renewables. Slovenia has a similar scheme, but uses tax deductions.

Carbon sequestration – A number of governments offer financial support for afforestation and the conservation of forests and agricultural land. Canada, for example has a support programme for permanent forest cover and the Czech Republic and Belgium support afforestation of unused agricultural areas, while Spain offers support for reforestation. Many countries combine these fiscal instruments with the enforcement of regulations and standards – forest codes in the Russian Federation, for example, and the enforcement of regeneration after harvesting in Estonia.

Waste management – Here the most common fiscal instrument is a landfill tax. Rates per ton of waste

vary from SwF15 ($9) in Switzerland to NKr300 ($33) in Norway. Taxes can vary by waste type, depending on whether or not it is organic as in Slovenia and the United Kingdom, and they can also be lower if the landfill is sealed and recovers methane as in Austria. Some countries, such as Norway, also encourage local authorities to burn their waste by having lower taxes for incineration than for landfill. Another option is to offer subsidies to local authorities for improving their waste management infrastructure – as in Canada, Croatia, Greece and Slovakia.

Market instruments

As well as using fiscal and financial measures to support their climate change policies, governments have also introduced market-based systems in the form of Green Certificates. These are akin to the emissions trading credits that governments use at the international level to meet their targets under the Kyoto Protocol, except that at present these certificates are traded only at the national level.

One of the first domestic emissions trading schemes has been implemented by the UK. It covers all six GHGs defined under the Kyoto Protocol. There are plans to include power generation companies in the emissions trading scheme and to allow participants in other schemes, such as the Renewables Energy Obligation, to convert targets under those schemes into tradable permits.

Denmark introduced a system of tradable carbon dioxide allowances or quotas in March 1999 for the period 2000–2003 as part of the electricity market reform. The CO_2 Quotas Act came into force in January 2001.

The European Community has created a framework to ensure compatibility among the national trading schemes of its member States, as part of its package of measures for the implementation of the Kyoto Protocol. The European Parliament adopted the directive on EC-wide emission trading at the end of 2003 with a view to establish the scheme in 2005.

Canada launched a pilot programme that certifies private, voluntary trades of emission reductions. Certified reductions would be eligible for recognition within any future mandatory scheme for emission reductions. Other countries are also considering emissions trading (Austria, the Netherlands, New Zealand, Norway, Sweden). Switzerland intends to launch between 2005 and 2007 the pilot phase of its emissions trading scheme covering large emitters, companies and energy intensive producers not covered by the carbon dioxide tax.

All these systems and schemes aim to reduce the emissions and to maximize the use of renewable energy while offering a degree of flexibility. They require energy producers to derive a certain proportion of their output from renewable sources and issue certificates according to the extent that they have done so. Producers that have exceeded their targets can then sell certificates to others who need them to achieve their targets. Australia, for example, issues Renewable Energy Certificates and hopes that between 2001 and 2010 this will help increase the proportion of energy produced from renewables from 10.5% to 12.5%. The United Kingdom similarly requires all licensed electricity suppliers to supply a specified and growing proportion of their sales from renewables sources; the aim being to achieve 10% by 2010 – a measure that would reduce emissions by an estimated 9 million tons of carbon dioxide and by 2020 by 28 million tons.

Some schemes involve trading certificates between producers and consumers. Thus Sweden's Green Certification Scheme gives energy producers one certificate per megawatt-hour of energy that they produce from renewable sources – solar, wind, biomass, geothermal, wave or small hydro. Industrial energy consumers, except energy-intensive industries, then have to buy these certificates to cover a set proportion of their use.

Although this trading is currently taking place at the national level, there should soon be more opportunities for companies to trade internationally. The European Commission has issued a 'Directive on the Promotion of Electricity from Renewable Sources' which addresses technical issues related to accurate and reliable certification of green electricity. As more member states comply with these standards their companies should be able to trade certificates across national borders.

Voluntary and negotiated agreements

Most countries, while committed to introducing climate change policies, have been concerned that these should not undermine their international

competitiveness. They have therefore tried to ensure that new measures for industry, and particularly energy-intensive industries, are introduced on a voluntary or negotiated basis – though set in a wider policy framework that exerts pressure on industries and individual companies to join the agreements and to set and achieve clearly defined and legally binding targets. These agreements have often been supplemented with other measures that can help companies meet their targets, such as training, advice, information on best practices and government support for energy audits – as in Australia, Canada, Finland, the Netherlands, New Zealand, Norway, Switzerland, the United Kingdom and the United States. In Australia an evaluation of its voluntary agreement programme in 1999 showed that, in addition to reducing emissions from industry, the programme had improved the capacity of government and industry to identify, monitor, manage and report on greenhouse gas emissions.

Although the agreements may be voluntary they can still involve sanctions for non-compliance. In Switzerland, for example, companies that fail to meet their targets may have to pay a carbon dioxide tax; in France they are fined. Japan too has recently strengthened its remedial action against companies that fail to meet their agreed targets. This combination of voluntary and mandatory elements seems to be more effective than agreements that depend on voluntary action alone. In New Zealand, where the 1995–2000 voluntary agreement scheme successfully achieved a reduction of 1,500 Gg CO_2 in 1999, the Government is considering a successor scheme with mandatory elements such as linkages to carbon charges.

These agreements can also be linked to other regulations such as European Union's Integrated Pollution Prevention and Control Directive. In the United Kingdom, for example, the government will grant an 80% rebate on the Climate Change Levy to energy-intensive industries that commit themselves to increase energy efficiency while complying with that directive.

Box 4.5 Promoting renewable energy in Germany

Germany has a successful and long-standing commitment to policies and measures to increase the share of renewables in electricity supply. Between 1990 and 2001 the proportion rose from 3.8% to 7% and seems on track to increase to 12.5% by 2010 – the target set by the European Union. By 2020 the Government expects the figure to reach 20%. Wind power, in particular, has increased almost exponentially, with 8,700 MW of installed capacity in 2001, generating one-third of the world's wind-powered electricity; an additional 20,000–25,000 MW could be installed offshore by 2030.

In the developed countries voluntary agreements have been concluded to reduce emissions from many sources:

Appliances –Several countries have launched new voluntary agreements with manufacturers to increase the energy efficiency of appliances. The European Union has also introduced a code of conduct for digital television equipment, for example, and has reached agreements with manufacturers of other electronic equipment to reduce standby power consumption.

Fugitive emissions – These include, for example, leakages of methane as a result of oil and gas production and transportation, as well as from coal mining. In the United States, natural gas and coal companies have joined voluntary agreements that are estimated to have reduced emissions in 2000 by 22,000 Gg CO_2, while the Government has also helped to develop improved technologies and practices and encouraged industry to adopt them. Such agreements would be valuable in many EIT countries where fugitive emissions are a major problem.

Transport – One of the most prominent agreements in the transport sector is between the European Union and European and Asian automobile manufactures. For the first commitment period to 2010 the target is to achieve average emissions of 140 grams of carbon dioxide per kilometre for all new cars and light commercial vehicles sold in the EU. However the targets are non-binding so it remains to be seen how effective they will be.

Process-related carbon dioxide emissions – A number of industries, such as cement, iron and steel, aluminium, glass and lime, produce carbon dioxide as a by-product but do not have cost-effective ways of removing it from waste gases. Most agreements in the iron and steel industries therefore attempt to reduce emissions by making the process as energy efficient as possible. In the case of cement, however, one way of cutting emissions is to minimize the amount of clinker (material remaining after smelting a metal ore) that is used in cement manufacture. Australia, Belgium, France and Germany have encouraged this option through voluntary agreements.

Process-related nitrous oxide emissions – Nitrous oxide occurs as a by-product of the manufacture of adipic acid, nitric acid or ammonia. In the case of adipic acid one of the cost-effective solutions is to pass the waste gas through a catalytic converter – an option

that is encouraged through voluntary agreements in Belgium, Finland, Germany, Italy and Japan, though in some cases this is backed up with legislation. Catalytic converters are also expected to become available soon for nitric acid production.

Aluminium production – There are ways to optimize aluminium production so as to minimize emissions of perfluorocarbons. Australia, Canada, France, Germany, Japan, the Netherlands, Norway, Slovenia and the United States all have voluntary agreements to encourage this. In Norway, for example, the resulting reductions are equivalent to 4% of total 1990 greenhouse gas emissions.

Semiconductor production – This also generates fluorocarbon emissions but these too can be reduced by optimizing the process and also by treating the waste gases. The World Semiconductor Council has committed itself to reducing emissions by 10% between 1995 and 2010, and the United Kingdom, for example, has used this framework to produce a voluntary agreement. Norway and the United States have also conducted agreements to reduce or phase out the use of sulphur hexafluoride in these processes.

Fluorocarbon gases in other products – Refrigerators and air conditioners use hydrofluorocarbons as refrigerants. Austria, Switzerland and the United Kingdom have voluntary agreements to reduce their use and the European Union plans to integrate mobile air-conditioning into the existing voluntary agreements with European car manufacturers. Germany and the United States also have voluntary agreements on the use of perfluorocarbons in fire extinguishers.

Carbon sequestration – Many countries, including Croatia, Estonia, Finland, Japan, Latvia, Lichtenstein, Slovakia, Sweden and the United States have voluntary agreements for sustainable forest management. Others, including Australia, Bulgaria, Canada and New Zealand have agreements to support specific projects. New Zealand's East Coast Forestry Project, for example, aims to offset about 3% of the country's 1990 carbon dioxide emissions. Japan has a project to promote urban tree planting and the use of wood.

Regulations and standards

Economic measures, market instruments and voluntary agreements are complemented with corresponding regulations and standards. These have been used across the whole spectrum of climate change activities.

Renewable energy targets – Many countries have introduced mandatory targets and quotas for electricity suppliers. In Australia, for example, by 2010 they are expected to generate 12% of their electricity supplies from renewable sources. In the United Kingdom the target for the same date is 10%, with financial penalties for companies that do not meet their quotas. The European Union also has an umbrella target of 22%. Some countries, such as Germany should be able to achieve this, though many others do not yet appear to have the necessary regulations or other instruments in place.

Power generation efficiency – Some countries are introducing or strengthening the efficiency standards for power generation – particularly for coal-fired power stations. Following an extensive benchmarking exercise, Australia, for example, has established Generator Efficiency Standards; participating plants enter into legally-binding agreements to achieve emission reductions, primarily through adoption of best practices.

Pollution – One of the most comprehensive sets of regulations is the European Commission's Integrated Pollution Prevention and Control Directive (IPPC). This requires national governments to regulate pollution from various types of industrial site and requires operators and authorities to take appropriate measures and introduce best practices. The directive applied to new and upgraded sites from 1999, and will apply to all relevant sites from 2007. The EU has also provided guidance documents that emphasize among other things the value of combined heat and power plants. Several EIT countries that have ambitions to join the EU, such as Bulgaria, have also prepared plans to implement the directive. Two of the main challenges for the future implementation of the IPPC directive are to find solutions that are cost effective and that balance energy reduction objectives with those of pollution control (which might result in increased use of energy).

Appliances – Many countries have introduced regulations and standards to appliances, among other things for energy efficiency. These have been supplemented by tax measures, labelling and information campaigns. Since 1998 Japan's 'Top Runner' programme, for example, has used the most efficient appliances of today as the standards of tomorrow. This programme has the potential for saving around 30,000 Gg CO_2 – cutting the energy requirements of home video recorders by 59%, of

refrigerators by 30% and of computers by 83%.
Buildings – A number of countries now have standards for energy efficiency in new buildings – including Australia, Austria, France, Japan, New Zealand and the United Kingdom. Australia, for example, has set a minimum level of thermal resistance for walls and a minimum level of thermal efficiency for water heaters. These standards can also be regularly updated: France, for example, reviews them every five years: in 2000 the Government raised the standard for housing by 15% and for commercial buildings by 40%.

Industrial applications – There are now extensive regulations on the use of various types of fluorocarbons in industrial applications, including hydrofluorocarbons (HFCs) which are used as refrigerant fluids in refrigeration and air-conditioning devices, in fire extinguishers and as foam-blowing agents. The strictest regulations aim at phasing them out for specific applications – as in Austria, Denmark, Liechtenstein and Switzerland – or at some banning or controlling imports. Regulations are usually backed up by compulsory inspections and some countries, such as France and Japan, demand that the refrigerants be recovered at the end of the product's life.

Production processes – HFCs are produced as by-products during the production of other fluorinated chemicals, and can be emitted into the atmosphere: HFC-23, for example, is emitted in the production of HCFC-22. However, emissions can be substantially reduced by waste gas treatment and a number of countries, including the Netherlands and the United Kingdom, require producers to install and optimise this technology.

Agriculture – Here regulations are primarily aimed at reducing emissions of nitrous oxide resulting from the use of nitrate fertilizers or animal manure. The European Union has a Nitrates Directive and France has introduced regulations on nitrous oxide emissions from soil. Some of these regulations also reduce emissions of methane – by encouraging better management of animal manure and minimising the anaerobic conditions in which the gas is emitted.

Waste – Almost all countries have targets and standards for waste management. Thus, the United States now has stringent landfill rules that require the largest operators to collect and burn methane emissions – regulations supported by a Landfill Methane Outreach Programme that promotes cost-effective emission reductions at large landfills; these measures are thought to have cut emissions by half. Many countries also have regulations that require or

Box 4.6 Energy efficiency measures in non-Annex I countries

Albania – The government has taken a number of mitigation measures in the residential and industrial sectors. Nine measures representing 22% of the mitigation potential of the whole portfolio were in the residential sector; five addressed thermal efficiency in households; two addressed appliance efficiency (lighting, refrigeration); and two addressed better control of consumption (thermo time switches for electric water heaters and the introduction of prepaid meters). Measures in the industrial sector represented 47% of the mitigation potential of the portfolio, and included options related to the efficiency of boilers, motors and lighting.

Armenia – The Energy Master Plan envisioned the modernization of power generating capacities and the adoption of combined-cycle and other more efficient power stations. These options would result in an energy saving of 120,000–190,000 tons of fuel per year. The plan also considered improving energy efficiency in the electricity and heat supply industries and in the communal and residential sectors. By 2010 these measure are expected to result in annual emission reductions of 609,000 tons of carbon dioxide. Other measures include reductions in irrigation water losses that would enhance hydropower production by 1,000 GWh annually.

Columbia – Proposed actions include the introduction of efficient lighting in the residential sector, with potential savings of 500 GWh in ten years. The 'Efficient and rational use of energy programme' which started in 1995 and involves the standardization, certification and labelling of appliances has potential savings of 9,300 GWh by its tenth year of operation. In addition, energy savings in industry are expected to reduce electricity consumption by 10%.

Georgia – The Government plans to increase the efficiency of power generation from fossil fuels, and to reduce transmission and distribution losses in the power grid. Sectoral measures include the promotion of energy saving technologies in industry, the improvement of energy efficiency in the tertiary sector (lighting, refrigeration and air conditioning)
as well as in heating and hot water supply.

India – The Energy Conservation Act, adopted in 2001 reflects the commitment by the Government to address climate change by improving energy efficiency. Key activities under this act include setting up of a new government institution to deal with energy efficiency, to prepare guidelines for energy conservation to raise consumer awareness and to disseminate information on options for efficient use of energy.

Indonesia – Here the measures envisaged include removal of various subsidies for electricity and fuel, encouraging the introduction of energy-efficient equipment and technologies through tax incentives and soft loans, introducing mandatory energy audits for industry and commercial sectors, improving the efficiency of appliances and setting energy standards for buildings, as well as offering tax incentives for owners of efficient buildings.

Republic of Korea – The Government has developed a number of energy efficiency policies. Within the industrial sector, it has established energy intensity targets by industrial product, and prepared a Five-year Energy Conservation Plan for energy-intensive industries such as chemicals and metals, as well as introducing an Energy Audit programme and making efforts to improve the efficiency of industrial equipment. For the building industry the measures include mandatory building insulation, requiring energy-efficient building design, as well as introducing building audits and new standards and labelling for equipment and appliances. For the automobile industry the measures include fuel economy ratings and labelling, fuel economy targets, better traffic management, improving driving practices, encouraging small car ownership, and a progressive emission tax. Within the power sector the Government is rationalizing the coal industry and introducing emissions abatement facilities in power stations.

Lebanon – Measures here have included the replacement of old electric motors in the industrial sector, the replacement of old boilers and furnaces, and process improvements in the cement industry. The Government is also considering the development of hybrid electric vehicles.
Mexico – The Government has created a support fund for energy saving and the Federal Electricity Commission has offered relevant information to consumers. One initiative is the ILUMEX project which involves the promotion of compact fluorescent bulbs.

Philippines – For the period 1999–2008 the Government has introduced 12 mitigation measures targeting various sectors, including industry (energy audits), residential (electrical appliances) and power supply (loss reductions). By 2008 these aim to have achieved energy savings of around 71 billion barrels of fuel-oil equivalent – which could result in $1.1 billion in foreign exchange savings and an average reduction in electricity power needs of 491 MW. In addition, there is the ALGAS project for which there is a potential reduction of 106 million tons of carbon dioxide equivalent, at cost savings varying from $26 to $5.4 per ton.

Thailand – The Government has identified energy-efficiency measures on both the demand and supply sides. The demand-side management programme has, for example, addressed improvement of lighting and cooling technologies, including refrigeration and air conditioning in both residential and commercial sectors. The programme could mitigate about 57 million tons of carbon dioxide per year in total on a no-regrets basis – producing savings per ton ranging from $323 for residential lighting to $46 for refrigerators. Residential cooling abatement does have positive costs – of $3.6 per ton – but is still cost-effective.

Uzbekistan – Planned energy-saving measures in energy industries involve four projects aimed at upgrading power plants, reducing emissions by 1.4 million tons of carbon dioxide by 2010. There are also technical efficiency projects in the oil and gas sectors that should reduce emissions by 1.3 million tons of carbon dioxide by 2010. A number of other measures should result in substantial reductions in emissions of carbon dioxide by 2010. These include 19 energy-efficiency measures in industry involving technology upgrading (4 million tons), improving energy efficiency in the tertiary and household sectors (4 million tons), in agriculture (3 million tons), and in transport (0.75 million tons).

encourage the separate collection of waste fractions and require recycling rather than land filling for organic and certain other types of waste as well as pre-treatment for some waste that does go to landfill. A number of countries also have regulations for the disposal of specific waste fractions, including packaging, electrical and electronic equipment, sewage sludge and material recovered from cars. Other standards concern incineration and the improvement of combustion efficiency.

Box 4.7 Renewable energy measures in non-Annex I countries

The non-Annex I countries have reported on a wide variety of measures to promote renewable energy:

Albania – The Government has considered five renewable energy measures including the development of solar water heating systems, and programmes aimed at developing hydropower (including mini-hydro) and wind-power generation. It is also considering photovoltaic systems for water pumping.

Argentina – The Government has developed legislation and regulations, including fiscal incentives, to promote the use of renewable energy.

Barbados – The country has installed 32,000 solar water heaters, saving 30–35 MW of electricity power

Chile – A wind project has been submitted under Activities Implemented Jointly which could reduce carbon dioxide emissions by three million tons.

Costa Rica – Here 92% of power needs are being met through renewable energy sources. Geothermal potential amounts to 990 MW and wind potential to 600 MW.

Georgia – The country has considerable hydropower resources, capable of generating 80,000 GWh per year. Plans include a more rapid start for hydropower plants under construction, the reconstruction, modernization and rehabilitation of existing plants, and the rehabilitation and construction of small plants. By 2010 these measures would supply about 10,000 GWh of hydropower. Six projected small plants costing $13 million could generate 6,000 GWh in 25 years of operation and reduce carbon dioxide emissions by 1.8 million tons. Georgia is also considering the use of geothermal energy which by 2010 could, for example, meet the hot water and heating needs of 0.5 million inhabitants of the capital, Tbilisi. Three geothermal projects are being considered, at a cost of $47 million with the potential to reduce carbon dioxide emissions by 7 million tons.

Jamaica – Communities in rural areas are using biofuels, and electricity generation also makes use of bagasse (sugar cane waste). Renewables account for 10% of commercial energy.

Republic of Korea – Korea is aiming for renewable sources to supply at least 2% of energy demand by 2006. Options being considered are photo-voltaic systems, solar water heating systems, wind power and the use of ethanol.

Malaysia – The Government is planning to develop hydropower, as well as cogeneration systems using biomass – including rice husks, fuel wood and palm oil waste. It is also considering photo-voltaic systems in urban areas to reduce the load on the national power grid.

Philippines – The Energy Plan 1999–2008 has a renewable energy capacity target of 410 MW installed – including wind (182 MW), ocean energy (30 MW), solar (19 MW), micro-hydro (8.5 MW) and biomass.

Thailand – The Government has developed a 'Plan for the demonstration and promotion of alternative energy production' aiming for a total of 150 MW, including solar energy, hydropower and biomass energy.

Country experience in emissions reduction

As a result of these and other policies many developed countries have managed to reduce their emissions. The European Union as a whole, as constituted in 1990, successfully reduced emissions in 2000 to below the level in 1990. This was due partly to an economic slowdown in the early or mid-1990s as well as in some cases to liberalization of energy markets which led to shift from coal to natural gas. Greater use of nuclear power also reduced greenhouse gas emissions. But proactive climate change policies also played an important part – such as increasing the share of renewables in the energy supply mix and improving energy efficiency.

Denmark – Here the impressive reductions resulted from strong government support and ambitious target-driven policy. Denmark made more use of combined heat and power plants which not only increased efficiency but also 'decarbonized' the fuel supply mix, mainly thanks to a shift from coal to renewable energy and natural gas. These results were achieved despite high and stable economic growth: between 1990 and 2000 GDP increased by 27%.

Finland – The decrease in emissions stemmed mainly from a shift from coal and peat to natural gas, and an increased share of renewables especially hydropower, as well as an upgrading of nuclear power plants. At the same time Finland engaged in a more proactive energy efficiency and transport policy.

France – The stabilization of emissions was mainly achieved by reducing emissions of nitrous oxide from the chemical industry and increasing the share of nuclear power in electricity generation.

Germany – Unification resulted in major economic restructuring and a considerable overall reduction in

carbon dioxide emissions. Some of the most effective policies were reductions in the use of lignite and the promotion of wind energy. There were also substantial reductions in methane emissions from coal production and waste management. Improvements in agriculture reduced emissions of both methane and nitrous oxide.

United Kingdom – Here the decrease in emissions was largely attributed to the effect of market liberalization in the energy sector and the resulting switch from coal to natural gas. The UK also has a coherent and ambitious national climate change policy with specific targets that go beyond internationally agreed ones.

By 2000 almost all the EIT countries had reduced their emissions to below their 1990 levels. Decreases ranged from 17% in Hungary to 66% in Latvia and were due primarily to steep economic decline during a period of radical restructuring. This trend could easily have been reversed from the mid-1990s as economic conditions improved. In fact while most of these countries enjoyed a revival in economic growth their emissions grew at a much slower pace and in some countries continued to decline – as in the Czech Republic, Hungary, Poland and Slovakia.

This suggests that in these countries economic growth has been decoupled from emissions growth – due to profound economic reforms and improvements in efficiency, combined with a switch from coal to gas in energy supply. However, these may have been one-off gains: as the EIT countries move towards the energy intensities typical of advanced countries, this decoupling effect is likely to become less pronounced.

The non-Annex I countries have taken a wide range of measures to reduce emissions, some of which are presented in Box 4.7. Promoting energy efficiency and renewable energy remained among the key responses of these countries. While these measures helped to slow down the emission growth in many developing countries, similarly to the developed countries they also helped to achieve important multiple benefits such as reduced air and water pollution, reduced traffic congestion and creation of new jobs, especially in rural areas.

Both the Convention and the Kyoto Protocol consider the possibility that climate mitigation policies by the Annex I countries could affect the economies of some developing states that are highly dependent on the production, processing and export of fossil fuels, especially oil.

This issue has been explored in several forums which have considered methodological issues, such as modelling and insurance to identify gaps and limitations to current approaches. In particular, discussions focused on the role of private insurers in managing natural disasters and climate change risks, as well as on specific issues such as risk assessment methodologies and uncertainties in the context of the impact of response measures. There have also been discussions on the potential for the affected countries to diversify their economies and their exports.

Given the complexity and diversity of this issue the UNFCCC secretariat has established links with relevant entities with which it can collaborate – including the United Nations Environment Programme, the United Nations Conference on Trade and Development, the Global Environment Facility, the World Trade Organization, and the International Monetary Fund.

Carrots and sticks

Countries all over the world have thus been gathering experience on the most effective ways to reduce emissions of greenhouse gases. In some cases they guide energy producers towards climate-friendly forms of production through taxes and other incentives; in others they apply specific regulations – a combination of the carrot and the stick. They can also encourage consumers in the direction of more climate-friendly lifestyles – by setting new standards for housing and consumer products, for example, or improving public transport or creating the infrastructure for better management of waste. Each country will arrive at its own optimum combination, depending on local circumstances. All countries, however, also hope that changes in technology will widen their range of options. This is the subject of the next chapter.

Chapter 5

The promise of technology

Just as the rise in greenhouse gas emissions has been the product of old technologies – from coal-fired power stations to internal combustion engines – so the reduction in emissions will rely on the deployment of new and more efficient technologies that could form the basis of economies that are less carbon-intensive. Most of this development will necessarily take place in developed countries, but developing countries should also be able to benefit through technology transfer.

Climate-friendly technologies take many forms – small scale and large scale, short term and long term, from improved blades for wind-turbine generators at one end of the spectrum to the development of nuclear fusion at the other. Large countries should be able to contribute right across the range. The United States National Energy Policy, for example, recommends the use of an array of existing and new technologies to reduce greenhouse gas emissions, including improving the energy-efficiency for vehicles, buildings, appliances and industry, as well as the development of hydrogen-based technologies, and improvements in coal, gas and nuclear technologies. Smaller countries with more limited budgets for research and development frequently specialize in their own areas of expertise: Iceland, for example, is one of the world's leading users of geothermal energy and has a major research and development effort in this area, while Denmark is a world leader in wind power.

Developing countries, with limited research capacity of their own, are more likely to rely on technology transfer. A 1990 report from the IPCC working group on 'Participation of Developing Countries' pointed out that "...as the greenhouse gas emissions in developing countries are increasing with their population and economic growth, rapid transfer, on a preferential basis to developing countries, of technologies which help to monitor, limit or adapt to climate change, without hindering their economic development, is an urgent requirement."

Government efforts to stimulate these technologies start with support for research and development. They can, for example, offer either grants or contracts to universities, individual private companies or industry-led consortia to run demonstration projects or produce prototypes. Encouragingly, although developed countries have reduced their overall budgets for energy research they are increasing them for climate-friendly technologies, such as advanced renewables.

Governments can also help ensure that these technologies are commercialized. They can, for example, offer incentives to producers in the form of tax credits and production subsidies for technologies that are close to commercial viability, such as micro-turbines, solar cells, solar heating, advanced biomass-based technologies, and propulsion systems and fuel cells in transport. Many governments are

All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall:

...Promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases...

(Article 4.1.c)

also giving a kick-start to sales through government procurement – as happens with renewable energy systems in Canada – thus increasing the scale of production and driving down costs through economies of scale. Governments can also encourage consumers through demonstration projects as well as through tax credits and rebates. The EU is also involved through its 'Organization for the Promotion of Energy Technologies' – which has benefited many EIT countries.

As indicated in the previous chapter, many governments are also involved at the final stage of the technological cycle – adoption and diffusion – trying to remove barriers to the use of new technology, whether economic, regulatory, organizational or social, while setting appropriate technical standards and organizing training schemes. At the same time they can launch education and information campaigns to increase public awareness.

Priority areas for research

The pivotal technologies will be in the field of energy. Here the main objectives are:

- *Efficiency* – Delivering the needed services with less energy, particularly in power production and transport.
- *Alternative sources* – Technologies that use energy sources such as natural gas which have lower greenhouse gas emissions, or to nuclear or renewable energy which have zero emissions.
- *Carbon sequestration* – Technologies that capture carbon at different stages of energy transformation, or that can subsequently store it, in geological formations, for example.

Even when such technologies are commercially viable, however it will take some time before they have an effect on emissions. The International Institute for Applied Systems Analysis in Austria suggests that for a new energy resource and its associated technology to increase its market share from 1% to 50% takes between 50 and 100 years.

Governments have also been supporting efforts to reduce emissions from industrial processes, particularly those using fluorinated gases. A number of countries, including Australia, France, Japan, New Zealand, Spain and the United States, also aim to stimulate research on mitigation in agriculture.

Another priority for technology development is carbon sequestration. The United States has a large research and development budget on carbon sequestration and capture from energy production activities – examining the feasibility of a variety of storage sites and fossil energy systems as well as determining the environmental acceptability of large-scale storage and developing technologies that produce valuable commodities from carbon dioxide reuse.

International research networks

Although research may be dispersed across many different countries it can also benefit from international cooperation. This is taking place, for example, in hydrogen and fuel cell technologies. In 2003, the United States launched the International Partnership for the Hydrogen Economy to advance research, development, and deployment of hydrogen production, storage, transport and distribution technologies. The partnership will also foster collaboration on fuel cell technology and common codes and standards for using hydrogen fuels. Other countries participating in this initiative include Australia, Brazil, Canada, the European Community, France, Germany, Iceland, India, Italy, Japan, Korea, Norway, the Russian Federation, and the United Kingdom. The United States, with international and private sector partners, has started FutureGen a $1-billion 10-year demonstration project to create the world's first coal-based, zero-emissions electricity and hydrogen plant.

There is also international cooperation in fusion energy. The International Thermonuclear Experimental Reactor is a $5-billion research project designed to harness nuclear fusion, which could offer a major new source of clean energy. Participants include Canada, China, the European Union, Japan, the Russian Federation, the Republic of Korea and the United States.

There is also collaboration on the development and deployment of technologies for carbon sequestration. In 2003, the United States launched an international Carbon Sequestration Leadership Forum, together with Australia, Brazil, Canada, China, Colombia, India, Italy, Japan, Mexico, Norway, the Russian Federation, the United Kingdom, and the European Union – subsequently joined by Germany and South Africa.

Technology is of course only a part of the picture and most countries will combine new technologies with economic and other measures. But there are clear differences in emphasis. Most European countries tend to give greater weight to economic measures to give industries the incentive to innovate; thus far carbon taxes have been the driving force though it seems that in future the main economic factor will be the Kyoto Protocol's cap-

The developed country Parties... shall take all practicable steps to promote, facilitate and finance... the transfer of, or access to, environmentally sound technologies and know how to other Parties, particularly developing country Parties...

(Article 4.5)

Box 5.1 Capturing carbon dioxide in geological structures

Carbon dioxide can be stored underground in many types of geological structure including deep saline formations, disused coal mines and depleted oil and gas reservoirs. Together these could hold hundreds of thousands of gigatons of carbon. One of the most significant examples is in the Sleipner oil and gas field in the North Sea. Carbon dioxide removed from natural gas in oil fields is normally vented into the atmosphere. Since 1996, however, the Norwegian company Statoil has been pumping one million tons of carbon dioxide per year into a sandstone layer 1,000 metres below the sea bed. One of Statoil's main motivations was to save on Norway's offshore carbon tax. On the basis of tax savings alone, the incremental investment cost of $80 million was paid back in less than two years.

Statoil is now planning another project for the Snohvit oil and gas field in the Barents Sea. This has been one of the first projects to take a number of environmental considerations into account at the outset. In this case, the carbon dioxide will be separated from the wellstream on land and then piped back and stored in an impermeable layer below the gas field.

and-trade system and the resulting prices of credits and quotas. The United States, on the other hand prefers a voluntary approach to climate mitigation while putting greater emphasis than European countries on technological change. It is difficult to gauge which approach will have greater impact in the long term. It seems clear, however, that rigorous mitigation policies produce quicker results in reducing emissions and can also stimulate technological change. In Norway, for example, the high carbon tax introduced in the early 1990s induced Statoil, the largest oil and gas company, to make rapid progress in technologies of carbon capture and storage (Box 5.1).

Technology transfer

If developing countries, with limited research capacities of their own, are to take advantage of many of these new developments they rely on technology transfer. This need for technology transfer was emphasized in 1992 in Agenda 21, for example, and the UNFCCC Convention in Articles 4.3, 4.5 and 4.7 and since then issue has been pursued at a number of meetings (Figure 5.1). Further impetus was provided in 1998, for example, when the Conference of the Parties called upon the industrialized countries to provide lists of environmentally sound technologies that were publicly owned, and upon developing countries to submit their technological needs. The Conference also asked all Parties to stimulate private sector investment, and to identify projects and programmes on cooperative approaches.

Most importantly the decision called for a consultative process to consider a list of 19 specific issues and associated questions. To further this process, the secretariat organized three regional workshops – in Africa, Asia and the Pacific, and Latin America and the Caribbean – along with an informal consultation in the United States. These workshops, which drew on the IPCC's 'Special Report on Methodological and Technological Issues in Technology Transfer', generated many useful background papers and submissions from Parties, along with a number of ideas for the development of a technology framework.

The work of the COP culminated in a 'technology framework' that was finally agreed in 2001 at the seventh Conference of the Parties in

Box 5.2 The UNFCCC technology information clearing house, TT:CLEAR

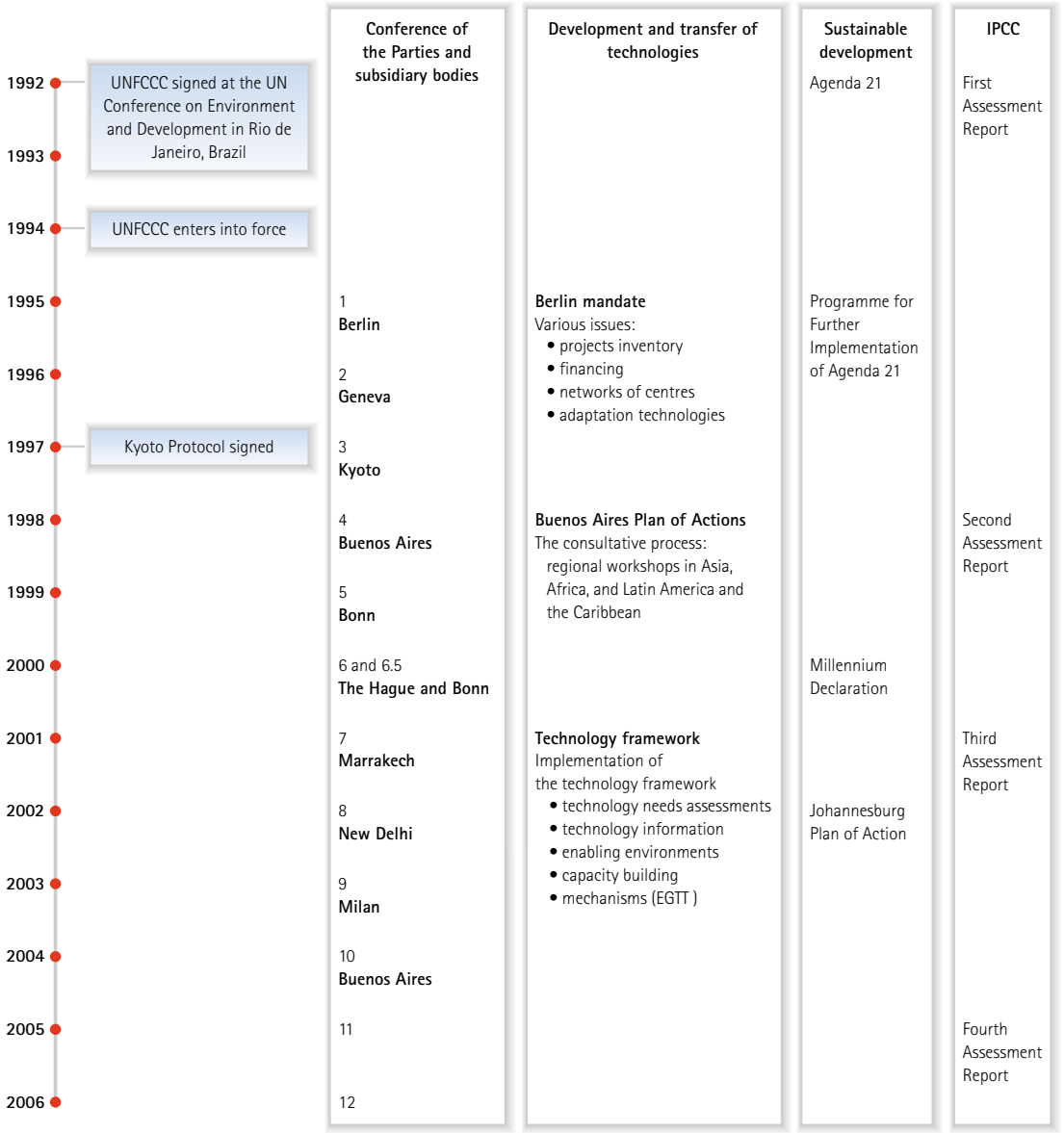
In order to improve access to information on environmentally sound technologies the UNFCCC secretariat has established a technology information clearing house, called TT:CLEAR. This offers valuable information to government specialists and practitioners as well as to public-interest groups, businesses, trade associations and intergovernmental organizations.

TT:CLEAR is a web-based system that enables users to find information on:

- Technology transfer projects and programmes
- Case studies of successful technology transfer
- Environmentally sound technologies and know-how
- Organizations and experts
- Methods, models, and tools to assess mitigation and adaptation options and strategies
- Relevant internet sites for technology transfer
- Ongoing work of the Parties and the Expert Group on Technology Transfer, such as issues under negotiation, documents and meetings, and implementation of the technology framework.

TT:CLEAR is accessible from the UNFCCC home page (http://unfccc.int) or directly at http://ttclear.unfccc.int

Figure 5.1 Developing a framework of technology transfer



Marrakech. The framework covers five key themes and areas for action:

- Technology needs and needs assessments
- Technology information
- Enabling environments
- Capacity-building
- Mechanisms for technology transfer

The Marrakech Accords also provided for the establishment of an Expert Group on Technology Transfer (EGTT). This now comprises 20 experts, including three members from each of the developing country regions (Africa, Asia and the Pacific, and Latin America and the Caribbean), one from the small-island developing states, seven from Annex I Parties, and three from relevant international organizations.

The Expert Group has been considering technology needs. For this purpose it has been cooperating with UNDP in the preparation of its handbook on methodologies for technology needs assessments which will also have an additional section on adaptation technology.

The technology framework has also been developed in a number of other ways. These include the development of methodologies for needs assessments, the launch of a technology transfer information clearing house, TT:CLEAR (Box 5.2), the creation of a network of information centres, and the drawing up of a list of activities needed for capacity-building.

Hydrogen filling station in Reykjavik, Iceland.

Financing technology transfer

Finance for technology transfer can come from a number of sources: grants or loans through official development assistance or the Global Environment Facility – as well as in the form of investments from the private sector. The Marrakech Accords created a Special Climate Change Fund under the Convention to provide additional financial assistance to different areas, including the transfer of technology, and it is expected that this will become operational in 2005.

Since 1991 the Global Environment Facility has made grants worth hundreds of millions for energy technology-related projects. The main areas of activity have been:

- *Barrier removal* – Developing and promoting markets for commercial and near-commercial technologies by removing barriers rather than by subsidizing equipment
- *Long-term cost reduction* – Carrying out research, demonstration and commercialization activities to lower long-term technology costs
- *Market development strategies* – For expanding the use of renewable energy

So far the GEF has focussed on technologies for mitigation of greenhouse gas emissions. It will continue to do so and will also start supporting the transfer of technologies that meet the special needs of adaptation, including through the Special Climate Change Fund.

Governments have also reported a number of initiatives to promote private sector participation in

Box 5.3 Building a hydrogen economy

Hydrogen has enormous potential for energy generation. Ultimately consumers should be able to use hydrogen energy for transportation, electric power generation, and portable electronic devices. Before that point, however, there are many issues to be considered – related to cost and performance as well as to customer awareness and acceptance. Consumers will expect products that are safe, convenient, affordable and environmentally friendly. Private enterprises will be looking for business opportunities in generation, distribution, combined heat and power plants and in vehicle fleets.

The hydrogen economy will comprise not merely a set of technologies but rather a whole system of elements that are closely interrelated and interdependent – from production, delivery, storage and conversion to end use. Some of the main challenges will be:

- Ensuring safety
- Building government-industry partnerships to demonstrate and commercialize the technology
- Coordinating activities by diverse stakeholders
- Maintaining strong research and development programmes in both fundamental science and technology development
- Implementing effective public policies
- Providing customer education
- Developing codes and standards.

Reducing emissions from energy supply and infrastructure

Low emission, fossil-based power and fuels

- Zero-emission power, hydrogen, and other value-added products
- High-efficiency coal/solid feedstock
- High-efficiency gas fuel cell/hybrid power systems

Hydrogen

- Hydrogen production from nuclear fission and fusion
- Integrated hydrogen energy systems
- Hydrogen production
- Hydrogen storage and distribution
- Hydrogen use
- Hydrogen infrastructure safety

Renewable Energy and Fuels

- Wind energy
- Solar photovoltaic power
- Solar buildings
- Concentrating solar power
- Biochemical conversion of biomass
- Thermochemical conversion of biomass
- Biomass residues
- Energy crops
- Photoconversion
- Advanced hydropower
- Geothermal energy

Nuclear

- Existing plant research and development
- Next-generation fission energy systems
- Near-term nuclear power plant systems
- Advanced nuclear fuel cycle processes
- Nuclear fusion

Energy infrastructure

- High-temperature superconductivity
- Transmission and distribution technologies
- Distributed generation and combined heat and power
- Energy storage
- Sensors, controls, and communications
- Power electronics

Reducing emissions from energy use

Transportation

- Light vehicles – hybrids, electric, and fuel cell vehicles
- Alternative-fuelled vehicles
- Intelligent transportation systems infrastructure
- Aviation
- Transit buses – urban duty-cycle

Buildings

- Building equipment, appliances, and lighting
- Building envelope (insulation, walls, roof)
- Intelligent building systems
- Urban heat island technologies

Industry

Energy conversion and utilization

- Resource recovery and utilization
- Industrial process efficiency
- Enabling technologies for industrial processes

Enhancing capabilities to measure and monitor emissions

- Hierarchical measuring and monitoring systems
  - for energy efficiency
  - for geologic carbon sequestration
  - for terrestrial carbon sequestration
  - for ocean carbon sequestration
  - for other greenhouse gas

Reducing the climate effects of non-carbon-dioxide greenhouse gases

Methane emissions from energy and waste

- Anaerobic and aerobic bioreactor landfills
- Conversion of landfill gas to alternative uses
- Electricity generation technologies for landfill gas
- Advances in coal mine ventilation air systems
- Advances in coal mine methane recovery systems
- Measurement and monitoring technology for natural gas systems

Methane and nitrous oxide emissions from agriculture

- Advanced agricultural systems for nitrous oxide emission reduction
- Methane reduction options for manure management
- Advanced agricultural systems for enteric emissions reduction

Emissions of high global-warming potential gases

- Semiconductor industry: abatement technologies
- Semiconductor industry: substitutes for processes producing gases with high global warming potential
- Semiconductors and magnesium: recovery and recycle
- Aluminium industry: perfluorocarbon emissions
- Electric power systems and magnesium: substitutes for SF_6
- Supermarket refrigeration: hydrofluorocarbon emissions

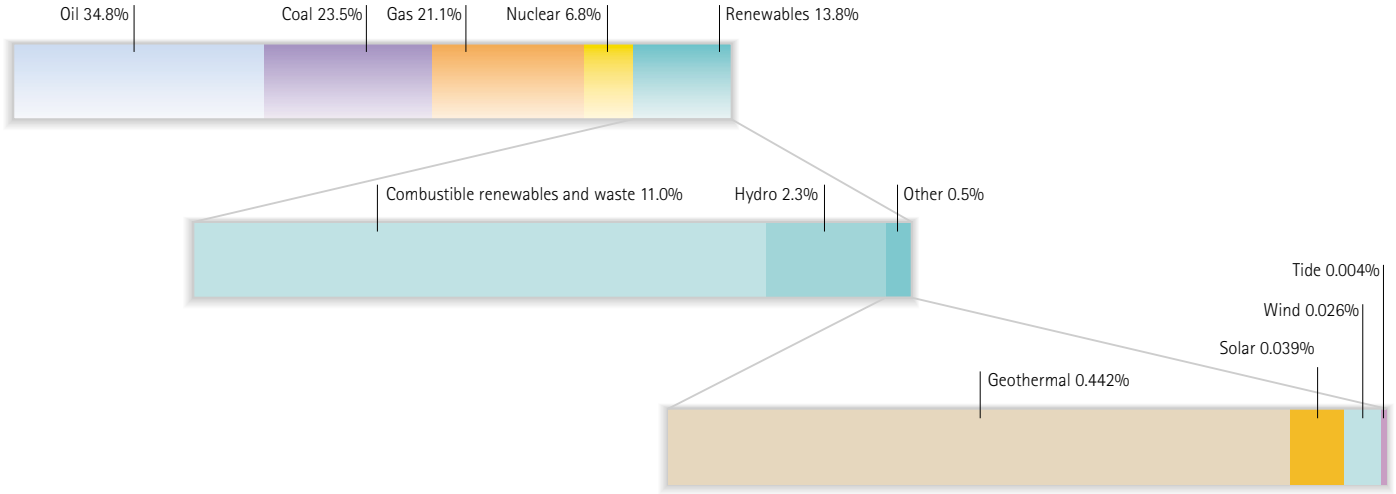
Nitrous oxide emissions from combustion and industrial sources

- Nitrous oxide abatement technologies for nitric acid production
- Nitrous oxide abatement technologies for transportation

Emissions of tropospheric ozone precursors and black carbon

- Abatement technologies for emissions of tropospheric ozone precursors and black carbon

Figure 5.2 Fuel shares of world total primary energy supply, 2000



Source: Renewables in global energy supply, IEA, 2002

technology transfer. They have, for example, given financial support for the development and commercialization of technologies. They have also tried to bring producers into contact with potential users through web-based databases and information clearing houses. In addition, some governments have provided companies with technical assistance and financial guarantees against risks in international transactions.

Future technology options

Many currently available technologies offer significant opportunities for cutting emissions and, as the IPCC indicates in its Third Assessment Report, technical progress has been faster than expected – as with turbines, the elimination of industrial by-products such as nitrous oxide emissions from adipic acid production, hybrid engine cars, fuel cell technology, and underground carbon dioxide storage. The IPCC

concluded that existing mitigation technologies, along with their expected improvements, could some time between 2010 and 2020 reduce greenhouse gas emissions to levels below those in the year 2000.

In addition, many other technology options show promise for the near and long term. Some of these are listed in Box 5.4. Their likelihood of success can only, of course, be a matter of speculation; apart from the intrinsic viability of the technologies their use will depend, for example, on advances in competing technologies, on market forces and on many other factors.

The IPCC suggests that the greatest mitigation potential is in the building and energy sectors. For power generation there is still considerable potential for increases in efficiency. Over the past ten years gas-turbine, combined-cycle power plants, for example, have increased their efficiency from 35% to 60% and show the greatest potential for future improvements.

But just as important as efficiency is security of supply. Power shortages and cascading power cuts in North America and Europe in recent years have concentrated attention on this issue and the World Energy Council predicts that the measures needed to ensure security will lead to higher energy costs.

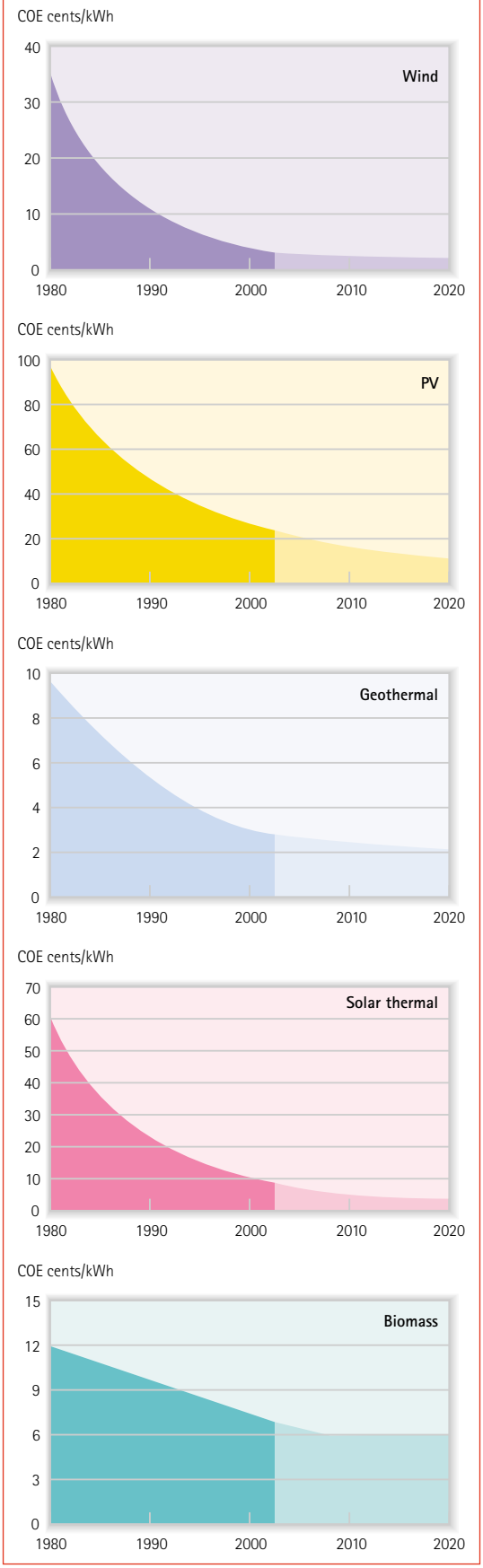
Forests, agricultural land, and other terrestrial ecosystems also offer significant mitigation potential, using existing technology at relatively low costs. For transportation the potential is lower but even small changes could have a large impact given the rapidly increasing number of vehicles. Improvements in conservation and sequestration of carbon will also make an important contribution – although the effects are not necessarily permanent they can at least create a breathing space in which to develop other options.

The potential for renewable energy

The share of renewables in the world energy supply is already significant amounting to about 14% at the beginning of the 21st century (Figure 5.2). Admittedly, energy from less traditional sources, such as wind or solar thermal, is still produced in small quantities due to high costs. There is however a clear downward trend - these sources of energy become less and less costly, as can be seen from Figure 5.3. This facilitates their penetration in the energy production systems.

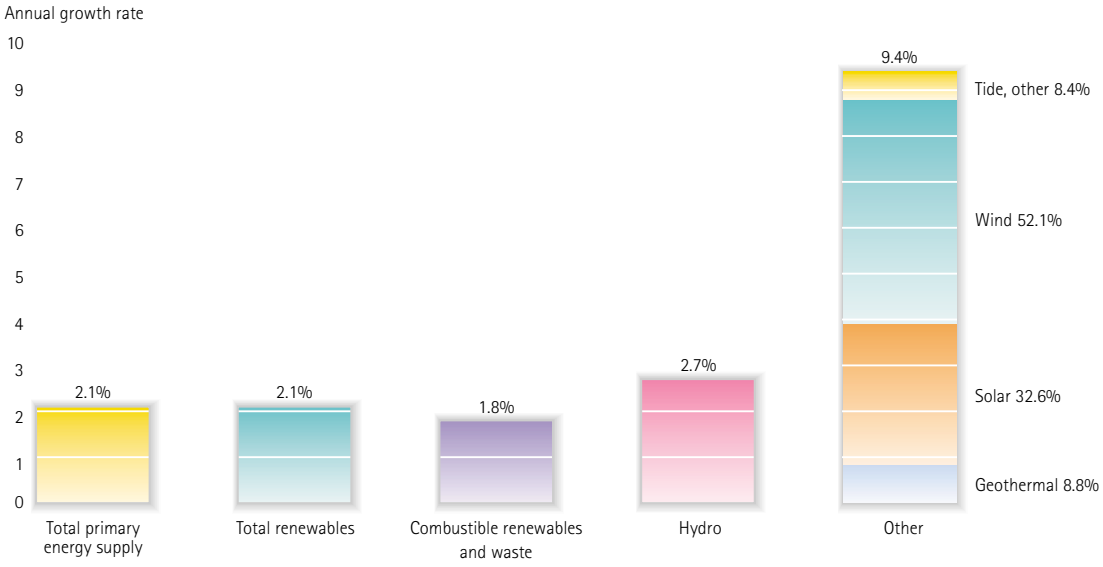
As a whole, output from renewables has been growing at roughly the same rate as total primary energy supplies. However this masks different growth rates within different forms of renewable source. This is illustrated in Figure 5.4 which shows that slightly slower growth in combustible renewables and

Figure 5.3 Renewable energy cost trends, cents per kilowatt-hour



Source: NREL Energy Analysis Office, 2002

Figure 5.4 Annual growth of world renewable energy supply, 1971–2000

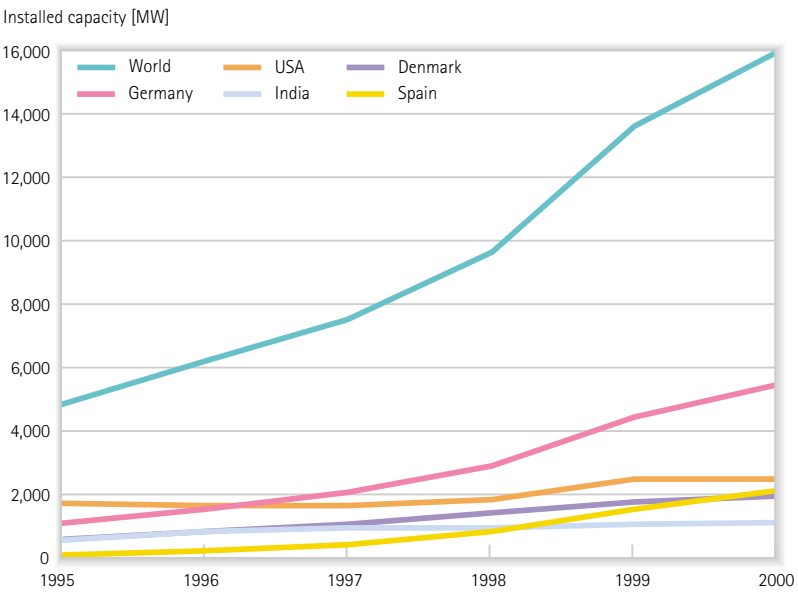


Source: IEA (2002)

waste has been offset by more rapid growth in hydro, and in the 'other' category within which the most rapid growth is for wind power.

The rapid growth rate for wind power is partly a result of starting from a low base in 1971, but also of recent technological progress. Currently it accounts for around 0.3% of global installed generation capacity and around 0.1% of total global electricity. Over the past decade growth in output has been even more rapid – an average of 25% annually (Figure 5.5). By 2000 total capacity had reached 16,000 MW and by 2010 it could reach 30,000.

Figure 5.5 Wind power – global installed capacity, 1995–2000



Hydrogen energy technologies

Hydrogen and fuel cell technologies offer the long-term potential for domestically-based energy systems that have near-zero emissions. Before hydrogen can achieve its promise, however, it will have to overcome many challenges – technical, economic and institutional (Box 5.3).

These issues are now being addressed in a growing number of countries. The United States, for example, has committed $1.7 billion for the first five years of a long-term programme – to develop hydrogen infrastructure, fuel cells, and hybrid vehicle technologies. The European Union has made a similar commitment – up to €2 billion over five years to conduct research and development, including a hydrogen fuel-cell bus demonstration programme in nine cities. Other countries with active research programmes include Australia, Canada, China, Iceland, India, Italy, Singapore and the United Kingdom.

Carbon dioxide capture and storage

One of the most effective ways of mitigating carbon dioxide emissions, at least in the short and medium term, is through capture and storage. Recent studies suggest that up to 2050 it should be possible to store half of cumulative global emissions – and at costs comparable to other mitigation options.

The easiest opportunities for capture and storage are where carbon dioxide is produced in large quantities at single locations – at power plants, oil and gas fields, and energy-intensive industrial sites. It is much more difficult to capture and store gases

that emerge from dispersed locations such as heating systems or vehicles.

Carbon dioxide can be captured at power stations or industrial plants before or after combustion. A present it usually takes place post-combustion. The technology for this is now well developed and involves scrubbing the flue gases with amine solvents. It has the disadvantage, however, that it requires treating relatively high volumes of gases for a small yield – absorbing large amounts of energy and requiring significant capital investment. Pre-combustion capture, on the other hand, can be more efficient. This involves reacting the fuel with oxygen or air to produce a mixture of hydrogen and carbon monoxide which is then treated with steam catalytically to convert it to carbon dioxide and more hydrogen. At this stage the carbon dioxide can be removed fairly economically since it is at a higher concentration than it would be in flue gases. Pre-combustion technologies, however, depend on redesigning power stations.

The opportunities for storage and capture have raised considerable international interest. A number of large-scale sequestration projects are now underway and membership of the Carbon Sequestration Leadership Forum has now reached 16 countries plus the European Union.

Taking advantage of technological changes

New technologies should thus open up a new range of opportunities. This will be particularly important for energy – producing and delivering power more cheaply and offering renewable alternatives to fossil fuels. Transport systems too could be transformed by the wide availability of hydrogen. Much of the necessary research and development will take place in the developed countries, either at the national level or through international networks of institutions. But developing countries urgently need these options as well – so technology development also needs to be accompanied by technology transfer. Inevitably, however, these technologies will take time to come on stream. In the meantime, in addition to mitigating emissions and pursuing new technologies, countries will also need to adapt to climate changes that are already underway – an imperative that is considered in the next chapter.

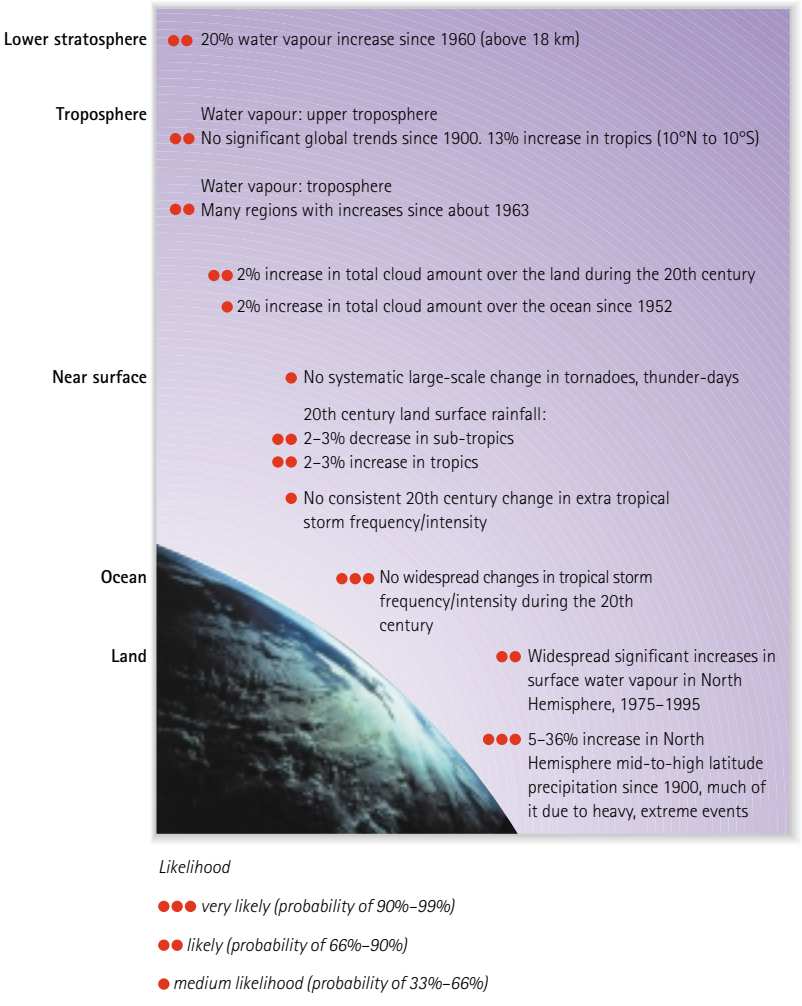
Chapter 6

Learning to live with climate change – strategies for adaptation

The world is already witnessing changes in mean temperature, shifts in the seasons, and an increasing frequency of extreme events. This is set to continue, for the global climate system has considerable inertia: even if countries all over the world reduce emissions now, concentrations of greenhouse gases will continue to increase and global temperatures will continue to rise. Under these circumstances, most countries must start adapting to climate change now – and do so for the foreseeable future. Many are now giving adaptation a greater priority, though much of this work is still at the research and assessment stage.

Although there is still considerable uncertainty, especially at the national level, the general trends of climate changes and their impacts are now becoming clearer (Figure 6.1). The Intergovernmental Panel on Climate Change, through a series of assessment reports, has come to three overall conclusions: that natural systems are vulnerable to climate change and some will be irreversibly damaged; that human systems too are sensitive and some are vulnerable; and that for both natural and human systems this vulnerability varies across regions (Box 6.1).

Figure 6.1 Observed variations of climate-related indicators



Some of the most significant adverse effects will be:

- Most tropical and sub-tropical regions will see a general reduction in potential crop yields – for most projected increases in temperature
- Most regions in mid-latitudes will, with some variations, see a general reduction in potential crop yields, for increases in annual average temperatures of more than a few degrees Celsius
- Populations in many water-scarce regions, particularly in the sub-tropics, will have even less water
- More people will be exposed to vector-borne diseases such as malaria and water-borne diseases such as cholera, and more will die from heat stress
- Heavy precipitation and sea-level rises will increase the risk of flooding for human settlements – tens of millions of inhabitants in the settlements studied
- Higher summer temperatures will increase the demand for energy for space cooling.

Potential benefits include:

- Some regions at mid-latitudes will have increased crop yields for increases in temperature of a few degrees Celsius
- An increase in global timber supply from appropriately managed forests
- More water in some water-scarce regions – for example, in parts of southeast Asia
- Reduced winter mortality in mid- and high latitudes
- Higher winter temperatures will reduce energy demand for space heating.

Zones of vulnerability

Most parts of the world are vulnerable to the effects of climate change, but the impact is likely to be greater in developing countries. This is partly the result of physical geography: a number have long, low-lying coastlines and they, particularly the small-island developing states, are already suffering from severe floods, droughts, tropical storms, salt water intrusion, storm surges, coral reef damage and

Box 6.1 Key regional and sectoral findings on vulnerability and adaptation

The IPCC published its Third Assessment Report in 2001. In addition to presenting a range of future scenarios it also reached important general conclusions on the impact of climate change on different regions and sectors.

Natural systems are vulnerable to climate change, and some will be irreversibly damaged

Natural systems can be especially vulnerable to climate change because they have limited adaptive capacity and as a result can suffer significant and irreversible damage. Those particularly at risk include glaciers, coral reefs and atolls, mangroves, boreal and tropical forests, polar and alpine ecosystems, prairie wetlands, and remnant native grasslands. While climate change may increase the abundance or range of some species, for others it will increase the risk of extinction with a resulting a loss of biodiversity. And as the magnitude and rate of climate change increase so will the geographical extent of the damage or loss, and the number of systems affected.

Human systems are also sensitive to climate change, and some are vulnerable

A number of human systems are sensitive: water resources; agriculture and food security; forestry; coastal zones and fisheries; human settlements; energy and industry, insurance and other financial services; and human health. The extent of their vulnerability, however, varies with geographic location, time, and social, economic and environmental conditions.

Vulnerability varies across regions

The vulnerability of human populations and natural systems to climate change differs substantially across regions and across populations within regions. Some regions are particularly vulnerable because of their physical exposure to climate change hazards or their limited adaptive capacity. Most less-developed regions are especially vulnerable because a larger share of their economies are in climate-sensitive sectors and their adaptive capacity is low due to low levels of human, financial, and natural resources, as well as limited institutional and technological capability.

changes in the migratory patterns of important species of fish.

Many of the larger countries also have extensive arid zones and marginal areas that were already suffering from environmental degradation and rapid population growth – problems that will be exacerbated by climate change, with serious implications for agriculture, food security and water resources. But as well as being geographically more exposed to the impacts of climate change, many developing countries are vulnerable because they lack the required technologies, financial resources, the institutions or the trained people to deal with the consequences.

The situation is somewhat easier for the developed countries. They too have some fragile ecological zones but have been able to invest more in protecting them. They are also in a better position to adapt since they can draw on their resources to deal with the effects of climate change.

In both developing and developed countries, the effects can also be much greater for indigenous communities who rely most directly on their immediate environments for subsistence and livelihood – often living in the more remote and ecologically fragile zones.

Agriculture and food security

Perhaps the most fundamental concerns are for agriculture and food. Many countries have considered how various climate change scenarios will affect agricultural crops and plants – including wheat, maize, rice, corn, cotton, vegetables, grapes and grasslands – and found potential impacts, both positive and negative. On the positive side there could be an increase in crop production resulting from longer growing seasons and higher concentrations of carbon dioxide in the atmosphere. On the negative side higher temperatures could lead to lower soil moisture, greater levels of infestation by weeds and pests, the spread of infectious diseases and a decrease in biodiversity.

Overall the disadvantages appeared to predominate – suggesting falls in output ranging from 15% to 50%. There are similar scenarios for livestock: some countries anticipate higher levels of carbon dioxide and longer growing seasons for pastures, while others predict a decline in livestock

All Parties… shall:

…Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures … to facilitate adequate adaptation to climate change…

(Article 4.1.b)

production resulting from a reduction in pasture areas or a decrease of about 30% in the productivity of existing pastures.

In addition to the effects from changes in mean climate there are also risks from climatic variability. For agriculture this could be even more critical. Thus, although many scenarios predict an increase in the productivity of grasslands due to warmer temperatures and higher concentrations of atmospheric carbon dioxide, overall productivity could be hit by the effects of extreme weather conditions, such as high rainfall leading to flooding and increased frequency of droughts.

Coastal zones and marine ecosystems

Almost all countries with coastlines foresee damage to infrastructure and ecosystems as a result of rising sea levels, warmer sea water and storm surges. Small island developing states are already being affected by rises in sea levels and these and other countries estimate that a further rise in sea level of between 50 centimetres and one metre would encroach on densely populated areas and damage valuable agricultural land through salt water intrusion. In addition, the rise in water temperature would change patterns of water circulation which would not only affect ecosystems but also threaten some economic activities, including tourism. On top of this are the effects of more intense and frequent storms. Most vulnerable to all these changes are coral reefs, coastal soils, mangroves, estuarine wetlands and low-lying coastal ecosystems.

Fisheries

Climate change could affect fisheries in a number of ways. The productive habitats of some species could be affected by a rise in sea level and associated flooding while others could be affected by a rise in sea temperatures or increasing salinity. This will have an impact not only on the working methods and livelihoods of fishing communities but also on diet and nutrition for the population at large.

Water resources

Even without climate change, many countries face various problems of water supply. The rapid growth of cities, as well as rising demands from agriculture and industry, along with the pollution of water bodies, have reduced per capita water supplies – problems already compounded by climatic variability and extreme weather events. Since land and water are such critical resources, changes in the availability of either could lead to social conflict.

Climate change could bring some benefits – through higher rainfall in zones that are currently arid. But a number of countries anticipate problems. They find it difficult to estimate the effects of climate change on precipitation at the regional or national levels, so few have been able to predict changes in water run-off, but using water balance models they have concluded there could be deterioration in water availability and water quality.

In some cases higher temperatures imply decreases in surface water and more frequent droughts – along with higher rates of evaporation from hydro-electric dams which would reduce power generation. Droughts, floods and other extreme events could also damage the water supply infrastructure, and heavier rainfall could wash away soil and exacerbate erosion.

Human health

The relationships between climate and health are poorly understood and the data are limited. So instead of using models to address the effects of climate change on particular diseases, most countries rely on qualitative assessments, or have used statistical correlations between climate characteristics and population and mortality data.

While emphasising the degrees of uncertainty, they have concluded that increases in temperature, changes in precipitation, and rises in air pollution are likely to increase the incidence of many diseases: vector-borne diseases such as malaria and dengue; water-borne diseases such as cholera and typhoid; and diseases related to heat stress, such

as dehydration, rashes, vascular and renal disorders, viral conjunctivitis and influenza. Rising temperatures are also likely to lead to an increase in cardiovascular diseases. In the poorest countries these effects would be amplified by existing poor health conditions, the lack of adequate water supplies and sanitation and the shortage of government funds for health and environmental services.

Terrestrial ecosystems and forests

Many countries have looked at the likely effects on forests and rangelands. Although they used models that were not directly comparable, in most cases they concluded that the impacts would be negative, including decreases in biomass of 10% to 15%. The rising concentration of atmospheric carbon dioxide would also have variable effects: for some types of forest or grassland ecosystems this would lead to an initial increase in biomass, while for others a doubling of carbon dioxide concentration would reduce biomass by 2.5%.

Several countries foresee shifts in ecosystem zones, which could result in greater desertification and an extension of arid or semi-arid areas of between 20% and 40%. Effects on ecosystems, including forests, could lead to increased fire hazard, a loss of moisture, a shift in the extent of forests, a loss of biodiversity, and declines in the production of fodder and food, along with increased mortality due to disease.

Economy and infrastructure

Some countries reported on potential economic effects beyond those related to agriculture and fisheries. Tourism, particularly winter tourism, would be affected by more extreme weather conditions, or shifts of climatic zones. Transport links could be weakened as it becomes more expensive to maintain infrastructure – especially roads and railways that have been damaged by floods, landslides and storms. Power supplies too could be affected: changes in patterns of water run-off to rivers or lakes critical to hydro-electric plants would affect power production while power lines would be vulnerable to storms and other extreme events.

A number of developed countries have also highlighted the impact on their insurance industries. Claims due to natural disasters have risen over the past decade. It has not been possible to attribute this directly to climate change but future climate changes could make it more expensive to arrange property insurance against storms, flooding or drought.

Box 6.2 Key concepts in impacts, vulnerability and adaptation

The Intergovernmental Panel on Climate Change (IPCC) in its Third Assessment Report provided explanations of the following terms:

Adaptation – Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Adaptation policy – Action taken by the governments including legislation, regulations and incentives to mandate or facilitate changes in socio-economic systems aimed at reducing vulnerability to climate change, including climate variability and extremes. Changes can be made in practices, processes, or structures of systems in response to projected or actual changes in climate.

Adaptive capacity – The ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Climate change impacts – Consequences of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts.

Sensitivity – The degree to which a system will respond to a change in climatic conditions (e.g., the extent of change in ecosystem composition, structure, and functioning, including primary productivity, resulting from a given change in temperature or precipitation). The responses may result in either beneficial or harmful effects.

Vulnerability – The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, as well as of its sensitivity, and its adaptive capacity.

Impact assessments and research

The need for adaptation to climate change is now undeniable. The question is not 'whether to adapt?', but 'how to adapt?' The IPCC defines adaptation as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities".

Unsurprisingly, most adaptation activity has focused on impact assessments and research. This involves estimating the potential impact of climate changes, judging how dangerous they are likely to be, and suggesting potential means of adaptation. Impact assessments have, however, evolved considerably over the past ten years and these have

helped raise public awareness and paved the way for practical action. Some of the key concepts are explained in Box 6.2.

Nevertheless these studies have considerable limitations. This is partly because of the degree of uncertainty surrounding climate change – its magnitude, intensity and regional characteristics – but also because of the diversity of economic, political and social environments in which these changes will take place.

Researchers in both developed and developing countries have pointed out weaknesses in both methodology and data. One of their most important tools is the 'general circulation model' which they use to simulate changes in the world's climate. Although considerably improved over the past decade, these models are not yet able to offer accurate simulations, especially of precipitation, at a regional or national level even for today's climate. So they can say little about future local patterns of climate change – neither its magnitude, nor even its direction. Nor can they indicate the likelihood of extreme weather events. Added to these difficulties are the uncertainties in future socio-economic conditions. As a result, these models have yet to produce results that are useful for developing adaptation policy at the national or local level.

As the IPCC noted in its Third Assessment Report: "Current knowledge of adaptation and adaptive capacity is insufficient for reliable predictions of adaptations; it is also insufficient for rigorous evaluation of planned adaptation options, measures and policies of governments…there is little research on the dynamics of adaptation in human systems, the processes of adaptation decision making, conditions that stimulate or constrain adaptation, and the role of non-climate factors…".

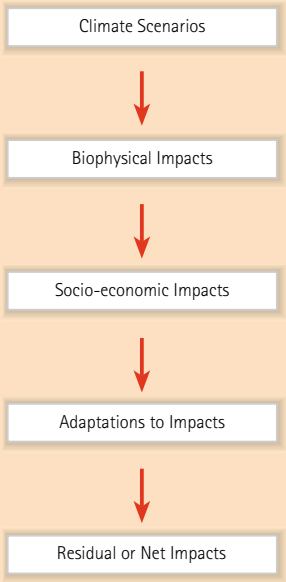
These limitations have prompted researchers to look for other approaches to adaptation. In the early years, their first generation of assessments were scenario based using general circulation models to construct a range of possible long-term scenarios to which policy makers could respond. In recent years, however, their 'second generation' of assessments are 'vulnerability-based' – looking at current climate variability and the ways in which people are actually adapting and then using this information to consider what will happen in the future given changes in both the natural and the socio-economic environment.

The two approaches, 'scenario-based' and 'vulnerability based', are not mutually exclusive (Box 6.3). Indeed they are often used in parallel: policy makers can use scenario-driven studies to

Box 6.3 Two approaches to vulnerability and adaptation assessments

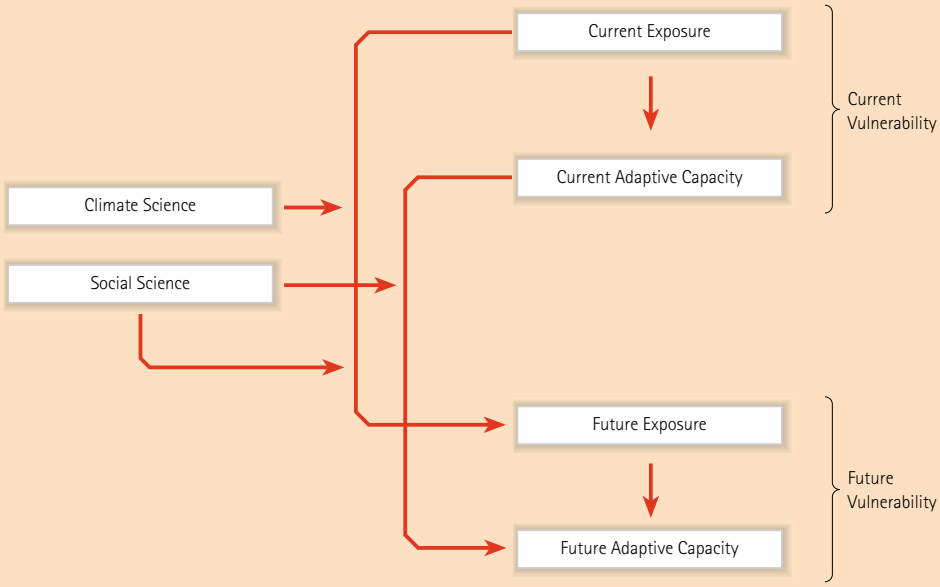
What are the climate change impacts?

First generation of assessments
'Scenario-based approach'



How to adapt?

Second generation of assessments
'Vulnerability-based approach'



understand key impacts at different levels and regions while using vulnerability studies to develop policies for adaptation.

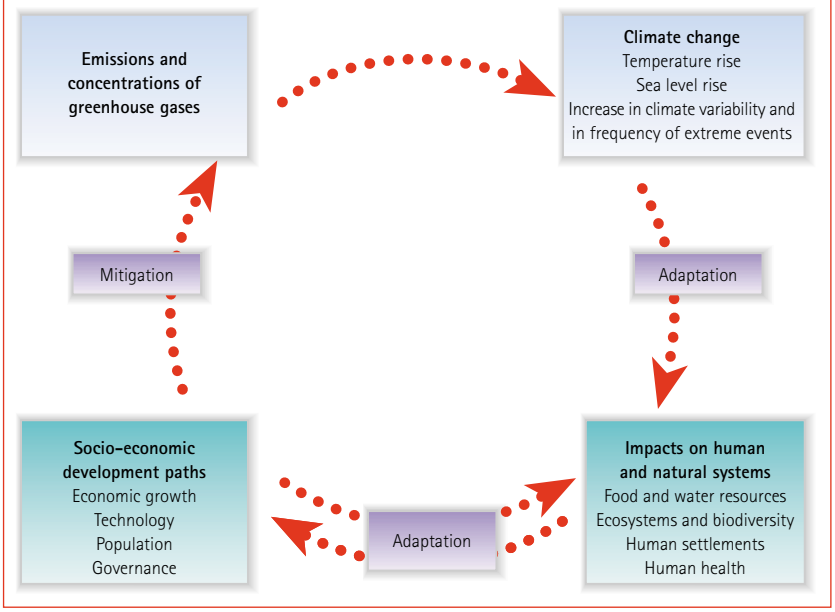
Frameworks for action

At the national level countries should now be developing policy frameworks and laying the foundations for adaptation – identifying, evaluating and removing the barriers to adaptation, improving research and assessing the requirements of key sectors. Thus far however, few countries have taken the necessary steps and progress has been slow – hampered by the complexity of the issue, uncertainties about future impacts, and a general lack of relevant theoretical and practical knowledge.

Nevertheless in their national communications many countries report that they are giving adaptation a greater priority in their climate change strategies and research programmes, and a number have allocated increased funding for this purpose.

These efforts lead to more comprehensive assessments that build up a more integrated framework – looking at the interactions between climate change and both human and natural systems, and the implications for socio-economic development (Figure 6.2).

Figure 6.2 Climate change – an integrated framework



In the United Kingdom, for example, this kind of assessment has been used to take climate change into account in water resources management, catchment abstraction management, and the maintenance of water supplies during droughts. It has also been used to consider potential increases in river

Box 6.4 The special situation of the least developed countries

The least developed countries (LDCs) are particularly vulnerable to climate change since they lack the resources for adaptation. Recognizing this, Article 4.9 of the Convention states that "the Parties shall take full account of the specific needs and special situations of the least developed countries in their actions with regard to funding and transfer of technology".

In 2001 in order to support the LDCs the Conference of the Parties adopted a comprehensive work programme which established a process for creating 'national adaptation programmes of action' (NAPAs). In preparing the NAPAs the LDCs are using rigorous, bottom-up methodologies to identify their most urgent adaptation priorities and are then presenting the resulting NAPAs to the international donor community for support.

To guide and advise LDCs on the preparation and implementation of NAPAs there is now an LDC Expert Group which includes nine members from LDCs and three from industrialized countries, all of whom possess specific expertise. Upon request from the LDC Parties, the group provides technical guidance and advice on the preparation and on the implementation strategy of NAPAs, including the identification of possible sources of data and its subsequent application and interpretation. The Group is also developing recommendations on capacity-building needs, on promoting synergies with other activities in the region and with other multilateral environmental conventions, and on how to integrate NAPAs into regular development planning.

LDCs receive financial support for this activity from the Global Environment Facility (GEF) and its implementing agencies. For this purpose the GEF administers an 'LDC Fund' which supports the LDC work programme, including NAPAs and other activities. Only a few countries will complete their NAPAs in 2004; the bulk are expected to finalize them in the course of 2005.

The LDC work programme also addresses other LDC priorities, including strengthening national climate change secretariats and focal points, providing training in negotiating skills and language, strengthening the capacity of meteorological and hydrological services, and also promoting public awareness and the development and transfer of technology.

flows with implications for flood defences and flood plains, and rises in sea levels that affect the long-term management of shorelines. A number of other countries have also allocated additional resources to improve flood prevention, flood warning systems and the protection of coastal infrastructure. In some cases they have also been making links between climate change and natural disasters – which can lead to revisions of laws concerning such disasters.

The European Union has also been taking an integrated approach when considering adaptation policies for agriculture. Thus it has encouraged greater flexibility in land use, crop production and farming system and will use its programmes of subsidies and incentives to influence production and management practices at the farm level.

Some countries have been applying new methods such as stakeholder analysis, risk assessment techniques, decision-support systems and multi-criteria analysis, as well as using a sustainable livelihoods approach. To clarify the key issues and help design responsive strategies for adaptation they have also developed new techniques for scenario building that developing countries can also use to integrate adaptation objectives into the broader goals of sustainable national development.

Throughout this process it is important to bridge the gap between the research community and policy makers. But more generally the aim should be for the widest possible participation of stakeholders – who need to be involved from the outset to ensure that policies reflect the priorities of a diverse range of interest groups, at all levels of governments and throughout the business community and civil society.

International cooperation

Developed countries will be able to finance their own efforts at adaptation, but the situation is different for many developing countries which will have to rely to some extent on international support. In 2001 the Conference of the Parties in Marrakech considered channels for this assistance and established three new funds: the Special Climate Change Fund to support adaptation, transfer of technologies, activities in major GHG-emitting sectors, and economic diversification; the Least Developed Countries Fund to support a work programme for LDCs which includes, among other things, the preparation and implementation of their National Adaptation Programmes of Action (Box 6.4); and the Kyoto Protocol Adaptation Fund which would also finance measures to adapt to climate change. The operation of all three funds would be guided by the Conference of the Parties to the Convention and operated by the Global Environment Facility.

Adaptation projects implemented by national agencies can also be financed through other aid channels, both bilateral and multilateral, including through United Nations bodies or other international organizations. The range is illustrated in Box 6.5 which shows that the activities vary considerably in scope and magnitude. In some cases a whole project is dedicated to vulnerability and adaptation while in others these form just part of a larger programme. And while some focus on one country others can cover a number of countries – as with UNDP's 'Adaptation policy framework' and UNEP and GEF's 'Assessment of impacts of and adaptation to climate change' which includes 24 projects. Projects initiated in recent years involve, for example, developing tools to integrate climate change into development,

Box 6.5 Examples of international cooperation on adaptation

Activities and projects	Purpose and scope
United Nations programmes and other international organizations	
UNDP. UNEP. GEF. Programmes on enabling developing countries to prepare their first and second national communication in response to UNFCCC commitments, including their vulnerability and adaptation assessments	Provides support to more than 70 developing countries to compile their first national communications to the UNFCCC, including: development of national greenhouse gas inventories; assessment of potential impacts of climate change and adaptation; analysis of potential response measures; and preparation of action plans to address climate change and its adverse effects.
UNDP. UNEP. GEF. National adaptation programmes of action (NAPA) projects	Provide support for preparation of the NAPAs in least developed countries, including synthesis of available information on adverse effects of climate change; participatory assessments of vulnerability to current climate variability; identification of key adaptation measures; country-driven criteria for selecting priority activities to address adverse effects of climate change and development of proposals for such activities.
UNDP. GEF. Pacific Island Climate Change Assistance Project (PICCAP)	Provides support to the countries of the region for meeting their reporting obligations under the UNFCCC, including comprehensive and detailed vulnerability and adaptation assessment, and integration of climate change strategies into national development priorities and plans.
UNDP. GEF. Capacity-building for Stage II adaptation to climate change in Central America, Mexico and Cuba	Provides support to eight countries of the region for preparing for Stage II adaptation, including through elaborating a pilot project applying an adaptation policy framework for preparing adaptation strategies, policies and measures.
UNDP. Canada. Switzerland. Netherlands. Elaborating an adaptation policy framework (APF)	Develops an adaptation policy framework in order, inter alia, to provide guidance for developing and assessing climate change adaptation policies and measures and to facilitate incorporation of adaptation to climate change into a country's national development strategy.
UNEP. GEF. Assessment of impacts of and adaptation to climate change in multiple regions and sectors (AIACC)	Aims at enhancing scientific understanding and capacity in developing countries for continued research on climate change impacts, adaptation and vulnerability; strengthening networks for collaborative, interdisciplinary research; and providing input to IPCC work and into national communications. Includes 24 projects.
UNEP. India country case study: developing decision making tools for assessment of vulnerability to climate change	Supports the development and application of an integrated assessment of vulnerability to food insecurity, climate change risks and adaptation strategies to manage disaster risks, while promoting sustainable development.
UNDP. GEF China: targeted research related to climate change	Provides support to China for developing and enhancing its capacity in research areas of relevance to compliance with the UNFCCC, including those relating to identification of key vulnerabilities and adaptation to climate change.
World Bank. GEF. Caribbean Planning for Adaptation to Global Climate Change (CPACC)	Provides support to 10 Caribbean countries in their assessment of, and preparations to cope with, adverse effects of climate change, adaptation planning and capacity-building linked to adaptation planning. Assists the Government of St Vincent and the Grenadines with the formulation of its first national communication to the UNFCCC.
World Bank. GEF. Caribbean: Mainstreaming Adaptation to Climate Change (MACC)	Provides support to Caribbean Community (CARICOM) countries for creating an enabling environment for adaptation to climate change, building upon the Caribbean Planning for Adaptation to Global Climate Change (CPACC) project, as Stage II adaptation activity through support to: (i) the mainstreaming of climate change considerations into development planning and sectoral investment projects; (ii) appropriate technical and institutional response mechanisms for adaptation to global climate change; and (iii) regional climate change monitoring and modelling.

Box 6.5 Examples of international cooperation on adaptation *continued*

Activities and projects	Purpose and scope
United Nations Department of Economic and Social Affairs (UN/DESA). Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States	Programme of action relevant to adaptation to climate change. This includes survey and monitoring of climate change and sea-level rise; assessment of the effects and the socio-economic implications of the impact of climate change, climate variability and sea-level rise on small island developing States; and formulating comprehensive strategies and measures on adaptation to climate change.
WMO. Finland. Preparedness to Climate Variability and Global Change in Small Island Developing States	The overall objective of the programme is to provide tools for better planning for sustainable development in the Caribbean Region through strengthening the national meteorological systems in the regions so that they will provide the information needed for planning purposes at national and international levels. The project also supports countries in fulfilling their international commitments such as those of UNFCCC.
Bilateral and multilateral projects	
Australian Agency for International Development: South Pacific Adaptation and Vulnerability Initiative	Over seven years this initiative aims to build Pacific island country capacity to adapt to the future impact of extreme weather events and climate change and strengthen regional collaboration between key stakeholders.
Canadian International Development Agency (CIDA): Capacity Building Support for Adaptation to Climate Change in the Sahel	The main goal of this project is to support efforts by CILSS member countries to combat climate change by building the capacities of the AGRHYMET Centre (Regional Training Centre for Agrometeorology and Operational Hydrology and their Applications) to analyze vulnerability and develop adjustment strategies.
German development assistance: Climate Protection Programme for Developing Countries	This programme is carrying out a broad range of individual measures relating to the identification of climate change threats and capacity building to integrate climate in development. Partner countries get support to prepare and implement measures for adaptation.
The Netherlands: Netherlands Climate Change Studies Assistance Programme	Provides support for country studies consisting of technical and sectoral studies, including summaries for policy makers of national communications.
Swiss Organization for Development and Cooperation (SDC) in cooperation with IUCN: Climate Change, Vulnerable Communities and Adaptation	International research and policy initiative that seeks to strengthen the role of ecosystem management and restoration activities in reducing the vulnerability of communities to climate-related hazards and climate change.
United Kingdom Department for International Development (DFID): Improving the Response Options Developed Through the Millennium Ecosystem Assessment	The aim of this project is to gain a deeper understanding of the possible consequences of eco system changes and of the sources of resilience in an innovation. Climate Change adaptation is part of the scope of the study. For relevant decision-makers and public globally.
United States Agency for International Development (USAID): Climate Change Initiative (CCI) and follow up	To provide technical assistance to more than 40 field missions and central and regional offices of USAID. One emphasis of the initiative is on decreasing vulnerability of developing and transition countries to the threats posed by climate change.

bringing new or non-traditional expertise to the field, and studying climatic variability and extreme weather events.

The Asian Development Bank, Canada and New Zealand, for example, have been cooperating with the Governments of the Cook Islands and the Federal States of Micronesia on an integrated risk- and cost-benefit-based approach to adaptation, and the mainstreaming of adaptation. Canada and Australia are also helping other developing countries to enhance their capacities and to develop policy frameworks for adaptation.

Donors, both bilateral and multilateral are financing many other activities which, although not

specifically related to the Convention, are also helping developing countries adapt to climate change. Germany, the United States and the United Kingdom among others are incorporating climate considerations into current or planned activities and trying to ensure that their projects are resilient to climate change or take the associated risks into account. This includes projects involving policy advice, the creation of public awareness, as well as planning activities – whether long-term strategic development planning or mid-term sectoral planning in water management, for example, agriculture, forestry, ecosystem management, coastal zones or health care. The German Government's anti-poverty 'Action Programme 2015' also includes adaptation efforts – focusing on the links between climate change, natural resource management and economic development plans in six developing countries.

Donors are also taking climate change into account when helping developing countries prepare for and manage different types of disaster. USAID, for example, devotes $425 million per year on climate-related disaster preparedness, mitigation, and relief, including funds for watershed management, flood preparedness and response, and climate forecasting and research.

From reaction to adaptation

At the individual and community level, people have no option but to react to the immediate effects of climate change – by, for example, switching their crops, improving water management, moving their houses, or seeking alternative forms of employment. National strategies are more complex, however. Governments too often have to react to immediate crises, particularly extreme weather events, but they also have the responsibility to take a longer view – to assess what is likely to happen in the coming years or decades. This is hard to judge since existing climate models do not produce estimates sufficiently detailed at the national level. Focusing on adaptation is also particularly difficult in developing countries where budgets are tight and there may appear to be more pressing calls on government budgets – so for adaptation too, developing countries will have to rely on external support, and a number of funds have already been created. But if countries, poor or rich, are to invest more in climate change activities whether for mitigation or adaptation, they will have to carry public opinion with them. This is the subject of the next chapter.

Chapter 7

Involving the public

Climate change will affect everyone on the planet – so it is vital that everyone is aware of the risks of global warming and of the part they can play in averting its damaging effects. Thus far much of the credit for raising public awareness of climate change must go to NGOs – who have worked closely with concerned scientists at both national and international levels. But as climate change activities have become a more integral part of public policy, governments too have become keen to increase public understanding and participation.

All Parties… shall:

i) Promote and cooperate in education, training and public awareness related to climate change and encourage the widest participation in this process, including that of non-governmental organizations…

(Article 4.1)

Agenda 21, the action plan of the United Nations Conference on Environment and Development, emphasized this need for widespread public participation, and the Framework Convention on Climate Change reiterated this in Article 4, calling on all parties to cooperate in the education, training and awareness raising that would help people assess the issues and participate fully in decision making – whether through governments, community organizations or NGOs.

Article 6 of the Convention expands upon this by calling on all Parties to promote and facilitate these activities at the national, regional, and sub-regional levels and, where appropriate, through relevant international bodies (Figure 7.1). In 2002 the Conference of the Parties, in setting out the work programme on Article 6, called for the widest possible participation in climate change negotiations and greater involvement from youth.

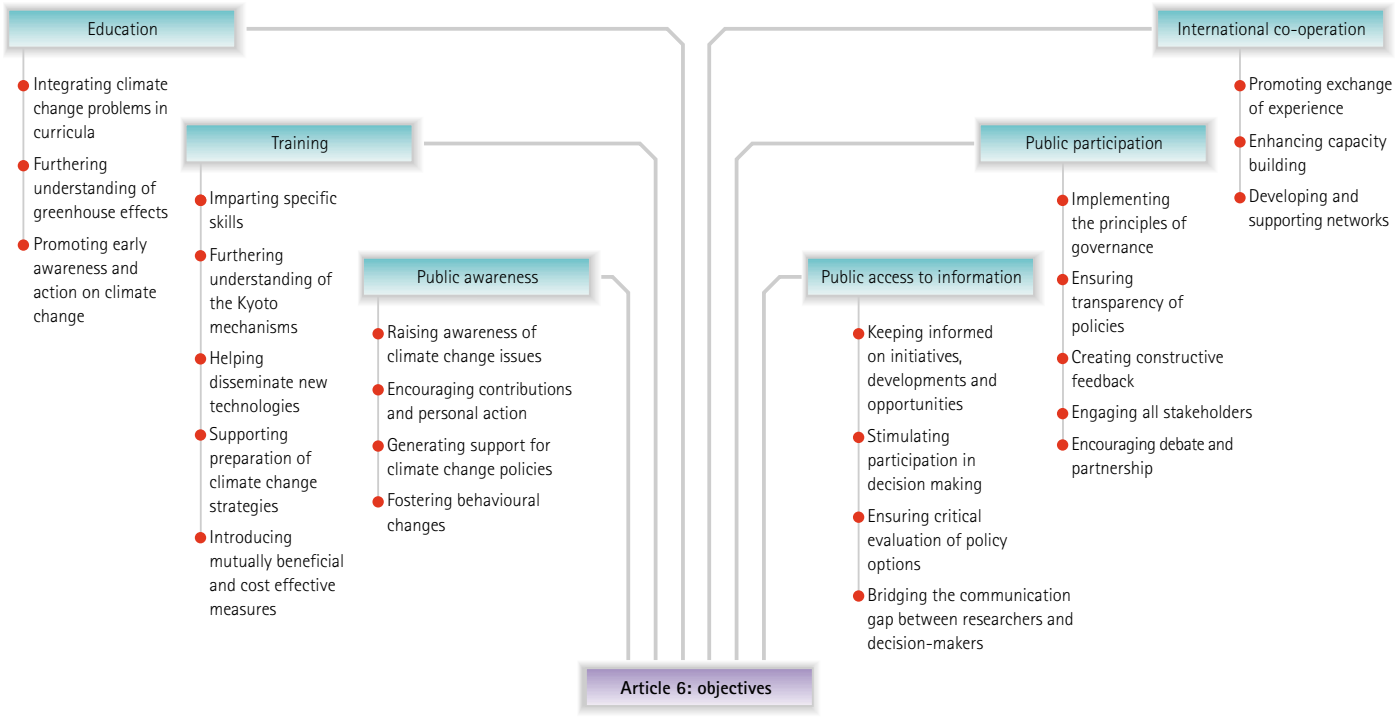
In response, governments all over the world have undertaken a variety of activities to inform and educate the public and they report that many more people are aware of the implications of climate change either on its own or as part of their more general concern for the environment. While levels of awareness vary from country to country they have increased over the decade since 1992, especially after 1997 and the signing of the Kyoto Protocol.

There have been five important overall achievements:

General awareness – Both policy makers and the general public are now better informed about climate change, both the scientific issues and the actions that can be taken to mitigate it.

Cooperation with stakeholders – Governments have been working with many stakeholders, including educators, environmental NGOs and business and industry groups.

Figure 7.1 The objectives of Article 6 of UNFCCC – promoting public participation



Community awareness – These and other groups have been working with communities to help them become more familiar with climatic issues – and the environmental, social and economic implications.

Public support – Climate change now ranks higher on the list of public priorities.

Personal action – Many more people have now been motivated to take personal action to reduce greenhouse gas emissions in the workplace and at home.

Much of this achievement has been the result of efforts by NGOs. Despite their limited resources, NGOs in both developed and developing countries have taken the lead in raising public awareness on climate change – gathering the latest information from climate change experts as well as through NGO networks and using this through their own campaigns and through the media to keep the issue at the forefront of public attention.

Government initiatives to raise public awareness

Governments too have been playing a major role. Some of their options are indicated in Figure 7.2. Governments and scientific bodies can, for example, initiate public information campaigns directly through advertising campaigns, or they can prepare information kits that explain the overall issues while offering tips for individual action. Ministries of the environment in most developed countries now have web sites that provide basic information on climate change, along with important documents, key contacts and links to relevant government departments and to other organizations active in national climate change programmes.

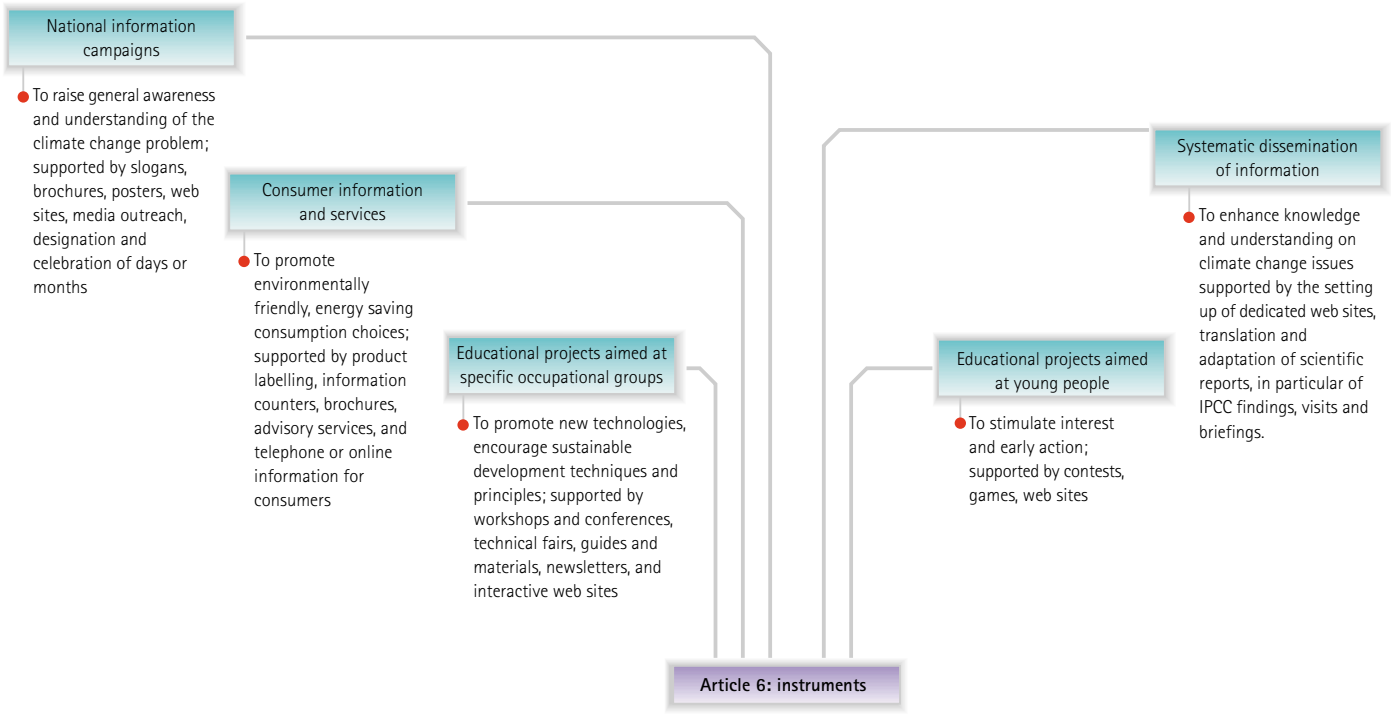
Governments have also established partnerships with media networks. In some cases they use these to broadcast success stories and make public service announcements – but they can also provide the necessary information to journalists who can write articles and prepare TV programmes that explain the issues in a direct and popular fashion.

At the same time governments can also target information at specific groups – from schoolchildren, to engineers, to farmers.

Students and teachers

Students and teachers are a key audience for climate change activities. Not only can they learn about the issues themselves, they can also pass this knowledge on to a wider audience. Many environment ministries and education ministries have already introduced materials related to climate change into the curricula

Figure 7.2 Ways of raising awareness on climate change



of primary and secondary schools, and others are proposing to do so. Some of this work also takes place internationally: the United States, for example, supports climate change education in developing countries by offering scholarships for secondary school students.

Universities too are playing an active part and some offer climate-change courses that can lead to degrees and diplomas. The University of Copenhagen in Denmark, for example, and the University of the West Indies in Barbados offer climate change as a central theme for study at the doctoral level.

Training materials for industry

Governments and other organizations can publish manuals and other training materials to help industries, especially those that are energy intensive, to develop climate-friendly strategies.

Education and awareness in the transport sector

One of the largest greenhouse gas emitters is the transport sector. Planners, civil engineers and other professionals need to be stimulated to think beyond what is normally taught in schools of planning or civil engineering and introduce new approaches to climate-friendly transport.

The automobile industry too has an important role to play in designing and manufacturing more appropriate vehicles. Many have also been working with governments and automobile associations, and for new vehicles they have introduced voluntary labelling programmes that provide information on both fuel efficiency and carbon dioxide emissions.

Energy ratings for buildings

A useful way of getting climate change ideas across is when rating new or existing homes for energy efficiency. The United States, for example, issues an 'Energy Star' label for homes; those awarded this rating on average achieve energy savings 35% greater than those set out in the national Model Energy Code. The Government also provides information and training for architects and builders and encourages owners or occupiers to improve the energy efficiency of their homes by offering free 'energy audits' along with appropriate information and advice. These activities augment fiscal and other measures such as direct grants, relief from income tax, and reduced rates of purchase tax on equipment and services that improve efficiency.

Influencing consumer behaviour

Governments have been trying to make consumers aware of the energy performance of appliances, particularly heating and cooling systems, and have also advised people on other ways to move towards lifestyles that consume less energy. Japan's innovative public education campaigns, for example, encourage consumers to re-use shopping bags, reduce thermostat settings and pack refrigerators more efficiently.

Businesses too have taken initiatives to alert both individual customers and their business partners of the climate change implications of consumption. In the Netherlands, for example, Businessforclimate, among other activities, offers a carbon dioxide meter

that allows business to calculate their emissions and express them in terms of trees. The German company '550ppm' offers software that calculates for customers the emissions associated with a particular product and enables customers to offset this by purchasing 'emission reduction benefits' generated by companies whose activities reduce greenhouse gas emissions.

Influencing farmers

Developed countries have also been informing and educating farmers on more sustainable agricultural practices and ways to reduce emissions of both carbon dioxide and nitrous oxide. Australia and Switzerland, for example, have provided information on ecological farming practices. Belgium, Germany, Estonia and Greece have been promoting organic farming, while Canada has taken initiatives on agricultural environmental stewardship. Hungary and the Russian Federation have programmes for environmental agriculture; Bulgaria and Lithuania have codes of practice for agriculture while New Zealand has one for the use of fertilizers. The United States provides nutrient management tools.

Farmers can also influence carbon storage in soils. They can, for example, cease tilling the soil and use organic farming methods and fertilizers. Canada, for example, is promoting 'no-tillage' regimes and provides farmers with the necessary information and support. As a result, by 2010 Canada expects its soils to have switched from being net sources of emissions to net carbon sinks. In the United States agricultural soils already offset 2% of total annual greenhouse gas emissions – of which 56,000 tons are removed annually by keeping environmentally sensitive farmland from production.

Waste management

In addition to promoting more efficient waste management through regulations and taxation, a number of countries have engaged in education and training activities for both businesses and consumers. Sweden, for example, has a public education programme and Japan promotes the use of recycled products.

Encouraging public participation

At the same time as providing information on climate change both NGOs and governments have been making efforts to encourage greater public participation (Figure 7.3). Thus most governments have been undertaking public consultations on their action plans or on domestic policy options, or on the ratification of the Kyoto Protocol. Local governments too, many of whom are committed to reducing emissions within their own areas, have invited public

Figure 7.3 Encouraging public participation

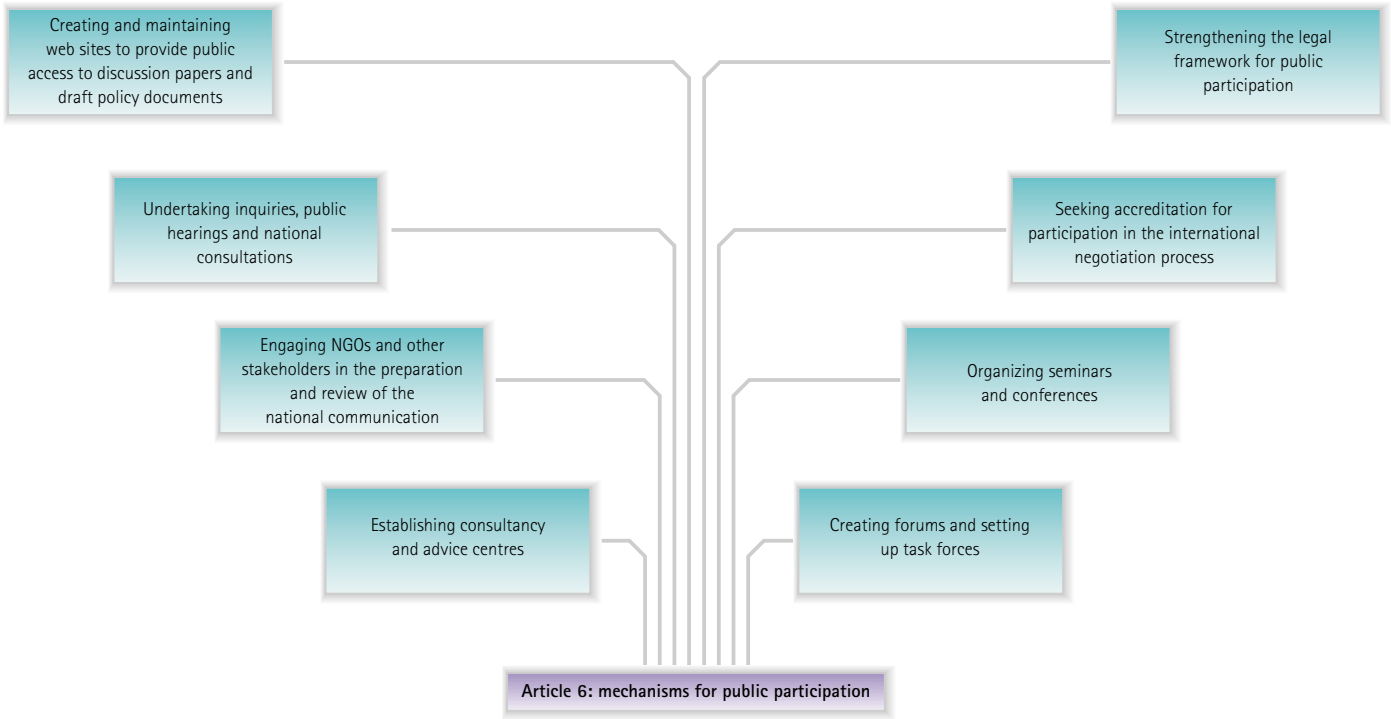
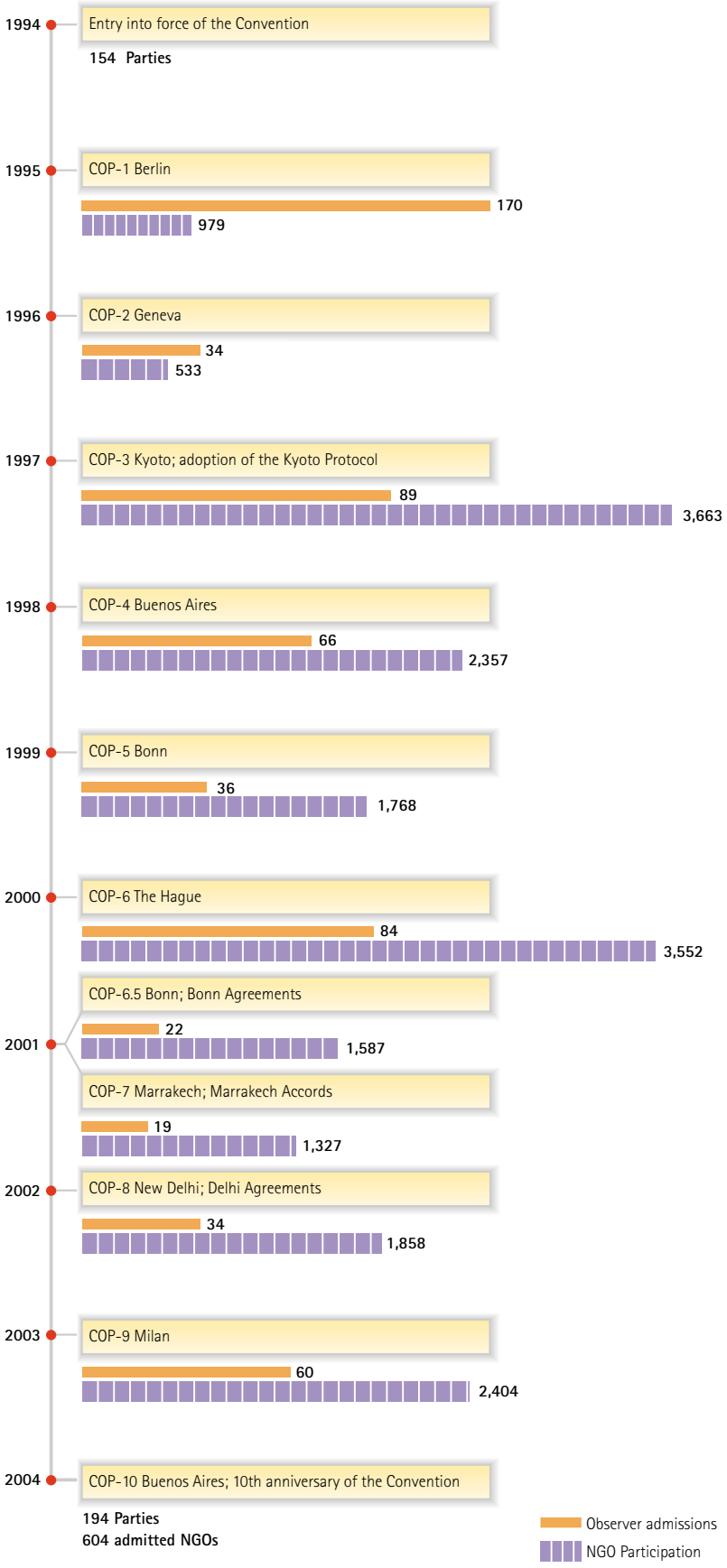


Figure 7.4 Participation of NGOs in UNFCCC events



consultations on policies related to climate change and on allocations of public funds.

At the local and national level there are many potential channels for public participation. These include:

Environmental NGOs (ENGOs) – As well as running campaigns at the local and national levels ENGOs have also played a major role in intergovernmental processes.

Research-oriented independent NGOs (RINGOs) – These are scientists and researchers who act of sources of independent scientific information for discussion in the Convention's subsidiary bodies and emphasize the role of research and science in the negotiations.

Business and industry organizations (BINGOs) – These represent the business lobby at intergovernmental activities.

Indigenous people's organizations (IPOs) – Indigenous peoples have spiritual and socio-cultural relationships to their lands, many of which will be vulnerable to climate change. Since 2001, these organizations have been acknowledged as a constituency in climate change negotiations.

Local governments – As well as engaging with their own constituencies and with national governments, some local and municipal authorities have attended Conferences of the Parties and made statements, generally through Mayors of larger cities.

These five constituencies cover a variety of interests but there are also many other lobbying groups, representing parliamentarians, for example, trades unions, faith groups, women and youth, who have participated at UNFCCC events (Figure 7.4).

Article 6 of the Convention also emphasizes the importance of intergovernmental organizations (IGOs), not just for providing financial and technical support but also in collecting and disseminating information on climate change. Organizations such as UNEP, UNDP, UNESCO and the United Nations Institute for Training and Research (UNITAR) have carried out needs assessments for both institutional and human resource capacity building, for example, and have been supporting capacity building and training in a number of developing countries. UNITAR has also developed training packages on vulnerability and adaptation and on greenhouse gas abatement.

From concern to experience

Relatively few people nowadays are unaware at least in outline of the potential hazards of climate change. So far, they have got most of their information through the media – from radio or TV programmes, or press articles or blockbuster Hollywood movies. Even so, the prospects and the implications can appear remote from everyday life. That is likely to change in the years ahead as governments issue new climate-related regulations and manufacturers advertise more climate-friendly products. Dealing with climate change will thus steadily evolve from an abstract concern to a lived experience. One of the most important drivers for this change will be the Climate Change Convention – and particularly the Kyoto Protocol, which is considered in the following chapter.

Chapter 8

Strengthening efforts – the Kyoto Protocol

In the ten years since it entered into force the United Nations Framework Convention on Climate Change has laid the groundwork for concerted international action. It was not until 1997, however, with the signing of the Kyoto Protocol, that this commitment hardened to more specific time-bound targets. As well as setting these goals the Protocol also offers a number of innovative mechanisms that can help Parties achieve them: the Clean Development Mechanism, joint implementation and emissions trading – mechanisms that, to some extent, are already working even before the Protocol has entered into force.

ALL THE NEWS WITHOUT FEAR OR FAVOR

The Japan Times

Friday, December 12, 1997

1st EDITION ¥160

Conference adopts Kyoto Protocol

Greenhouse gas emissions to be cut by average of 5.2%

KYOTO COP3

Kyoto convention's success open to debate

Gist of Kyoto Protocol

TODAY

The Conference of the Parties may… adopt protocols to the Convention.

(Article 17.1)

The Convention was the first historic step in a global effort to halt the growth of greenhouse gas emissions. However, it lacked specific quantitative targets and firm timelines for achieving tangible emission reductions. Parties to the Convention felt a need to strengthen the commitments, to build on the momentum created by a rapidly developing climate change process, and to capitalize on its achievements.

After the Convention had been in force for one year it was clear that most industrialized countries had yet to take sufficient action. The first Conference of the Parties in 1995, through the 'Berlin Mandate', called therefore for greater efforts, recognizing that commitments of developed countries under the Convention were "not adequate" and agreeing to "*take appropriate action beyond 2000, including the strengthening of the commitments of Annex I Parties … through the adoption of a protocol or another legal instrument*". The Berlin Mandate also specified that the negotiation process should "*not introduce any new commitments*" for developing countries but reiterated the need to continue to advance the implementation of their existing commitments. The two years of negotiations resulted in 1997 in the signing of the Kyoto Protocol. This, as further developed in the 2001 Marrakech Accords, required the industrialized countries to meet specific targets and establish a robust system for monitoring their activities.

Overall, under the Kyoto Protocol in the first commitment period developed countries have to reduce emissions of the "basket" of the six greenhouse gases by at least 5% cent compared to the 1990 level. Individual targets are differentiated: the majority should reduce their emissions – Hungary, Japan and Poland by 6%, US by 7% and the European Community as a whole by 8%. Later the EC approved an internal distribution of targets for its members. New Zealand, Russian Federation and Ukraine should not exceed their 1990 levels, whereas for Australia, Iceland and Norway the targets are set at, respectively, 8%, 10% and 1% above the 1990 level (Box 8.1). Not all countries listed in Annex I were Parties to the Convention in 1997, when the targets were set, and for that reason Belarus and Turkey, for example, were not assigned targets under the Protocol.

Adoption of the Kyoto Protocol with its legally binding targets is a clear indication that developed countries are determined to take the lead in modifying longer-term trends in anthropogenic

emissions (Article 2 (a)). The Protocol is an important block in the emerging international climate regime. Through its impact on technology innovation, efficiency standards and behavioural changes, especially in the energy and transport sectors, it could contribute to reshaping the world economy in the 21st century. It could thus help many countries to move towards sustainable production and consumption patterns. In that sense, the Protocol can also be seen as a potentially powerful economic instrument.

As a recognition of the need to make the next steps on the way to achieving the ultimate objective of the Convention the Protocol contains provisions for a periodic review of commitments. Parties agreed to demonstrate progress achieved by 2005 in order to show where they stand in meeting the targets set for the first commitment period 2008–2012. It is difficult to foresee how the commitments beyond 2012 may look like. Parties are yet to agree on the scope and the timeline for these future commitments. Progress in the first period would certainly make it easier to accept more challenging targets for the future.

The Kyoto Protocol will only be effective if the Parties comply with their commitments, have the means to verify compliance and also use reliable emissions data. The Protocol, together with the 2001 Marrakech Accords, includes a set of compliance and monitoring procedures that are designed to enforce the Protocol's rules, address any compliance problems, and reduce the chances of calculation or accounting errors.

The Protocol's procedures for reporting and review are based on those of the Convention – and on the experience of a decade of activities under the climate change process. They stipulate, for example, that Annex I Parties have to set up national systems and methodologies for the preparation of greenhouse gas inventories. Parties must also estimate emissions from various sources as well as their removals by sinks – using methodologies developed by the Intergovernmental Panel on Climate Change. In addition they have to provide 'supplementary' information to demonstrate their compliance with the Protocol. These and other reports are then reviewed by expert teams who identify any compliance problems.

The compliance system is among the most comprehensive and rigorous systems to be found in international treaties. The Compliance Committee, to be established under the Protocol, will be charged with resolving potential disputes. Its main thrust is to be a facilitative rather than a "punitive" body (Box 8.2).

Box 8.1 Quantitative targets under the Kyoto Protocol

Party	Kyoto Protocol emissions target (% to the base year level of GHG emissions)	Emission target under the EC agreement (% to the base year level of GHG emissions)
Australia	+8	–
Austria	–8	–13
Belgium	–8	–7.5
Bulgaria*	–8	–
Canada	–6	–
Croatia*	–5	–
Czech Republic*	–8	–
Denmark	–8	–21
Estonia*	–8	–
European Community	–8	–
Finland	–8	0
France	–8	0
Germany	–8	–21
Greece	–8	+25
Hungary*	–6	–
Iceland	+10	–
Ireland	–8	+13
Italy	–8	–6.5
Japan	–6	–
Latvia*	–8	–
Liechtenstein	–8	–
Lithuania*	–8	–
Luxembourg	–8	–28
Monaco	–8	–
Netherlands	–8	–6
New Zealand	0	–
Norway	+1	–
Poland*	–6	–
Portugal	–8	+27
Romania*	–8	–
Russian Federation*	0	–
Slovakia*	–8	–
Slovenia*	–8	–
Spain	–8	+15
Sweden	–8	+4
Switzerland	–8	–
Ukraine*	0	–
United Kingdom of Great Britain and Northern Ireland	–8	–12.5
United States of America	–7	–

** Countries that are undergoing the process of transition to a market economy.*

Sources: Annex B to the Kyoto Protocol and "Preparing for Implementation of the Kyoto Protocol", European Commission Communication to the Council and the Parliament, COM(1999) 230, 19 May 1999.

Box 8.2 Compliance under the Kyoto Protocol

The Compliance Committee will consist of two branches: a *Facilitative Branch* and an *Enforcement Branch*. The former would provide advice and assistance to Parties in order to promote compliance, whereas the latter will have the power to determine consequences for Parties that encounter problems with meeting their commitments. Both branches will be composed of 10 members, including one representative from each of the five geographic regions – Africa, Asia, Latin America and the Caribbean, Central and Eastern Europe, and Western Europe and Others, one from the small island developing states, and two each from Annex I and non-Annex I Parties. If consensus were not possible, decisions of the Facilitative Branch would require a three-quarters majority, whereas decisions of the Enforcement Branch would require, in addition, a double majority of votes from both Annex I and non-Annex I Parties. The Committee will also meet in a *Plenary meeting* with participation of the members of both branches, assisted by the *Bureau*, which will consist of the chairs and vice-chairs of each branch.

Each branch has its own area of responsibilities. The requirement that the use of the flexibility mechanisms be supplemental to domestic action, for example, falls under the purview of the Facilitative Branch, as is the commitment of Annex I Parties to strive to minimize adverse impacts of their actions on developing countries. The Facilitative Branch also provides an "early-warning" if a Party seems to have problems with meeting its emission targets. In response to these problems, the Facilitative Branch can make specific recommendations and also mobilize financial and technical resources to help Parties comply.

The Enforcement Branch, for its part, is responsible for determining whether an Annex I Party is complying or not with its emission target or reporting requirements. It can also decide whether to adjust a Party's inventory, in the event of a dispute between a Party and the expert review team on the quality or completeness of the greenhouse gas inventory data. Consequences for failing to meet an emission target include: deduction of emissions at a rate of 1.3 times the amount of the excess emissions from the Party's target for the second commitment period; suspension from eligibility to sell credits and the request to prepare a *compliance action plan* detailing the action the Party intends to take to meet its target in the next commitment period. Any Party not complying with reporting requirements must develop a similar plan and Parties that are found not to meet certain criteria will be banned from participating in the flexibility mechanisms. There are no financial penalties or "automatic" consequences envisaged at this stage and an appeal procedures are in place.

The Compliance Committee will base its decisions on reports from expert review teams, deliberations of the subsidiary bodies, submissions from Parties and other official sources. Competent intergovernmental and non-governmental organizations may submit factual and technical information to the relevant branch. If a Party believes that it was denied due process it can appeal against a final decision of the Committee to the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol only in the case of decisions of the Enforcement Branch relating to the emissions target.

Achieving Kyoto targets in the agreed timeframe will be not an easy task for many countries. Australia and the United States have already announced that they will not ratify the Protocol out of concerns that actions to meet the targets to which they agreed in Kyoto could be onerous. The Protocol, recognizing that the quantified emissions targets are tough and that some countries may face difficulties in implementing domestic policies to meet them, introduced three mechanisms that allow them to benefit from actions outside their national borders. They are frequently called the "flexibility" mechanisms: the Clean Development Mechanism (CDM), joint implementation (JI), and emissions trading. These mechanisms are discussed below.

The Clean Development Mechanism

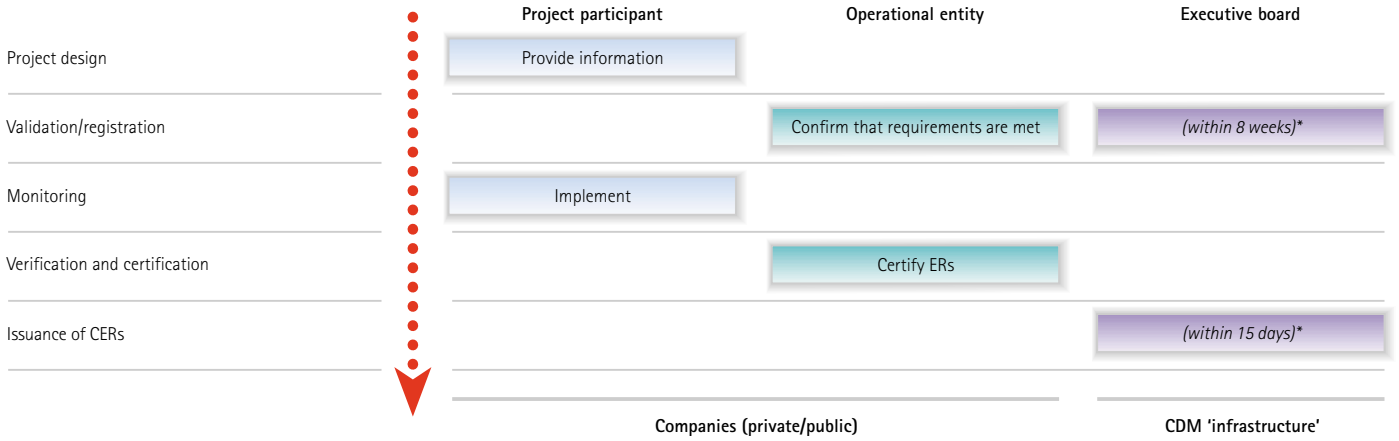
The CDM was the surprise of Kyoto. It is designed as an element of the sustainable development strategy allowing industrialized countries investing in "clean" projects in developing countries also to gain emissions credits. These credits are given in the form of certified emission reductions (CERs) which, like all the other Kyoto accounting units, are expressed in tons of carbon dioxide equivalent. The financing country can use these units to offset its own emissions of greenhouse gases during a given period, or sell them to another country. It can also bank them for use during a subsequent period. Since these investments are viewed in a positive light they also add to the reputations of project developers and investors. At the same time the recipient country gains from an increase in investment – which may be from private or public sources – in sustainable development.

This is very much a bottom-up approach: anyone can propose a CDM project (the CDM governance is explained in Box 8.3). Their proposal will be accepted if it is environmentally sound, satisfies the CDM Executive Board and meets the host country's criteria for sustainable development. The only exceptions are nuclear energy projects for which it is not possible to gain CERs. Another benefit of the CDM is that it can also help the most vulnerable developing countries through the Adaptation Fund to be established under the Protocol: 2% of the proceeds of each project are contributed to this Fund, though the least developed countries are exempt from this requirement.

The CDM Executive Board

Since its institution in 2001, the CDM's Executive Board has been working well and has received positive feedback from the annual Conference of

Figure 8.1 The CDM project cycle: roles and responsibilities



*an automatic step unless a review is requested

the Parties. Within a year of the Marrakech Accords, the Board has established its procedural guidelines and approved the first set of baselines and monitoring methodologies. This was a remarkable achievement as a decade-long debate about practical approaches to determining baselines could not produce tangible results. By now, more than 60 such methodologies have been received of which well over a dozen have been cleared for use by projects across a wide range of sectors. This experience also serves now as a basis for consolidating these methodologies in order to streamline the process while ensuring the integrity of the system. For smaller-scale projects the Board has also been able to approve 14 simpler methodologies that can reduce development time and transaction costs.

In addition, the Board serves as an accreditation body for companies that wish to become 'designated operational entities' (DOEs) –

Box 8.3 The governance of the Clean Development Mechanism

The CDM is a unique and dynamic mechanism that does not fit into conventional schemes of official development assistance in that it enables the private sector to come up with ideas and projects and with opportunities for investment. It thus needs a responsive and quick-acting system of governance.

At present the CDM functions under the authority of the Conference the Parties (COP). When the Protocol has entered into force, however, the Conference of the Parties meeting as the Meeting of the Parties to the Protocol (COP/MOP) will assume this role.

For everyday operations, the CDM is supervised by an Executive Board which comprises 10 members (and 10 alternates). Elected by the COP, four are from Annex I Parties and six from non-Annex I Parties. Members function in their personal capacity, take an oath of service and must disclose any conflicts of interest. Meetings and documents of the Board are public and are broadcast through a live web-cast, unless the Board is considering a confidential matter.

The main functions of the Board are to approve methodologies for baselines and monitoring, to register projects and to issue credits. In addition, it serves as an accreditation body for 'designated operational entities' (DOEs) – companies which at the global level are permitted to validate and request the registration of projects, to verify and certify resulting emission reductions or removals and accordingly request the issuance of CERs. The DOEs, as part of the CDM infrastructure, serve as the 'extended arm' of the Board and play an important role in helping to speed up the process and avoid bottlenecks.

The Board also draws on expert panels and groups– through a ten-member Methodologies Panel and a five-member Accreditation Panel as well as through working groups on afforestation and reforestation and on issues related to small-scale projects. The Board can also consult additional experts for tasks requiring specialized input.

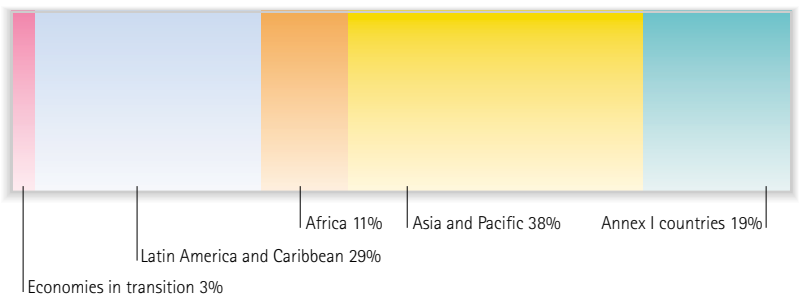
There are also opportunities for public input. This is not only essential to ensure transparency but also provides valuable additional expertise. The Board seeks public input on each methodology and on each applicant entity as well as for each proposed project.

If a strong market materializes for CERs, the administrative expenses of the CDM will be met from a share of the proceeds – at rates that can be determined once operating costs and the value of the CERs have been established. Until then, some Parties have agreed to make voluntary contributions, and part of the costs are recovered through fees levied for case-specific work, such as for accreditation and registration of projects, at levels which depend on the project's size.

qualified to validate projects and verify and certify emission reductions, as provided for in Article 12 of the Kyoto Protocol. So far, the Board has accredited, and provisionally designated, four companies that can thus now work as its 'extended arms'. Another 21 companies, five of them in developing countries, are at various stages of the accreditation process.

Within a year after approving the first methodologies, requests for registering projects started to arrive. More than 30 potential CDM projects are now at an advanced stage of preparation, having completed the phase where they have been put up for public comment. If the DOEs involved in these projects soon validate them, further requests for registration can be expected soon. Once a DOE has validated a project, registration by the CDM Executive Board is automatic after eight weeks – or four weeks in the case of small-scale projects – unless there are objections from at least three Board members or a Party involved in the project.

Figure 8.2 Distribution of designated national authorities



CDM project activities will generate a significant number of certified emission reductions (CERs) – especially for projects that are eligible for credits retroactively. Once monitoring requirements are satisfied CERs are issued into accounts of Parties in the CDM registry. This registry will be operational before the end of 2004. Thus, credits could be logged properly, as agreed among the project partners, and may eventually be used to meet the Kyoto Protocol targets.

The CDM has generated an enormous amount of interest and engagement from businesses and project developers. National governments too have been enthusiastic and more than 60 have now created 'designated national authorities' (DNAs) which are needed to participate in the CDM. The distribution of these national authorities around the world is indicated in Figure 8.2.

The CDM Executive Board has tried to make the processes open and transparent and, apart from agenda items that require confidentiality, it holds its meetings in public and broadcasts them live over the web. Corresponding videos and documentation are also available on the web site along with an archive of the UNFCCC's CDM news facility. The Board and the secretariat frequently issue calls for participation from the public as well as from experts.

The CDM has thus made good progress within a short period. Ultimately, however, it must be judged by the quality of the projects and whether they are meeting a sizeable demand.

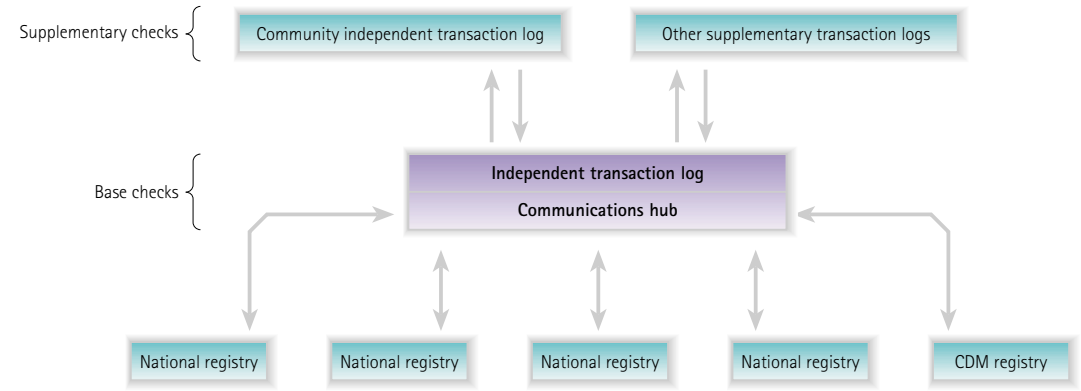
Joint implementation under the Kyoto Protocol

The second project-based mechanism – joint implementation – works in a fashion similar to the Clean Development Mechanism, except that in this case both countries are Annex I Parties having emissions targets under the Protocol.

There are two ways in which the projects can be carried out. 'Track 1' is for countries that have effective accounting systems in place, with reliable inventories and registries. In this case, as long as the national guidelines and rules on project activities are transparent, credits can be transferred, as of 2008, without any international supervision.

'Track 2' is for countries that cannot meet these requirements – or if the countries involved simply prefer this option and adopt it as their national guideline under 'Track 1'. In this case, the activity is to be supervised by an international body, the Article 6 Supervisory Committee, which functions rather like the CDM Executive Board,

Figure 8.3 Registry systems under the Kyoto Protocol



National registries and the CDM registry are electronically linked to the international transaction log which is also linked to other logs operated by countries that want to carry out supplementary checks.

albeit with a lighter hand. Again the Committee, which is supported by the Convention secretariat, can accredit companies to act on its behalf – as 'accredited independent entities' – to make determinations on project activities and emission reductions.

JI projects, with the corresponding exchange of units, cannot start until the Protocol entered into force. Countries interested in this mechanism build on considerable work undertaken during the pilot phase of 'activities implemented jointly' (AIJ) under the Convention. Since 1995 there have been a number of AIJ projects and programmes in many sectors and regions. Those involved – in host and investor countries and at the international level – have been able to gain experience in operating a project-based mechanism. They have learned how to establish baselines and monitor regimes and how to assess socio-economic and environmental impacts. They have also benefited from setting up the appropriate institutional structures, developing project documents to international standards and negotiating with commercial interests.

Emissions trading

The principles for emissions trading were established in the Marrakech Accords, whose rulebook determines the Parties that are eligible, the units they can trade, and the reserves that they have to keep. In fact, some – the European Union, Canada and Japan – have already been developing their own trading systems along these lines. The EU will launch its system (EU-ETS) on 1 January 2005; CDM credits can be fed into this system from the outset, and JI credits from 2008. A fully fledged Kyoto-based trading system, with the appropriate systems of registration, is thus about to be launched even before the Protocol itself enters into force.

Setting up registry systems

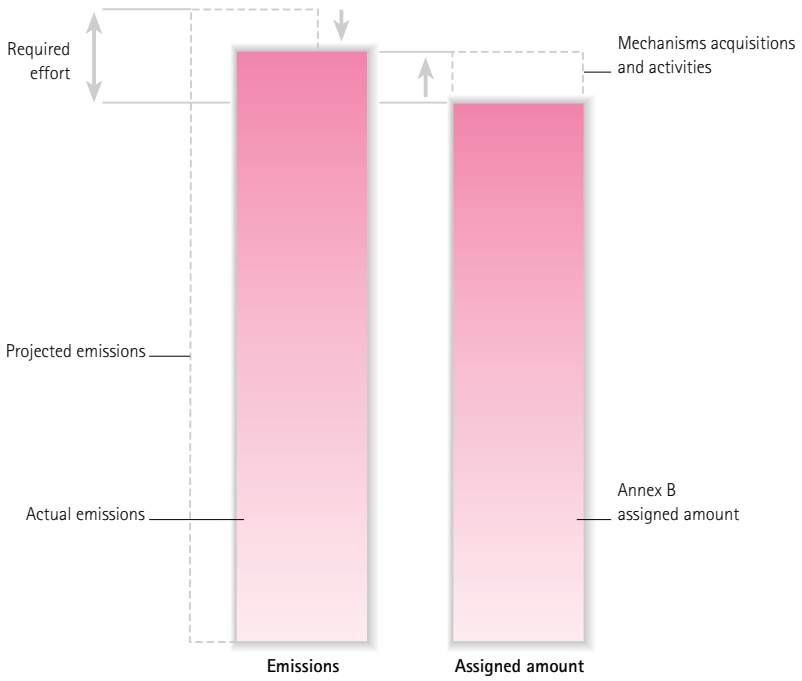
The cornerstones for proper accounting under the Kyoto Protocol are the registry systems. Each Party with targets has to establish a national registry – an electronic database, with accounts for both the government and private businesses, that records all movements of credits, whether as a result of emissions trading or of CDM or JI projects. These registries can then be linked to allow transfers across international borders. The buying country can use these units to help it comply with the Protocol.

The role of transaction logs

The secretariat is establishing an international transaction log linked to national registries (Figure 8.3) which will be ready in 2005. The 'base checks' in this log will verify that all transactions comply with the rules. In addition, groups of countries can also establish supplementary transaction logs to conduct further checks on transactions involving their registries. At present, the only such log under development is the 'Community Independent Transaction Log' of the European Union.

To ensure compatibility, all these registries will need to conform to the common data exchange standards before they are initialized. These standards, which have been developed by the UNFCCC secretariat in collaboration with developers of national registries, include coordinated transaction and reconciliation processes as well as the common data formats and security mechanisms. The systems will also need to keep pace with technological advances and ensure high security standards. For this purpose, registry administrators can join a forum through which they can co-operate in the operation of the network.

Figure 8.4 Required effort by industrialized countries



Kyoto market dynamics

The basic elements of the Kyoto Protocol trading system have now been established, but many questions remain, particularly about the likely size of the carbon market over the period 2008–12. This will depend on a number of factors, notably the level of future emissions and the 'required effort' to meet the Kyoto targets, also termed the 'Kyoto gap'. The number of units available for trading will depend too on the number of CDM and JI credits generated. Also important will be the approach taken by countries that have surplus allowances: will an EIT country, for example, trade these units or instead bank them to meet its own future compliance commitments?

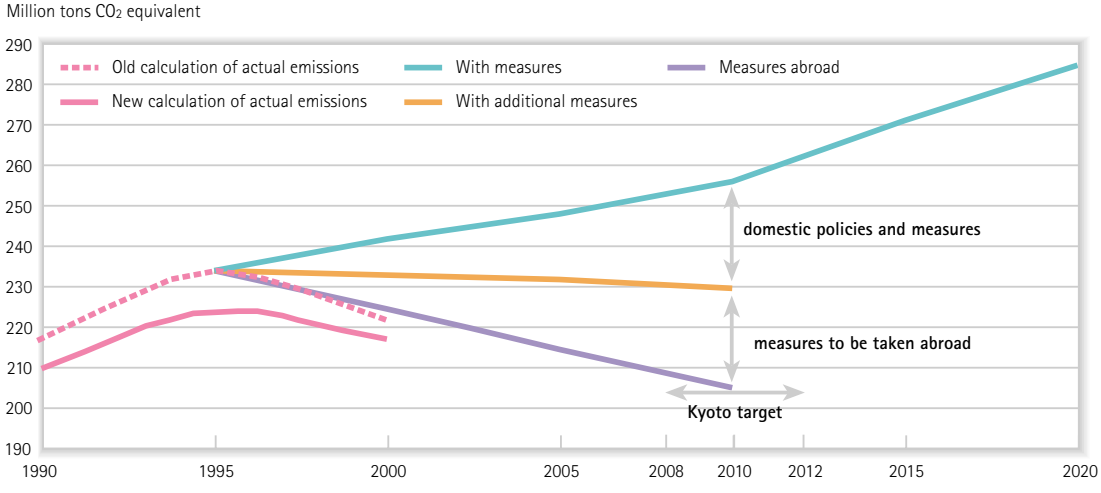
The Annex I countries that have ratified the Kyoto Protocol can meet their obligations through a variety of means. First they can take domestic action to bring their projected emissions below the business-as-usual projections. If this is not enough they will have to either increase their removal of greenhouse gases from the atmosphere by forest management, for example, or by acquiring units – through CDM, JI or trading. The 'required effort' to achieve compliance is illustrated in Figure 8.4.

Since the Protocol was adopted in 1997, there has been substantial progress, notably through the 2001 Marrakech Accords which have become the basis for ratification by a significant number countries. The Conference of the Parties has also furthered the implementation of the Protocol and taken the CDM under its authority, so that when the Protocol is ratified the entire system can start to operate immediately.

To date 124 countries have ratified and are readying themselves for when the Protocol comes into force – while also anticipating the needs beyond 2012. The wave of ratifications in the lead up to the 2002 World Summit on Sustainable Development in Johannesburg demonstrated the importance of the Kyoto Protocol as a symbol of multilateral cooperation on climate change and sustainable development – and of the potential for markets to contribute to equitable solutions.

Even at this stage, however, it is clear that different countries are aiming to meet their Kyoto targets in their own ways according to national

Figure 8.5 Netherlands: the potential for using Kyoto mechanisms



circumstances and opportunities. Some intend to use most of the Protocol's mechanisms. The Netherlands, for example, plans to use domestic policies to achieve half its emissions reductions and use the Kyoto mechanisms for the other half (Figure 8.5).

Norway too, while expecting to achieve the bulk of its reductions through domestic policies and measures, will make up the rest through the market mechanisms. Denmark will use a similar combination, but determine the balance according to costs – using domestic reductions until the price reaches a threshold of DKRr120 (€16) per ton of carbon dioxide and covering the rest through the Kyoto mechanisms and the EU Emissions Trading Scheme. Canada and New Zealand also intend to use the Kyoto mechanisms and anticipate that a significant contribution to meeting their targets will come from removals through land use change and forestry. Australia too sees this as important, though it does not intend to ratify the Protocol.

Conversely, other countries such as Sweden, plan very limited use of the Kyoto mechanisms and intend to meet the target almost entirely from domestic reductions. France, for example, intends to make use of green taxes. Some countries have also set domestic sub-targets: thus, Japan has an overall reduction target of 6% but has translated this into a reduction of 7% for industry, and 2% for the residential and commercial sectors while allowing emissions from the transport sector to grow by 17%.

Parties recognize too that the Kyoto targets are only the first step towards continued and long-term reductions in emissions, and that the situation will continue to develop as technology evolves and as capital and other markets respond to the signals from national and international policy on climate change. A number of European countries have already set more ambitious targets for the longer term. The United Kingdom, for example, announced in 2004 that its plans for the energy supply system would result in reductions in emissions of 60% by 2050.

Other countries have emission reduction targets, though not within the Protocol. The United States announced a target for the subsequent decade of an 18% reduction in carbon intensities, to be achieved through a combination of measures; some voluntary and incentive based, some mandatory.

If they are to achieve their Kyoto objectives the richer industrialized countries will need to make major efforts. Most EIT countries on the other hand believe that they will be able to hit their targets relatively easily. This is mainly because the base year of 1990 represented a high point in industrial emissions and since then many of the heavy industries that gave rise to that pollution have collapsed or retrenched and most countries have reformed their energy markets and increased energy efficiency. As a result they should not only be able to meet their targets but do so by a sufficiently large margin to allow them to sell some of their allowances and swap others through joint implementation projects.

Both the highly industrialized and the EIT countries, in addition to orienting themselves towards their targets have also started to strengthen their institutions so that they can conform to the Kyoto Protocol's more stringent requirements. They have been coordinating the climate change activities of different government departments – ministries of energy and economic affairs, for example, along with those of transport, agriculture and forestry. They have also been bringing in different levels of government – regional, local and municipal – and in some cases delegating to them specific aspects of climate change policy, such as those related to territorial planning, buildings management, energy conservation, transportation or waste. At the same time both central and regional governments have been making greater efforts to involve stakeholders and target groups.

Indeed in some countries, when it comes to comprehensive plans and action programmes it is regional governments that take the lead – pursuing more rigorous approaches to climate change than the central government. This is evident in the United States. New Jersey and Oregon were the first states to commit themselves to reducing greenhouse gas emissions. Massachusetts and New Hampshire have also introduced a cap on emissions

for energy suppliers along with a permit trading system – and more recently governors of 10 north-eastern states have pledged to join a regional cap-and-trade programme. But probably the most noteworthy example is California. The state's 'Renewable Portfolio Standard' (RPS) requires sellers of electricity to increase their use of renewable energy by 1% per year, and in 2002 the legislature required the state's Air Resources Board to set a standard for the greenhouse gas emissions from passenger vehicles and light trucks; in June 2004 the Board proposed a 30% reduction to be phased in 2009 and 2014. In all, 37 states now have their own greenhouse gas inventories. Australian states too have proposed emission reductions: New South Wales adopted legislation for carbon trading as early as 1996, but actual trading can only take off if the central Government establishes binding emission targets.

Box 8.4 The EU Emissions Trading Scheme

The European Commission in 2003 issued a Directive setting out a framework for Member States to allocate tradable emissions allowances to enterprises on their territories and to initiate trading of such allowances. The allowances will be distributed to energy installations with a rated input greater than 20 MW, plus installations greater than a certain size in the steel, minerals and paper industries. The EU Emissions Trading Scheme (EU ETS) is expected to cover 45% to 50% of the EU's total carbon dioxide emissions and is set to create the world's largest mandatory greenhouse gas emissions trading scheme.

The scheme's design takes advantage of the experience with existing trading schemes but also adds a number of innovations. Most climate policy analysts view this as an impressive development but still have some concerns – about equity, enforcement and efficiency. One problem is that some of the 25 EU member states may not have the capacity to apply the system effectively – lacking some of the necessary institutions and also accurate information about greenhouse gas emissions.

Member states are determining the distribution of certificates and submitting 'national allocation plans' to the European Commission. Through the assessment of these plans the Commission will play an important role in setting the overall balance of supply and demand on the allowance market.

For those installations covered by the scheme, the EU Member States are allowed to waive requirements under the Integrated Pollution Prevention and Control Directive (IPPC). In order to lead to a net reduction in greenhouse gas emissions compared to previous existing policies, the overall emission reduction requirement will therefore need to be at least as stringent as the requirements under the IPPC Directive.

The scheme allows for future extension to other greenhouse gases as well as to other sectors such as transport. It also allows for links to other national emissions trading schemes from non-EU states. A separate 'linking directive' further allows for credits from joint implementation and Clean Development Mechanism projects.

The scheme has monitoring and reporting guidelines that allow a tiered approach representing different levels of detail. The most accurate tier incorporates installation-level data and indicates the extent to which these deviate from national or IPPC default values. This has the advantage of allowing data to be collected by sector – generating information that could then be fed into revisions of national greenhouse gas inventories.

Domestic emissions trading systems

The introduction of emissions trading between countries within the Kyoto Protocol has stimulated interest in emissions trading generally – and, as in the United States, a number of other schemes have already been introduced either at national or state levels for emissions trading between companies.

All national schemes involve governments setting an absolute cap on emissions and allocating individual polluters a share of that cap in the form of certificates or permits to emit a certain tonnage, usually of carbon dioxide, each year. If they emit more than their allowance they are fined. Polluters who emit less than they are entitled to can sell their spare permits on an emissions market.

The first economy-wide, national-level scheme was launched in the United Kingdom in 2002. This covers six greenhouse gases and has different types of participants. 'Direct participants' agree to make absolute emissions reductions in return for incentive payments – these include all types of organizations from breweries, to supermarket chains to local authorities. 'Climate Change Agreement Participants' are energy-intensive companies that already have emission-reduction or energy-efficiency targets. These two types of participants are allocated tradable emission allowances and to meet their targets they can make 'in-house' emission reductions or they can buy allowances from other participants. In addition any individual or organization can join the market as a 'Trading Participant'. In the first year of operations nearly one thousand companies traded over seven million tons of carbon dioxide: 31 direct participants, 866 companies with Climate Change Agreements and 35 traders.

Other countries have also launched emission trading schemes, though these may be limited to energy companies. As part of its electricity reforms Denmark, for example, introduced an allowances, or quota, scheme for the period 2002–03 involving eight companies responsible for more than 90% of total carbon dioxide emissions from the energy sector. These were allocated quotas based on previous emissions which, between 2001 and 2003 were progressively reduced from 22 to 20 million tons CO_2. However the penalty for exceeding quotas is fairly low

so instead of reducing emissions some producers found it cheaper to pay the fines.

Norway is planning to shift from its current system of carbon dioxide taxes to an emissions trading scheme that by 2008 should cover around 80% of greenhouse gas emissions. Switzerland too intends to launch the pilot phase of the emissions trading scheme for 2005–07 mostly for emitters, companies and energy intensive producers not covered by the carbon dioxide tax. Other countries considering emissions trading include Australia, Austria, Canada, Netherlands, New Zealand, and Sweden.

With other countries in Europe also considering trading systems, the European Union Emissions Trading System (EU ETS) should help ensure comparability. The Emissions Trading Directive of 2003 established the basis for the EU ETS (Box 8.4). Although most trading initially will be within national boundaries, the EU ETS opens the possibility for trading between companies across international borders and, through the Linking Directive, allows credits from the CDM and JI to enter as of 2005 and 2008, respectively (subject to the Kyoto Protocol's entry into force). Most non-EU countries intend to link their systems to the EU ETS which will further increase the liquidity of carbon markets.

Inspiration for action

Though the Kyoto Protocol has yet to enter into force it has already had a profound impact on public perceptions of climate change, even in countries that do not intend to ratify it. This is partly because the Protocol itself has become a focus of international attention, but also because its provisions have already generated a wide range of activities: the Clean Development Mechanism, for example, has already demonstrated its worth in encouraging investment in sustainable development projects, and the idea of emissions trading is gathering force across the world. There seems little doubt that the next decade of climate change policy will be shaped by the effectiveness of the instruments which the Kyoto Protocol provides and the action it inspires.

Epilogue

Ten years have passed since the Convention entered into force. In those ten years, scientific evidence that human activity is destabilizing the global climate has accumulated and hardened. Few now question the premise of climate change. Though some seize upon the prospect that change might benefit their patch of the globe and others are content to hope for a technological fix, there is a solid and broad consensus that climate change is one of the main challenges of the 21st century – a threat not only to the global environment but also to global prosperity and global security.

It is accepted that, however brave the response to this challenge, some change is now inevitable and that preparation to adapt to its adverse impacts is a task for all. Furthermore, these impacts will be most severe for those poor countries and communities least able to cope, creating further inequities in an already tense world.

It is understood, too, that action to keep change within globally tolerable limits – to "prevent dangerous anthropogenic interference with the climate system" in the words of the Convention – must reach uncomfortably deep into the inner workings of industrial economies, transforming patterns of production and consumption, precluding the ease of "business as usual", demanding innovation. For this reason alone, it is not surprising that these ten years have witnessed much economic defensiveness, even as agreement has crept forward.

Yet ten years – or even the 16 that have passed since the United Nations first took up the issue – is a very short time in the life of a global issue, very short too in the secular scale of change and reaction. In fact, the reaction of the global community to an absolutely new challenge has been remarkably swift in historical terms. We can look back with pride on the first steps we have taken.

These ten years have brought climate change into every statesman's vocabulary. The Convention established an obligation to cooperate, to produce and exchange information, to use common measures for that purpose. The Kyoto Protocol, in addition to setting a first emission constraint, promulgated market-oriented mechanisms to provide economic incentives for limiting emissions and to lower the cost of doing so.

Yet the clock is ticking and 2005 is a year when we must all grasp the nettle of designing climate strategy beyond 2012. What can we learn from our experiences that will illuminate the way ahead? Will it be a linear progression or will there be a choice of pathways to suit different interests and different national circumstances? How can we engage economic actors in the climate negotiations – and convince them that considerations of the zero sum game are not paramount? How can demand for clean air and lower fuel bills be mobilized to support climate-friendly policies? How can legitimate concerns with negative economic impacts be addressed?

The Convention's principles remain an essential guide to our forward vision. Our strategy must be equitable to be effective. Those with the capacity must be in the lead; those with resources must assist. But the principles must be used to encourage progress. Responsibilities are common, as well as differentiated. All those involved must be seen to move in the same direction, even if at different speeds on different routes. And ways must be found to compare effort, so that all are seen to be pulling their weight, pulling their oar in the same boat.

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Acronyms

AIJ	Activities Implemented Jointly
CHP	combined heat and power
COP	Conference of the Parties
CDM	Clean Development Mechanism
DAC	Development Assistance Committee (OECD)
EC	European Community
EIT	economy in transition
EGTT	Expert Group on Technology Transfer
ET	emissions trading
ETS	emissions trading system
EU	European Union
FDI	foreign direct investment
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gases
GWP	global warming potential
HFCs	hydrofluorcarbons
IGO	intergovernmental organization
IPCC	Intergovernmental Panel on Climate Change
JI	joint implementation
LDCs	least developed countries
LUCF	land-use change and forestry
NAPA	national adaptation programme of action
NGO	non-governmental organization
ODA	official development assistance
OECD	Organisation for Economic Co-operation and Development
PFCs	perfluorcarbons
PPP	purchasing power parities
SBI	Subsidiary Body for Implementation
SBSTA	Subsidiary Body for Scientific and Technological Advice
UNDP	United National Development Programme
UNEP	United National Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

1995 IPCC global warming potential (GWP) values

Global warming potential (GWP) values based on the effects of greenhouse gases over a 100-year time horizon

Greenhouse gas	Chemical formula	IPCC GWP 1995
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Hydrofluorocarbons (HFCs)		
HFC-23	CHF_3	11,700
HFC-32	CH_2F_2	650
HFC-41	CH_3F	150
HFC-43-10mee	$C_5H_2F_{10}$	1,300
HFC-125	C_2HF_5	2,800
HFC-134	$C_2H_2F_4$ (CHF_2CHF_2)	1,000
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1,300
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
HFC-143	$C_2H_3F_3$ (CHF_2CH_2F)	300
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3,800
HFC-227ea	C_3HF_7	2,900
HFC-236fa	$C_3H_2F_6$	6,300
HFC-245ca	$C_3H_3F_5$	560
Perfluorocarbons (PFCs)		
Perfluoromethane	CF_4	6,500
Perfluoroethane	C_2F_6	9,200
Perfluoropropane	C_3F_8	7,000
Perfluorobutane	C_4F_{10}	7,000
Perfluorocyclobutane	c-C_4F_8	8,700
Perfluoropentane	C_5F_{12}	7,500
Perfluorohexane	C_6F_{14}	7,400
Sulphur hexafluoride	SF_6	23,900

The world has taken major strides towards meeting the challenge of climate change, moving on from scientific analysis, to public concern, to the signing of an international legal instrument – the United Nations Framework Convention on Climate Change. This was a critical achievement.

Ten years ago, when the Convention came into force, the world's leaders pledged to tackle one of the greatest threats to the future of the human race. Since then, the experience has been both disturbing and encouraging: disturbing in that climate change and its potential threats have become even more visible; encouraging in that the Convention and the Kyoto Protocol have laid the foundation for a concerted response.

This publication looks at recent emissions trends and prospects, then sets the stage for future policies by considering how climate change concerns fit in with strategies for sustainable development. It also considers ways of both combating climate change and adapting to it – together with the likely technological developments and ways of ensuring greater public involvement. Finally, it explains the significance of the Kyoto Protocol and what this implies for the next generation of climate change policies.