Global Pollution and Climate Change

One hundred years ago, Claude Monet painted scenes of London through its smoggy atmosphere. That was *local* pollution. What is relatively new and even more worrying is *global* pollution – that is pollution emitted locally that has global effects.

The first example that arose in the 1980s was damage to the Earth's ozone layer. International action has been taken to phase out the use of the chemicals responsible although full recovery of the ozone layer will take at least a century.

Another example is pollution that leads to global warming and climate change. This Briefing will explain how this pollution occurs, how it leads to climate change, what the damaging impacts might be and what action can be taken to reduce them.

The greenhouse effect

First we need to understand how the earth's temperature is regulated. The Earth absorbs the heat energy of sunshine mainly at the surface. To maintain a steady temperature a balancing amount of energy is then radiated upwards from the surface at longer, infrared, wavelengths. Some of the gases in the atmosphere which are present naturally, particularly water vapour, carbon dioxide and methane, absorb some of this infrared radiation so acting as 'blankets' over the surface. Close control is thereby kept on global temperature, with the Earth's surface nearly 30ºC warmer than it would otherwise be, providing an average climate very suitable for human life. It is called the 'greenhouse effect' because the glass in a greenhouse has similar properties to the atmosphere.

Increases in the amount of gases such as carbon dioxide in the atmosphere are occurring because of emissions from human activities such as the burning of fossil fuels (coal, oil and gas) or through deforestation. These increases are sufficient to lead on average to substantially increased warming.

Most rapid change in last 10,000 years

The climate record over many thousands of years can be built up by analysing the composition of the ice, and the air trapped in the ice, obtained from different depths from cores drilled into the Antarctic or Greenland ice-caps. Fig 1 is a record of the change in temperature at which ice was laid down (the change in global average temperature is about half the change at the poles) and of the atmospheric carbon dioxide content over the last 160,000 years.

The Earth's climate is in a long term warm phase that began about 20,000 years ago when the last ice age ended; the last warm period was about 120,000 years ago. The main triggers for ice ages have been small regular variations in the geometry of the Earth's orbit about the sun which affect the distribution of solar radiation at the Earth's surface. The next ice age is expected to begin in about 50,000 years time.

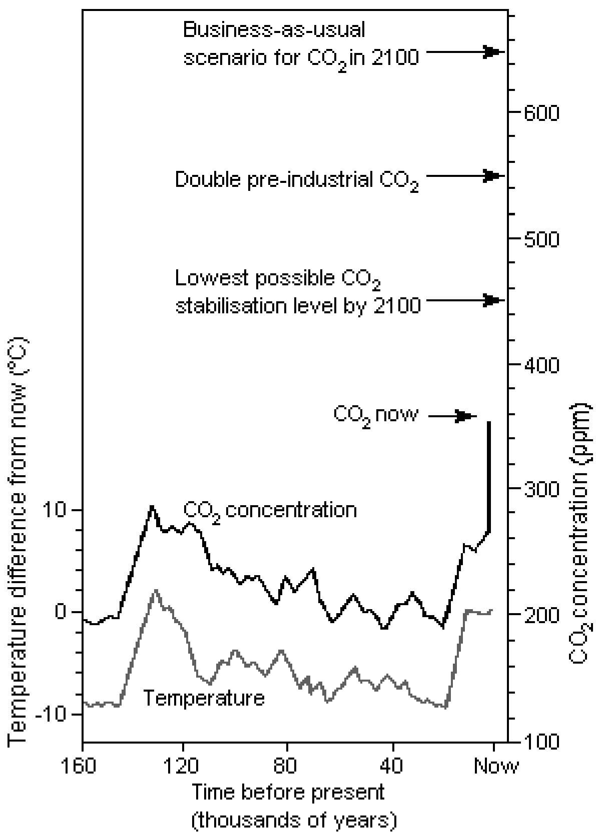

Fig 1. Record from an Antarctic ice core.

A strong correlation exists between atmospheric temperature and carbon dioxide content. This is partly because the amount of carbon dioxide in the atmosphere is dependent on factors strongly connected to the average temperature. Also, the carbon dioxide content in its turn influences the temperature through the greenhouse effect.

Over the past 200 years human activities have increased the amount of carbon dioxide in the atmosphere by over 30% – well beyond the range of its natural variation during the last million years or more. If the increase continues and if adequate action is not taken to stem it, the atmospheric carbon dioxide content will reach double its pre-industrial value during the 21st century.

As a result the average rate of warming of the climate is expected to be greater than at any time during the last 10,000 years. This is not necessarily bad; some communities may experience a net benefit. But many ecosystems and humans will find it difficult to adjust to this extremely rapid rate of change.

International agreement about the science

Although there is a lot of uncertainty concerning the detail, the basic science underlying global warming and climate change is well understood and is not in question. Hundreds of scientists from over fifty nations including the world's leading scientists in the field have contributed as authors or reviewers to the Assessments of the Intergovernmental Panel on Climate Change (IPCC) of which the most recent was in 2001. Because of the uncertainties it is easy either to exaggerate the possible impacts to calamitous proportions or to suggest that too little is known to justify any action.

What the IPCC has done is explain clearly what is known together with the major uncertainties. Then, taking account of all relevant scientific data, best estimates have been provided of climate change and its impact over the coming century, and the options for mitigating action. In the paragraphs that follow are summarised a few of the IPCC's main findings that will form the agenda for the years ahead.

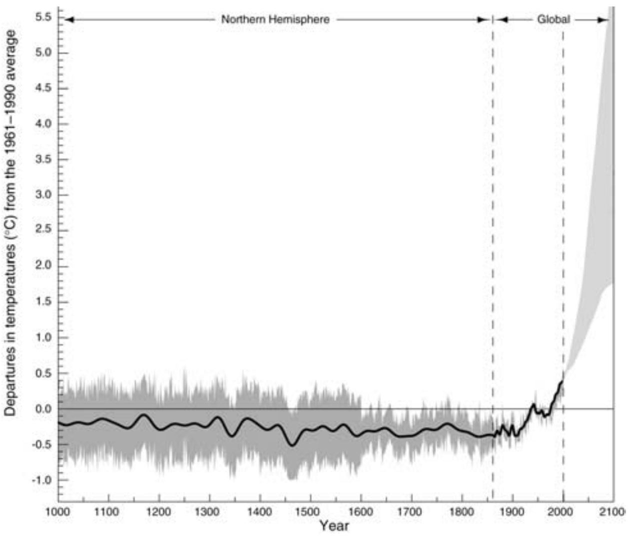

Fig 2. Variations of Earth's surface temperature: 1000-2100. To 1861, N. hemisphere, proxy data; 1861-2000, Global, instrumental data; 2000-2100, shaded area shows range of projections of temperature increase based on a variety of CO_2 emissions scenarios.

Climate variability and recent warming

The average air temperature near the Earth's surface over the past century (Fig 2) shows a lot of variability due to influences such as volcanic eruptions, variations in the heat from the sun and natural variations that occur in the absence of any external influences. The increase since the 1970s is considered to be largely due to the increase of greenhouse gases (especially carbon dioxide) because of human activities. In terms of global average temperature the 1990s have been particularly warm. Not only was 1998 the warmest year on record, the first eight months of 1998 were themselves the warmest of those months on record; a striking statistic. If carbon dioxide concentration increases during the 21st century to more than twice its pre-industrial value (Fig 1) then calculations show that the global average temperature will rise (Fig 2) by about 2.5ºC (range of uncertainty estimated as 1.5 to 4.5ºC).

When compared with the temperature changes we commonly experience, a rise of 2.5ºC does not seem very large. But remember it is a rise in the *average* annual temperature over the whole globe. Between the middle of an ice age and the warm periods in between ice ages, the global average temperature changed by only about 5 or 6ºC (Fig 1). So a 2.5ºC rise represents about half an 'ice age' in terms of climate change. For this to occur in less than 100 years, as we have already noted, is very rapid change.

So far we have presented climate change in terms of average temperature. But we are more likely to experience change through extreme weather such as floods, droughts and storms. Such events continually occur because of the large natural variability of climate. As human communities, especially with their increasing populations, become increasingly vulnerable to these extremes, a key question is whether such events will become more intense or more frequent with global warming. It is to that question we will now turn.

The impacts of global warming

In some locations, the impacts of global warming may be positive. For some crops, increased carbon dioxide aids growth and at high northern latitudes winters will be less cold and the growing season longer. However, because humans and ecosystems have adapted closely to the current climate, most climate change, especially if the change is fast, is likely to have negative impacts. The main impacts are likely to be changes in sea level, rainfall, and temperature extremes.

First, largely because of thermal expansion of ocean water and accelerated melting of glaciers, sea level is likely to rise by about half a metre by 2100. Sea defences in many coastal regions will need to be improved, albeit at considerable cost. However, such adaptation is not possible for countries with large river deltas such as Bangladesh, Southern China and Egypt and for many islands in the Pacific and Indian Oceans.

A second major impact of global warming is likely to be on water supplies. Warming of the Earth's surface means greater evaporation and, on average, a higher water vapour content in the atmosphere. Because the latent heat of condensation is the main energy source for the atmosphere's circulation this leads to a more vigorous hydrological cycle. In many areas, heavy rainfall may become heavier while semi-arid areas may receive less rainfall. There will be more frequent and more intense floods or droughts, especially in the sub-tropical areas that are most vulnerable to such events.

In many places, water is becoming a critical resource; a former Secretary General of the United Nations said that he expected the next war to be about water not oil! Floods and droughts already cause more deaths, misery and economic damage than any other type of disasters.

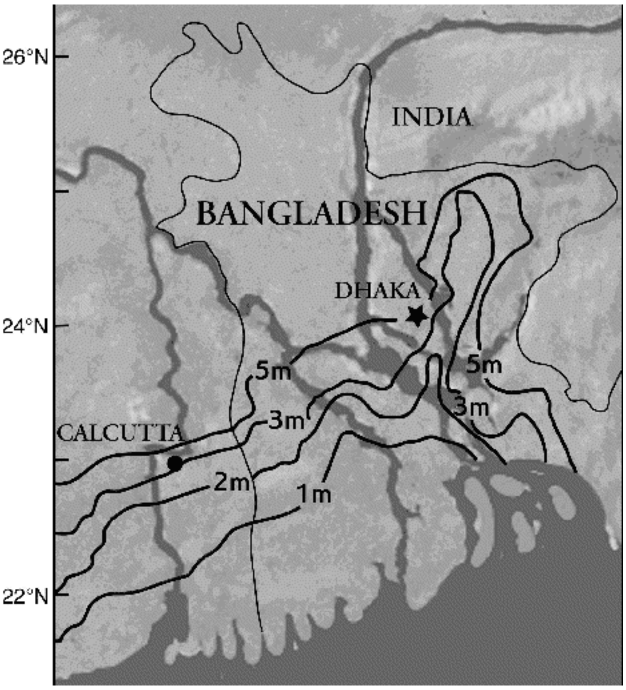

Fig 3. Bangladesh: the impact of sea-level rise. About 7 million people live below the 1m contour.

Any increase in their frequency or intensity could be the most damaging impacts of global climate change.

Studies of food supplies in a globally warmed world suggest that the world-wide quantity of available food supply might not be greatly affected. Some regions might be able to grow more while others grow less. However, the *distribution* of food production would change, not least because of changed water availability.

The regions likely to be adversely affected are those in developing countries in the sub-tropics. Agricultural production will become inadequate to meet local needs of rising populations. Considering food supply, sea level rise and the incidence of floods and droughts, a recent carefully researched study (N. Myers, 1995, *Environmental Exodus*, Climate Institute, Washington DC, USA) has estimated that there may be 150 million environmental refugees by 2050.

Other likely impacts are on human health (increased heat stress and more widespread vector borne diseases such as malaria) and on the health of some ecosystems (e.g. forests) which will not be able to adapt rapidly enough to match the rate of climate change.

International political action

At the Earth Summit held in Rio de Janeiro in 1992, around 160 nations agreed the Framework Convention on Climate Change (FCCC). Three widely accepted principles will govern the international agreements needed to meet the threat of climate change.

Precautionary Principle; already clearly imbedded in the FCCC. This states that the existence of uncertainty should not preclude the taking of appropriate action. The objective for such action is simply stated as the stabilisation of the concentrations of greenhouse gases (such as carbon dioxide) in the atmosphere in ways that allow also for necessary economic development.

Polluter Pays Principle; which implies the imposition of measures such as carbon taxes or carbon trading.

Principle of Equity; (both Intergenerational and International) which is the most difficult to apply. However, a proposal of the Global Commons Institute that is being widely discussed applies the second and third principles by allowing for the eventual allocation of carbon emissions to nations on an equal per capita basis while also allowing for emissions trading.

A start was made at Kyoto in 1997 with agreement to a Protocol (yet to be ratified) requiring developed nations to reduce their emissions of greenhouse gases by the year 2010 by 5% on average compared to 1990. This is a first step, hopefully demonstrating commitment by the developed world. Necessary post-Kyoto action, however, will be more demanding. Developing countries who wish to industrialise also need to join the action; in this they will need substantial encouragement (eg appropriate technology development and transfer) to enable them to develop industrially without vast increases in carbon dioxide emissions.

To meet likely FCCC requirements for carbon dioxide stabilisation, the rate of increase of global emissions must first be substantially slowed; then there must be reductions in these emissions to well below 1990 levels before 2100. Studies show that the necessary action to achieve carbon dioxide emissions such as in scenario B in Fig 4, if carefully planned and phased, is likely to cost less than 1% of the Global World Product, much less than the likely cost of damage and adaptation would be if there were no action at all.

The achievement of scenario B will require rapid development and deployment of appropriate technology and a great deal of determination on the part of the world community.

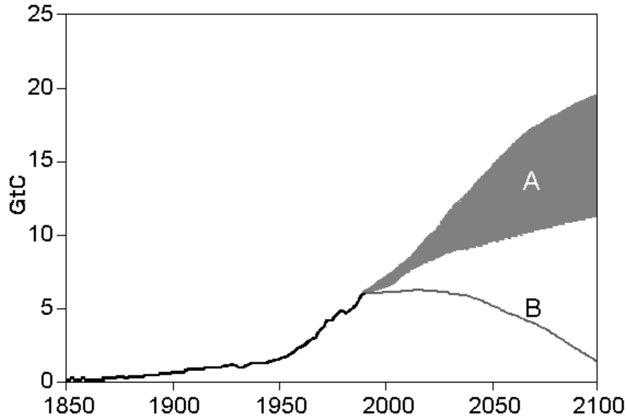

Fig 4. Global carbon emissions from fossil fuel use, 1850-1990 and projected to 2100, in billions of tonnes of carbon (GtC). Region A shows range of likely emissions under 'business-as-usual', and curve B an emission scenario that would lead to stabilisation of the atmospheric carbon dioxide concentration as required by the FCCC.

Action to mitigate climate change

To mitigate the effects of global climate change, action is required to reduce the human-induced emissions of carbon dioxide. This has large implications, for the energy sector in particular. Technology is already available for much of what is required, for instance to generate and use energy much more efficiently and to develop renewable energy sources such as solar, wind, water, biomass and others, which are not dependent on fossil fuels.

Action can also be taken to increase the sinks that remove carbon dioxide from the atmosphere (eg by reducing deforestation and increasing forestation or by direct sequestration of carbon dioxide) and to reduce methane emissions from, for example, leakage from mines and landfill sites. The main role of governments and world agencies will be to stimulate markets and to encourage the development and use of the most appropriate clean technologies.

A challenge for everybody

• for scientists, to provide better information about likely climate change and its various local impacts,

• for governments, to set the necessary framework,

• for business and industry, to seize the opportunities for innovation and use of 'clean' technologies and

• for all communities and individuals in the world, to support the action being taken and contribute to it.

What can the individual can do?

• ensure maximum energy efficiency in the home (over 25% of CO_2 emissions are from domestic energy use) through good heat insulation and through the use of high efficiency appliances (eg low energy light bulbs, Grade A or B appliances).

• ensure maximum energy saving – do not overheat rooms and turn off lights when not required.

• support, where possible, the provision of energy from renewable sources; e.g. purchase 'green' electricity now that this option is available.

• use public transport, and walk and cycle where possible, and use a fuel-efficient car (over 25% of CO_2 emissions come from transport).

• consider the environment when shopping; eg buy goods produced with low energy use and products that originate from renewable sources.

• through the democratic process, encourage local and national government to deliver policies that properly take the environment into account.

Bibliography

John Houghton, *Global Warming: the complete briefing,* 2nd edition (Cambridge: CUP, 1997).

The IPCC Reports are online at **www.ipcc.ch**

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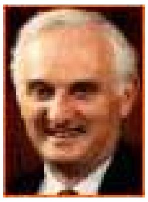

Sir John Houghton is the chairman of JRI. He is co-chairman of the Scientific Assessment Working Group for the Intergovernmental Panel on Climate Change, and a member of the Government Panel on Sustainable Development, and from 1991 to 1998 was Chairman of the Royal Commission on Environmental Pollution. He has written several books including *Global Warming: the complete briefing* and *The Search for God: can science help?*.

THE·JOHN·RAY·INITIATIVE

The John Ray Initiative promotes responsible environmental stewardship in accordance with Christian principles and the wise use of science and technology. JRI organises seminars and disseminates information on environmental stewardship.

Inspiration for JRI is taken from John Ray (1627-1705), English naturalist, Christian theologian and first biological systematist of modern times, preceding Carl Linnaeus.

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