The Challenge of Global Warming –
Global challenges need global solutions

Sir John Houghton FRS

It has always been important to look after our local environment if only so that we can pass on to our children and grandchildren an environment at least as good as we have enjoyed. Today, however, it is not just the *local* environment that is at risk but the *global* environment. Small amounts of pollution for which each of us is responsible are affecting everyone in the world. For instance, very small quantities of chlorofluorocarbons (CFCs) emitted to the atmosphere from leaking refrigerators or some industrial processes have resulted in degradation of the ozone layer; carbon dioxide that enters the atmosphere from the burning of fossil fuels, coal, oil and gas is leading to damaging climate change. The perils of human induced climate change are now recognised much more widely, frequently described by responsible scientists and politicians as probably 'the greatest problem the world faces' and as a 'weapon of mass destruction'. *Global* pollution demands *global* solutions.

The necessary global solutions need to address human attitudes very broadly, for instance those concerned with resource use, lifestyle, wealth and poverty. They must also involve human society at all levels of aggregation - international organisations, nations with their national and local governments, large and small industry and businesses, non-governmental organisations (e.g churches) and individuals. To take into account the breadth of concern, a modern term that is employed to describe such environmental care is 'sustainability'.

What is sustainability?

Imagine you are a member of the crew of a large space ship on a voyage to visit a distant planet. Your journey there and back will take many years. An adequate, high quality, source of energy is readily available in the radiation from the sun. Otherwise, resources for the journey are limited. The crew on the spacecraft are engaged for much of the time in managing the resources as carefully as possible. A local biosphere is created in the spacecraft where plants are grown for food and everything is recycled. Careful accounts are kept of all resources, with especial emphasis on non-replaceable components. That the resources be *sustainable* at least for the duration of the voyage, both there and back, is clearly essential.

Planet Earth is enormously larger than the spaceship we have just been describing. The crew of Spaceship Earth at six billion and rising is also enormously larger. The principle of Sustainability should be applied to Spaceship Earth as rigorously as it has to be applied to the much smaller vehicle on its interplanetary journey.

Sustainability is a word that not only concerns physical resources, but applies equally to activities and communities. Environmental sustainability is also strongly linked to social sustainability – referring to sustainable communities - and sustainable economics. *Sustainable Development* provides an all-embracing term.

There have been many definitions of Sustainability. The simplest I know is ‘not cheating on our children’; to that may be added, ‘not cheating on our neighbours’ and ‘not cheating on the rest of creation’. In other words, not passing on to our children or any future generation an Earth that is degraded compared to the one we inherited, and also sharing common resources as necessary with our neighbours in the rest of the world and caring properly for the non-human creation.

The science of global warming

One of the biggest current challenges for sustainability is Global Warming. By absorbing infra-red or ‘heat’ radiation from the earth’s surface, ‘greenhouse gases’ present in the atmosphere, such as water vapour and carbon dioxide, act as blankets over the earth’s surface, keeping it warmer than it would otherwise be. The existence of this natural ‘greenhouse effect’ has been known for nearly two hundred years; it is essential to the provision of our current climate to which ecosystems and we humans have adapted.

Since the beginning of the industrial revolution around 1750, one of these greenhouse gases, carbon dioxide, has increased by over 35% and is now at a higher concentration in the atmosphere than for many hundreds of thousands of years. Chemical analysis demonstrates that this increase is due largely to the burning of fossil fuels - coal, oil and gas. If no action is taken to curb these emissions, the carbon dioxide concentration will rise during the 21st century to two or three times its pre-industrial level.

The climate record over recent centuries shows a lot of natural variability arising from external factors (such as changes in the sun's energy or the influence of volcanoes) or from internal variations within the climate system. However, the rise in global average temperature (and its rate of rise) during the 20th century is well outside known natural variability in recent modern human times. The year 1998 is the warmest year in the instrumental record that goes back to 1860. A more striking statistic is that each of the first 8 months of 1998 was the warmest on record for that month. There is very strong evidence that most of the warming over the last 50 years is due to the increase of greenhouse gases, especially carbon dioxide.

Over the 21st century the global average temperature is projected to rise by between 2 and 6 ºC (3.5 to 11 ºF) from its pre-industrial level; the range represents different assumptions about greenhouse gas emissions and the sensitivity of the climate. For *global average* temperature, a rise of this amount is large. The difference between the middle of an ice age and the warm periods in between is only about 5 or 6 ºC. So, associated with likely warming in the 21st century will be a rate of change of climate equivalent to say, half an ice age in less than 100 years – a larger rate of change than for at least 10,000 years. Adapting to this will be difficult for both humans and many ecosystems.

The impacts of global warming

Talking in terms of changes of global average temperature, however, tells us rather little about the impacts on human communities. There will be some positive impacts, for instance a longer growing season at high latitudes. But most impacts will be adverse[1]. One obvious impact will be due to the rise in sea level (of about half a metre a century, equivalent to 20 inches) that is mainly occurring because ocean water expands as it is heated. This rise will continue for many centuries – to warm the deep oceans as well as the surface waters takes a long time. This will cause large problems for human communities living in low-lying regions. Many areas, for instance in Bangladesh (Figure 1), southern China, islands in the Indian and Pacific oceans and similar places elsewhere in the world will be impossible to protect and many millions will be displaced.

[1] A well illustrated account of climate change and its impacts is that of Al Gore*, An Inconvenient Truth, Rodale, New York, 2006*

There will also be impacts from extreme events. The extremely unusual heat wave in central Europe during the summer of 2003 led to the deaths of over 20,000 people. Careful analysis leads to the projection that such summers are likely to be average by the middle of the 21st century and thought of as cool by the year 2100.

Water is becoming an increasingly important resource. A warmer world will lead to more evaporation of water from the surface, more water vapour in the atmosphere and more precipitation on average. Of greater importance is the fact that the increased condensation of water vapour in cloud formation leads to greater release of latent heat of condensation. Since this latent heat provides the largest source of energy driving the atmosphere's circulation, the hydrological cycle will become more intense. This means a tendency to more intense rainfall events and also less rainfall in some semi-arid areas. The most recent estimates indicate by 2050 a typical increase in many places of around a factor of five in the risk of the most extreme floods and droughts. Since, on average, floods and droughts are the most damaging of the world's disasters, their greater frequency and intensity is bad news for most human communities and especially for those regions such as south-east Asia and sub-Saharan Africa where such events already occur only too frequently. It is these sorts of events that provide some credence to the comparison of climate with weapons of mass destruction.

Sea level rise, changes in water availability and extreme events will lead to increasing pressure from environmental refugees. A careful estimate[2] has suggested that, due to climate change, there could be more than 150 million extra refugees by 2050.

Can we believe the evidence?

How sure are we about the scientific story I have just presented? It is largely based on the assessments by the world scientific community carried out through the work of the Intergovernmental Panel on Climate Change (IPCC)[3]. I had the privilege of being chairman

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[2] Myers, N., Kent, J. 1995. *Environmental Exodus: an emergent crisis in the global arena*. Washington DC: Climate Institute.

[3] *Climate Change 2001* in four volumes, published for the IPCC by Cambridge University Press, 2001. Also available on the IPCC web site www.ipcc.ch. My book, John Houghton, *Global Warming: the complete briefing*, 3rd edition, Cambridge University Press, 2004 is strongly based on the IPCC reports. Furthermore, a review I have recently written (John Houghton, Global Warming, Reports Progress in Physics, 68 (2005) 1343-1403) provides a concise summary of the science and associated impacts.

or co-chairman of the Panel's scientific assessment from its beginning in 1988 to 2002. Many hundreds of scientists from many countries were involved in its work. No assessments on any other scientific topic have been so thoroughly researched and reviewed. In June of 2005, the Academies of Science of the world's eleven most important countries (the G8 plus India, China and Brazil) issued a statement endorsing the IPCC's conclusions[4].

Unfortunately, there are strong vested interests that have spent tens of millions of dollars on spreading misinformation about the climate change issue. They first denied the scientific evidence and more recently have argued that its impacts will not be large, that we can 'wait and see' and in any case we can always 'fix' the problem if it turns out to be substantial. The scientific evidence cannot support such arguments.

International agreement required

Global emissions of carbon dioxide to the atmosphere from fossil fuel burning are currently approaching 7 billion tonnes of carbon per annum and rising rapidly. Unless strong measures are taken they will reach two or three times their present levels during the 21st century and climate change will continue unabated. To halt climate change during the 21st century, emissions must be reduced to a fraction of their present levels before the century's end (Figure 2).

It is essential that all countries join the international agreements being negotiated under the Framework Convention on Climate Change (FCCC). The UK government, for instance, has taken a lead and has agreed a target for the reduction of greenhouse gas emissions of 60% by 2050 - a target that recognizes that developed countries need to make greater reductions to allow some headroom for developing countries. Economists in the UK government Treasury Department have estimated the cost to the UK economy of achieving this target as no more than the equivalent of 6 months' growth over the 50 year period[5].

What actions can be taken?

Three sorts of actions are required if such reductions are to be achieved. First, there is energy efficiency. Very approximately one third of energy is employed in buildings (domestic and commercial), one third in transport and one third by industry. Means are available to double

[4] <www.royalsoc.ac.uk/document.asp?id=3222>

[5] from an Energy Report by the UK government's Policy and Innovation Unit (PIU) 2002

the efficiency of energy use in all three sectors, in many cases with significant savings in cost. Secondly, a wide variety of non-fossil fuel sources of energy are available for development and exploitation, for instance, biomass (including waste), solar power (both photovoltaic and thermal), hydro, wind, wave, tidal and geothermal energy. Thirdly, there are possibilities for sequestering carbon that would otherwise enter the atmosphere either through the planting of forests or by pumping underground (for instance in (oil and gas fields). The opportunities for industry for innovation, development and investment in all these areas is large. Technology Transfer from developed to developing countries is also vital if energy growth in developing countries is going to proceed in a sustainable way.

Stewards of Creation

People often say to me that I am wasting my time talking about environmental sustainability. 'The world' they say 'will never agree to take the necessary action'. I reply that I am optimistic. One reason I give is that I believe that God is committed to His creation and that we have a God-given task of being good stewards of creation[6].

What does Christian stewardship of creation mean? In the early part of Genesis, we learn that humans, made in God's image, are given the mandate to exercise stewardship/management care over the earth and its creatures (Gen 1 v26,28 & 2 v15). We therefore have a responsibility first to God to look after creation - not as we please but as God requires – and secondly to the rest of creation as ones who stand in the place of God.

We are only too aware of the strong temptations we experience, both personally and nationally, to use the world's resources to gratify our own selfishness and greed: not a new problem, in fact a very old one. In the Genesis story of the garden, we are introduced to human sin with its tragic consequences (Genesis 3); humans disobeyed God and did not want him around any more. That broken relationship with God led to broken relationships elsewhere too. The disasters we find in the environment speak eloquently of the consequences of that broken relationship.

Those of us in the developed countries have already benefited over many generations from

[6] see a set of introductory essays, *A Christian Approach to the Environment*, published 2005 by the John Ray Initiative (www.jri.org.uk); for a collection of papers addressing the meaning of stewardship especially but not exclusively from a Christian standpoint, see *Environmental Stewardship* (ed R J Berry), T & T Clark 2006; also see M S Northcott, *The Environment and Christian Ethics*, CUP 1996

abundant fossil fuel energy. The demands on our stewardship take on a special poignancy as we realize that the adverse impacts of climate change will fall disproportionately on poorer nations and will tend to exacerbate the increasingly large divide between rich and poor. Our failure to be good stewards is a failure to love God and a failure to love our neighbours, especially our poorer neighbours in Africa and Asia. The moral imperative for the rich countries is inescapable.

New Attitudes

Not only do we need goals but also new attitudes and approaches in the drive towards sustainability – again at all levels of society, international, national and individual.

For instance, sustainability will never be achieved without a great deal more sharing. Sharing is an important Christian principle. John the Baptist preached about sharing (Luke 3 v11), Jesus talked about sharing (Luke 12 v33), the early church were prepared to share everything (Acts 4 v32) and Paul advocated it (2 Cor 8 v13-15). The opposite of sharing - greed and covetousness - is condemned throughout scripture. At the individual level, a lot of sharing often occurs. At the international level it occurs much less as is well illustrated by the most condemning of world statistics - that the average flow of wealth in the world is from the poor to the rich.

One of the biggest ‘sharing’ challenges faced by the international community is how emissions of carbon dioxide can be shared fairly between nations. Currently great disparity exists between emissions by rich nations compared with poorer ones. Expressed in tonnes of carbon per capita per annum, they vary from about 5.5 for the USA, 2.2 for Europe, 0.7 for China and 0.2 for India. Furthermore, the global average per capita, currently about 1 tonne per annum, must fall substantially during the 21st century (Figure 3). A proposal by the Global Commons Institute[7] is that emissions should first be allocated to everybody in the world equally per capita, then transfer of allocations be allowed through trading between nations. The logic and the basic equity of this proposal is in principle quite compelling – but is it achievable? A further aspect of sharing, increasingly recognized by aid agencies, is to share our skills with the third world - for instance in science and technology.

[7] for more details see <www.gci.org.uk>

You may ask, 'but what can I as an individual do?' There are some actions that all of us can take[8]. For instance, we can ensure our homes and the appliances or the car we purchase are as energy efficient as possible. We can buy 'green' electricity, shop responsibly, use public transportation, car-share more frequently and use our bikes where feasible. We can become better informed about the issues and support leaders in government or industry who are advocating or organising the necessary solutions. To quote from Edmund Burke, a British parliamentarian of 200 years ago, 'No one made a greater mistake than he who did nothing because he could do so little.'

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[8] see, for instance, 'For Tomorrow Too', booklet from Tearfund, www.tearfund.org 2006

Figure Legends

Figure 1 Land affected in Bangladesh by various amounts (in metres) of sea level rise. About 10 million people live below the 1m contour.

Figure 2. Global emissions of carbon dioxide from fossil fuel burning (in billions of tonnes of carbon) up to 1990 and as projected to 2100 under World Energy Council scenarios[9]. The A and B curves refer to various 'business as usual' assumptions and Curve C is the 'ecologically driven scenario' that would lead to stabilization of carbon dioxide concentration at about 450 ppm.

Figure 3. Carbon dioxide emissions in 2000 per capita for different countries and groups of countries[10]. The global per capita average is shown by the dotted line.

[9] from *Energy for Tomorrow's World: the realities, the real options and the agenda for achievement*. World Energy Council Report 1993

[10] after M Grubb 2003, World Economics **3**, p 145