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Honorary Scientist, Hadley Centre for Climate Prediction and Research and Formerly Chief Executive, Meteorological Office, U.K.
Born in 1931

Achievement: For pioneering research on atmospheric structure and composition based on his satellite observation technology and for promotion of international assessments of climate change.

GLOBAL WARMING, CLIMATE CHANGE AND SUSTAINABLE ENERGY

The remarkable development in the understanding of climate over the last 50 years has been one of the great achievements in modern science. Key to this success has been the exploitation of the rapid expansion of space and computer technologies. Observations from orbiting satellites have brought measurements of the structure, composition and dynamics of atmosphere, ocean and land for the first time on a global scale and continuous in time. The largest computers have provided means for modelling the coupled atmospheric and ocean circulations and of analyzing the large amounts of data that have become available from space and other sources.

Of especial importance has been the observation of changes that have occurred because of human activities. Some of these involve *local pollution* emitted on a local scale. But, of increasing concern has been *global pollution* through widespread emissions of pollutants that permeate the whole atmosphere and remain for long periods. The two prime examples are the depletion of ozone through chlorofluorocarbons and the changes of climate that result from emissions of carbon dioxide from the burning of fossil fuels.

The Earth's climate is now beginning to change at a rate greater than for at least 10,000 years. Adapting to such rapid change will be increasingly difficult for both humans and many ecosystems. The main impacts will be from sea level rise and from more frequent and intense extreme events and disasters such as heat waves, droughts and floods. Such events will lead to pressure from many millions of environmental refugees.

In addition to these main impacts, there are changes about which there is less certainty but if they occurred would be highly damaging and possibly irreversible. For

instance, the Greenland ice cap may begin to melt down and the Gulf Stream in the north Atlantic may seriously weaken with large implications for patterns of circulation in the oceans.

How sure are we about this scientific story? Since 1988, the world scientific community has carried out thorough assessments of the science of human induced climate change through the work of the Intergovernmental Panel on Climate Change (IPCC). The Panel's conclusions have recently been endorsed in a statement from the Academies of Science of the world's eleven most important countries (the G8 plus India, China and Brazil).

International action regarding climate change began in 1992 with the establishment at the Earth Summit at Rio de Janeiro of the Framework Convention on Climate Change (FCCC) - agreed by over 160 countries. The Objective of the FCCC is "to stabilise greenhouse gas concentrations in the atmosphere at a level that does not cause dangerous interference with the climate system" and that is consistent with sustainable development. Such stabilisation would require that emissions of greenhouse gases, such as carbon dioxide, into the atmosphere must not only stop growing but be reduced to a small fraction of their present levels well before the end of the century. The reductions must be made globally; all nations must take part. However, because of large differences in emissions from different countries, ways need to be found to achieve the reductions required that are both realistic and equitable.

The Kyoto Protocol set up by the FCCC represents a beginning for the process of reductions by those developed countries that have ratified it. Within the Protocol is introduced international trading of greenhouse gas emissions so that reductions can be achieved in the most cost effective ways. Following the Kyoto Protocol in 2012, it is essential that all countries join in the stronger agreements that will then be required concerning future emissions.

Three sorts of actions are available to achieve the reductions required. First, there is energy efficiency. Large savings can be made in the three main sectors - buildings, transport and industry - many 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. These need to be rapidly developed to provide for energy needs in the long-term, Thirdly, possibilities exist for sequestering carbon that would otherwise enter the atmosphere either through the planting of forests or by pumping underground (for instance in spent oil and gas wells). The opportunities for industry for innovation, development and investment in all these areas is large.

Some argue that we can 'wait and see' before action is necessary. The science cannot support that position. For instance,

because the oceans take time to warm, there is a lag in the response of climate to increasing greenhouse gases. A commitment to substantial change already exists, much of which will not be realised for 30 to 50 years. Further emissions just add to that commitment. Energy infrastructure also lasts typically for 30 to 50 years. What is built now needs to be appropriate to a world with much lower emissions of carbon dioxide.

People often suggest 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 for three reasons. First, I have experienced the commitment of the world scientific community in painstakingly and honestly working together to assess what needs to be done. Secondly, I believe the necessary technology is available for achieving satisfactory solutions. My third reason is that I believe we have a God-given task of being good stewards of creation. Exercising this role of stewards provides an important part of our fulfilment as humans.

We, in the developed countries have already benefited over many generations from abundant fossil fuel energy. The demands of our stewardship take on a special poignancy as we realize that the adverse impacts of climate change fall disproportionately on poorer nations and tend to exacerbate the increasingly large divide between rich and poor. In our modern world we concentrate so much on economic goals - getting rich and powerful. Stewardship or long-term care for our planet and its resources brings to the fore moral and spiritual goals. Reaching out for such goals could lead to nations and peoples working together more effectively and closely than is possible with many of the other goals on offer.