# Theme 1 - Defining what is at stake

## Presentation: Climate Change, Global Warming and the Oceans

### Presenter: Sir John Houghton

#### **Climate change**

Since the last Ice Age, generations of human beings have organised their activities to take advantage of locally available resources of food, fuel, fibre and forage. Human settlements, their agriculture, water use and commercial activities have adapted to the current climate (that is, temperature and rainfall) and its variability. Any large, rapid change in climate will affect these activities and the resources on which they depend and will require rapid, and probably costly, adaptation to re-establish the match between climatic resources and human needs.

Climate extremes are an important manifestation of the natural variability of climate. During recent decades, different parts of the world have experienced extreme temperatures, record floods, droughts and windstorms. There is no strong evidence that these weather events are outside the natural range of climate variability of the last few centuries. However, their impact serves to emphasise the vulnerability of human communities to climate variations and extremes. In particular, during the later years of the 1980s and the 1990s, the insurance industry has experienced unparalleled losses due to extreme weather events, providing a good illustration of this increased vulnerability.

Significant climate change is expected over the next century because of the increase in greenhouse gases (especially carbon dioxide and methane) which is occurring as a result of human activities (especially fossil fuel burning and deforestation). This increase is leading to an overall warming of the earth's surface such that, if no environmental pressures or controls are introduced, an increase in global mean temperature of about 2.5 degrees centigrade (ranging from 1.5 to 4 degrees centigrade) can be expected by the year 2100. This would represent a change of climate more rapid than has been experienced by the Earth at any time during the last 10,000 years.

Estimation of the likely future climate change is made complicated because of the effects of anthropogenic aerosols (microscopic particles in the atmosphere), which originate particularly from the sulphur-containing gases emitted from power stations - effluents which also give rise to the acid rain problem. These aerosols reflect sunlight and so tend to cool the Earth's surface. However, they are very short-lived (a few days), so that they are concentrated near industrial regions. Nevertheless, their effects on the climate, even quite far away from these regions, can be considerable. Because of the acid rain problem, emissions of sulphur-containing gases are being severely controlled, especially in North America and Europe. However, they are growing rapidly in Asia, although controls can also be expected there in due course.

In making detailed predictions of climate change, the influences of both the atmosphere and the oceans have to be taken into account. In climate models the circulations of the atmosphere and the oceans are coupled together in a sophisticated manner. Of particular interest and concern are changes in the oceans over long time scales (several hundred years or more) which could occur as a result of anthropogenic influences and which could have substantial effects on the climate.

#### The impacts of climate change

The main impacts of the expected climate change are a rise in sea level and changes in rainfall and temperature extremes.

The expected rise in sea level of about 0.5m (ranging from 0.2m to 1m) by the year 2100 arises mostly from the expansion of water in the oceans because of the increased temperature and from the melting of glaciers; the contribution from changes in the ice sheets in the Arctic and Antarctic is expected to be small. Adaptation, at a cost, to such a rise will be possible in many coastal regions. However, adaptation will be extremely difficult, if not impossible, in some particularly vulnerable areas such as the delta regions of

large rivers in Bangladesh, Egypt and Southern China and the many low-lying islands in the Indian and Pacific Oceans. The situation in many of these areas will be exacerbated because the land is sinking at a similar rate to the rise in the water levels expected from global warming. This is for reasons such as tectonic movement and the extraction of ground water. Substantial loss of land will occur in these areas and many millions of people are likely to be displaced (for instance, 6 million live below the 1m contour in Bangladesh).

The changes in rainfall are likely to be manifested particularly through increased incidences of both droughts and floods in some places. For instance, in continental areas at mid-latitudes in the Northern Hemisphere - for example in North America and Southern Europe - summers are likely to be warmer with increased evaporation from the surface and possibly with less average rainfall; drought conditions can therefore be expected to occur more frequently and may sometimes be more prolonged. In Southern Asia more intense monsoons can be expected, with increased tendency to flooding (although if large anthropogenic aerosol concentrations were present over Asia, this effect could be reduced). As the demand for water increases in nearly every country, substantial tensions can be expected, especially in regions where the water from major river systems is shared between nations. The Secretary General of the UN has suggested that wars in the future are likely to be about water rather than oil.

Studies of global food supplies in a globally warmed world tend to suggest that the global quantity of available food supply might not be affected by very much - some regions might be able to grow more while others grow less. However, the regions likely to be most affected by reduced food production are those in developing countries in the sub-tropics where there are rapidly growing populations. In the areas most seriously affected there could be large numbers of environmental refugees.

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

These impacts of anthropogenic climate change will generate substantial social and political implications, and also implications for world security. Of particular concern are some developing countries which will be substantially disadvantaged and in which a large number of environmental refugees will be created (studies have suggested 150 million by the middle of next century).

#### Action regarding climate change

The scientists of the world involved with climate and climate change have worked together through the Intergovernmental Panel on Climate Change (IPCC), formed in 1988 to present policy-makers with their best information regarding the future climate. I was privileged to chair the Scientific Assessment of the IPCC which was agreed and published in 1990. Despite the substantial uncertainties in future predictions, a wide consensus was achieved by the world scientific community regarding the Assessment's findings. Assisted by that scientific consensus, a Framework Convention on Climate Change was agreed at the Earth Summit in Rio in 1992. Its objective, stated in Article 2, puts action regarding climate change in the context of sustainable development. It states:

The ultimate objective of this Convention . . . is to achieve . . . stabilisation 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.

To find the best way to meet the demands of this objective will require a great deal of debate and discussion, based on the best scientific and technical information, across all scientific (including social scientific) disciplines.

The actions required to mitigate the effects of global warming are to increase the processes which remove carbon dioxide from the atmosphere (for example by reducing deforestation and increasing afforestation) and to reduce the emissions of both carbon dioxide and methane from anthropogenic sources (for example by increasing energy efficiency and by the development of energy sources which have much lower carbon

dioxide emissions).

The science of global warming and climate change is very complex and involves frontier regions of science and technology (such as the dynamics of non-linear chaotic systems, the development of complex models, space observation, large-scale data handling and management systems). It is also probably the area of science where the greatest interaction is currently occurring between the international scientific community and the world political arena. It is therefore a very demanding, exposed and exciting area of science in which to be involved. The further challenge to humanity is to face the need to care for the planet with all its living systems in a thoroughly responsible way.