Environmental Studies
FACT SHEET
www.curriculum-press.co.uk
Number 191

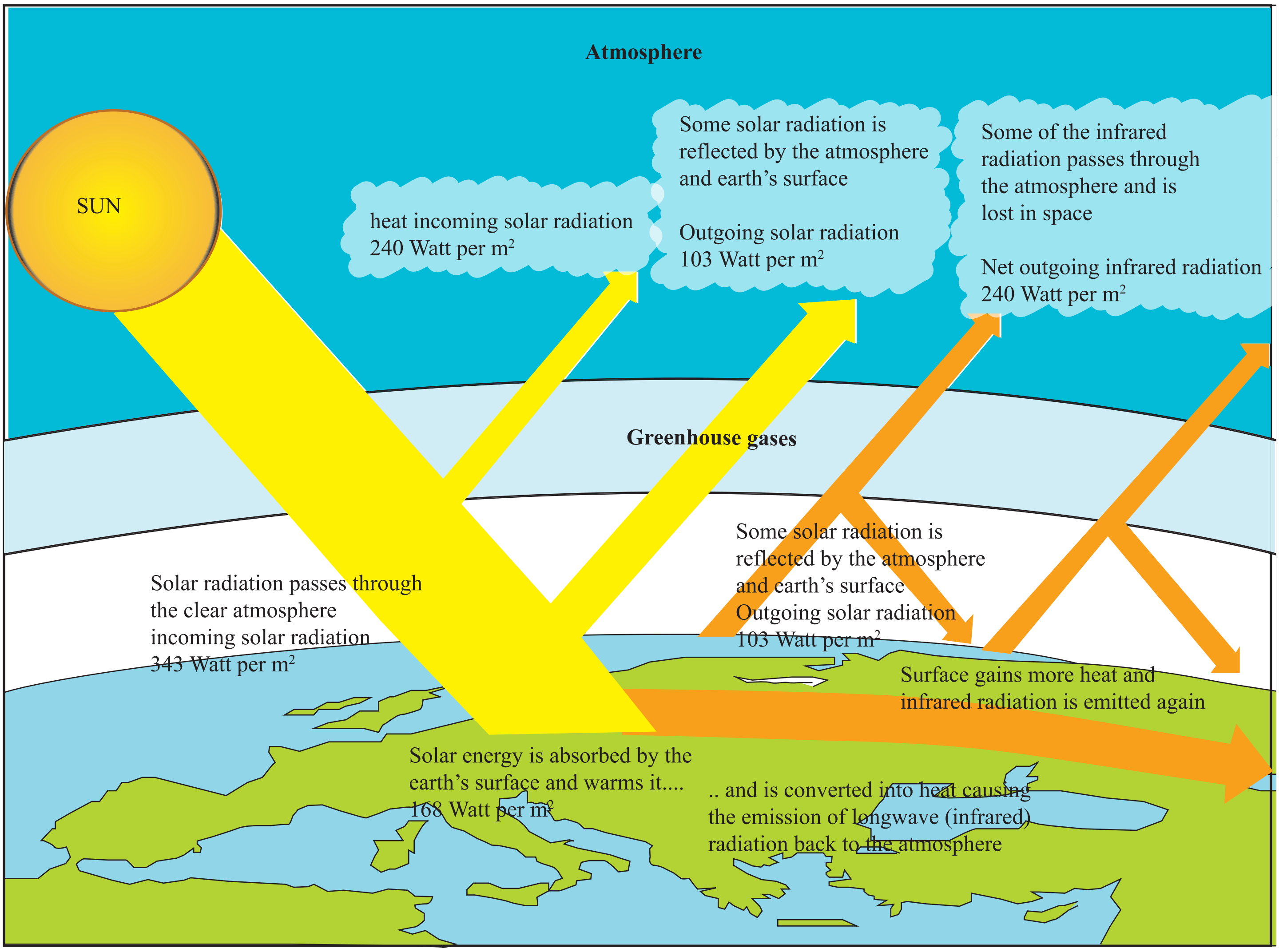
Climate change

Climate change is one of the top policy problems for humanity. First of all, it is a global problem. It is driven by the energy economy – so it is at the heart of economic development. The consequences are great. Secondly, it is slow moving, and we cannot observe it day by day, or even year by year. It is a complicated problem, and one in which there are many powerful lobby groups – namely TNCs related to the energy industry – with much vested interest in preserving the status quo.

There has been an awareness of greenhouse gases for over 100 years. The first study into the effects of a doubling of CO_2, was carried out by a Swedish academic, Svante Arrhenius in 1896. He suggested that a doubling of CO_2 could lead to an increase in temperature of 5C. However, he thought it would take some 700-800 years for CO_2 to double, whereas it might only take 150 years.

Solar radiation reaches the earth as short-wave or ultra-violet radiation (Fig. 1). Some of it is reflected by clouds. The ultra-violet radiation heats the earth and the earth in turn emits long-wave or infrared radiation, which heats the atmosphere. In the past, there was a balance between incoming and out-going radiation.

Fig. 1 The greenhouse effect



Greenhouse gases – such as water vapour, carbon dioxide, methane, oxides of nitrogen, CFCs – trap some out-going radiation. Without greenhouse gases, the earth's atmosphere would be like that of the moon, and human life would not be possible. However, over the last century or so, humanity has added more and more greenhouse gases to the atmosphere, and the balance between incoming and out-going radiation has been disturbed. Different greenhouse gases have different properties (Table 1) with respect to time in the atmosphere, global warming potential and proportion of emissions.

Table 1: Characteristics of greenhouse gases

	Lifetime in the atmosphere (years)	100-year global warming potential (GWP)	Proportion of greenhouse gas emissions in CO_2 equivalent
Carbon dioxide	5-200	1	77%
Methane	10	23	14%
Nitrous oxide	115	296	8%
Hydrofluorocarbons (HFCs)	1-250	10-12,000	0.5%
Perfluorocarbons (PFCs)	2500	5,500	0.2%
Sulfur Hexafluoride (SF)	3,200	22,200	1%

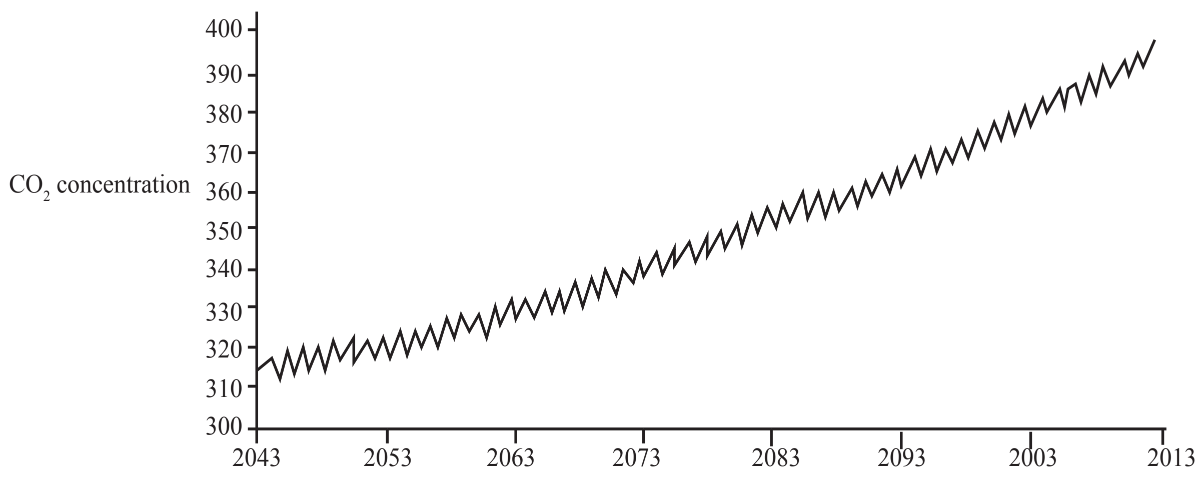
Annual production of greenhouse gases (in carbon equivalent) is approximately 55 billion tons. The carbon dioxide part of this total is around 35 billion tons, which from the burning of fossil fuels. Some 3.5 billion tons comes from land use changes (deforestation, clearing land for pasture).

The Keeling Curve (fig. 2) shows variations in atmospheric CO_2 over time. It is based on readings from the top of Mauna Loa, Hawaii (a location unaffected by industrial pollution). Before the Industrial Revolution levels of CO_2 were about 280 ppm (parts per million). By 1958 they had risen to 320 ppm and in 2013 they reached 400 ppm. Over the last 3 million years CO_2 has fluctuated between 150 ppm and 300 ppm. Hence 400 ppm is unknown territory. There is very strong correlation between increased CO_2 and increases in temperature over the last 400,000 years.

There is also a seasonal pattern to atmospheric CO_2. Rates are higher in winter and spring, and lower in summer and autumn. During winter in the Northern Hemisphere, deciduous trees reduce their photosynthesis and shed their leaves, thereby releasing CO_2 into the atmosphere. During summer, the trees build up their carbon content, thereby withdrawing atmospheric CO_2 and building up the plant mass.

There are natural variations in CO_2, methane and temperature for example. These are caused by volcanic eruptions, the reabsorbtion of carbon in oceans, Milankovitch cycles (variations in the earth's orbit and axes). However, the recent rise in CO_2 is more dramatic and more intense than many of these natural variations. The Earth has warmed by 0.8°C since the Industrial Revolution and it has not stopped warming yet. Even if no more greenhouse gases were emitted, the Earth would warm by a further 0.6°C, since the oceans take longer to respond to greenhouse gases. However, we are increasing emissions of greenhouse gases rather than reducing them

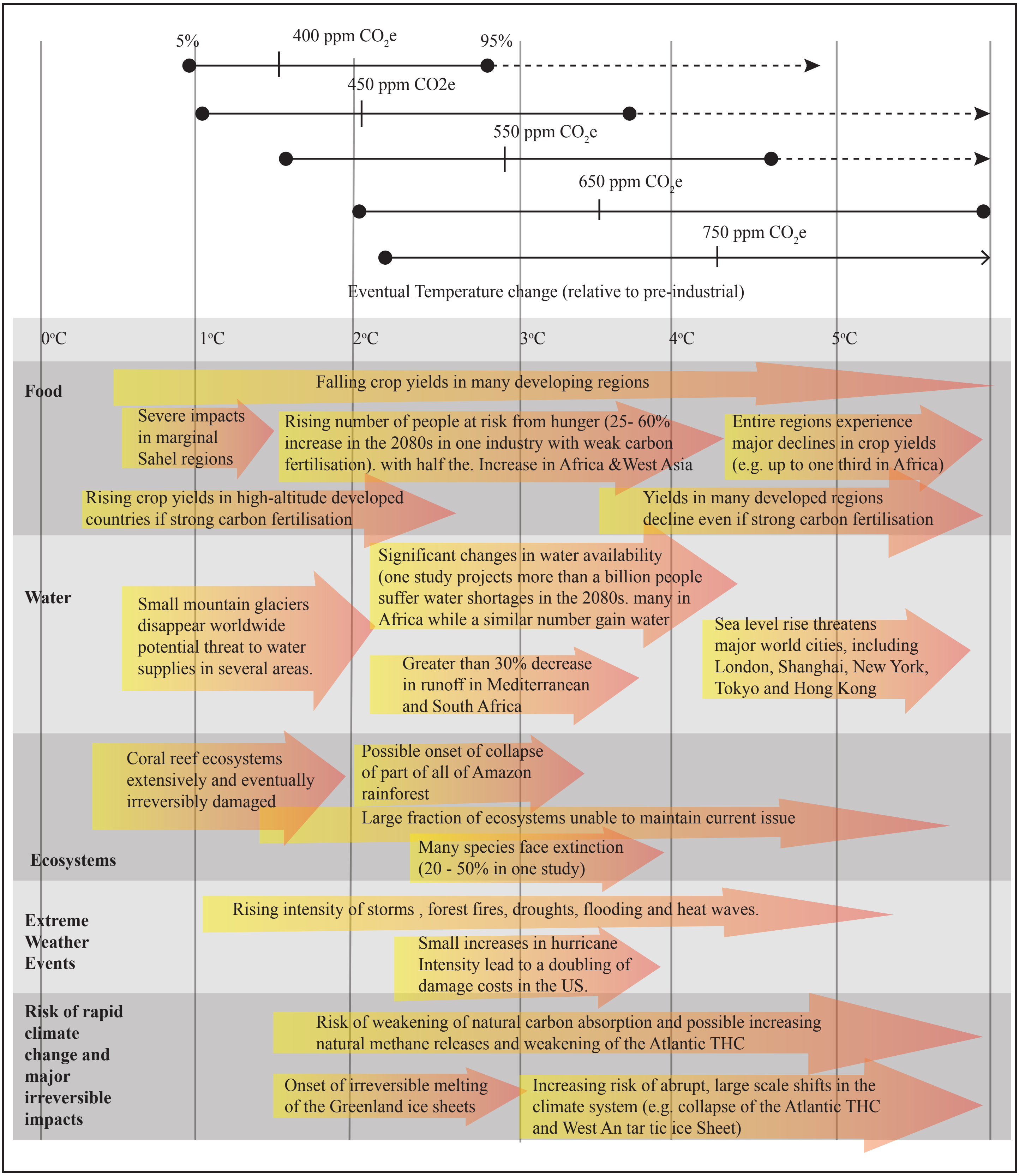
Fig. 2 The Keeling Curve



Consequences

The consequences of climate change could be dire. According to the Stern Report (Fig. 3) climate change will affect food supply, water supply, functioning of ecosystems, survival of species and produce extreme events.

Fig. 3 The impacts and costs of global warming – The Stern Report



For any category, the greater the increase in temperature, the greater the risk. Hence, if we can limit the rise of CO_2, and temperatures, the consequences will be smaller.

In the Sahel region of Africa, it is suggested that for a rise of over 1°C there could be severe impacts on food production. A 4°C rise in temperatures could reduce African crop yields by 50%. At 1°C rise in temperatures may cause small mountain glaciers to disappear – at 4°C the melting would have a noticeable effect on sea level rise, threatening major world cities such as London, Shanghai and Tokyo.

Certain regions are very vulnerable. Alongside the Sahel, the Mediterranean Basin (Spain, Italy, Greece, and North Africa) is ‘at risk’. In these regions, the climate is already dry, and any further drying is likely to cause widespread problems to water supply and food production. Evidence from climate models suggests further drying is likely.

Other areas are at risk of sea level rise. Over the last century, sea levels off the north east USA have increased relative to the land by 30 cm. If temperatures continue to rise it is possible that sea levels will rise by up to 1 m.

The potential impact on food production is great. By 2080 it is predicted that there will be a decline in food production in South Asia, Sub-Saharan Africa, south-west USA, northern Australia, and Latin America. In recent years food production has decreased in many areas due to lengthy droughts, increased temperatures and floods.

Higher CO_2 concentrations are acidifying the oceans. Ocean acidification has a major impact on shellfish, plankton and coral reefs. Corals could experience major die backs.

Mitigation and adaptation

Mitigation refers to attempts to reduce what we are doing to cause climate change. Adaptation refers to measures that are taken to live with climate change e.g. protect cities from storm surges, helps crops deal with drought, use of heat tolerant or salt tolerant species. Even with mitigation there is a time-lag (the oceans are warming up more slowly than the land) so there will have to be some adaptation.

Up to 75% of the increase in global warming is due to burning fossil fuels, so reducing this must be the top priority. Changing land-uses are the second largest contributor, and methane third. What methods are feasible and what is most cost effective? What needs to be done to keep temperature increases to less than 2°C? Any solution is going to take time – the global economy depends on fossil fuels and it may take until 2050 to change the way the world economy functions.

Nevertheless, many of the requirements are in place

- increased energy efficiency – regulate appliances standards e.g. on fridges
- electrification of cars
- photovoltaic roofs
- increased use of biofuels
- improved building standards (insulation, double- and triple-glazing)
- metering to reduce use
- a shift from fossil fuels to zero carbon sources e.g. solar, wind, hydropower.

Nevertheless, there are problems. The potential for renewable energy often occurs where population density is low. Long distance transmission lines may be needed, but there are technical and financial issues with their development. In addition, new sources of fossil fuels (Canadian tar sands, hydraulic fracking) continue to increase the demand for, and production of, fossil fuels.

International Policy

There have been a number of policies aimed at reducing climate change. The 1992 Earth Summit, the world’s leaders adopted the United Nations Framework Convention on Climate Change (UNFCCC). Its main aim was to stabilise concentrations of greenhouse gases in the atmosphere. Unfortunately, little progress has been made. The 1997 Kyoto Protocol tried to implement the Treaty. However, there was disagreement between countries. Low income countries wanted to be allowed to burn fossil fuels (just as high income countries had done earlier). The USA was not prepared to cut back its emissions if other countries were not doing the same. China was unwilling to accept any binding obligations until the USA took the lead! China is now the world’s largest emitter of CO_2 although per capita emissions are much lower than the USA.

At the 2011 Durban conference, the Parties to the UNFCCC agreed to reach a definitive agreement by 2015. All countries are to accept binding agreements to reduce their emissions of greenhouse gases. This is due to be ratified by 2018 and come into force in 2020.

Conclusion

It appears that despite the dire warnings of the potential impacts of climate change, the world’s leaders are not taking any action fast. Action appears to be more evident at a local level or even a household level. The national economy and economic development is still relying on large amounts of fossil fuels.

Questions

1. According to table 1, which greenhouse gas
(i) has the longest residence in the atmosphere?
(ii) the greatest global warming potential?
(iii) is the most comment greenhouse gas in the atmosphere?

2. Describe the changes in CO_2 between 1958 and 2013.
Compare the impacts of a 5°C rise in temperature with that of a 2°C rise in temperature.

Answers

1 (i) Sulphur hexafluoride
(ii) Sulphur hexafluoride
(iii) Carbon dioxide

2. `It has increased at a steady rate from about 315 ppm in 1958 to around 400 ppm in 2013, an increase of about 27%. This trend is true for both the summer minimum of CO_2 ppm and the winter maximum of CO_2 ppm.

Acknowledgments: This Factsheet was researched and written by Garrett Nagle.
Curriculum Press, Bank House, 105 King Street, Wellington, Shropshire, TF1 1NU
Environmental Studies Factsheets may be copied free of charge by teaching staff or students, provided that their school is a registered subscriber. **ISSN 1351-5136**