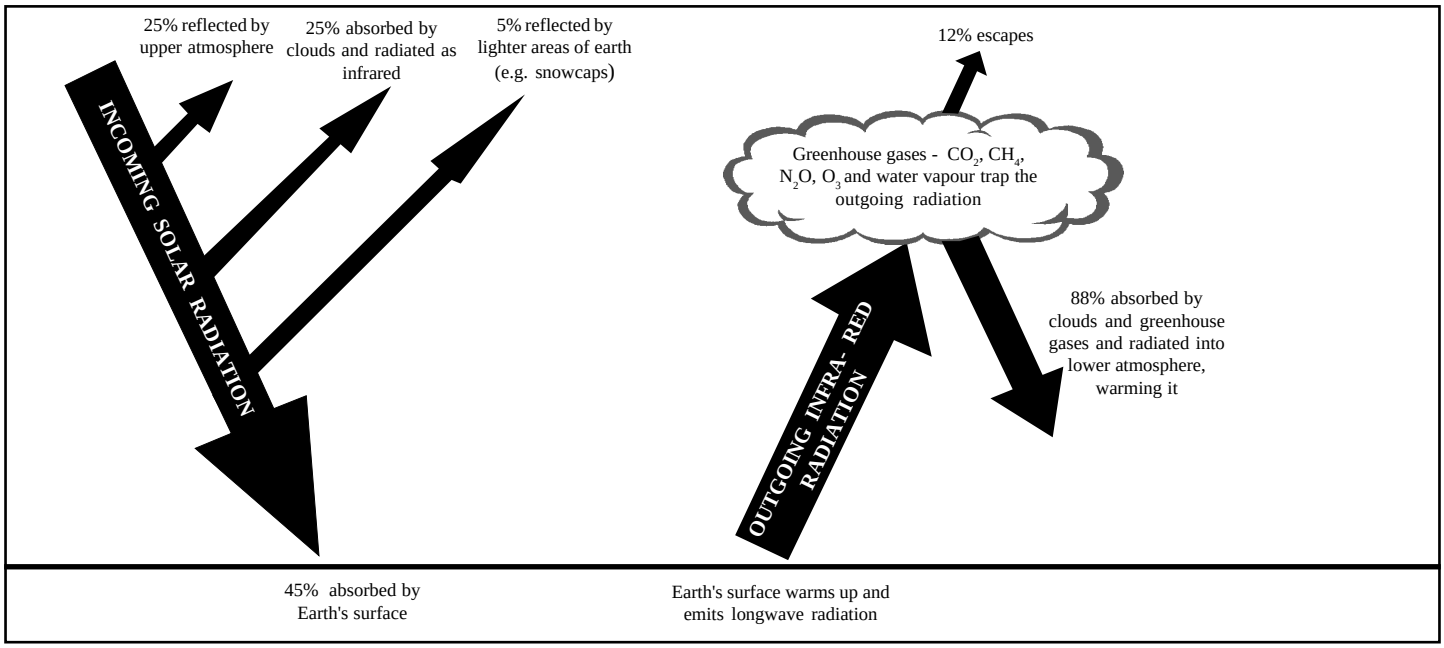
Geo Factsheet

Number 54

The Greenhouse Effect in the UK

The greenhouse effect refers to the increasing temperature of the lower atmosphere (troposphere) as a result of the heat-trapping effect of gases such as carbon dioxide, methane, nitrous oxide and CFCs. Such gases allow incoming short-wave radiation to pass through but block outgoing long-wave radiation (Fig 1). The greenhouse effect is an entirely natural process and is essential for life on earth. However, human activity is increasing the concentration of these gases, further raising tropospheric temperatures and this is known as the enhanced greenhouse effect or, less scientifically, as global warming.

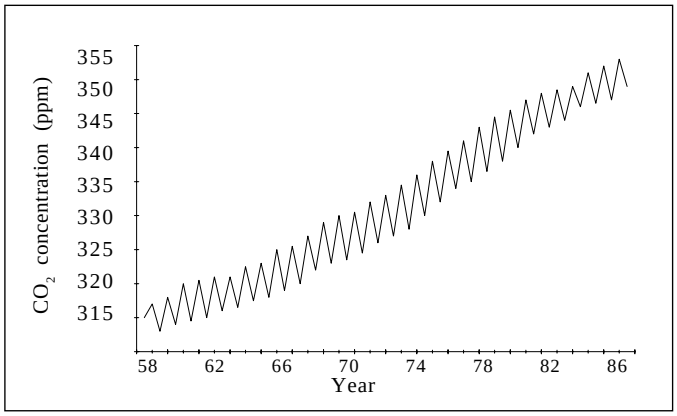
Fig 1. The greenhouse effect



Rising carbon dioxide levels

The increase in greenhouse gases is due to various human activities including burning fossil fuels in power stations, factories and vehicles, cement manufacture, use of CFC propellants in aerosol cans and burning of tropical forests. Since 1850, the CO_2 concentration in the atmosphere has increased dramatically (Fig 2).

Fig 2. Carbon dioxide in the atmosphere



Exam Hint *- When interpreting graphical information candidates should comment on small scale fluctuations as well as the general trend. In Fig 2 for example, CO_2 concentrations fluctuate seasonally - highest in winter, lowest in summer - but the overall trend is that carbon dioxide concentrations have increased.*

Rising sea levels

The Earth's temperature has risen by over 0.5°C since 1850, raising sea levels as a result of thermal expansion and the melting of the polar ice caps. The UN Intergovernmental Panel on Climatic Change predicts that sea level could rise by as much as 1m by the year 2100. Over the past century, the mean sea level is estimated to have risen by around 10 to 15cm and the rate of rise is thought likely to increase over the next hundred years or so. Estimates of the likely effects of global warming suggest additional rises in the sea level of perhaps 20cm by 2030, with a likely range of 10 to 30cm.

The expected rise of sea level could have a pronounced effect on low lying areas such as deltas and coral reefs. 9% of Bangladesh and up to 15% of the Nile Valley and Delta could be inundated, considerably reducing the amount of arable land available. Some 8 million people in Egypt would be made homeless and many cities, including London, Los Angeles and Miami would be threatened. However, it is not just the greenhouse effect that is to blame; the extraction of oil and groundwater, subsidence, tectonic and isostatic movements are all complementary forces. Moreover, scientists still do not fully understand the mechanics of the atmosphere.

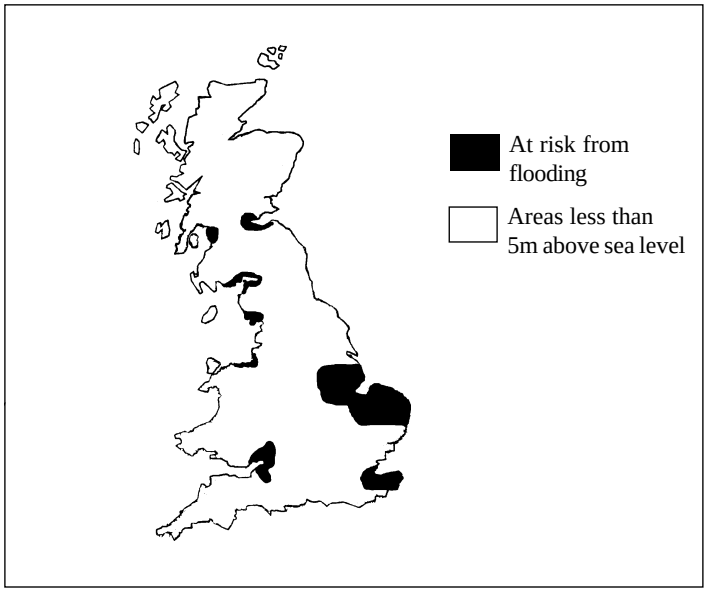
The effect of rising sea levels in the UK

In the UK, rising sea levels could have adverse effects, particularly coastal flooding and erosion, unless action is taken. In certain parts of the country (notably the south-east) the rise in the sea level relative to the land may be greater than this owing to subsidence. Since the last ice age, the British Isles has been readjusting in the north and west following glacier load removal, which has resulted in a gradual uplift. However, gradual subsidence has occurred on the margins of the North Sea basin in the east and south-east.

Estimates vary, but it may be of the order of 1mm per year, and such subsidence has caused the loss of numerous villages from low-lying east coast areas since Roman times.

Fig 3 shows the areas of Great Britain where a sea level rise could have a significant effect (shaded areas indicate land which is less than 5m above sea level). Some of these include major conurbations or high grade agricultural land. Major road and rail links situated near the and coast power stations situated on low lying land would also be at risk. In Northern Ireland, such areas are confined to narrow coastal strips and no significant areas exist inland.

Fig 3. Areas at risk from rising sea level in the UK



The effects of sea level rise may be intensified by possible increases in the incidence of storms and thus wave activity, the greatest impact being likely on the exposed western coasts facing the Atlantic. One report has suggested that the north-east Atlantic has become notably rougher over the last 25 years.

Effects on freshwater supplies

As well as direct effects such as coastal erosion or the flooding of coastal areas, higher mean sea levels could also have an impact on underground water resources. The zone of mixing of sea water with freshwater in rivers is constantly changing and a rise in sea level can cause it to move upstream.

A similar effect can occur between freshwater contained in rocks under the land and salt water in sea floor sediments, causing intrusion of salt water beneath the land. This would adversely affect irrigation and domestic water supplies abstracted from the lower reaches of rivers. As a result, the water would have to be removed at points further upstream to avoid salt water.

Rising sea level could also affect coastal habitats, particularly coastal wetlands and salt marshes. The extent to which ecosystems are likely to be affected would depend on the rate of sea level rise, the ability of ecosystems to adjust and the extent to which habitats are prevented from migrating inland by coastal defences.

The effect of global warming on the UK

Increasingly, human activities are influencing global climate. Between 1985 and 1994, temperatures have been about 0.2°C warmer than average compared with 1961-1990 and during the 1985-1995 decade, the average global atmospheric CO_2 concentration has risen by about 5%. Temperature is expected to continue to increase at a rate of about 0.2°C per decade. Higher rates of increase will occur in the south-east, especially during summer. It will be about 0.9°C warmer than the average of 1961-1990 by the 2020s, and about 1.6°C warmer by the 2050s. The likely impacts of climatic change on the UK for the 2020s are:

- There will a 200 km northward shift of the UK climate along a south east to north-west gradient.
- Annual precipitation over the UK as a whole is expected to increase by about 5% by the 2020s and by nearly 10% by the 2050s. Winter precipitation will increase everywhere but more substantially over southern UK.
- The contrast in the UK's climate is likely to become exaggerated, for example, the currently dry south-east will tend to become drier and the wet north-west will get even wetter! Drought in the south-east and flooding in the north-west may both become more common.
- Sea level is expected to rise at a rate of about 5cm per decade. This is likely to be increased in southern and eastern England by the sinking land whereas in the north-west it will be offset by rising land (as a result of glacial unloading).

Some of the positive and negative effects of these changes are summarised in Table 1.

Exam Hint *- Candidates should not try to remember estimates of increases of temperature or sea level. Since many of these are scientific guesstimates, candidates should concentrate on the principles.*

Table 1. The likely effects of a changing climate in the UK

Positive effects	Negative effects
Increase in timber yields (up to 25% by 2050's) especially in the north of the UK (with perhaps some decrease in the south).	Increase in soil desiccation, soil erosion and the shrinkage of clay soils.
Northward shift of farming zones by about 200-300 km per degree centigrade of warming, or 50-80 km per decade. This will improve some forms of agriculture, especially pastoral farming, in the north-western part of the UK.	Increase in animal (especially insect) species as a result of northward migration from the continent and a small decrease in the number of plant species due to the loss of northern and mountainous climates.
Enhanced potential for tourism and recreation as a result of increased temperatures and reduced precipitation in the summer, especially in the southern UK.	Decrease in crop yields in the south-east of the UK.
	Increase in river flow in the winter and a decrease in the summer, especially in the south.
	Increase in public and agricultural demand for water.
	Increased damage due to storms, flooding and erosion on natural and human resources and human resource assets in coastal areas.
	Increased incidence of certain infectious diseases in humans and of the health effects of episodes of extreme temperature.

By the 2050s, the UK climate will be about 1.5°C warmer and 8% wetter than the period of 1961-1990. Average sea levels will be about 35cm higher than 1961-1990 and the probability of storm surges will have increased. By 2050, the UK will be subjected to more intense rainfall events and extreme wind speeds, especially in the north. Gale frequencies will increase by about 30%.

The effect on the UK's water supplies - the 1988-1992 drought

One of the most serious effects of the enhanced greenhouse effect in the UK is the increased possibility of water shortages and drought. A drought is an extended period of dry weather leading to conditions of extreme dryness. Partial drought is a period of at least 15 consecutive days with less than 0.2mm of rainfall. Absolute drought is a period of at least 29 consecutive days during which the average daily rainfall does not exceed 0.2mm. In large parts of the UK there were periods of absolute drought in 1988-92.

The drought in the UK was caused by a number of factors:

- Low summer and winter rainfall
- During the drought, the summers were also much warmer and drier, especially in the south and east of Britain - this increased losses due to evaporation and transpiration
- Increased abstraction of water

The 30-year average rainfall for the UK is 912 mm. Between 1988 and 1992, drought affected much of southern Britain. During that time the annual average rainfall was 717mm, a reduction of 20%. The period between March 1990 and February 1992 was lower than in any previous two-year period since accurate records began in 1767. The 7 months preceding March 1992 were the driest in England this century.

This period of low rainfall was felt most severely in the south-east. The 1991-2 winter recharge of underground water in the chalk hills, the region's most important source of water, was less than 15% of normal and some areas received nothing at all. In East Anglia groundwater levels fell by up to 8 metres, the lowest levels ever recorded.

The drought became severe because an exceptionally dry winter failed to refill reservoirs and underground water storages. Low rainfall was not the only problem. The long, hot summers of 1989 and 1990 brought record rates of evaporation of water from the soil. In a typical year, rainfall is 650mm over south-east England but 550mm of this is lost to evaporation. The soil-moisture deficit (SMD) is the amount of rain needed to wet the soil to the point where it stops absorbing water. Only then can water percolate down to the water table. Usually autumn rains satisfy the SMD. However, during 1988-92, SMDs in the south-east lasted through to early winter and, in some cases to the following spring. When the rains finally came in 1992, they were so intense that water ran off the surface rather than percolating to the water table.

Drought can be managed in a number of ways; water supplies can be transferred, recycled or even increased through construction of new reservoirs. However, rather than expanding supplies, better management and use of existing resources is needed. This involves more than the short-term steps, such as hosepipe bans, but long-term measures such as the installation of domestic meters, reduction of leakages and education campaigns to promote more economical use of water in industry, on farms and in the home.

Conclusion

By 2050, London's climate will be similar to that of Bordeaux today. The south and east of the UK will become hotter and drier whereas the north and west of the country will become wetter with more frequent flooding (Table 2). Average UK temperatures will rise from 9°C to 10.6°C, and global sea-levels will rise by about 35cm. This will cause problems in low lying coastal areas as well as for groundwater in coastal areas. There are a number of implications of these changes:

- Tourism and recreation will increase
- Farming in upland areas will become more profitable
- Farming in lowland areas will be subjected to more soil erosion and decreased yields
- Climatic zones will move northwards by approximately 300 km
- Increased drought will lead to increased building subsidence
- There will be more storms and flooding

Table 2. Greenhouse scenarios

0.5°C increase	**1.0°C increase**	**1.5°C increase**
Summer and winter precipitation increases in the north-west by 2-3%. Summer precipitation decreases in the south-east by 2-3%. This implies that annual run-off in the southern UK decreases by 5%.	Summer and winter precipitation increases in the north-west by 4%. Summer precipitation decreases in the south-east by 5%. Annual run-off in the southern UK decreases by 10%.	Summer and winter precipitation increases in the north-west by about 7%. Summer precipitation decreases in the south-east by 7-8%. Annual run-off in the southern UK decreases 15%.
Frequency of the 1995 type summer (drought) increases from 1 in 90 to 1 in 25 years.	Frequency of 1995 type summer increases from 1 in 90 to 1 in 10 years.	Frequency of 1995 type summer increases from 1 in 90 to 1 in 3 years.
Disappearance from the British Isles of a few niche species. e.g. alpine wood fern, oak fern.	Disappearance from the British Isles of certain species e.g. ptarmigan, mountain hare.	Further disappearance from the British Isles of several species.
In-migration of some continental species and expansion of some species, e.g. Red Admiral and Painted Lady butterflies, Dartford Warbler.	Expansion of range of most butterflies, moths and birds such as Golden Eye and Redwing.	In-migration of several species.
Increase in overall UK timber productivity by 3%.	Increase in overall UK timber productivity by 7%.	Increase in overall UK timber productivity by 15%.
Increase in demand for irrigation water by 21% and in domestic demand by an additional 2%.	Increase in demand for irrigation water by 42% and in domestic demand by an additional 5%.	Increase in demand for irrigation water by 63% and in domestic demand by an additional 7%.
Decrease in energy consumption for space heating by 6%.	Decrease in energy consumption for space heating by 11%.	Decrease in energy consumption for space heating by 16%.

Acknowledgements; *This Geo Factsheet was researched and written by Garrett Nagle*
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