WinACC
Winchester Action on Climate Change

Local effects of climate change – Introduction

Climate change is a global issue. Global average surface temperatures have been rising by about 0.15° to 0.2°C per decade over the last 30 years and this is highly likely to continue if emissions of greenhouse gases associated with human activity continue at or above the present level. Climate change is also a local issue, and the effects which might be experienced locally in the south of England, and more particularly in Hampshire, are the subject of this series of short briefings.

The primary effects will be related directly to changes in Hampshire's climate. The precise climatic change which is likely to be experienced by a particular region of the globe is one of the least well understood aspects of climate science, but it is possible to make quantitative estimates based on numerical models (see section 1 below). There will also be indirect changes resulting from climate change, such as rises in mean sea level, causing coastal flooding (see section 2 below) and reductions in water supplies, caused by drought (see section 3 below).

Secondary effects are likely to include changes in agricultural production, both locally and elsewhere in the world, which will affect our food supply in terms of absolute and seasonal availability of particular foods and their price. Changes in the productivity of agricultural land in parts of the world are likely to be one of the factors driving movements of human populations, along with direct climate changes making some marginally habitable areas uninhabitable. These movements may include increased pressures on human migration (see section 4 below) towards more temperate areas of the world, such as the United Kingdom. There will also be effects on plant and animal life in terms of biodiversity (see section 5 below), the number and types of species and their abundance. Changes in habitats are inevitable as the global climate warms. The nature and rate of these changes will make it very difficult for many species to adapt and will lead to extinctions locally and globally, and also cause the ranges of many plant and animal species to move.

Further sections will be added as they become available.

1 The impact of climate change on extreme weather events in southern England

The Earth's climate is changing. Global temperatures are rising and are predicted to continue to rise for the foreseeable future. Because of the relatively slow response time of climatic systems, a further increase globally of about another 0.6°C is inevitable, even with no further increase in greenhouse gas concentrations. Assuming that greenhouse gas emissions caused by human activities will continue, the size of the future rise in temperature will depend on the rate of these emissions and on the efficacy of carbon sinks (natural systems that absorb carbon dioxide). In the United Kingdom, the average temperature in central England has risen 1°C since the 1970s and the average sea surface temperature around the United Kingdom has risen 0.7°C in the last 30 years [1].

The increased energy in the atmospheric system, which follows from the increased temperatures, is likely to lead to increases in the intensity and also the frequency of what are currently regarded as the most extreme events. The kinds of extreme weather events which might be experienced in the United Kingdom include summer heat waves and associated droughts, unusually intense storms and associated high winds, unusually heavy precipitation, and unusually cold spells in winter.

The precise effects of global climate change on particular regions, such as the United Kingdom, is one of the least well understood areas of climate science, but it is possible to make projections based on the balance of probabilities. A recent UK government sponsored study based its projections on computer modelling of future climate change effects and their impacts [2]. It included three sets of results based on high, medium and low global greenhouse gas emission projections, with the medium emissions scenario being closest to that which is being followed at the moment.

Using this medium emissions scenario and the central estimate results, the projections for south east England in the 2020s, relative to the mean values for the period 1961-1990, show an increase in winter mean temperature (+1.3°C) and a bigger increase for summer mean temperature (+1.6°C), and an increase in summer mean daily maximum temperature of 2.1ºC. This might be expected to be reflected by more frequent and/or more intense heat waves. An increase in winter mean precipitation (+6%) and a decrease in summer precipitation (-8%), with little change to annual precipitation totals, are indicated. This, combined with increasing temperature, might be expected to produce more extreme precipitation events in winter. By the 2050s, projections relative to the same 1961-1990 reference period show these trends continuing with increased winter mean temperature (+2.2°C), increased summer mean temperature (+2.7°C), increased winter mean precipitation (+16%) and decreased summer mean precipitation (-18%).

Research which has been conducted using climate models to predict regional effects has also suggested that north western Europe will indeed experience more frequent, longer lasting and more intense heat waves, like that of summer 2003, as the 21st

century progresses [3]. Soil moisture deficit resulting from decreased summer precipitation will interact with raised temperatures to increase heat wave duration. The most obvious impacts include increased pressure on water supplies and agriculture, but also include increased mortality in vulnerable groups such as the elderly, consistent with the 2000 additional deaths in the United Kingdom associated with the heat wave of 2003.

Heavy winter precipitation events are predicted to increase in intensity and in frequency in north western Europe, increasing the likelihood of flooding of vulnerable areas. Extreme wind speeds associated with winter storms are also predicted to increase, with increased damage to buildings and other infrastructure. Storm surges associated with intense low pressure systems are also likely to increase in magnitude, adding to the risk of flooding of low lying coastal areas. Such areas are already at risk from rising mean sea level, itself partly the result of factors associated with climate change (thermal expansion of sea water as its mean temperature rises, and additional water from accelerated melting of ice sheets and glaciers). In addition the south of England is sinking by about 1 mm per year as a result of the northern UK rising in response to the removal of the weight of ice which melted at the end of the last ice age.

The periods of unusually cold weather experienced in the winter of 2009-2010 and in December 2010 in north west Europe are probably linked to the marked warming of the Arctic and associated loss of polar sea ice coverage in autumn and early winter [4]. The UK Meteorological Office has reported December 2010 as the coldest December on record in the United Kingdom, but Arctic sea ice extent has also been at a record low for December 2010 according to the US National Snow and Ice Data Center. Arctic warming leads to raised air pressure, and increases the flow of polar air towards north west Europe. When there is a much reduced pressure gradient between the Azores high pressure and the normally low pressure around Iceland, this causes much reduced movement of warmer, moister, maritime air from the south west and allows much colder, dryer polar air to dominate our weather. This may become a feature of our winter weather in the medium term until further warming changes weather patterns again.

[1] DEFRA (2009), UK Climate Projections (UKCP09) Briefing Report

[2] DEFRA (2009), UK Climate Projections (UKCP09) Climate change projections

[3] Beniston, M. et al (2007), “Future extreme events in European climate: an exploration of regional climate model projections”, Climatic Change Vol. 81, p. 71-95

[4] Honda, M. et al (2009), “Influence of low Arctic sea-ice minima on anomalously cold Eurasian winters”, Geophysical Research Letters Vol. 36

2 Increased risk of breaches to flood defences, including the Thames Barrier

Global warming is happening and, even if mankind takes radical action now, the relative slowness of the climate system to react to change means that warming will continue for centuries.

As the oceans warm up they expand and so sea level rises. Melting glaciers and ice-caps also contribute to rising sea level. The latest (June 2009) predictions from Defra/DECC show likely absolute sea-level rises around the UK between 12 and 76 cm by the end of the century even if strenuous efforts are made to cut emissions and actively remove CO_2 from the atmosphere [1]. In the very worst case absolute sea level around the UK might rise by 93 to 190 cm.

On a global scale, coastal flooding is now more frequent than at the start of the 20th century. This is largely a result of an increase in average sea level rather than a change in the frequency or intensity of storm events. There is continuing uncertainty as to whether global warming will lead to increased storminess and any future changes are likely to vary from region to region. For the UK, in 2004 scientists said there was no observational evidence for regional trends in either storm surge frequency or magnitude over recent decades. However, in Europe, the frequency and severity of storms would be likely to increase if, in line with current trends and model predictions, north polar regions continue to warm more than the tropics. This would lead to greater temperature differences between northern land masses and the sea which would produce stronger convection which, in turn, would inject more energy into weather systems. In addition, warming of the sea would increase evaporation leading to more rain and snow. Thus, in the UK, more intense summer downpours could lead to flash flooding while winter rain and snow falls are expected to become more frequent and heavier, also potentially causing more flooding.

It follows therefore that both coastal and inland regions are likely to become more susceptible to flooding during this century. Indeed, over most of Eurasia, the number of areas[1] showing increases in annual precipitation is higher than those showing decreases both since 1901 and since 1997. In February 2011 two research papers were published that indicate that rising concentrations of greenhouse gases in the atmosphere caused by human activities may already be influencing the intensity of rainfall and increasing the risk of substantial damage from the associated flooding [2]. This appears to occur because, as predicted theoretically, atmospheric water content increases exponentially with temperature. More rapidly Modelling shows that it is very likely that the rise in greenhouse gases can explain floods that occurred in the UK in October-November 2000.

In 2010 the Environment Agency, the UK's principal flood risk management operating authority, said it planned to spend £431 million on coastal and inland flood defences in England and Wales. [3] Smaller rivers are managed by Local Authorities or Internal Drainage Boards. Over 5 million people in England and Wales live and work in properties that are at risk of flooding from rivers or the sea. However, it is

[1] The areas considered were squares of 5 degrees latitude by 5 degrees longitude.

often not economic or even desirable to prevent all forms of flooding in all locations, and so the Environment Agency uses its powers, and its funding, only to reduce the likelihood or consequences of flooding rather than to prevent it completely. In effect this means that many places in England and Wales are at increasing risk of being flooded in the coming century.

Recent examples of the damage done, and misery caused, by floods in the UK are Cockermouth (2009) and River Severn (2007). Further afield one thinks of Pakistan, Niger, Provence (all in 2010) and Poland and other parts of Central Europe (1997 and 2010). Rising sea level is already causing great concern to the inhabitants of the Maldives and other low-lying islands. More locally, in Hampshire the risk of flooding is likely to increase in river valley flood plains, and in coastal areas as a result of the combination of heavier and more frequent storms and sea level rise.

Probably the most significant flood defence structure in the UK is the Thames Barrier which, since 1982, has protected London during exceptionally high tides, storm surges and times of high river flow. [4] In 1997 it was estimated that the cost of London flooding would have been £13 billion; this was increased to over £75 billion in 2001. Closures of the barrier, to prevent flooding, have increased over time. Just over two thirds of closures have been since 2000. The barrier was closed four times in the 1980s, 35 times in the 1990s, and 80 times since 2000. As sea level rises, and if there is an increase in storm surges, the Thames Barrier will have to close more frequently to prevent overtopping of the flood defences upstream of the barrier. The current recommendation of the Thames Estuary 2100 project is for a maximum of 50 barrier closures a year; more frequent closures would lead to an unacceptable risk of equipment failure. It has been estimated that the limit of 50 closures per year will begin to be exceeded from 2135 onwards.

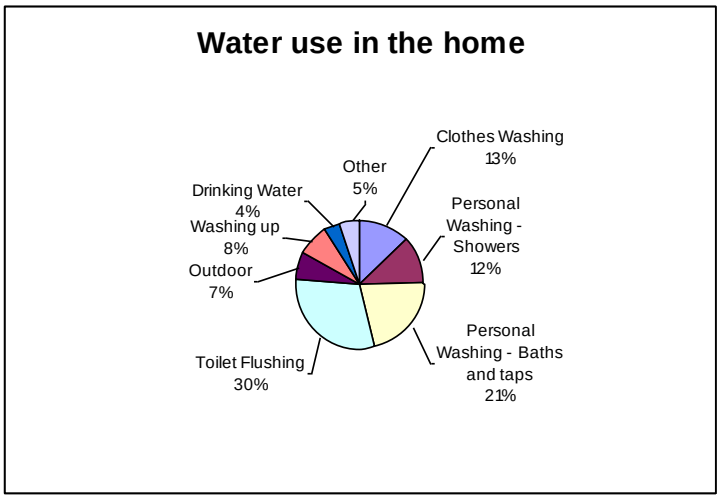
[1] Lowe, J. A., T. P. Howard, et al. (2009). UK Climate Projections science report: Marine and coastal projections. Exeter, UK, Met Office Hadley Centre**:** pp.99.

[2] Min, S.-K., X. Zhang, et al. (2011). “Human contribution to more-intense precipitation extremes.” Nature **470**: 378-381. Pall, P., T. Aina, et al. (2011). “Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000.” Nature **470**(doi:10.1038/nature09762): 382-386.

[3] http://www.environment-agency.gov.uk/homeandleisure/floods/31738.aspx. Accessed 27/2/11.

[4] http://en.wikipedia.org/wiki/Thames_Barrier. Accessed 27/2/11.

3 Water stress



On average, each person in the UK uses 150 litres of drinking water per day at home. This figure includes cooking, cleaning, washing and flushing (see Figure) and has been rising by 1% a year since 1930. [1] About one third of the drinking water each person uses is essentially wasted – it runs straight down the plughole or down the toilet. However, if you include the amount of water embedded within consumer products, particularly crops that need irrigating, food and drink but also manufactured goods, our water consumption is around 3400 litres every day! This consumption level is not sustainable in the long-term.

The amount of water that is available for use in homes and elsewhere is the product of a series of separate processes. Water supply depends on the amount, intensity and seasonal distribution of rainfall which in turn is susceptible to changes in climate. Heavier rainfall is harder to 'capture' and is more likely to run-off rapidly, overload drains, cause flooding and end up in watercourses than to soak into the ground and refill aquifers (underground layers of water-bearing permeable rock or less consolidated materials (gravel, sand or silt) from which water can be extracted). Land use, and particularly the relative area covered by crops, grass and woods, as opposed to the area covered by buildings, concrete and tarmac, has a large influence on how much rain soaks into the ground. Once water finds its way into an aquifer, where it can be abstracted from wells or springs, or accumulates in a surface reservoir, it has to treated to make it drinkable. It is then pumped through a network of pipes from which losses in the form of leaks can be relatively high. Finally it reaches the point of use.

The population of SE England is steadily increasing, the changing climate seems to increasingly concentrate rainfall in the winter months, the distribution network is old and relatively leaky and the *per capita* consumption is increasing year on year. Consequently in 2007 the Environment Agency classified South-east England, which includes all of Hampshire and therefore Winchester, as an area of 'serious water stress' (defined according to the availability of water, current and forecast demand, and population growth). Surprisingly, the UK is said to have less available water per person than most other European countries. London is drier than Istanbul, and the south-east of England has less water available per person than the Sudan and Syria.

Part of the solution to water stress has to be the reduction of waste, for example by introducing more efficient toilets and by relying on the persuasive powers of water meters, and does not necessarily mean that the use of water has to be restricted. On the other hand, an eventual re-design of our water infrastructure is inevitable

particularly to reduce or even eliminate the use of treated potable water for flushing toilets and to make use of 'grey water' or locally collected untreated rainwater for this purpose. Even ignoring the energy required to heat domestic hot water, water use also has implications for greenhouse emissions and climate change. Around 240 kWh of electricity, equivalent to the emissions of around 120 kg of carbon dioxide, is used every year to pump an average of 500 litres of water to each family every day. Lastly, as the climate changes, it seems likely that demand will increase whether it is for irrigating local crops, watering our gardens or just taking more showers to keep cool. In the coming decades water will become an increasingly valuable resource in South-east England. Although in one sense it is free how it is shared out among users is likely to lead to marked changes in our daily lives.
[1]
http://www.waterwise.org.uk/reducing_water_wastage_in_the_uk/the_facts/the_facts_about_saving_water.html. Accessed 27/2/11.

4 The impact of climate change on human movements into Southern England

The International Panel on Climate Change (IPCC) stated in 1990 that the greatest single global impact of climate change may be on forced human movements. This claim was further substantiated by the findings of the IPCC Fourth Assessment Report in 2007. Climate change-induced migration could have significant implications for the global economy, international development and the cost of maintaining individual, political and state security.

The human population is projected to peak at 9 to 9.5 billion by 2050. The majority will continue to live in towns and cities, many of which are located in areas susceptible to the gradual sea level rise resulting from global warming. In addition, climate change is already increasing the frequency of intense storms, flooding, droughts and wild fires while the melting of glaciers will exacerbate water shortages and flash flooding. These trends are likely to continue and perhaps accelerate, affecting both urban and rural areas. More gradual but no less serious climatic changes, such as the effects on ecosystems and crops, put great stress on people's livelihoods. Estimates for different climate change scenarios suggest that by 2050 climate change could lead to the forced movement of 50 to 200 million people within or across national borders on a temporary or permanent basis [1] although these figures have been hotly disputed [2].

For those with the resources, forced human movements can be an adaptation to escape from danger. However, in extreme cases and for those with fewer resources, movements may result from a failure of adaptation, an attempt to escape from imminent suffering or death. In this case migrants are unlikely to have the resources to travel long distances to cross national boundaries. This view is supported by a recent report[2] which showed that - in Bolivia, Senegal and Tanzania - people affected by environmental degradation linked to climate change rarely crossed

country borders but moved to other rural areas or nearby towns in their own country. A similar conclusion is suggested by the consequences of the recent devastating flooding in Pakistan.

A moral argument exists that the people forced by climate change to emigrate should, if they wish, be accommodated by host countries in proportion to each host country's cumulative emissions. However, although this principle is consistent with Articles 1 and 4.8 of the United Nations Framework Convention on Climate Change [3], it is questionable whether international or even regional agreement could be reached on this.

While previous anxieties about mass emigration driven by climate change may be unfounded, severe water stress and crop failures in Mediterranean countries may mean that a significant number of EU citizens may wish to move from the Mediterranean area to Britain, and under current rules they would be entitled to do so. A similar situation may arise from the flooding of the Netherlands Hampshire - with its two ports, numerous additional harbours and numerous nearby airports - could potentially provide entry points for non-EU citizens forced by climate change to emigrate. However the number of climate refugees arriving in southern England is likely to be determined by the policies of the government of the day and the effectiveness of any immigration controls.

[1] Warner, K., 2008, Human Security, Climate Change and Environmentally Induced Migration UNHCR/ UNU report.

[2] Tacoli, C., 2011, Human Settlements Working Paper Series Rural-Urban Interactions and Livelihood Strategies – 28, IIED.

[3] Byravan, S and Rajan S.C., 2005, Nature, 434, p 435.

5 The impact of climate change on biodiversity and habitats in Hampshire

Historically, the principal causes of loss of biodiversity in Hampshire have been the destruction and fragmentation of habitats, and over-exploitation including the use of fertilisers and pesticides. However, by 2050 climate change is likely, as elsewhere in the world, to become the major cause unless massive reductions in global greenhouse gas emissions are made. By 2080 the climate of Hampshire may resemble that of Portugal today with mean temperatures in January increasing by 3°C and in July by 6°C, while annual rainfall may decline markedly with frequent severe summer droughts. In Hampshire the habitats likely to suffer the most are water meadows, chalk down land and chalk streams as drought and higher temperatures take their toll on many species of the current flora and fauna. Freshwater species are likely to be lost as winterbournes disappear. Beech trees are shallow rooted and consequently drought intolerant and are likely to be replaced, at least partially, by limes. Veteran trees of all species are likely to be blown down by more frequent, severe storms. Existing coastal habitats are likely to be lost as a result of inundation and erosion caused by severe storms and sea level rise although some reclaimed land may revert to coastal marsh. Warming seas, and even ocean acidification, may also affect marine organisms. On the other hand, the changes in climate will encourage the northward movement of continental species seen today only at lower latitudes.

The European Environment Agency (EEA) has recently warned that most species and habitats across the continent are in poor condition and the risk of extinctions continues to rise. According to the UK Centre for Ecology and Hydrology the dormouse, otter, golden eagle, cuckoo, swallowtail butterfly, garden tiger moth, stag beetle, great crested newt, honeybee, several kinds of bumblebee all risk extinction as their habitats shrink or become less viable. The WWF have recently estimated that loss of Biodiversity in Europe will cost around €1.1 trillion per year in 2050, or nearly 4% of the EU's GDP. Although Mediterranean countries are likely to be the most seriously affected the impact on Hampshire and the rest of the UK is likely to be considerable.

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