Defra
Science Notes 5
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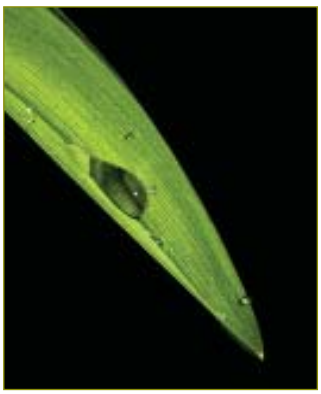
Uncharted waters – how will climate change affect our water resources?

Water is one of our most important resources, yet it is something we in the Western world often take for granted. But because of activities like farming and burning fossil fuels, which release heat-trapping greenhouse gases into the atmosphere, our climate is changing, affecting how water is distributed around the planet.

In this note we look at our vital water resources, examining the factors that affect their availability and distribution and ask how they will be affected by climate change.



Why is water important?

Water is essential for all living things. 50-70% of an adult's body weight is made up of water. For plants, water is a vital component of their process (photosynthesis) for making food.

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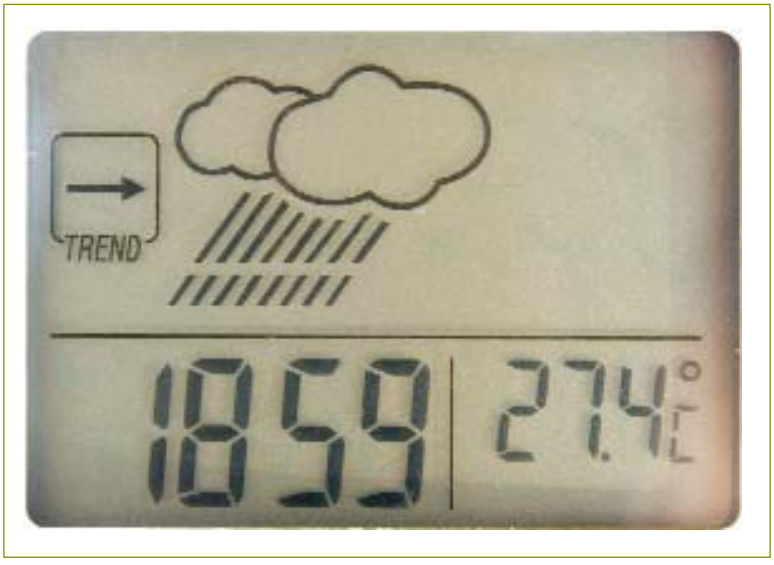
Where does water come from?

You can find water in a number of different forms – as a liquid, as a solid (ice or snow) and as gas (steam or water-vapour). Whether water is a solid, liquid or gas depends upon the temperature and pressure; at low temperatures (below 0°C) and high pressure you'll find it as ice, but under higher temperatures (above 100°C) or lower pressures you'll find it as steam or water vapour. In between it will be a liquid – in rivers, reservoirs and the sea.

The journey that water takes around the planet, from the land to the sky and back again, is known as the water cycle. Surface water (seas, rivers etc) is heated by the sun and turned into vapour (evaporation). Plants and animals also produce water vapour when they breathe, releasing it into the atmosphere. The water vapour eventually cools and forms tiny droplets becoming clouds (condensation). As the droplets become bigger and heavier they are released as rain, sleet or snow, bringing the water back down to earth. Some of the water soaks into the ground and gets trapped between rocks or layers of earth (groundwater) but most of it flows downhill as streams and rivers, eventually reaching the sea.



How will climate change affect our water?

Increasing the temperature by just a few degrees could change the form in which we find water on the planet. Ice and snow could melt and liquid water could evaporate, altering the global pattern of water availability and having a significant effect on living things.

Water, water, everywhere…

Scientists believe that climate change is likely to cause a rise in sea levels for two reasons. Firstly, as liquids are warmed their molecules move further apart and take up more room. Consequently, as our climate warms, the water in the sea will expand and sea levels will rise to accommodate it. Secondly, current temperature increases seem to be greater at the poles, putting the ice sheets in the Arctic and Antarctic at risk of melting, potentially pouring even more water into the seas and raising sea-levels further. If all of the Antarctic ice was to melt, sea levels would increase by about 57 metres.

Another factor that can cause rising sea levels rises is deforestation. Cutting down forests increases the risk of flooding because upland forests and wetlands soak up a lot of water. Many forests have been removed for development and logging, causing rainwater to run off the land rather than be held in the soil. This has increased the amount of water in rivers and seas and eroded the soil in the process.

Scientists also have evidence that climate change will change the pattern of rainfall. This means that when it rains it will rain more heavily, but the periods without rain will grow longer. We will need to be prepared to deal with both wetter and drier conditions.

… But not a drop to drink?

Despite expected increases in sea levels, we should also expect an increase in droughts, and not just in the South-East of Britain.

Many millions of people in areas of Asia and South America, who rely on glaciers as their water source, will face shortages. Although increasing temperatures means more rain, overall it means less snow in the mountains. Glaciers won't be replaced once they melt – already the area of Peru covered by glaciers has shrunk by a quarter over the last 30 years. The snow will also melt earlier in the year, gushing into rivers and streams and bursting banks. Unless the excess water is captured for drinking it will be lost to the oceans.

In South-East of Britain, the drought that started in November 2004 is probably the worst in the last 100 years. As much as 70% of the public water supply is provided by aquifers, underground water held in porous rocks, which rely on autumnal and winter rainfall to refill. Aquifers only refill when the soil is completely drenched. In 2006, the autumnal rain did help to restore rivers and reservoirs to normal levels, but it wasn't sufficient to help the aquifers. The South-East aquifers will need more than twice the average winter rainfall to recover.

What will this mean?

More droughts won't just affect where we get our next glass of water from – researchers at the Met Office suggest that by 2100, one third of the world will be experiencing extreme drought. Farmers will have to find ways of growing crops using less water. Researchers are testing a technique used in Australian vineyards called 'partial root zone drying' where the crop is watered on alternative sides – the drier side becomes stressed and the plant is 'tricked' into closing its pores, so less water escapes into the atmosphere. Instead, the plant uses every drop of water to grow and as a result produces the same amount of fruit using half the amount of water.

Kew Gardens conservation scientists are advising gardeners to adopt water saving techniques such as mulching and composting. We might also need to rethink the types of plants we grow, moving towards more Mediterranean style gardens and crops that can cope with less water.

As an island, Britain has always been at the mercy of the sea. The Department of Trade and Industry's Foresight Flood and Coastal Defences project predicts that the risk of flood and coastal erosion could increase significantly by the end of the century with increased winter rainfall, storminess and sea level rise. The actual changes however, will be dependent on patterns of growth, development and measures to manage the risks, as well as climate change and sea level rise.

The UK Climate Impacts Programme has produced a series of maps that predict how the UK might change according to the sea level increase. If we take care to reduce our dependence on fossil fuels, known as a low emission scenario, then sea level rise could be limited to 20cm by 2080. However, in a high emission scenario, where we continue to pump greenhouse gases into the atmosphere at current levels, we might expect sea levels to rise anywhere up to 80cm.

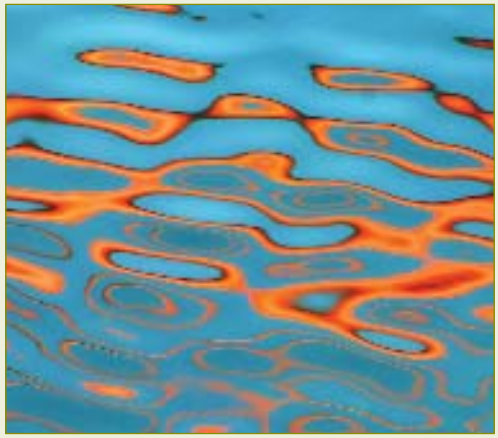
A lack of water and an increase in temperature is also a dangerous combination for our forests, increasing the risk of wildfires, particularly in the developing world – two years of the worst drought in the past 40 years has produced devastating effects in the Amazonian rainforest. Scientists believe that even if global temperatures increase by less than 3°C then risk of wildfires in South America, Central Asia and Southern Africa will more than double. This could increase overall global warming even more because the forests will absorb less carbon dioxide than they release.

Wild animals and plants also need a good supply of water to survive – droughts and floods can change their habitats, affecting how they eat and where they live, and in turn changing the landscape around us. For example, drought could cause trees with shallow roots, such as beech trees, to die out as they won't have access to sufficient water. Drier soils also make it harder for birds to probe the soil for food. Heavy rainfall can cause trees to be damaged and soil to be waterlogged, making survival difficult for worms and insect larvae that like damp not wet soils. Changes to the water system are also dangerous for the food web. For instance, drought conditions will threaten mayfly larvae which need fast flowing oxygenated water to survive. This in turn will affect the number of fish or bats that rely on the larvae as food. Marine plants and animals have also evolved to live in specific conditions but recent increases in carbon dioxide are making the oceans more

What will this mean? continued

acidic, changing the pH of the water. This could have damaging effects on the shells of shellfish and coral reefs in particular because the mineral they are made of dissolves in more acidic environments.

The tension between droughts and flooding will also affect the incidence of disease. Increased flooding could spread water related diseases by disrupting sanitation and contaminating water sources. Droughts also encourage the growth of fungi, white flies, locusts and rodents and concentrate contaminants in rivers, threatening the quality of food and water supplies and therefore public health.



Starting at the beginning

It's clear that having too much or little water will have serious consequences for us all. On an individual basis we can do more to use our water resources more efficiently – installing low flush toilets or using sensor activated taps so they aren't left running. Less conventional methods include recycling rainwater during the summer months to water the garden, or reusing water from washing machines, dishwashers and showers (known as greywater). We should also reconsider how we manufacture and produce our goods and services – how much water goes into an average week's shopping?

Different products require different amounts of water – an average cup of coffee (125ml) 'costs' 140 litres of water to make but producing a 150g hamburger requires 2400 litres! On average meat products require more water through livestock grazing on irrigated crops, drinking and washing. For example, to produce 1kg of boneless beef, the cattle will use about 6.5kg of grain, 36kg of roughage, and 155 litres of water for drinking and cleaning.

UNESCO (United Nations Educational Scientific Cultural Organisation) has developed a 'water footprint', which shows how much water individuals typically use in different countries . The differences between countries are large, with the USA water footprint being almost four times as much as China's.

Global average virtual water content of some selected products, per unit of product from water footprint of nations.

Product	Litres of water
1 cup of coffee (125ml)	140
1 cup of tea (250ml)	35
1 slice of bread (30g)	40
1 apple (100g)	70
Rice (1kg)	3000
1 pair of shoes (bovine leather)	8000
1 cotton T-shirt (medium sized, 500g)	4100
1 microchip (2g)	32

Further Information

Government has overall responsibility for the legislative/policy framework for management of water. More information can be found at
http://www.defra.gov.uk/environment/water/index.htm

- **The Environment Agency has a specific duty to secure the proper use of water resources, while it is the general duty of every water company to maintain a public water supply system for the use of domestic customers and for domestic purposes (drinking, cooking and sanitation) by business customers.**
  http://www.environment-agency.gov.uk/
- **The Office of Water Services as the independent regulator of the water industry, is responsible for ensuring that water companies meet those duties.**
  http://www.ofwat.gov.uk/
- **UK Climate Impacts Programme**
  http://www.ukcip.org.uk/
- **Hadley Centre**
  http://www.metoffice.com/research/hadleycentre/
- **UK Groundwater Forum**
  http://www.groundwateruk.org/html/forum/forum.htm
- **World Health Organisation (Water pages)**
  http://www.who.int/topics/water/en/
- **UNESCO-IHE, 2004**
  Water Footprints of Nations. Value of Water Research Report Series No. 16, November 2004.
- **World Water Week**
  http://www.worldwaterweek.org/
- **Natural England**
  http://www.naturalengland.org.uk
- **Water wise – tips to help you save water**
  http://www.waterwise.org.uk
- **Defra science website**
  http://www.defra.gov.uk/science