

FOOD, ENERGY, WATER AND THE CLIMATE: A PERFECT STORM OF GLOBAL EVENTS?

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SUMMARY

There is an intrinsic link between the challenge we face to ensure food security through the 21st century and other global issues, most notably climate change, population growth and the need to sustainably manage the world's rapidly growing demand for energy and water. It is predicted that by 2030 the world will need to produce 50 per cent more food and energy, together with 30 per cent more available fresh water, whilst mitigating and adapting to climate change. This threatens to create a 'perfect storm' of global events.

Science and technology can make a major contribution, by providing practical solutions. Securing this contribution requires that high priority be attached both to research and to facilitating the real world deployment of existing and emergent technologies. On food, we need a new, "greener revolution". Techniques and technologies from many disciplines, ranging from biotechnology and engineering to newer fields such as nanotechnology, will be needed. On water, managing and balancing supply and demand for water across sectors requires a range of policy and technological solutions. Meeting the demand for energy, while mitigating and adapting to climate change, will require a mix of behavioural change and technological solutions.

THE DRIVERS BEHIND THE PERFECT STORM SCENARIO

Background

After 20 years of low food commodity prices, the price shock of 2007/08 brought agriculture, food production and food security sharply back into the limelight. Wheat and maize prices peaked at around triple their early 2005 levels, with an even higher peak in rice prices (IMF 2008). High commodity prices quickly fed through into increased costs to consumers in developed and developing countries alike (FAO 2008), escalating to civil unrest in some, ranging from strikes in Italy to riots in Haiti.

Whilst food prices have now stabilised we should avoid being complacent (current stocks of major cereals are at a 40 year low, which implies continued uncertainty). The predicted increase in demand for food, energy and water in the next 20 years, driven by the growing population coming out of poverty will ultimately put pressure on food prices. This is described below.

Population increase and urbanisation

Global population is set to increase to around 9 billion by mid-century, rising at a rate of 6 million people per month, with Africa's population alone projected to double from 1 billion to 2 billion (UNPD 2006) during this period. This continued population increase combines with other transformational change, particularly in the developing world as people move from rural livelihoods to cities, cities that will need to be serviced with food, water and energy. Half the world's population now live in cities, a figure projected to rise to 60% by 2030 (UNPD 2007). It is estimated that there will be 29 cities with greater than 10 million inhabitants in 2025, up from 19 today. Half of these new 'megacities' will be in Asia.

Economic changes

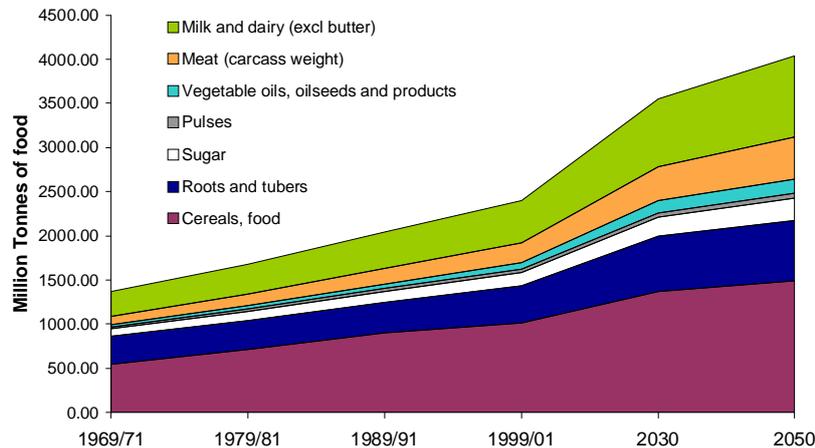
Population increase will be coupled to increasing prosperity. Economic advances projected for the developing world will help lift millions from poverty, but in other respects will add to the challenges. As incomes rise in developing and middle income countries, people eat more meat and dairy products, causing a rapid growth in demand for agricultural commodities to feed livestock. Strong growth in demand over the past few decades has been driven particularly by rising consumption in China and Brazil, and the future trend is likely to be strongly influenced also by the extent of income growth in India and sub-Saharan Africa, where per capita meat consumption is still low (FAO 2003).

Rising demand for food, energy, water and land

The FAO projects total crop and livestock demand and production will rise by around 40% between 2008 and 2030, i.e. a yearly increase of 1.5% (Figure 1). However, this overall figure conceals the larger increase in meat demand (FAO 2006, UNPD 2006). The World Bank predicts a 50% rise in cereals demand compared with an

85% increase for meat between 2000 and 2030 (World Bank 2008). Other assessments predict a doubling of meat demand by 2050 (Beintema 2008). The overall projected rate of demand growth is lower than in previous decades (FAO 2006, IPCC 2007), but must be met within the greater constraints on land, water and energy use outlined below.

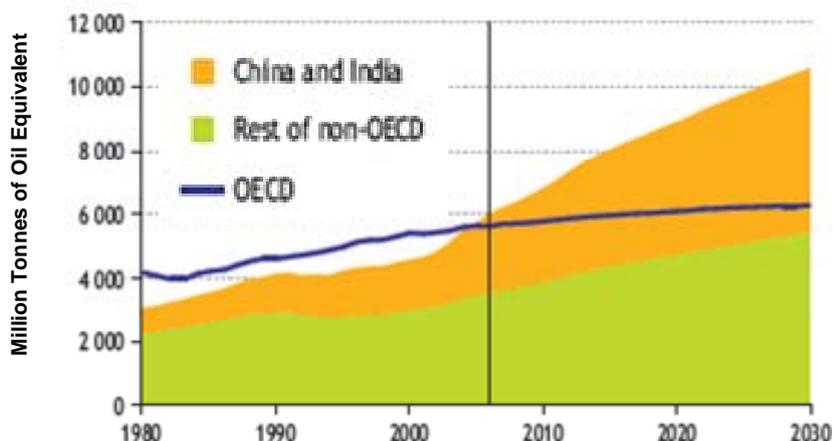
Figure 1: Predicted world food requirements up until 2050



The predicted increases in food demand are predominantly through meat and dairy products. (UNPD 2006 and FAO 2006)

Energy demand is projected to increase by 45% between 2006 and 2030, based on the IEA's reference scenario (IEA 2008). Biofuels for transport and biomass for heat and electricity will be used to meet some of this demand, leading to greater competition for land and crops between energy and food markets (Mitchell 2008). The majority of this energy demand rise is predicted taking place in the non-OECD, notably China and India, Proportionally, through the use of coal (Figure 2)

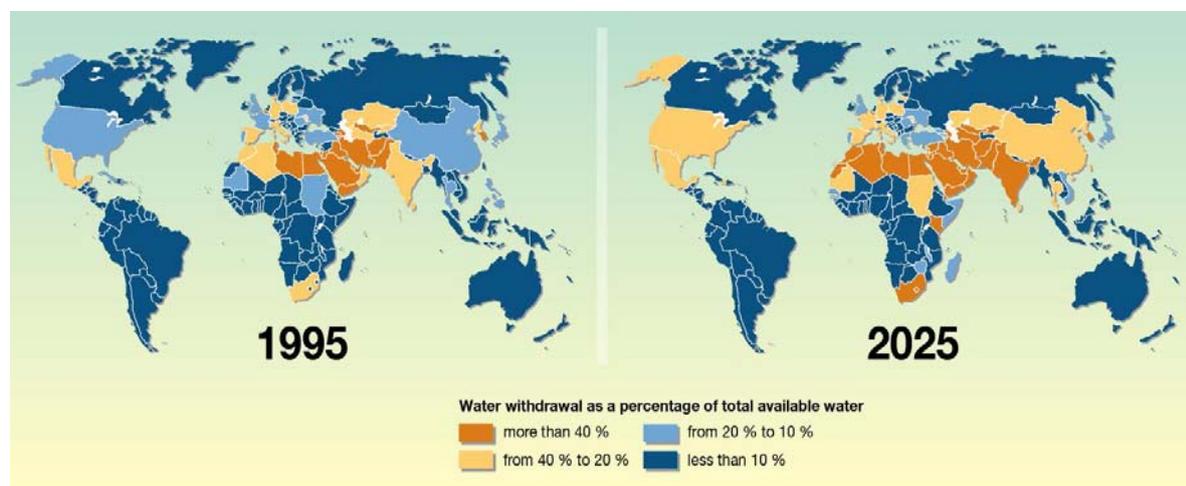
Figure 2: World primary energy demand by region



Energy demand in non-OECD is now greater than the OECD, predominantly in China and India (IEA 2008)

Today, 1.2 billion people live in areas already affected by water scarcity, and this figure is projected to increase as global water demand rises (IWMI 2007). Water demand is a function of population, incomes, diets and the extent of irrigated agriculture, leading to a wide range of projections into the 2020s and 2050s (IWMI 2007, Shen 2008, Shiklomanov 2000). It has been estimated, based on mid-range population scenarios, that demand for water for agriculture could rise by over 30% by 2030, while modelling based on the IPCC's SRES scenarios suggests that total global water demand will rise by 35–60% between 2000 and 2025 (Chatres 2008, Shen 2008). Figure 3 shows the predicted global water withdrawal levels between 1995 and 2025.

Figure 3: Predicted water scarcity and stress in 2025



Water withdrawal is defined as the loss of water for some use by humans. (UNEP 2008)

Agriculture is by far the largest user of water world-wide, at around 70% of total supplies (FAO 2007). The agricultural sector will increasingly need to compete with the world's growing cities for water. As a result, it is unlikely that water will remain a 'free' commodity in the future

It seems inevitable that demand for land will progressively increase, both for food production and linked to the urbanisation and energy trends noted above (IWMI 2007). This growing competition and concern can be illustrated by increased purchases of land in the developing world by some countries with hot and dry climates, such as Egypt, Libya, Saudi Arabia and China. Multinational companies are also investing in agricultural land.

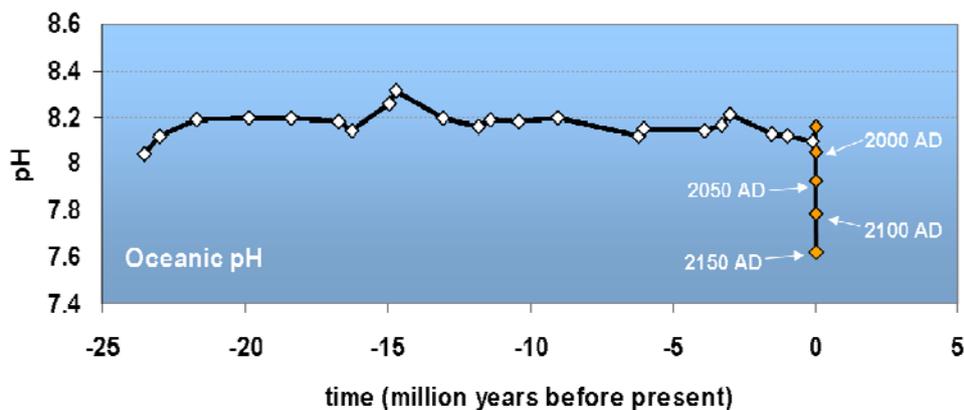
The challenge for global agriculture is to grow more food on not much more land, using less water, fertiliser and pesticides than we have historically done.

Climate change

The backdrop against which these demands must be met is one of rising global temperatures, impacting on water, food and ecosystems in all regions, and with extreme weather events becoming both more severe and more frequent. Rising sea levels and flooding will hit hardest in the mega-deltas, which are important for food production, and will impact too on water quality for many.

Oceans will become warmer, more acidic, less diverse and over-exploited. The ocean acts as a reservoir for carbon dioxide, but the resulting increase in acidity, seriously impact ocean food webs and ecosystems, on which many of the world's poor are dependant (Figure 4). Continued over-fishing is expected to further pressure these delicate resources.

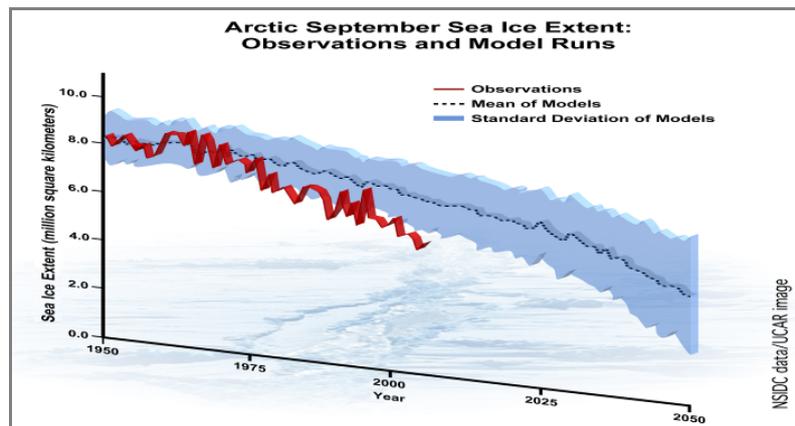
Figure 4: Change in surface ocean pH over the last 25 million years and changes predicted if emissions continue unabated



CO₂ released into the atmosphere has been taken up by the oceans, a process known as 'ocean acidification'. If greenhouse gas emissions continue unabated, the pH of the ocean could decrease by another 0.2 to 0.4 pH units by 2100, which would be a hundred times faster than any natural change over the past 25 million years. Ocean acidification is already affecting marine life, and the evidence indicates that it is likely to cause grave harm to important marine ecosystems if the concentration of CO₂ in the atmosphere rises above 450 ppm.

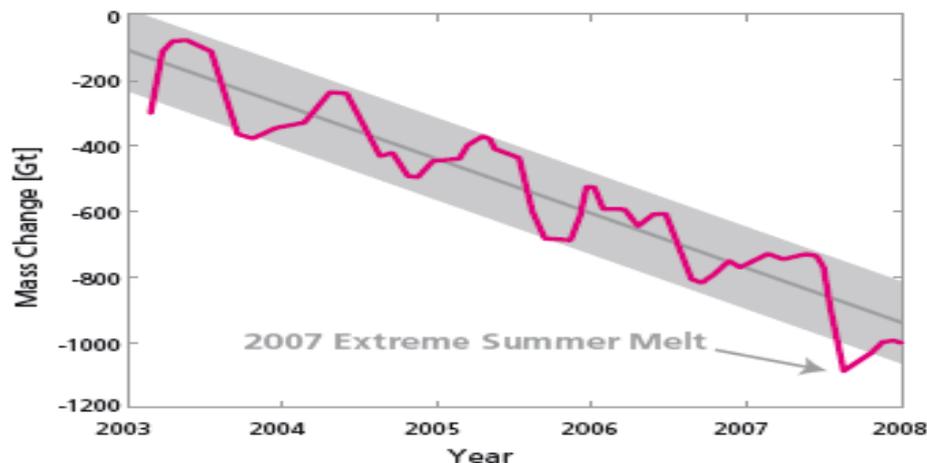
Even since the last report of the Intergovernmental Panel on Climate Change (IPCC) in 2007, new evidence suggests that climate change is impacting the real world faster than the models predicted, and global greenhouse gas emissions are continuing to rise at the high end of projections. For example, in 2007 the IPCC concluded that large parts of the Arctic were likely to be ice-free in the summer by the end of the 21st century. Record lows in sea ice extent in 2007 and 2008, combined with other evidence on ice thinning and age, have caused scientists to radically review these estimates, with some analyses now suggesting the Arctic may be near ice-free by 2030 (Figures 5 and 6). This has major implications not just for the Arctic region but for the world as a whole, as strong positive feedbacks effects are expected to drive climate changes even faster.

Figure 5: Uncertainty in predicting arctic sea ice extent



The dark blue line shows the average decline in Arctic sea ice extent predicted by 18 computer models, and the light blue shaded area shows the uncertainty around the modelled changes. The red line shows the actual rate of sea ice retreat, which is occurring at a faster rate than predicted by any of the computer models (National Snow and Ice Data Centre 2007)

Figure 6: Change in mass of the Greenland ice sheet 2003-08



The graph shows the loss of ice from the Greenland ice sheet over recent years, as estimated from satellite measurements. The red line shows the actual observations and the grey shaded area shows the 90% confidence level around the fitted straight grey line. On average, the loss of ice contributed 0.5 mm/yr to global sea level rise, total sea level rise is approximately 3.1 mm/yr (from Synthesis Report of the Climate Change Summit in Copenhagen, March 2009).

The need is both to mitigate climate change and to adapt to that which it is too late already to avoid is clear. It has been suggested that global greenhouse gas emissions must be reduced by *at least* 50-60% by 2050 compared to current levels. The UK's target to reduce emissions by 80% on that timescale means that all sectors must make a major contribution, achieving steps changes in past performance.

THE CONTRIBUTION OF SCIENCE AND TECHNOLOGY

Science and technology has long been a major driver for UK and global prosperity, and has helped meet the ever increasing demand for energy, food and commodities. Global food production has more than doubled in the past 40 years, despite only an 8% increase in the use of land for agriculture since the 1960s (IPCC 2007). Much of the success over this period can be attributed to technological and process innovations, such as the introduction of chemical pesticides, fertilisers, irrigation and crop improvement through breeding.

Science and technology must play a leading role in meeting increasing demand over the coming decades in a sustainable manner. Scientific evidence also underpins the range of domestic policies and international agreements needed.

On food, we need a new, “greener revolution”. Important areas for focus include: crop improvement to increase yields and tolerance to stresses such as droughts; smarter use of water and fertilisers; new pesticides and their effective management to avoid resistance problems; introduction of novel non-chemical approaches to crop protection; reduction of post-harvest losses; and more sustainable livestock and marine production. Techniques and technologies from many disciplines, ranging from biotechnology and engineering to newer fields such as nanotechnology, will be needed.

On water, managing and balancing supply and demand for water across sectors requires a range of policy and technological solutions. Agricultural water use efficiency can be improved through the development of drought resistance crops, and the use of low-cost and efficient drip irrigation systems by small farmers. Solutions for water storage, such as underground reservoirs, will be needed, particularly in areas where climate is expected to radically alter river flow patterns through melting of glaciers and changes in precipitation. In the home, recycling of domestic ‘grey water’ will be needed to reduce consumption.

Meeting demand for energy while mitigating climate change will require a mix of behavioural change and technological solutions. Renewable, carbon capture and storage and nuclear energy technologies are the options to de-carbonise electricity generation – which the Climate Change Committee estimates must be largely achieved within around two decades, but innovative technologies and processes will also be needed to radically reduce emissions from transport, buildings and industry, and increase the efficiency of energy use throughout the economy.

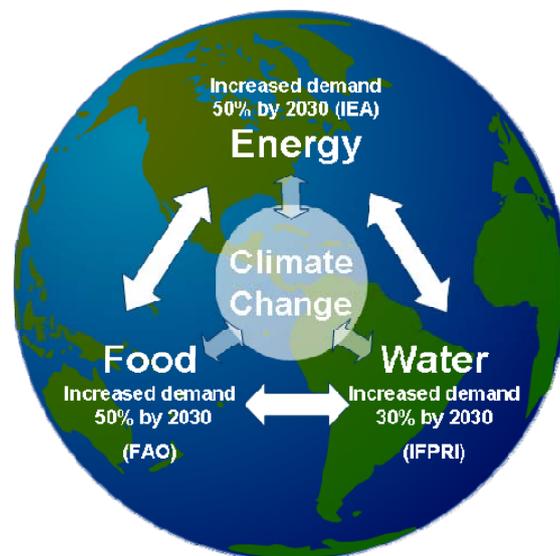
CONCLUSIONS

The growing global population coming out of poverty will create an increased demand for food which will need to be produced on not much more land, using less water, fertiliser and pesticides than we have historically done. Through the 21st century this is achievable, but must be tackled coherently with other global challenges of climate change and energy, food and water security. It is predicted that by 2030 the world will need to produce around 50 per cent more food and energy, together with 30 per cent more fresh water, whilst mitigating and adapting to climate change. This threatens to create a 'perfect storm' of global events (Figure 7). The key questions for policy makers and scientists are these:

- Can 9 billion people be fed equitably, healthily and sustainably?
- Can we cope with the future demands on water?
- Can we provide enough energy to supply the growing population coming out of poverty?
- Can we do all this whilst mitigating and adapting to climate change?

These issues are inextricably linked. Science has contributed greatly in the past to finding solutions, and it can do so into the future if the investments are made. A new greener revolution can be built on the foundations of the first green revolution, but we will need to fully explore the range of science and technology opportunities at our disposal in the 21st century in order to overcome the greater constraints. This vital contribution from science will not happen by default.

Figure 7: The Perfect Storm scenario



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