



## Agriculture and Climate Change

Standard Note: SN/SC/3763

Last updated: 17 July 2012

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- This note records some predictions and comment relating to the effect of climate change on agriculture and forestry. Other related notes are [How UK farmers could reduce greenhouse gas emissions](#) (SN/SC/4340) and [Food Security: UK Policy](#) (SN/SC/4985).
  - Worldwide effects of climate change are already having an effect, via increases in world food prices, partly because of extreme weather events in countries as far apart as Australia and Russia.
  - Within the next decades, climate change is likely to have severe effects on UK agriculture. Increased numbers of extreme events – such as floods – may be the most serious immediate problem.
  - The effects may be partially mitigated by planting different crops and developing new varieties.
  - The position is complicated because local effects of global warming are extremely difficult to estimate. Although the UK has been getting warmer, we have had record floods in the summer of 2007, then two cold winters in 2009/10 and 2010/11. Short-term uncertainty makes planning difficult.
  - A Met Office report in December 2011 shows the difficulty of trying to reach an agreed conclusion about the effects on UK agriculture.
  - In the longer term, rising sea level will be a severe problem because so much of the UK's most fertile land is close to the sea and at a low altitude.
  - Soil erosion could be a serious problem in hot dry summers, but the UK is probably better placed than Mediterranean countries that could face severe problems after only a small temperature increase.
  - A Defra risk assessment in 2012 emphasises potential benefits and business opportunities as well as threats.

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## **1 The effect of climate change on agriculture and Coalition policy**

Hilary Benn announced a council on food security in November 2008, noting:

"By 2050 there will be nine billion of us living on this small and fragile planet. And the question is: do we have the capacity to feed the equivalent of another two Chinas? Global food production will need to double just to meet demand. We have the knowledge and the technology to do this, as things stand, but the perfect storm of climate change, environmental degradation and water and oil scarcity, threatens our ability to succeed."<sup>1</sup>

Agriculture is less vulnerable to climate change than is forestry. Farmers can choose which seeds to plant and how to manage them. Forests would adapt far too slowly to climate change to be able to maintain their health. However, it is difficult for farmers to plan for dealing with greater uncertainty and changing rainfall patterns. In the UK even increases of temperature are not certain since a decline in the Gulf Stream over the next decades is a real possibility, potentially leading to the UK having far lower temperatures than it currently does.

A PQ in December 2010 showed what the Government is doing. James Paice described support for reduction of farm emissions, continuing:

Farmers and land managers are also vulnerable to the effects of climate change and will need to take action to adapt sustainably. The Government are looking at enhancing existing advice and guidance arrangements to support voluntary adaptation action. DEFRA also undertakes research on the impact on climate change in the farming sector; future funding will depend on the specific projects undertaken.

We will support the sector through the development of training packages to deliver integrated advice, which will cover both mitigation and adaptation objectives.

Funding is currently available for farmers under Rural Development Programme for England (RDPE) to address challenges including climate change. For example, Environmental Stewardship provides farmers with a range of management options that are able to deliver multiple objectives, including climate change mitigation and adaption benefits. Climate change was embedded as an over-arching theme into Environmental Stewardship following the 2008 Review of Progress. An evaluation of the RDPE is

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<sup>1</sup> Defra Press Release, *Hilary Benn calls for global agreement to secure the future of our food as he appoints Council to advise on UK food strategy*, 10 December 2008

currently under way and we look forward to its findings on the effectiveness of the programme which will be available early in 2011.<sup>2</sup>

However, Willie Bain pointed out that the Government had terminated funding for Farming Futures, a project to inform farmers about the effects of climate change and possible action to take.<sup>3</sup>

The Met Office stresses the difference between a world average temperature increase of 2<sup>0</sup>C and an increase of 4<sup>0</sup>C:

The differences between the impacts of a global mean temperature rise of 2 °C and 4 °C are stark. A rise of 4 °C could result in a decrease in yields of all major cereal crops across most major regions of production. However, by limiting temperature rises to 2 °C the production of some cereal crops could actually increase at mid-to-high latitudes, with negative impacts limited to regions where farming is already under threat, especially in semi-arid and tropical regions.<sup>4</sup>

Recent UK weather patterns have not conformed to the simple expectations of global warming. The floods of June 2007 are important because most models expect drier summers. However, more extreme weather events are also expected. Agriculture in the UK 2007 described severe effects.<sup>5</sup> Nevertheless, UK farm incomes rose by about 10% over the year, because other factors outweighed the bad weather. The cold winters of 2009/10 and 2010/11 might be the start of a trend, related to changing airflow over the Arctic.

A former page on the Defra website contained some general points:

How will climate change impact my business and what can I do to adapt?

Britain's farmers will feel the impact of our changing climate very directly, and this can present both threats and opportunities. The potential threats include:

- prolonged and more frequent droughts
- changes in rainfall distribution
- more storms and other extreme weather events
- rising sea levels
- increased and changing pest loads
- increased risk of heat stress in livestock farming
- possible changes in soil water balance.

There also may be opportunities for new crops and enterprises as temperatures increase and growing seasons lengthen.

While research suggests that climate change will not appear to threaten the viability of UK agriculture overall, individual agricultural businesses need to be ready to seize

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<sup>2</sup> HC Deb 6 December 2010 cc25-6W

<sup>3</sup> HC Deb 6 December 2010 cc24-5W

<sup>4</sup> Met Office, *Tackling Temperature Rise*, 7 December 2009

<sup>5</sup> Defra, *Agriculture in the UK 2007*, chapter 1, 2 and 5

opportunities for new crops and markets, and to adapt to evolving pressures, such as water shortages and new pests and diseases.<sup>6</sup>

A report by the Royal Agricultural Society of England in 2008 concluded that the UK's soil and water research base had diminished catastrophically from its peak and was now failing to provide the required support for the nation's farmers and land managers. The lack of research increased the risk of British agriculture damaging the soil.<sup>7</sup>

In January 2009, the *Guardian* quoted a new study in the US journal *Science*:

Half of the world's population could face severe food shortages by the end of the century as rising temperatures take their toll on farmers' crops, scientists have warned. Harvests of staple food crops such as rice and maize could fall by between 20% and 40% as a result of higher temperatures during the growing season in the tropics and subtropics. Warmer temperatures in the region are also expected to increase the risk of drought...according to a new study.<sup>8</sup>

In January 2012, the *New Scientist* reported on further research suggesting that temperature increased will reduce crop yields more than previously supposed:

David Sobell of Stanford University in California used nine years of satellite images to track when wheat in the Ganges basin of India turned from green to brown, a sign that the plants had aged and the grain was no longer growing. He found the wheat turned brown earlier when average temperatures were higher. The data suggest that yield losses on the Ganges plain from an average warming of 2° C may be 50% greater than thought. (...) Earlier studies suggested that, by 2050, warming could cut wheat yields by 30% in places like India – a figure that may now be optimistic. Yet global yields need to rise 50% by then to feed the world's growing population.<sup>9</sup>

## 2 Defra Risk assessment, January 2012

On 25 January 2012, Defra published the [UK Climate Change Risk Assessment](#). The [section on agriculture](#) presents the threats from climate change but also the potential benefits and business opportunities. Here is the summary:

Climate change is projected to result in changes in temperature, rainfall patterns and sea levels, as detailed in the UK Climate Projections (UKCP09) analysis.

Although most of the impacts on the agriculture sector may be negative, potentially valuable new opportunities may also arise that can benefit existing agricultural activities and encourage farm diversification.

The Climate Change Risk Assessment (CCRA) has completed an assessment of a range of impacts for which this sector may need to prepare. Some of the key points from this assessment are summarised here.

The results presented here do not take account of changes in society (e.g. population growth, economic growth and developments in new technologies); nor do they take account of responses to climate risks (e.g. future or planned Government policies or private adaptation investment plans).

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<sup>6</sup> Defra, Agriculture and climate change former webpage

<sup>7</sup> RASE, *Dwindling science base poses threat to UK soil health – says Royal Agricultural Society of England Report*, 23 October 2008

<sup>8</sup> "Billions face food shortages," *Guardian*, 9 January 2009

<sup>9</sup> "Extreme heat ages vital crop", *New Scientist*, 4 February 2012

## **Focus on... Crops**

Warmer temperatures and higher concentrations of CO<sub>2</sub> in the atmosphere would lead to higher yields of many crops currently grown in the UK. These benefits will not happen, however, if rising temperatures and lower summer rainfall result in increased heat stress to crops and significant decreases in soil moisture.

In some cases, faster growth rates may reduce crop quality. Overall, yields of crops such as wheat and sugar beet are projected to rise. Grass yields may also increase, although in some parts of England and Wales dry conditions may limit this. In Scotland and Northern Ireland, where water stress may be less of a problem, there is the potential for more significant increases in grass yields, which may prove beneficial for livestock and dairy producers.

Confidence Medium

Increase in wheat yields: between 40% and 140% by the 2050s, assuming other factors affecting growth are not limiting (baseline: 1961-1990).

Increase in sugar beet yields: between 20% and 70% by the 2050s, assuming other factors affecting growth are not limiting (baseline: 1961-1990)

Increase in grass yields: between 20% and 50% by the 2050s, assuming other factors affecting growth are not limiting (baseline: 1970s-1990s)

There could also be opportunities to introduce new crops or to expand existing crops that are currently only grown in small quantities, especially in the south, such as blueberries and maize, for example, as well as new industrial, energy and pharmaceutical crops. However, increases in rainfall intensity or the frequency of intense storms could increase the risk of soil erosion throughout the UK, although the implications for crop yields are unclear.

## **Focus on...Flooding**

Agricultural land is projected to face an increased risk of flooding from rivers and the sea. Some of this land may become unsuitable for the agricultural activities it is currently used for. Although the area of grassland and rough grazing land flooded regularly by the sea might increase substantially, some of this may still be suitable for grazing.

Confidence High

High-quality horticultural and arable land likely to be flooded at least once every 3 years: 35,000 ha by the 2020s, 75,000 ha by the 2050s and 130,000 ha by the 2080s (current figure: about 30,000 ha).

The assessment of flood risk for the CCRA has assumed that there are no changes in existing flood and coastal erosion risk management measures;

the analysis takes account of current flood defences and protection against coastal erosion, but does not include any future changes as a result of adaptation policies or deterioration of existing flood defences and coastal protection measures. The figures here apply to river and tidal flooding in England and Wales only.

### **Focus on...Water**

The very dry spring in 2011 highlighted the importance of water availability at critical periods of growth in the agricultural production season and of potential vulnerability to unexpected variations.

Projected changes in rainfall and evapotranspiration would increase aridity levels and increase demand for extra irrigation, particularly for high-value crops where quality assurance is a key market requirement.

By the 2050s, southern, eastern and central England may have water needs greater than those currently experienced anywhere in the UK. Rising agricultural water demand due to a drier climate, coupled with rising water demand from other sectors (e.g. energy and water companies), could coincide with less water being available for agriculture.

Changes in the frequency of intense rainfall events, particularly following periods of dry weather, could contribute to increased nutrient runoff from agricultural land, which may affect local water quality. As well as harming biodiversity and ecosystems, this may affect the quality of water abstracted downstream, having cost implications for water treatment and potentially affecting the health of those using private water supplies.

Confidence Medium

Change in agricultural (spray irrigation) water demand in England and Wales:

between -10% and +80% by the 2050s and -4% and +110% by the 2080s (although baselines and projections vary significantly depending on region).

### **Focus on...Livestock**

Pigs and poultry may be particularly vulnerable to heat stress, with poultry suffering higher mortality rates and producing fewer eggs, while transportation of animals during heatwaves may pose major risks to their health and welfare. Heat stress is projected to begin affecting dairy production by the 2050s. By the 2080s, the impact may become significant for farmers operating on low margins and for regional economies reliant on exporting dairy products.

By extending the growing season in upland areas, however, warmer temperatures may result in more winter grazing and forage, assuming access is not limited due to wet conditions. Milder winters may reduce feed and bedding costs by cutting the length of time livestock need to be housed. If summers became hotter and drier, however, this may result in insufficient forage for grazing animals, particularly in the south of the UK.

Confidence Low

Lost milk production due to heat stress: between 0 and 110 million kg/year (between 0 and 1% of current total UK milk production) by the 2050s.

### **Focus on...Pests and Diseases**

The evidence that climate change will increase crop pests and diseases is weak. However, the interactions between crops, pests and pathogens are complex and currently poorly understood in the context of climate change. It is also difficult to analyse the future level of risk as agricultural pests and diseases are managed and controlled in a variety of ways.

For example, although climate has also been linked to the spread of some strains of Bluetongue virus, its emergence in northern Europe is not explained entirely by climate change but by a complex combination of drivers such as an increase in international transport.

As hot dry weather is unfavourable to most sheep parasites, the numbers of roundworms, blowflies and ticks may decrease in some parts of the UK.

### **The Challenge of Adaptation**

Agriculture is a particularly diverse industry, incorporating international agri-businesses and family farms and ranging from outdoor crop cultivation to indoor livestock rearing. The ability to adapt to climate change varies accordingly across the sector.

Many horticultural businesses, for example, are highly innovative and can adapt quickly, while some sub-sectors are less able to adapt or may be able to adapt to some changes but not to others. It is important to ensure that businesses are aware of the range of potential risks from climate change in order to adapt.

Seizing the opportunities and minimising the risks that may result from climate change requires investment in new technologies and better management techniques, such as:

- Improved water management: (e.g. water harvesting and on-farm storage) and improved irrigation techniques to improve water efficiency during dry spells.
- Changes in grassland species composition (e.g. with deep-rooting or drought-tolerant species).
- Changes in livestock production cycles (e.g. introduction of autumn lambing and calving).
- Planting of trees to provide shade for livestock and windbreaks for crops.

Adding to the challenge of adaptation is the fact that considerable uncertainty surrounds (i) the way different climate impacts on this sector may interact with each other and (ii) the socio-economic changes that will have a major influence on the continued evolution of UK agriculture. Specific knowledge gaps identified by the CCRA include:

- The potential impact of climate change on agricultural pests and diseases.
- The effects of climate change and climate extremes on water available for new and existing crops, especially in areas affected by sea level rise and coastal flooding.
- The effects of climate change on animal health and welfare, and particularly the effects of heatwaves and droughts.
- The ability of rural communities to adapt to the effects of climate change on their lives and livelihoods.

## **3 Researchers cast doubt on Defra's optimism on wheat yields**

Dr Mikhail Semenov, a researcher at Rothamsted, the agricultural research centre, said that Defra's conclusions on wheat yields are misleading:

"There is no doubt that the average UK wheat yield has doubled since the 1960s, however this increase in yield has resulted from a combination of several factors,

notably genetic improvement resulting in high-yielding varieties, better management of pest and diseases and higher applications of fertiliser."

Semenov explained that for the CCRA report to solely attribute an increase in yield to variations or changes in the mean temperature is "misleading" and not supported by other studies. The predictions made by the report could therefore have significant ramifications for the UK economy with wheat being the most important UK crop and a scientific priority area for the UK Government, he said.<sup>10</sup>

#### **4 The Met Office Report December 2011**

In December 2011, the Met Office produced [Climate: observations, projections and impacts](#) - a series of country reports on the effect of climate change up to 2100. In terms of agricultural planning it is frustrating that the best science does not produce more conclusive results. That must make it difficult to develop crops and agricultural practices suitable for the new conditions. The report explains in detail the various studies on which the conclusions are based:

##### Climate change projections

- For the A1B emissions scenario the UK is projected to experience temperature increases of up to around 3°C in the south and 2.5°C further north. The agreement between models is moderate in the south of the UK and low further north.
- Europe shows a strong contrast in projected precipitation changes, with large decreases in the south and large increases in the north. The UK falls towards the northern region with generally increasing precipitation, with projected increases of up to 10%, though some southern parts of the UK may experience decreases of up to 5%. There is generally good agreement between ensemble members over the north of UK, but moderate agreement further south, indicating uncertainty in the position of the transition zone between increasing and decreasing precipitation over Europe.

The conclusions about effects on UK agriculture are inconclusive:

##### Summary of findings for each sector

##### Crop yields

- Quantitative crop yield projections under climate change scenarios for the UK vary across studies due to the application of different models, assumptions and emissions scenarios.
- A definitive conclusion on the impact of climate change on crop yields in the UK cannot be drawn from the studies included here. There is some indication from global- and regional-scale studies for a difference in yield changes between the north and south of the UK. For instance, yield increases are projected for Northern Ireland and Scotland but declines projected in the South of England with climate change.
- National-scale studies included here note that the effects of heat stress during flowering on wheat variety crop yields in the UK should be quantified and implemented into crop models.

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<sup>10</sup> "Centre doubts UK government's wheat yield claims", *Agra Europe*, 18 April 2012



- Important knowledge gaps and key uncertainties include the quantification of yield increases due to CO<sub>2</sub> fertilisation, the quantification of yield reductions due to ozone damage and the extent to which crop diseases might affect crop yields with climate change.

#### Food security

- The UK is currently a country of extremely low undernourishment. Global-scale studies included here generally project that the UK is likely to remain food secure over the next 40 years, largely due to its high adaptive capacity associated with an ability to import food.
- Simulations from the AVOID programme project that population increases coupled with potential declines in crop yields by the 2080s could increase exposure to undernourishment in the UK, and that structural adjustment will be instrumental in decreasing exposure.
- One study concluded that the national economy of the UK presents a very low vulnerability to climate change impacts on fisheries by the 2050s. Another projects that the 10-year averaged maximum catch potential from 2005 to 2055 could increase by 1% under SRES A1B in the UK.

#### Water stress and drought

- Global- and national-scale studies included here project that the vulnerability to water stress with climate change is mainly focussed in the south and south-east of the UK. On the whole, these regions are projected to experience an increase in the frequency of droughts and water stress with climate change.
- Recent simulations by the AVOID programme project that the UK could experience a moderate increase in water stress with climate change, although the median estimate the models suggested no increase in water stress with climate change for the UK by 2100.

#### Pluvial flooding and rainfall

- Post-IPCC AR4 [Intergovernmental Panel on Climate Change Fourth Assessment Report] research for precipitation extremes over the UK focus upon understanding and quantifying uncertainties, and detection and attribution studies.
- Rainfall extremes are generally projected to increase, particularly during winter.
- Changes during summer are more uncertain.
- New work is exploring connections between changes in extreme precipitation and anthropogenic climate change.

#### Fluvial flooding

- Several European-scale and national-scale assessments suggest an increase in flood risk with climate change in the UK.
- Simulations from the AVOID programme support this. For the UK as a whole, the projections show a much greater tendency for increasing flood risk, particularly later in the century and particularly in the A1B scenario.
- However, national-scale studies have also shown that the UK exhibits a high degree of spatial variability in the sensitivity of rivers to changes in climate, and

projections of changes in flood hazard show large uncertainty, which is mainly due to climate modelling uncertainty. Further work is necessary to better account for the influence of natural variability and the uncertainties related to climate scenarios.

- This supports conclusions from the IPCC AR4 but now more regional detail across the UK is available.

Tropical cyclones

- The UK is not impacted by tropical cyclones.

Coastal regions

- Several global-scale and regional-scale assessments suggest that without adaptation, the UK could experience major impacts on coastal flooding from sea level rise (SLR).
- For example, one study shows that by the 2080s under a high SLR scenario and without adaptation, the average annual number of people flooded in the UK could be around 986,300; this is greatly reduced with adaptation (raising of flood dykes and the application of beach nourishment), to around 5,600.
- New work also demonstrates the potential benefits of climate change mitigation policy. For example, one study shows that aggressive mitigation could avoid an exposure of around 51,000 people to SLR in the UK, relative to un-mitigated climate change.
- These results add evidence to support the conclusions from the IPCC AR4.

## **5 Lords Select Committee on climate change challenges, 2010**

A Lords Select Committee report on the Common Agricultural Policy considered the challenge posed to UK Agriculture by climate change:

### **The challenge for EU agriculture and forestry**

15. The Commission paper on the challenges for agriculture and rural areas of adaptation to climate change, which was published alongside the White Paper of April 2009, gives an overview of the impacts of climate change on agricultural production. These include the following:

- rising atmospheric CO<sub>2</sub> concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events, affecting the volume, quality and stability of food production and the natural environment;
- climatic variations affecting the availability of water resources, the incidence of pests and diseases, and the quality of soils, leading to significant changes in the conditions for agriculture and livestock production;
- in extreme cases, the degradation of agricultural ecosystems, causing desertification and a total loss of the productive capacity of the land affected.

16. The paper states that, in the short term, the most serious consequences for agriculture are likely to result from the frequency and intensity of extreme weather events, and seasonal variations in precipitation patterns. It stresses that, since the local impacts of climate change will be diverse, some areas will have negative and positive effects at the same time with unknown net results. Overall net effects on farm

activities will vary across the EU and between farm types within the same region (paper SEC(2009)417, section 2.1).

17. Defra commented that climate change would affect, directly or indirectly, many or all of the important benefits that agricultural land provided to society: UK research findings broadly confirmed the likely impacts on agriculture identified by the Commission. Climate change impacts on UK forests would vary widely across regions: "in the north and west, productivity is likely to increase, while the current range of species—both those planted for production forestry and components of semi-natural ecosystems—may prove to be much less viable in the latter half of the century, and perhaps severely so in the south and east of the UK" (Defra evidence, p 186). The submission added that these impacts must be seen in the context of an increased demand for the services provided by trees, woodlands and the forestry sector, in particular, woodfuel supply for renewable energy production, and timber and wood products as a sustainable material, particularly in the construction sector.

18. Among the challenges to be faced by agriculture will be mitigation, the reduction of its contribution to climate change, as well as adaptation. For the RSPB, Dr Mark Avery questioned whether the agricultural community fully recognised how different agriculture would need to be in future decades: "not only will agriculture need to be able to operate under a future climate, but it will have to be able to operate under regulation and conditions where agriculture will have to be emitting far fewer greenhouse gases than it does now. The Climate Change Act calls for 80% reductions overall in the UK emissions by 2050. Agriculture will have to play a part; it may not be 80% reductions from agriculture, but it will have to be big" (Q 79).

19. Changes in the availability of water will be a major determinant of future agricultural practice. The Environment Agency stated that by 2050 in England and Wales, river flows in the late summer and early autumn could decrease by over 50% and as much as 80% in some places; total annual average river flow was expected to fall by up to 15% (Environment Agency, p 95). For the Agency, Tricia Henton told us that the reduced quantity of water had implications for water quality, if less water was available for the dilution of effluent from run-off from agricultural or other land uses, or of treated sewage effluent: "The implications of all of that are that there will be less water available for agricultural purposes, particularly in the south-east of England; ... and of course we have to balance the amount available for agriculture with that for public water supply, for industry and of course for wildlife, leaving some in the environment as a basis" (Q 220). Ms Henton also acknowledged that changes in the distribution of rainfall could give rise to severe flooding, as happened in Cumbria in 2009, and this had implications for soil erosion. The Cumbrian example was just one of several such incidences around the UK.<sup>11</sup>

Witnesses stressed both the magnitude of the challenge and the fact that farmers were good at adapting to change. There was also considerable scope for reducing water consumption.

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<sup>11</sup> European Union Committee, [Adapting to Climate Change EU agriculture and forestry](#), 2010, HL 91 2009-20