Adapting UK arable agriculture to climate change

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Summary

This paper examines climate change impacts and adaptation for arable agriculture in the UK. Possible effects for farmers are based on modelling of future conditions and experience of recent extreme events. Different adaptations may be necessary and the process of change may need to be encouraged. Key effects will be felt through changes in the timing of the crop calendar and hence the farming year in: quality, yield, pest and disease management and crop distribution. Farmers may adapt readily to changes in average climate since effects will be gradual, but adaptations to some extremes will require more forward planning. Possible adaptation options by farmers, e.g. changing crop cultivars, and the wider industry, e.g. developing new varieties, need to be considered. Given the range of permutations affecting the predictions of UK arable agriculture, the paper considers what more may be done to help the industry address problems and opportunities presented by climate change.

Introduction

Predicting the future for agriculture in the UK under climate change is probably more problematic than weather forecasting or even economic forecasting. To begin with it must combine both of these elements, together with global food trade and then consider farmer responses to all these issues. Yet there is considerable value in examining the risks that climate change presents for arable production in the UK, in the same way that industry considers other major drivers of change within its forward planning. By exploring and understanding what may happen under climate change, farmers are better placed to offset its negative effects and gain from its benefits.

Impacts of climate change on crops

Starting with just the effects of climate on crop growth and production, Table 1 shows the effects of different elements of climate change on aspects of UK agriculture and relates them to the uncertainty associated with projecting future patterns of climate. Such changes will affect both average and extreme weather events, but with the exception of carbon dioxide (CO_2) levels, changes will not be uniform across the country, with greater warming in the South East than in the North West.

The main impacts of climate change will be through:

- warmer temperatures and effects on the timing and duration of the growing season,
- changing rainfall totals and seasonality (in particular drier summer and autumn conditions but wetter winters),
- elevated atmospheric CO_2 levels and
- sea level rise.

Table 1: Impacts of different elements of climate change on agriculture and the confidence level associated with predicting each variable (after MAFF, 2000 but updated to UKCIP02 scenarios - Hulme et al 2002)

Climate	Expected change by 2050s* based on 1961-90 baseline	Confidence level	Effects on UK agriculture
CO_2	489-593ppm[+]	Very high	Beneficial effects for most UK crops: increased rate of photosynthesis, reduced water use.
Sea level rise	14-18cm[$]	Very high	Loss of land, salinisation of groundwater.
Annual Average Temperature	0.5-3°C	High	Accelerated growth, shorter and earlier growing season –may allow crops to be grown further north and at higher elevations. Also risk of adverse temperatures - reduced grain yield through more rapid development season, higher potential evapotranspiration.
Growing season start and end	20 days by 2020s (Medium High emissions scenario)	High	Change in timing of farm operations, earlier crop growth in spring, potential problems for farm operations due to wet soils in spring.
Precipitation Total	Summer: 0 to -40% Winter: 0 to +25%	Medium-High	Effects depend on extent of precipitation change but could increase risks of drought, water-logging, and transpiration, and reduce supply of irrigation water and soil workability.
Storminess	40% by 2080s (Medium High emissions scenario)	Low	Risk of lodging, soil erosion, increased leaching and pesticide/nutrient runoff, reduced infiltration of rainfall.
Climatic extremes	Varies by event	Very low	Potential changes in the risk of damaging events (heat waves, frost, drought, floods, intense rainfall events) affecting crop yields and quality, timing of farming operations.

* Figures based on UKCIP02 Low – High emission scenarios unless otherwise stated
[+] Absolute rather than change value of atmospheric CO_2 concentration
[$] Global sea level rise – UK values will vary depending on isostatic responses locally

The impacts of climate change alone on the agricultural industry could be direct and immediate, such as crop yields affected by increased temperatures, or field operations affected by heavy autumn rainfall. There may also be more subtle indirect impacts, for example, changes in market demand and UK and international prices through weather related impacts on crop yields, e.g. effect of drought in Australia in 2005/6 on global wheat prices.

Responses to change in average conditions

The main responses to the impacts of climate change fall into five main types:

1) Changes in the timing of the crop calendar and hence in the farming year. This will affect also the timing of cultivation, pesticide and fertiliser applications and for some crops the continuity of supply, e.g. cauliflowers.
2) Changes in quality and yield.

3) Production changes may be required to cope with effects on crop development and impacts of climate change on soil conditions, e.g. increased irrigation.
4) Pest and disease management.
5) Changes in crop distribution/ novel crops.

Not all effects are detrimental. There is general agreement in studies in the UK that many crop yields may increase under climate change (Downing et al., 2000; Ministry of Agriculture Fisheries and Food, 2000; Holman and Loveland, 2002). In the UK, the negative effect of temperature increases on determinate crops such as wheat is offset by the CO_2 fertilisation effect. But this assessment assumes that farmers will independently respond to climate change, for example by changing sowing and harvesting dates and cultivars. New or novel crops are also likely to be introduced (Holloway, 1997; Ministry of Agriculture Fisheries and Food (MAFF), 2000) but the net effect of all these changes on farming systems is less clear.

Results from integrated crop and farm modelling work suggest that radical adaptations to changes in average climate conditions may not be necessary by the 2020s, although partial adaptations may be needed in the short term, e.g. the mix of break crops may need to change on arable farms due to a decline in the yield of oilseed rape and an increase in sunflower yields (Hossell *et al*., 2001). Many of the changes modelled were relatively small, needing to be adopted only by the 2050s, but the more sensitive farm types may need to make adaptations by the 2020s. The early adaptations include changes in both working capital, e.g. variable costs, and investment capital, e.g. crop storage and irrigation (Table 2).

Table 2: Key adaptation triggers and the time scale for their impact (from Hossell *et al.* 2001)

Timescale	Adaptation trigger
2020s	Requirement for Increased irrigation capacity
	Decline in oilseed rape yields/improvement in sunflower yields
	Increased need for storage of crops between seasons
	Increase in arable production on livestock farms
	Change in spring work days
2050s	Decline in oilseed rape yields/improvement in sunflower yields
	Change in spring work days
	Change in autumn work days

Responses to extreme events

Changes in average climate conditions are likely to be gradual enough within the time horizon of the industry to allow successful adaptation to occur. However, some aspects of agriculture are vulnerable to extreme events. In recent years, farmers in the UK have been affected by hot summer conditions of 1995 (ADAS, 1999), 2003 and 2006, and particularly wet conditions such as the autumn/winter of 2000/2001 (Shepherd, 2001). In 1995, hot, dry conditions at the end of July occurred late enough not to affect wheat yields but potato quality (and therefore saleable yields) was badly affected by scab (*Streptomyces scabies*). In 2006 the hot conditions caused storage problems for potatoes, because they led to a break in dormancy (Farmers Weekly, 2006). This differential impact between crops, and even between impacts on the same crop, is an indication of how sensitive the production

levels could be to relatively small changes in the timing of extreme events such as the start of a high temperature/drought period (Hossell, 2003).

Adapting to climate change

Some adaptations needed to meet these changes will be relatively easy to adopt. For example, rapid responses are possible to a number of impacts identified from the hot UK summer of 1995, e.g. improved crop monitoring to detect changes in pest levels (aphids, cutworms and red spider mite infestations increased) or a wider spread of crop cultivars. Others, such as major commodity changes (e.g. establishment of vineyards) and those involving infrastructure changes (improved and increased irrigation capacity and efficiency, changes to livestock housing) will require long-term investment.

Yet it is important to consider even short-term adaptations at an early stage; for example a reduction in heating usage within glasshouse production systems as winter temperatures warm is an adaptation that may be rapidly adopted, since it requires no additional costs and may be achieved as required. However the reduced need for winter heating may affect the cost:benefit of investing in combined heat and power (CHP) or other waste heat supplies and so have longer-term implications for the economy of the farm.

The Defra-funded CHAMELEON (Changing Agricultural Management under climate Extremes Likelihood of Effects and Opportunities Nationally) project (due to finish in Spring 2008) is attempting to provide cost:benefits associated with adopting different adaptation options (Table 3) for different agricultural sectors in response to the range of climate extremes shown in Table 4. Consultations as part of the project with farmers in six regions around the UK have indicated that those adaptations currently being undertaken by farmers are the low cost operational ones such as earlier drilling in Eastern England to ensure good crop root development to withstand summer droughts.

Table 3: Arable adaptation options identified within the CHAMELEON project (cc0361)

Climate extreme	Adaptation triggers	Adaptation	Level of adaptation
Heat	Lower yields	Grow early maturing varieties	On-farm
		Grow alternative (novel) crops	On-farm
		Grow in cooler regions of UK	Industry wide
	Storage Issues	*Increase storage capacity/refrigeration*	On-farm/ Industry wide
	Change in pest/disease threat	Increased pesticide use	On-farm
		Change pesticide	On-farm
		Grow less susceptible crops	On-farm
Frost	Flowering affected	Grow a range of varieties	On-farm
	Lack of winter kill of pests	Increased pesticide usage	On-farm
	Less winter kill of weeds	Increased mechanical/chemical control	On-farm
		Better herbicides needed	Industry-wide
Moisture	**Field operations**	*Increase range of equipment to cope*	On-farm

Climate extreme	Adaptation triggers	Adaptation	Level of adaptation
availability	**affected**	More flexible mix of spring/autumn sown crops	On-farm
	Difficulty harvesting	Move cropping to lighter soils	On-farm/ Industry wide
	Reduced storage potential	Move cropping to lighter soils	On-farm/ Industry wide
Storm intensity	Soil erosion	*Adopt soil conservation techniques*	On-farm
	Increased risk of lodging	*Improve management/plant nutrition/cultivar*	On-farm/ Industry wide
	Damage to emerging crops	Increase inter-row cover crops	On-farm
Growing season length	Changes with fieldwork	More flexible mix of spring/autumn sown crops	On-farm/ Industry wide
Heat &/or Moisture availability	Increased need for irrigation	Grow drought tolerant crops	On-farm
		Increase water capture/storage capacity	On-farm
		Install irrigation (where possible)	On-farm
		Move cropping to wetter N&W	Industry wide
Moisture availability	Change in pest/disease requirements (less blight more aphids)	Change pesticides	On-farm
Growing season length	Greater weed growth	Increased mechanical/chemical control	On-farm
	Herbicides less effective	Increased mechanical control	On-farm
	Increased yield (in indeterminate crops)	Reduce area to meet demand	On-farm/ Industry wide
	Rapid growth of determinate crops	Extends geographical range	Industry wide
		Opportunity for double cropping	On-farm
	Changes in timing of operations	None (already need to be flexible)	On-farm
Storm intensity	Efficacy of pesticides	Change pesticide	On-farm
	Fewer spray days	Increase equipment specification	On-farm
		Wider tramlines	On-farm

Adaptations in italics are included in the preliminary cost:benefit exercise

In many instances existing adaptations are being undertaken for operational reasons and not specifically in response to climate change. The consultations have also highlighted the variation in attitudes across the country, with farmers in the north of England, Scotland and Northern Ireland less accepting of the need to undertake some adaptations (e.g. related to drought).

As shown in Table 3, farmers can undertake many adaptations themselves but individual circumstances will govern how rapidly they will be adopted. The CHAMELEON consultations suggest that farmers respond to events that happen between three and five

times in quick succession. The cost:benefit analyses should help to illustrate the most economic adaptation options for farmers and highlight where a response is needed within the wider agricultural industry (e.g. pesticide manufacturers, seed producers) before farmers can implement an adaptation.

Assisting the adaptation process

Changing climate has already begun to, and will continue to, affect farming in the UK. However, the degree to which adaptations will be taken up depends on the value farmers and the industry sees in them in the context of their own situation. In particular, responses to losses from climate change will be more rapidly adopted than responses to gains. It is key that all aspects of agriculture have real-world knowledge of the impacts of climate change on which to guide their decision-making. There may be considerable scope to influence the perception of these changes. Communicating information needs to be undertaken with care to ensure that a message is delivered that encourages both appropriate and timely adaptation.

Whilst awareness of climate change is high, acceptance of it as an issue that the industry needs to plan for, is not. Results from the ADAS Farmer's Voice survey for 2007 suggest concern about some impacts, e.g. prolonged summer drought or wet winter weather is very high (Table 4). But Farmer's Voice results from 2005 showed that existing adaptation to climate change is at a low level. On average, 16% of farmers over the UK reported that they had adapted their production in response to a climate event. This figure however, masks wide regional variation for example only 15% of farmers in the East Midlands have made adaptations compared to 25% in the North West). Farmers within the CHAMELEON consultation groups have stated that they welcome the opportunity to find out more about different adaptation options and to see how they work on other farms. Sharing of best practice and demonstrations of adaptation methods are likely to be a useful means to spread awareness of the issue and facilitate adaptation to it.

Table 4: Percentage of farmers concerned or very concerned by extreme weather conditions in England by region (Temple et al 2007)

Extreme weather condition	NE	NW	Yorks & Humb	E Mids	W Mids	East	SE	SW	Total
Extremely high temperatures	54	60	68	63	75	73	77	65	68
Occurrence of unseasonal frost	37	39	46	43	44	52	44	35	43
Intense rainfall events	72	75	75	69	69	72	66	70	71
Reduction in intensity/frequency of frost	50	46	60	54	46	56	53	40	49
Earlier start and/or later finish to growing season	32	37	48	36	42	46	41	34	39
Prolonged summer drought	66	59	70	71	74	80	78	76	75
Prolonged wet	71	82	73	70	70	66	67	70	71

winter weather									
No. of respondents	93	169	250	170	213	253	251	320	1719

Base: All respondents in England (1719)

Conclusions

The impacts of climate change are unlikely to be catastrophic for the UK under current scenarios; socio-economic effects are likely to have greater impacts in the short term. However, UK agricultural policy does not include adaptation measures and increasingly decisions are being made and policies implemented that will be affected by climate change. It is important to ensure that knowledge of climate change impacts is widespread within the industry and that this information is regularly updated in order to guarantee that any adaptations are considered within future business strategies and farm plans. The industry needs to understand both the nature of climate change (i.e. the sort of changes that may be expected, both to average as well as extreme conditions) and, more importantly, to realise that some of these changes are already happening and cannot now be avoided.

Accepting climate change as inevitable should allow for the consideration of its interactions with policies, particularly long-term policy frameworks such as the EU Water Framework Directive (due to be implemented by 2029). As yet little work has examined how climate change may conflict or support the aims of such policies. Yet there is a need to recognise that in setting baselines against which policy success may be measured, climate change impacts may create a moving target.

Understanding the need to adapt to climate change is part of the process of change that should to be adopted within the industry. But adaptation need is often overshadowed by discussion of the uncertainty of climate change predictions. Agricultural systems are constantly evolving and adapting to external drivers, such as policy changes, technological improvement and market demands. Climate change in that sense is just another driver, to be considered with the others.

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