Indicators and trends

Monitoring climate change adaptation

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How is changing climate affecting crop suitability and productivity in Scotland's agriculture?	Version
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Agricultural management and productivity are very closely related to the climate, with any climatic changes potentially resulting in both risks and opportunities for farming. A survey carried out by Farming Futures (in 2010) identified that 38% of all farmers surveyed said they were already affected by climate change and nearly 60% expected to be affected in the next ten years.

There is significant potential for Scotland's agriculture sector to benefit from projected climate change. For example, warmer temperatures will result in:

- Longer growing season;
- Increased growth rate and consequently higher yields for some crops;
- An increase in the range and type of crops that can be grown;
- Reduced frost damage to winter crops.

However, climatic changes also bring significant risks. For example:

- Temperature and rainfall extremes resulting in loss of productivity;
- Increased irrigation demand in some areas due to an increase in water stress during the summer;
- Increases in the duration and intensity of rainfall events resulting in flooding and water-logging;
- Loss of top soil due to wind erosion in drier periods and runoff during prolonged or heavy rainfall events ;
- Facilitated introduction and/or increased range of invasive species;
- Mild winters increasing the range and prevalence of pests and diseases for crops and livestock. Two of the most economically damaging for Scotland's agriculture are both significantly driven by climatic conditions.
    - Potato late blight epidemics are largely driven by the weather with periods of free moisture (high humidity, dew and rainfall) and moderate temperature being optimal for pathogen infection and spread.
    - Liver fluke spends much of its complicated life-cycle outside the host cattle or sheep, either within vector snails, or as cysts or eggs on pasture, its prevalence, seasonality and geographic spread are very much affected by temperature and rainfall.

Climate is also one of the key constraints with regard to land use. In areas where the limiting factor is related to soil moisture, climate change could result in a shift from land that is capable only of providing rough grazing to land that could be potentially improved, along with a significant expansion in prime agricultural land in eastern and southern Scotland. However, an increase of drought risk in some currently prime areas may necessitate changes in cropping systems, varieties and/or water management. These changes in the potential pattern of land use may therefore place Scotland's agriculture into conflict with other sectors in ensuring sustainable and effective use of resources.

Adaptation options

In order to maximise productivity levels and strengthen Scottish agriculture, it is important that the sector has both the capacity to capitalise on potential opportunities as well as the resilience to limit negative impacts from the risks.

The Land Capability for Agriculture (LCA) system provides a good measure of the availability of high quality ('prime') land for agricultural production as well as the distribution of other classes of land critical for the Scottish livestock industry. It is based on the degree of limitation that climate, soil and topography impose on agricultural production and cropping flexibility. Whilst it does not determine actual use, there is a good relationship between the classification it provides and *potential* use. Therefore, used appropriately the LCA can provide a useful framework to examine how different sectors of Scottish agriculture might adapt to climate change as agricultural opportunities increase or decrease dependant on the direction of change in LCA classification. The role LCA already has in both spatial planning and land management practice means that, if projected changes in classification are taken into consideration, it could also be used to scope and implement climate change adaptation strategies. The principles and proposals for sustainable land use contained in Scotland's Land Use Strategy have the potential to maximise opportunities and minimise risks at a larger scale than reactive autonomous adaptation most commonly seen at farm level.

The projected increase in drought risk in current areas of prime agricultural land in East Scotland is likely to restrict some land use options unless irrigation supply is increased. However, analysis using 2050's climate projections has identified 'hotspot' catchments based on current land use and management regimes where water supply will be limited. Whilst the majority of irrigation in Scotland is targeted at potato and horticultural crops, if irrigation was extended to reduce drought risk to cereals, then water-stressed catchments would become much more common throughout North-East and South-East Scotland. Long-term, farmers may therefore need to consider other forms of adaptation such as shifting cropping systems and changes to more drought resistant varieties. Declining river flows may also require regulatory intervention in order to maintain environmental flow conditions. SEPA are currently trialling a new approach to abstraction management, working with land managers in catchments that have been identified at risk of impact from irrigation abstraction and focussing on crop requirements, water efficiency, irrigation programming and use of storage ponds. 'Farming for a Better Climate' (Scotland's Rural College) and 'Future Proofing Scotland's Farming' (Soil Association Scotland, Quality Meat Scotland) provides practical advice to farmers which helps to support this approach.

Whilst average soil wetness risk is projected to reduce in some areas (enhancing land use options on currently marginal land), increases in heavy or prolonged rainfall events will lead to soils becoming periodically saturated resulting in increased runoff (and diffuse pollution of water bodies), erosion of fertile topsoils and impact on the workability (the capability of the land to support tillage) and trafficability (the capability of the land to support agricultural traffic without degrading soils) of the land in some areas. The Scottish Soil Framework (2009) contains particular emphasis on the pressures exerted by climate change and identifies the suite of relevant policies which aim to promote the sustainable management and protection of soils. Practical guidance to protect and improve farm soils, and therefore improve the profitability of farm businesses, has been coordinated and published by Scotland's Rural College.

Whilst the future trends of crop yields are largely difficult to predict, Scotland's highest input crops, such as potato, winter wheat and winter oilseed rape, are sensitive to out-of-the-ordinary weather. Farmers therefore need to:

- Consider utilising crop varieties that are known to be least sensitive to these extremes;
- Phase out practices that are damaging to soil and replace with practices that result in improved soil condition;

- Reduce reliance on sensitive crops by devising a wider range of economic products from less sensitive crops;
- Devise cropping systems that are more stable and resilient (e.g. based on varietal mixtures and mixed-species crops).

Crop diversification not only buffers impacts on crop production due to extreme events or increased variability, but can also increase the ability to suppress pest outbreaks and reduce pathogen transmission which can have critical impacts on yield and profitability. European greening measures, targeted at addressing a range of environmental challenges, includes crop diversification. The rules governing this applies to around 30% of Scotland's farms, but it is estimated that only 800-900 will need to grow any additional crops to comply, though many farmers are likely to need to reduce the dominance of their main crop. Between 2014 and 2015 the area of cereal crops planted fell by approximately 4%, which is seen as a reaction to the new crop diversification rules. However, given the inter-annual variation it is not yet possible to determine if the increase in diversity shown since 2013 is significant.

Diseases, pests and parasites have the potential to cause significant economic damage to agricultural businesses and it is therefore vital to maintain and improve reporting, monitoring research and management of critical species. The climatic variables which drive outbreaks of potato blight and liver fluke are utilised to provide a forecast for farmers which can enable preventative management and minimise the risk. AHDB Potatoes (a division of the Agriculture & Horticulture Development Board) provide the free Blightwatch scheme for growers across the UK, based on Met Office data, which predicts pathogen activity on the basis of minimum air temperature and relative humidity ('Smith Periods'). Liver fluke risk is forecast based on meteorological factors which influence the likelihood of summer infection of vector snails ('Ollerenshaw Index'), which is presented as regional fluke forecasts online at the National Animal Disease Information Service.

Whilst farmers are more aware of the risk of liver fluke as a result of recent increased incidence, the tendency is to be more reactive than proactive and treat the stock with chemical flukicides. However the emergence of flukicide resistance is reducing the ability to control the parasite in endemic areas. Preventative measures such as pasture drainage to limit the suitable habitat for the intermediate host snails, need to be considered in conjunction with other land and water management requirements in order to provide sustainable options. In some areas, however, there is likely to be conflict with wetland/ agri-environment schemes for which the snails may act as an indicator species or be a conservation target.

Chemical control is also the main component of late blight management with multiple applications of fungicides each season. Although drier summers are likely to reduce the incidence of potato late blight, an associated increase in irrigation may counteract the reduction in disease pressure. In addition, increased temperatures mean that when the disease does occur it is likely to spread more rapidly. Increasing fungicide usage carries negative economic and environmental consequences, but current research funded by AHDB Potatoes aims to produce a more refined decision support system to improve decision making for growers and optimise the efficiency of fungicide use. Long term, growers may also need to adapt by growing potato cultivars with higher levels of blight resistance, but currently, processing quality and yield are the main drivers of variety choice which is demand led by supermarkets and processors.

There is generally good data availability regarding the risk of certain critical pests and diseases and recording of actual outbreaks. However, impact is largely represented by prevalence data rather than evidence of economic or biodiversity loss which could aid in the promotion of improved and sustainable management strategies both at farm and policy level. There also needs to be a greater emphasis on understanding which crop varieties, livestock breeds and agricultural systems are

more resilient to climate change in general. Further research is also required to understand the scale and impact of changing land suitability and to develop integrated land-use planning strategies which take this into account.

Sharing research findings and practical experience is a critical element in improving the resilience of Scotland's agriculture as a whole. The Farming for a Better Climate programme provides practical advice, a forum for the farming sector and investigates, tests and shares practical measures to improve farm profitability via their Climate Change Focus Farms. Centres of expertise such as EPIC (Centre of Expertise on Animal Disease Outbreak) and the planned Centre of Expertise for Plant Health bring together Scottish-based expertise to provide effective knowledge exchange, promote innovative thinking and coordinate research and analysis to provide evidence-based advice which supports policy development and implementation.

What do the indicators tell us?

CXC's indicators focus on various aspects of exposure and vulnerability of Scotland's agricultural sector to climatic changes; some of the resulting impacts which can influence productivity within the sector; and highlight actions to improve resilience to the risks and capitalise on potential opportunities:

The RISK (and opportunity) from climatic factors directly or indirectly influencing the suitability and productivity of current agricultural land use and management practice:

- *Area of Prime Agricultural Land (Land Capability)* monitors the amount of prime agricultural land in Scotland over time. This indicator needs to be considered in combination with other aspects of land capability, notably drought risk and wetness risk (see *Wetness risk for agriculture (arable suitability and grassland suitability)*, and *Drought risk to agricultural land)*. There are approximately 11,000km^2 of prime agricultural land in Scotland. Prime land has increased by ca. 4% but most expansion occurred during 1971-1990 and there have only been small changes since (though with distinctive geographic variations). The total amount of prime land stabilised in the most recent reference period (1991-2010), but future projections indicate a significant expansion (20-40%).
- *Comparison of land capability against actual land use* seeks to characterise the relationship between the capability of the land and its actual use, although as yet no single value indicator has been devised to summarise this relationship. The most recent published figures defining the relationship are for 2011 though data to support analysis for 2000-2014 are available. Given the growing body of evidence that the LCA classification is changing in response to weather and climate, understanding how this potential relates to actual changes in land cover is vital. A key limitation in using this indicator is the difficulty in adequately attributing change in land use to a host of complex and inter-related drivers: climate induced changes in capability together with environmental, economic, social and political drivers.
- *Wetness risk for agriculture (arable suitability and grassland suitability)* utilises a component of Land Capability for Agriculture that identifies constraints on land use options through its limitations on trafficability and workability for arable land and poaching risk from livestock on improved grassland. Most climate projections imply that average annual wetness risk will be reduced particularly in East Scotland which may enhance land use options for currently marginal areas. However, many upland areas (and North-West Scotland in particular) will continue to be limited by saturation of soils.
- *Drought risk to agricultural land* uses a component of Land Capability for Agriculture that identifies constraints on land use options through its limitations on water availability in

the soil. Currently, a small amount of land suitable for arable cropping is exposed to drought risk due to the limited available water capacity of the soil at these locations but there is evidence that drought risk can become more pronounced in extreme years. Some future climate scenarios suggest that by 2050 as much as 50% of prime land may be defined as of moderate or severe risk of drought.

- *Area of cultivation under glass or plastic structures* uses data from the annual Agricultural Census to monitor the degree to which these structures are used to grow high quality soft fruits. Whilst growing under such structures can improve resilience to extreme weather and extend the growing period, these structures also increase the risk of some pests and diseases. The area of this type of crop management has increased from 80 hectares in 2003 to 1122 hectares in 2014, with the greatest increase being in 2012. It is important that the extent of structures, together with the efficacy of pest and disease management and impacts on surrounding land, are monitored to ensure they contribute to successful adaptation and not maladaptation.
- *Risk of liver fluke (Fasciola hepatica) in cattle and sheep* monitors the risk to Scottish sheep and cattle farmers from this highly pathogenic flatworm parasite, whose distribution and abundance can be largely determined by climatic conditions. The average risk of summer infection has increased over the past four decades, in part due to milder winters which result in an increased survival rate of flukes and host snails.

The IMPACT on factors influencing productivity and the suitability of land use and management practice:

- *Crop yields (including agronomic inputs and variability)* examines changes in both crop yield itself along with the accompanying levels of fertiliser and pesticides used. Yields have been generally stable for at least the last 15 years, however the potential variability due to weather extremes is highlighted by the drop in 2012 due to the wet summer and autumn, as well as the high point in 2014 due to the particularly warm summer. It is the highest input crops (e.g. potatoes, winter wheat and oilseed rape) which are most susceptible to unusual or extreme weather and farmers will need to consider a variety of strategies to reduce their sensitivity.
- *Abstraction of water for irrigation* shows that during 2013 approximately 17 million cubic metres of water were abstracted for irrigation purposes which was 39% of the total licensed volume. Abstraction levels were significantly higher in the East reflecting the dominance of arable farming in this area. The greatest abstraction occurred in the Tay region which coincides with the area projected to see the greatest increases in irrigation demand.
- *Range and prevalence of climate marker pests and diseases in crops: Number of potato blight outbreaks* examines any changes in this potentially devastating disease whose cycle is driven by available moisture and temperature. Across Great Britain, 267 outbreaks were reported in 2014, but there is no clear trend observable from the data currently available over the previous decade.
- *Prevalence of liver fluke (Fasciola hepatica) in cattle and sheep* shows there has been a consistent increase in liver fluke incidence over the last 15 years, with the latest prevalence figures showing 16%-17% infection rates in sampled cattle and sheep. Whilst changing weather patterns have contributed to this increase, animal movement, flukicide resistance, and wetland restoration are also potential drivers of change.

Evidence of ACTION which can increase resilience of farming to the risks and capitalise on potential opportunities created by climate change:

- *National agricultural crop portfolio and diversity index* monitors diversification in Scotland's crop portfolio as this has the potential to improve resilience by e.g. reducing pathogen transmission and buffering impacts on crops due to increased climate variability

or extreme events. There has been no significant overall trend in diversity over the last 6 years, but between 1988 and 2015 there was an overall decline largely dictated by an increase in both wheat and oilseed rape and a decline in the dominance of spring barley. However, spring barley continues to dominate, with nearly half of all arable land in Scotland utilised for its production.

Other relevant indicators

Crop suitability and productivity are very closely related to the state of agricultural soils. This is examined in more detail in the narrative (and associated indicators) *Condition of agricultural soils*.

To realise an agricultural opportunity, while retaining the biodiversity and wider ecosystem service value of land, careful management is required. Historically, agricultural intensification has been the primary driver in depleting the range of ecosystem services delivered by agriculture. This is examined in more detail in the narrative (and associated indicators) *Sustainable agriculture*.

Climate change is also expected to bring both risks and opportunities to Scotland's productive forestry. Two narratives (and associated indicators) focus on key issues for this other land-based industry:

- *Pests, diseases and invasive species (forestry)*
- *Suitability and productivity (forestry)*