Indicators and trends

Monitoring climate change adaptation

climate change
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How is climate change affecting Scotland's agricultural soils?	Version
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Soils play a vital role in maintaining ecosystem function and supporting ecosystem services including water regulation and purification, crop production and carbon sequestration. Soils and climate are very closely linked: climatic factors directly influence soil formation and the ability of soils to provide these crucial ecosystem services; and soils can influence climate via the storing of carbon and exchange of greenhouse gases with the atmosphere.

Projected warmer temperatures will stimulate a more rapid decomposition of soil organic matter with consequential increases in CO_2 emissions and a loss of carbon from the soil. As the organic content determines the capacity of soils to deliver key ecosystem functions, its loss will have significant consequences for both agriculture and the wider environment.

Soil erosion is another major threat to soil function that can lead to a reduction in soil quality, loss of soil carbon and off site impacts such as the pollution of aquatic environments due to increased sediment load. The trend towards drier summers shown by most climate projections will increase drought risk particularly in some parts of East Scotland. This will impact on crop and grass yields as well as increasing the risk of wind erosion on vulnerable soils.

Projected increases in heavy or prolonged rainfall events will lead to an increase in soils becoming saturated resulting in increased runoff and consequential erosion of fertile topsoils. Saturation of soils causes anaerobic conditions which inhibit root growth and result in nitrogen loss from the soil. It also limits 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. Whilst there is considerable spatial variability, largely determined by soil type, some parts of East Scotland may see a reduction in this risk across the whole year providing an increase in access period for farmers, whereas North-West Scotland will continue to have major wetness limitations to agricultural improvement of land.

The potential management and environmental impacts are significant and include:

<u>Farming</u>

- Reduced soil rooting potential due to loss of topsoil and soil organic matter.
- Need for re-seeding or re-application of fertilisers etc. due to water or wind erosion.
- Silt deposition increases the maintenance requirements of drainage and may increase flood risk.

<u>Wider environment</u>

- Eroded soil can clog river beds, impacting on fish and other aquatic life.
- Run-off of fertilisers leads to nutrient enrichment of water bodies, which may encourage growth of damaging algal blooms.
- The adhesion of pesticides onto soil particles may also pollute nearby water.

- Flooding risk may increase both locally and downstream due to blocked drainage or loss of channel depth.

Adaptation options

Simple changes in management practices may help to reduce the occurrence and intensity of erosion events, improve soil quality and so give rise to a range of benefits for farmers and reduce the risk to the wider environment e.g.

- Maintaining the residue of the previous crop provides a protective layer at the soil surface- reducing the likelihood of heavy rainfall eroding exposed soil.
- Incorporating organic matter (straw, animal dung, composted materials) into the soil can improve soil structure and reduced the risk of capping at the soil surface.
- Reducing the use of heavy machinery and restricting access to land during times of soil saturation will reduce compaction risk.
- Improving soil drainage will reduce the risk of anaerobic layers forming.

There are a number of financial incentives (as well as schemes offering advice and guidance) which are available to both the arable and livestock sectors of Scotland's farming industry. Keeping farming land in Good Agricultural and Environmental Condition (GAEC) is a requirement for some of these support scheme payments. These rules formalise methods of good practice and include: maintaining soil cover to protect against erosion after harvest until the end of winter (GAEC 4); reducing the poaching risk from livestock and the use of e.g. sediment traps if conditions limit available cover (GAEC 5); maintaining soil organic matter by restricting stubble burning and ploughing of semi-natural areas (GAEC 6); retaining landscape features to limit erosion (GAEC 7).

The Scottish Soil Framework (2009) was aimed at Scottish Government policy leads, environmental and research organisations and other key stakeholders. This highlighted that the potential impacts of climate change on soil are not restricted to agriculture. They should be considered in other policy areas as well, including Land Use, Water Quality and Flooding, Planning and Conservation, and Biodiversity. The objective of the Framework was to implement a process by which these key stakeholders would work together to achieve better soil protection across all policy areas.

The Soils Framework identified a key outcome as enhancing knowledge and understanding of soils and the strengthening of the evidence base for policy review and development. Scotland's Soils Website provides a platform for authoritative and scientifically robust data and information. This knowledge base is being used to design management tools for farmers, land managers and others to make informed decisions about sustainable soil management. Research is helping to fill some of the key gaps in knowledge (e.g. in relation to erosion and drainage).

Working with farmers to limit the amount of nutrients, pesticides and sediment reaching water environments is part of a co-ordinated national level approach to reduce the risk of diffuse pollution and meet the impact targets of the Water Framework Directive. A partnership approach

to reducing rural diffuse pollution is led by the Diffuse Pollution Management Action Group (DPMAG). In addition to its national strategy, DPMAG targets 'Priority Catchments' where a particular focussed approach is needed.

Appropriate soil management is central to the development of a sustainable approach to flood risk management. The catchment-based approach is also increasing our understanding and management of these interactions. This then enables the simultaneous reduction of the risk of flooding, while also improving the quality of the environment.

The Farm Soils Plan (2005) provided farmers with straightforward advice regarding protection of soils, and therefore their incomes, by increasing the sustainability of the land and ensuring they meet these requirements of support scheme payments. Farming for a Better Climate, run by SRUC on behalf of the Scottish Government, provides practical support together with information on the latest research and ideas. Many of these have been trialled at volunteer Climate Change Focus Farms to reduce farming's impact on the climate, improve farm performance and resilience to climate change.

Future Proofing Scotland's Farming (Soil Association Scotland, Quality Meat Scotland, the National Farmers Union of Scotland) provides events aimed at informing farmers and other land managers about adaptation measures that minimise the negative impacts of climate change while capitalising on opportunities, reduce on-farm greenhouse gas emissions and create sustainable agricultural enterprises based on low carbon principles. This supports the implementation of priority measures set out in key Scottish Government policies and strategies.

What do the indicators tell us?

CXC's indicators focus on various aspects of exposure and vulnerability of Scotland's agricultural soils to climatic changes, some of the resulting impacts, and highlight actions to address these risks:

The RISK from climatic factors that directly influence soil formation and the ability of soils to perform critical ecosystem services:

- *Soil erosion risk* summarises the best available knowledge regarding erosion risk to Scotland's soils. There is currently no systematic assessment of erosion in Scotland and it is often not possible to disaggregate the contributions of land cover and management, climate and soil properties. However, if land use patterns remain the same, increased winter rainfall is likely to increase erosion in the agricultural areas of Eastern Scotland but with considerable local variation, largely due to management practices.
- *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.

The IMPACT on soil carbon concentration (a key measure of soil condition) and potential indirect impacts on the water environment from soil erosion, run-off or leaching:

- *Soil carbon concentration in arable soils* uses the Countryside Survey which provides data on topsoil carbon concentrations for arable and horticultural soils. Between 1998 and 2007 there was a significant decline of around 9% in carbon concentration in the soil though much of this is attributed to land use change and management rather than as a direct result of a changing climate. However there are many uncertainties regarding local variation in carbon stock and accumulation rates which limit our ability to assess current, or forecast likely future, changes in the amount of carbon stored in Scotland's arable soil.
- *Freshwater bodies affected by diffuse pollution due to agriculture* uses pressure data collected by SEPA for all water bodies to provide evidence of runoff from and erosion of agricultural soils. Over 8% of water bodies in 2014 were under pressure from diffuse pollution from arable, livestock or mixed farming. This represents a significant improvement over the first period of the River Basin Management Plans with successful partnership working to develop and refine management approaches to reduce this pressure in priority catchments.

Examine the success of management ACTION to improve the condition of agricultural soils and limit the impacts on farming and the wider environment from climate change:

- *Agricultural production methods which reduce erosion risk (proportion of arable land using reduced/ zero tillage; soil cover)* quantifies and monitors the uptake of agricultural methods that reduce the risk of soil erosion. Reduced or zero tillage methods tend to be employed on smaller holdings with around 80% of arable land being tilled by more intensive systems which leave bare soil and little crop residue. In 2013 nearly 1/5 of soils were left bare (up from 15% in 2010 though there is likely to be considerable inter-annual variation). Whilst there is no data on the number of boundary landscape features as a whole, 2010 data provides some information on the number of holdings that have actively maintained or established these features over the previous three years.

Indicators not yet available due to a lack of suitable data for Scotland:

- Workable days on the land/ change in access period
- Extent and condition of field drainage

Other relevant indicators

Both drought and wetness risk to arable soils are components of Land Capability for Agriculture. *Area of Prime Agricultural Land (Land Capability)* examines the potential for climate change to alter the area and distribution of 'prime land' in Scotland with an associated change in the area of soils exposed to more intense agricultural production; and *Comparison of land capability against actual land use* summarises the best available knowledge regarding changes that are being observed.

Hedgerows, in addition to providing important habitat and aiding movement between larger natural areas, are also useful boundary features which can stabilise slopes and help to prevent eroded soil polluting waterways (*Extent and condition of natural landscape connections: hedgerows and ponds*).

Projected climate change is also likely to cause deterioration in the condition of deep peat habitats in some parts of Scotland. In addition to including internationally important habitats, deep peat areas represent a very significant carbon store (over 50% of Scotland's total soil carbon), therefore a number of indicators are focussed on these areas:

- *Extent of key habitats: deep peat*
- *Condition of key habitats: Area of modified deep peat soils*
- *Annual greenhouse gas (GHG) emissions from degraded peatlands*
- *Peatland restoration area*

Many of the risks posed by climate change to water bodies are due to knock-on impacts from the surrounding land and from potential changes in land use. This is examined in more detail in the narrative *Water quality and availability*.