Indicators and trends

Monitoring climate change adaptation

climate change

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Indicator name				Version
NA6 National agricultural crop portfolio and diversity index				03/06/16
Indicator type:	Risk/opportunity	Impact	Action	
			X	
SCCAP Theme	SCCAP Objective	CCRA risk/opportunity		
Natural Environment	N3: Sustain and enhance the benefits, goods and services that the natural environment provides	• AG25/AG51/AG52 Agricultural land classification and crop suitability • Cross-cutting (including changes in yields, human food supply)		

At a glance

- Over half of Scotland's arable land is used to grow barley, with the majority being winter rather than spring barley.
- Between 1988 and 2015 there was an overall decline in diversity largely due to annual fluctuations in the dominance of spring barley in the crop profile. An increase in diversity from 1988 to a peak in 1994 was due to an increase in both oilseed rape and wheat and a decline in the dominance of spring barley.
- Changes in agro-climate will not only impact on the sustainability of existing cropping but is likely to also create opportunities for new crops which may begin to alter the overall crop portfolio.
- Climate is likely to become increasingly important in influencing management options such as timing of operations and cultivar choice. However the main drivers of crop choice are likely to be based on market demands and prices
- European greening measures include crop diversification. The regulations impact on around 30% of Scotland's farms, but it is estimated that only 800-900 will need to grow any additional crops to comply, with a larger number likely to need to reduce the dominance of their main crop.
- Significant changes in crop portfolio and overall diversity are likely to be in response to factors such as policy reform, global production and trade, and advances in research and technology.

Latest Figure	Trend
Crop diversity index (2015): 0.72 Crop portfolio (2015): see Figure 2	No significant overall trend in diversity over the previous 6 years (2009-15), but an overall decline in diversity since 1988.

Why is this indicator important?

Climate change can influence agricultural crop production, both positively and negatively, in a number of ways (Olesen *et al*, 2011):

- Directly
  - Increasing CO2 impacts on the growth and physiology of the plants
  - Changes in temperature, rainfall, radiation etc. influence plant development and growth
  - Damage due to extreme weather events
- Indirectly
  - Changing suitability for planting certain crops
  - Changing occurrence of competitive weeds, pests and diseases
  - Pollution (e.g. nitrate leaching) or degradation of the soil (e.g. erosion)

There is therefore a need to ensure that farmers are able to a) sustainably maximise potential opportunity, and b) ensure that resilience is built into Scotland's agricultural system in order to be able to withstand shocks and adapt to future changes (Scottish Government, 2015b). Crop diversification has the potential to improve resilience in a number of ways e.g. increasing the ability to suppress pest outbreaks and reducing pathogen transmission; buffering impacts on crop production due to increased climate variability and/or extreme events (Lin, 2011; Abson *et al*, 2013).

The June Agricultural Census (Scottish Government, 2015a) collects annual data on land use, crop areas, livestock and the number of people working on agricultural holdings. This indicator uses the planted area data for 38 crops which have been consistently recorded since 2009[1].

The crop diversity index is based on Simpson's Diversity Index which ranges from 0 to 1, where the greater the number the greater the level of diversity. Here the number of crops for which data has been included remains constant in order to maximise the number of years for comparison (due to changes in data collection methodology), and therefore any change in the index is as a result of a change in the evenness (relative abundance) rather than number of crops grown.

Related indicators:
NA1 Comparison of land capability against actual land use
NA2 Area of Prime Agricultural Land (Land Capability)
NA3a/b Crop yields (including agronomic inputs and variability)
NA25 Range and prevalence of climate marker pests and diseases in crops: Number of potato blight outbreaks

What is happening now?

The latest diversity index for 2015 is 0.72 (Figure 1), but there has been no significant overall trend in diversity over the last 6 years with the index figure varying by +/- 0.02. The latest figures showed that over half of Scotland's arable land was used to grow barley, with the majority being winter rather than spring barley[2] (Figure 2). Approximately 20% of arable land was used to grow wheat, with oilseed

[1] See Appendix 1, Table 4

[2] Spring barley is sown in the spring and harvested the same year, whereas winter barley is sown in the autumn and harvested the following year

rape (winter and spring), oats (winter and spring) and potatoes (ware[3] and seed) being the other three single dominant crop types grown in Scotland's crop portfolio.

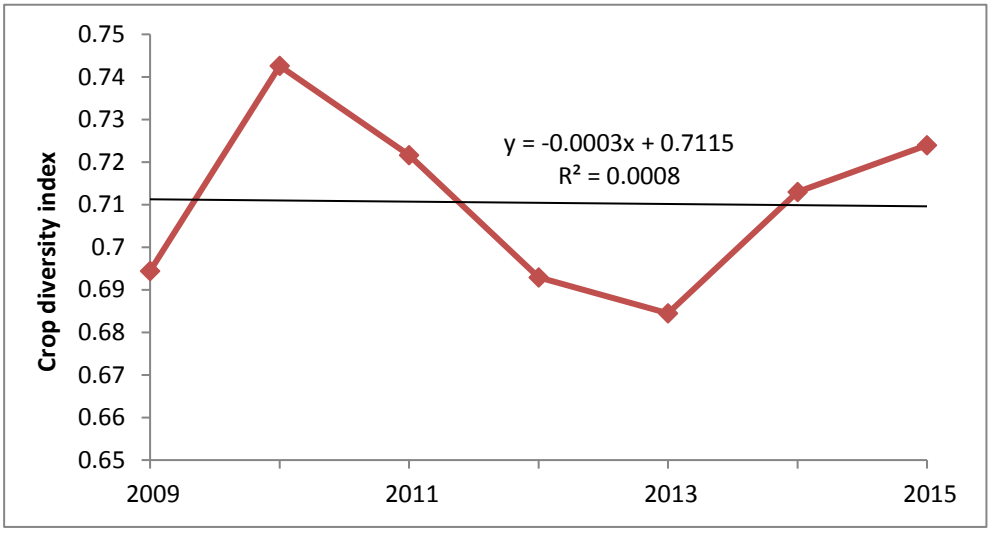

Figure 1 Crop diversity index (2009-2015) for the whole of Scotland. Crop diversity calculated using the Simpson's Diversity Index.

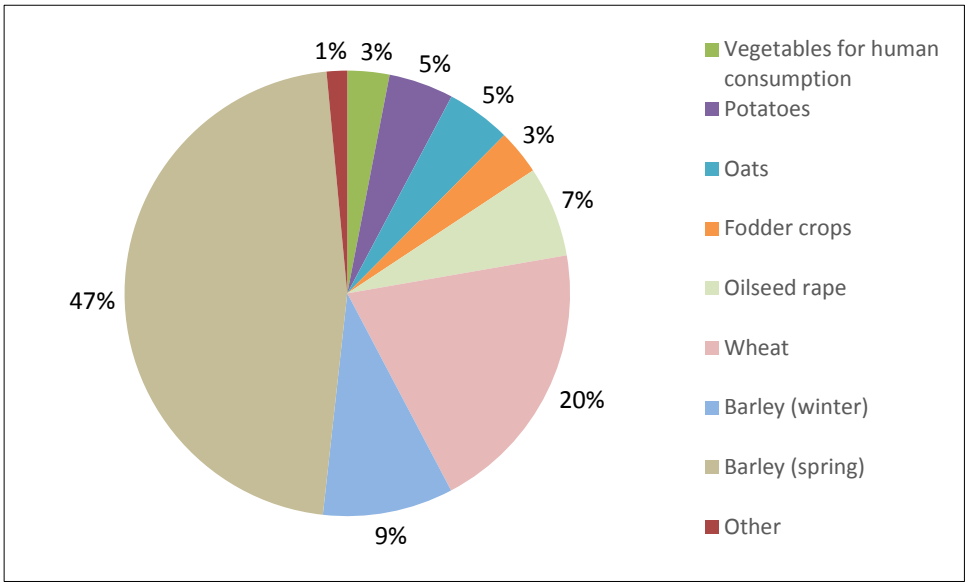

Figure 2 Comparison of major crop areas in Scotland[4] (2015)

What has happened in the past?

Between 1988 and 2015 there was an overall decline in the diversity of Scotland's crop portfolio (Figure 3). This was largely dictated by the annual fluctuations in the dominance of spring barley in the crop profile. The increase in diversity from 1988 to a peak in 1994 was due to an increase in both oilseed rape and wheat and a decline in the dominance of spring barley (Figure 4).

[3] Ware potatoes are grown ready for the consumer to eat, as opposed to those which are grown for seed

[4] For a definition of 'major crops see Appendix 1, Table 4

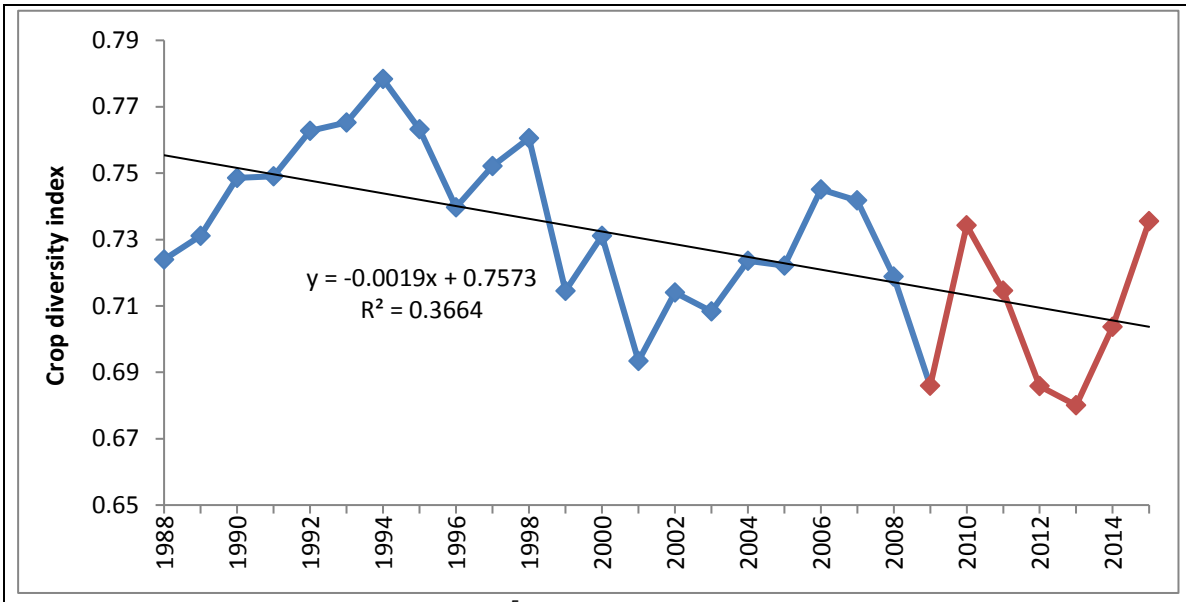

Figure 3 Crop diversity index (1988-2015)[5] for the whole of Scotland. Crop diversity calculated using Simpson's Diversity Index[6]

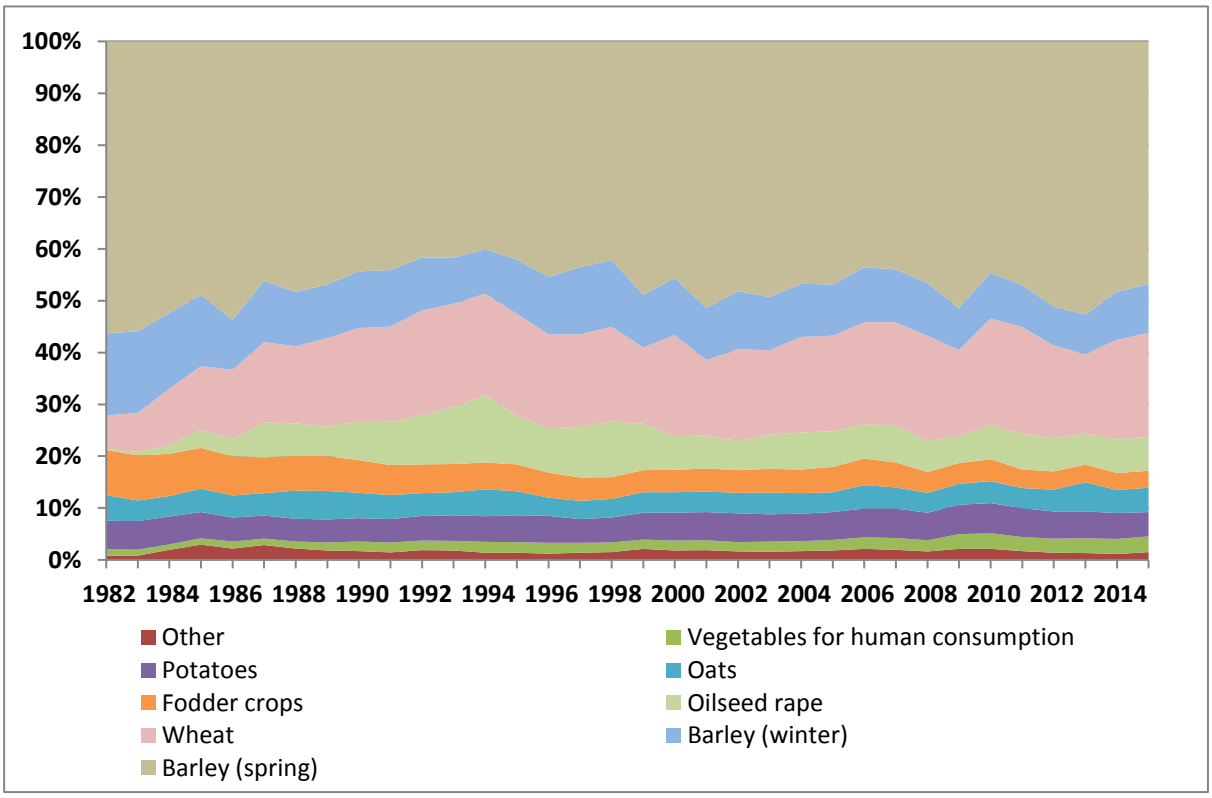

Figure 4 Comparison of Scotland's major crop portfolio (1982-2015)

[5] Whilst data is available from 1982, 1988 was chosen as a starting point in order to maximise the number of years with the greatest number of crop data available

[6] From 2009, data on land use was obtained from the Single Application Form (SAF). The use of SAF data has resulted in a step change in some of the land use results from 2009, especially for rough grazing and grass. This means that trends between 2008 and 2015 should be treated with caution.

What is projected to happen in the future?
Whilst the drivers of crop choice are likely to remain largely economic in origin (based on market demands and prices), climate influenced environmental drivers are projected to become increasingly important in influencing e.g. timing of operations and cultivar choice. These management changes may not, however, be able to adequately compensate for potential impacts on the yields of some crops and farmers as a result may need to consider altering crop choice itself. Changes in agro-climate will not only impact on the sustainability of existing cropping but is likely to also create opportunities for new crops which may also begin to alter the overall crop portfolio. Impacts on viability and industry response are likely to be very crop (and location) specific e.g.: • Although climate change is likely to affect the stability of barley yield through e.g. waterlogging in winter and water stress in drier summers, compared to other cereals, barley is an inherently resilient crop (Newton *et al*, 2013). Given it is of considerable economic importance for the whisky industry, it is highly likely that barley will therefore continue to be the dominant arable crop in Scotland. • By contrast, potato production is far more vulnerable to projected climate change which is likely to expose Scotland's potato crops to an increase in environmental stresses and a wide range of pests and diseases (Taylor & Stewart, 2013). As a consequence, in current research and breeding efforts there is a strong emphasis being placed on understanding and development of climate and pest resistance/ tolerance to better equip the Scottish potato industry to flourish in a changing climate. Future indicator development may therefore also need to consider genetic and phenotypic (rather than crop) diversity which may be critical in order to ensure stability, resilience and enhanced system function (Newton, 2010). The changing climate is also likely to result in significant shifts in land use. Analysis using both UKCIP02 (Brown et al., 2008) and UKCP09 (Brown et al., 2011) indicate a significant expansion of prime land, identified as being in the range of 20-40%. This is mainly a consequence of the shift towards warmer drier summers for the lowland agricultural areas of Scotland (in average years) evident in most climate change projections or scenarios. It is too early to determine whether this shift will also alter the overall crop portfolio and diversity of Scotland's farming.

Patterns of change

Interpretation of indicator trends
Until the mid-1950s, oats was the predominant cereal in Scotland and occupied around 75% of the arable land. The introduction of autumn-sown crops such as winter wheat, along with responses to changing market demands were largely responsible for these changes (Scotland's Environment Web, 2011). Arable crops, particularly barley, are often grown in rotation with grass or a break crop. Oilseed rape is often used as a break crop and has become the third most commonly grown crop in Scotland (after barley and wheat). The ban on the use of lindane, an organochlorine insecticide formerly used on up to 80% of Scotland's rape crops, coincided with a significant drop in the production area of oilseed

rape in Scotland by almost a half (largely due to a drop in the planting of spring rather than winter oilseed), and the areal figures have generally remained at this lower figure since then (Scottish Government, 2016).

European greening measures, targeted at addressing a range of environmental challenges, includes crop diversification. This aims to ensure that a wider range of crops are grown, to try and limit monoculture cropping and to improve soil quality. As a consequence, farmers with between 10-30 ha of arable land will need to grow at least 2 different crops, those with more than 30 ha arable land must grow at least 3 different crops, with the main crop covering no more than 75% of the arable land. This impacts on around 30% of Scotland's farms, but it is estimated that only 800-900 will need to grow any additional crops to comply (Scottish Government, 2013), though a larger number are likely to need to reduce the dominance of their main crop (NFU Scotland, 2014). 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 (Scottish Government, 2015c). However, given the inter-annual variation in diversity (Figure 3) it is not yet possible to determine if the increase in diversity shown since 2013 is significant.

A large amount of farm-level adaptation (including diversification) is likely to arise autonomously as farmers make within year and more long term management decisions in response to fluctuations in yield (e.g. timing of field operations and choice of cultivars). However, it is likely that more significant changes in Scotland's crop portfolio and overall diversity will be in response to other factors such as policy reform, global production and trade, and advances in research and technology (ACCSG, 2008).

Limitations

From 2009, data on land use was obtained from the Single Application Form (SAF). In 2012 25,000 holdings claimed Single Farm Payments. This data has been combined with land use data from all the other holdings, collected through June Census forms, to generate overall 2012 June Census results.

The use of SAF data has resulted in a step change in some of the land use results from 2009, especially for rough grazing and grass. This means that trends between 2008 and 2012 for these land use categories do not represent genuine changes in land use, but do represent differences in the way this data has been reported between 2008 June Census and 2009 to 2012 SAF. These trends should be treated with caution (Scottish Government, 2015a).

References

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Further information

Scottish agricultural statistics: http://www.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries Farming for a Better Climate: http://www.gov.scot/Topics/farmingrural/Agriculture/Environment/climatechange/Advice

Acknowledgements

Appendix One: Indicator meta data and methodology

Table 1: Indicator meta data

	Metadata
Title of the indicator	NA6 National agricultural crop portfolio and diversity index
Indicator contact: Organisation or individual/s responsible for the indicator	Anna Moss (CXC, University of Dundee)
Indicator data source	Abstract of Scottish Agricultural Statistics 1982 to 2015
Data link: URL for retrieving the indicator primary indicator data.	http://www.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/PubAbstract/Abstract2015

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	1982-2015
Frequency of updates: Planned or potential updates	Annual
Spatial coverage: Maximum area for which data is available	Scotland
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	From 2009, data on land use was obtained from the Single Application Form (SAF). In 2012 25,000 holdings claimed Single Farm Payments. This data has been combined with land use data from all the other holdings, collected through June Census forms, to generate overall 2012 June Census results. This development has led to a substantial reduction in statistical data collection and an overall improvement in the quality of land use statistics. The use of SAF data has resulted in a step change in some of the land use results from 2009, especially for rough grazing and grass. This means that trends between 2008 and 2012 for these land use categories do not represent genuine

	changes in land use, but do represent differences in the way this data has been reported between 2008 June Census and 2009 to 2012 SAF. These trends should be treated with caution.
Spatial resolution: Scale/unit for which data is collected	Data is available from this source at Scotland level
Categorical resolution: Potential for disaggregation of data into categories	
Data accessibility: Restrictions on usage, relevant terms & conditions	Public access to Scotland level summarised data

Table 3 Contributing data sources

Contributing data sources Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data.
• Land Use tables in *Abstract of Scottish Agricultural Statistics 1982 to 2015* http://www.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/PubAbstract/Abstract2015

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
Diversity Index: As the number of crop types has been kept constant it was deemed most appropriate to use Simpson's Index of Diversity: **1-D** where **D = ∑(n/N)2** The diversity index is based on proportion of land growing the following crops: Wheat; Barley (winter); Barley (spring); Oats (winter); Oats (spring); Triticale; Mixed grain; Oilseed rape (winter); Oilseed rape (spring); Peas for combining; Beans for combining; Potatoes (seed); Potatoes (ware); Aromatic, medicinal, culinary plants; Lupins; Turnips & swedes (fodder); Kale & cabbage; Rape; Maize; Fodder beet; Other fodder crops; Peas for canning & freezing; Beans for canning & freezing; Leeks; Cabbages & savoys; Brussels sprouts; Cauliflower; Calabrese; Turnips & swedes (human consumption); Carrots; Lettuce; Rhubarb; Other vegetables; Raspberries; Strawberries; Blackcurrants; Other soft fruit; Orchards 'Major crops' are those with a total growing area > 10,000 ha in 2015. Seed and ware potatoes have been combined. Winter and spring oilseed rape have been combined. Winter and spring barley have not been combined as they are largely used for different purposes. Vegetables for human consumption includes: Peas and beans for canning and freezing; Leeks; Cabbages and savoys; Brussels sprouts; Cauliflower; Calabrese; Turnips and swedes; Carrots; Lettuce; Rhubarb; Mixed and other vegetables. Other includes: Linseed; Peas and Beans for combining; Aromatic and culinary plants; Soft fruit; Orchards; Hardy nursery stock; Bulbs/flowers