Indicators and trends

Monitoring climate change adaptation

climate change
Scotland's centre of expertise connecting climate change research and policy

Indicator name				Version
NA2 Area of Prime Agricultural Land (Land Capability)				17/03/16
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, changes in soil condition, human food supply)

At a glance
• Land Capability for Agriculture provides a framework to examine how different sectors of Scottish agriculture might adapt to climate change- agricultural opportunities may increase or decrease depending on various factors. • Increasing temperatures has improved land capability and increased the area of prime land but this has been complicated by changes in soil moisture deficits which have been more variable. • Projected warmer, drier summers are likely to result in a significant expansion of prime land in lowland agricultural areas.

Latest Figure	Trend
Reference period 1991-2010[1]: 10,992km^2 of Scotland defined as prime agricultural land	Long-term trend towards increase in area but with important shorter-term variability and geographic differences. Medium confidence: there is good evidence to support the headline figures but further work is required to evaluate how this is modified by soil-climate interactions.

[1] 1:250,000 scale analysis. Use of 1:50,000 or 1:25,000 data would provide a different (lower) figure but these data are not available for all of Scotland.

Why is this indicator important?

Land Capability identifies the flexibility of the land for different land uses and functions. Based upon the established Land Capability for Agriculture (LCA) system (Table 1 in methodology section), the best quality land for agriculture is defined as prime land (classes 1, 2, 3.1). It provides a good measure of the availability of high quality land for agricultural production, particularly arable land which may be linked to 'food security' issues.

LCA classification (Bibby et al., 2008) provides an objective and published method of determining the agricultural quality of the land resource of Scotland. It is based on the degree of limitation that climate, soil and topography impose on agricultural production and cropping flexibility. It is a seven class system with Classes 1, 2 and 3.1 being described as prime agricultural land by the Scottish Government. Prime land also receives a degree of protection from development within the Scottish planning system.

A key principle of LCA is the concept of flexibility of potential use; it does not determine actual use although there is a general good relationship between it and potential use. In this context, LCA provides a useful framework to examine how different sectors of Scottish agriculture might adapt to climate change; if the LCA of a specific location or region changes, then agricultural opportunities can increase or decrease dependent on the direction of change.

Climate, as expressed through accumulated temperature and potential soil moisture deficit[2], is a key variable and provides the overall context for the final classification; in a sense it can be viewed as the primary factor in the classification. Any change in climate will therefore impact on the LCA classification. Long-term averages (typically 20 years) are used for the general classification but they mask considerable inter-annual variability. Scotland has a growing food and drink industry and any change to agricultural capability, either positively or negatively, will impinge on this industry sector and ancillary activities such as supply chains.

Soil management is a key element of the land sector's impact on climate change. It has the potential to both mitigate against climate change by maximising carbon storage, but also to release more carbon to the atmosphere, if management is inappropriate. Any expansion of arable cropping for example will increase the area under annual tillage which can increase carbon loss. Such a change may have a knock-on effect on the livestock sector.

Related indicators:
NA1 Comparison of land capability against actual land use
NA28 Wetness risk for agriculture (arable suitability and grassland suitability)
NA29 Drought risk to agricultural land

What is happening now?

The total amount of prime land has stabilised in the most recent reference period (1991-2010), although this masks small increases in east Scotland (notably north east Scotland) and small losses in south west Scotland (Figure 1).

[2] Soil moisture deficit is the amount of rain needed to bring the soil moisture content back to field capacity. Field capacity is the amount of water the soil can hold against gravity.

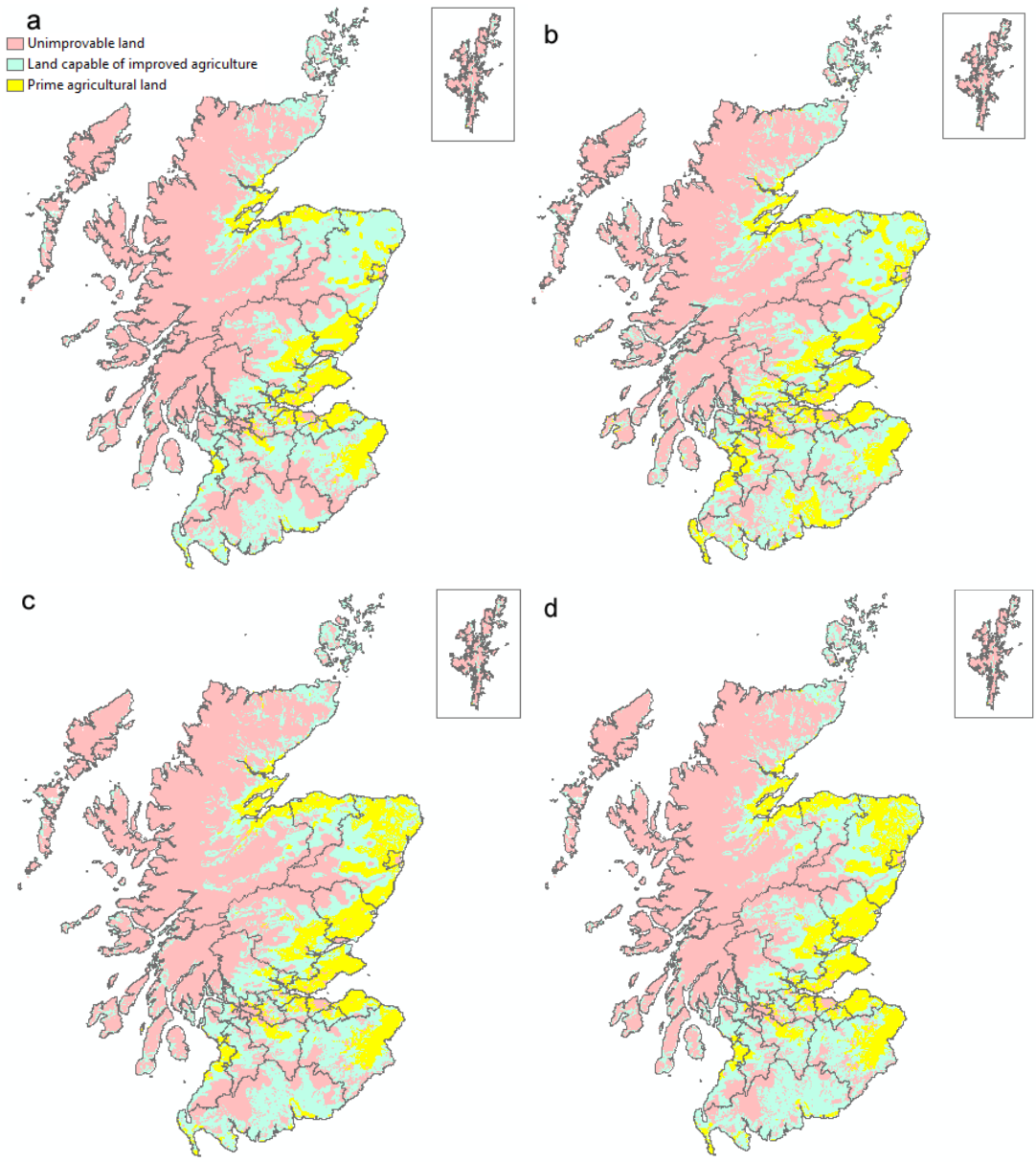

Figure 1 LCA summary for prime land and improved land (a) 1961-1980 (b) 1971-1990 (c) 1981-2000 (d) 1991-2010 [1:250,000 scale] (Brown & Castellazzi, 2014)

What has happened in the past?

Analysis of past change has been made using reference periods back to 1961-1980. Over this time period, the percentage of land in Scotland defined as prime land has increased by ca. 4% (this is ca. 18% expansion in prime land area excluding wetness risk) but most of this expansion occurred during the period 1971-1990 and there have only been smaller changes since then (although with distinctive geographic variations).

What is projected to happen in the future?

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% (Figure 2). 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.

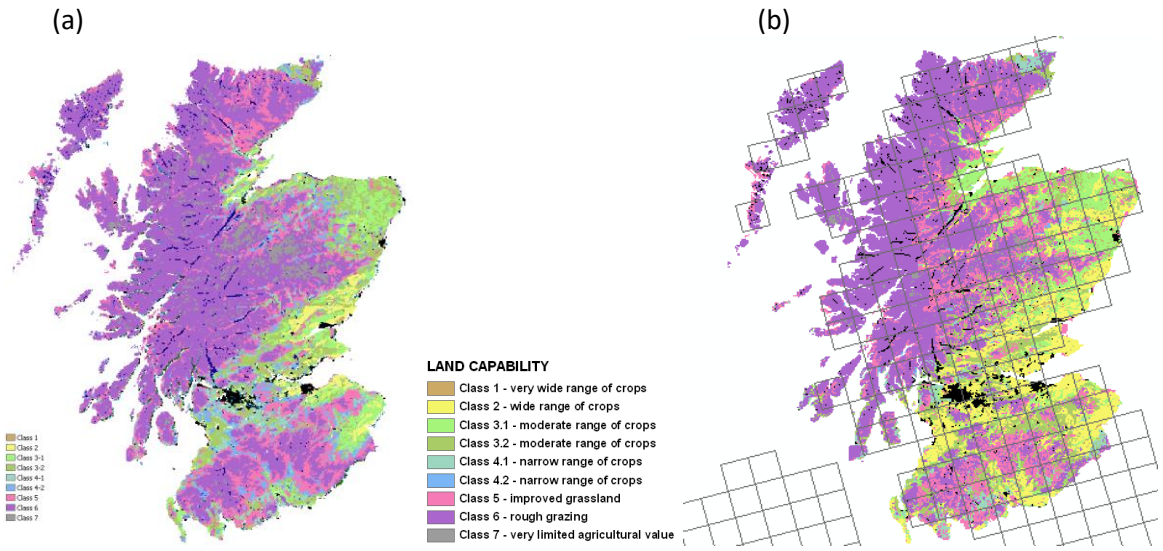

Figure 2 Changes in LCA (a) official 1:250,000 published version (1982) (b) 2050s (UKCP09 SCP ensemble mean) (Brown et al., 2011)

Patterns of change

In general, the expansion in prime land is predominantly in east Scotland, covering areas adjacent to existing core areas for prime land. South west Scotland exhibits a more variable trend with gains and losses over recent decades, although most future projections suggest that the pattern will be a dominant gain by the 2050s. By contrast north west Scotland remains fundamentally limited from reaching prime status by intrinsic soil and topographic constraints (Brown et al., 2011).

Interpretation of indicator trends

Land capability is influenced both by temperature increases and soil moisture deficits (i.e. drier conditions) which in Scotland are both associated in general with improved agricultural productivity and flexibility of land use. Temperature increases act to extend the growing season whilst drier soils reduce wetness risks (NB. if soils become too dry then they are classified to be higher drought risk but this is assessed separately as it is crop-specific).

The increase in temperatures over recent decades has improved land capability and the area of prime land but this has been complicated by changes in soil moisture deficits (linked to summer precipitation) which have been more variable (spatially and temporally).

In the future, the likely trend towards warmer drier summers (on average) shown by most climate projections means that a large expansion of prime agricultural land is anticipated. However this may be modified by an increased drought risk (see 'NA29 Drought risk to agricultural land' indicator).

Limitations

In addition to decadal variability, inter-annual variability is also a major influence on land capability and there is some evidence that some areas have experienced increased variability in yearly conditions, notably in SW Scotland (see Brown et al., 2014). This is currently not included in the indicator.

The metrics should be considered in combination with other aspects of land capability, notably drought risk and wetness risk, which may cause a downgrading of prime land status, also depending on adaptation assumptions made for irrigation and drainage respectively.

Other indicators, such as the area of land that may be potentially improved for agriculture, are also available. They show similar overall trends but with different spatial variations that can be important for land use options in some regions.

The following issues should also be noted:

1. LCA is a classification or model. As such, the mapped output does not exist on the ground as say a wheat field, soil type or a house does.
2. The suite of maps presented here is the result of modelling in a GIS environment; the area figure of extent has been derived from maps based on assessment in the field albeit using the same set of guidelines. These are different methodologies; GIS modelling is more systematic and objective but does not capture the nuances that field work can capture.
3. The projections into the future do not capture important soil-climate interactions. The predicted future extent of prime land in the 2050s presented here is likely to represent the maximum possible extent.
4. Like all maps displaying features of the environment, care must be taken in their interpretation and consideration given to the resolution of specific maps. Obvious features on the ground often simply cannot be represented on maps of any scale. LCA maps are indicative and rely heavily on the underpinning soil information and its interpretation.
5. LCA has a number of underpinning assumptions covering aspects of land management, investment, farm structure and social aspects such as farmer's age and distance to market.
6. Parcels of land identified as single LCA class are highly likely to contain land of lower or higher quality; indeed this aspect is built directly into the classification guidelines. The higher the quality of land, the less likely it is to include land of poorer quality
7. An LCA assessment is based on climate averages over decades; it does not capture year to year variation which can be quite extreme. This variation becomes greater in the lower land classes. As such, prime land is more 'stable' year by year but the climate in Class 2 and 3.1 land can be more representative of lower classes in a number of years.

Notwithstanding these caveats, LCA does provide a robust and straightforward way of assessing the inherent quality of land for agriculture and how agriculture might adapt in a changing climate. The data presented here is best applied at the national and regional levels and has been in a number of previous applications. The system was published in 1982 and the mapped output shortly afterwards; both are viewed with some degree of respect by a whole suite of relevant stakeholders who are aware of the strengths of the system, but also some of its constraints. Used appropriately, LCA is a good indicator and consideration should be given to extending its use beyond that of prime land, for example Classes 3.2-5.1 are the backbone of the Scottish livestock industry and there are climate change implications for those classes too.

References

Bibby, J.S., Douglas, H.A., Thomasson, A.J. & Robertson, J.S. (1982) *Land capability classification for agriculture*. Macaulay Land Use Research Institute, Aberdeen

Brown, I., Towers, W., Rivington, M. & Black, H. (2008) Influence of climate change on agricultural land-use potential: adapting and updating the land capability system for Scotland. *Climate Research,* 37, 43-57.

Brown, I., Poggio, L., Gimona, A. & Castellazzi, M. (2011) Climate change, drought risk and land capability for agriculture: implications for land use in Scotland. *Regional Environmental Change,* 11, 503-518

Brown, I. & Castellazzi, M. (2014) Changes in climate variability with reference to land quality and agriculture in Scotland. *International Journal of Biometeorology.* DOI: 10.1007/s00484-014-0882-9

Further information

Land Capability for Agriculture:

- http://www.macaulay.ac.uk/explorescotland/lca.html
- http://www.soils-scotland.gov.uk/data/lca250k
- http://www.hutton.ac.uk/research/themes/delivering-sustainable-production-systems/soils/land-capability

Farming and climate change:

- http://www.sruc.ac.uk/info/120175/farming_for_a_better_climate

Acknowledgements

Development of this indicator and primary authors of this document: Iain Brown & Willie Towers, James Hutton Institute.
This research has been funded by Scottish Government through their strategic research programmes: Environment: Land Use and Rural Stewardship (2006-11) and Environmental Change (2011-16).

Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	NA2 Area of Prime Agricultural Land (Land Capability)
Indicator contact: Organisation or individual/s responsible for the indicator	Anna Moss (CXC, University of Dundee)
Indicator data source	James Hutton Institute, unpublished
Data link: URL for retrieving the indicator primary indicator data.	Not Available

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	1961-2011
Frequency of updates: Planned or potential updates	As required
Spatial coverage: Maximum area for which data is available	National
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	Scale issues – this is national scale data using 1:250,000 soil mapping
Spatial resolution: Scale/unit for which data is collected	1km
Categorical resolution: Potential for disaggregation of data into categories	Already categorised.
Data accessibility: Restrictions on usage, relevant terms & conditions	Information needs to be used with caution due to key assumptions made.

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.
Soils (James Hutton Institute)

Climate (Met Office observed climatology and UKCP02/09) Topography (OS Profile data)

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
As per the standard LCA guidelines (Bibby et al., 1982) but modified as defined by Brown et al. (2008) to link accumulated temperature and soil moisture bioclimatic metrics with soils and topographic data. **Table 1** LCA classes and associated land uses (Bibby et al., 1982)

Class	**Category**	**Climate limitations**	**Land use**
1	Prime	None or very minor	Very wide range of crops with consistently high yields
2	Prime	Minor	Wide range of crops, except those harvested in winter
3.1	Prime	Moderate	Moderate range of crops, with good yields for some (cereals and grass) and moderate yields for others (potatoes, field beans, other vegetables)
3.2	Non-prime	Moderate	Moderate range of crops, with average production, but potentially high yields of barley, oats and grass
4.1	Non-prime	Moderately severe	Narrow range of crops, especially grass due to high yields but harvesting may be difficult
4.2	Non-prime	Moderately severe	Narrow range of crops, especially grass due to high yields but harvesting difficulties may be severe
5	Non-prime	Severe	Improved grassland, with mechanical intervention possible to allow seeding, rotavation or ploughing
6	Non-prime	Very severe	Rough grazing pasture only
7	Non-prime	Extremely severe	Very limited agricultural value