Department for Environment, Food and Rural Affairs

SP1104: The Impact of climate change on the capability of soils for agriculture as defined by the Agricultural Land Classification - Policy brief

Introduction

Climate science predicts that as a result of climate change the UK will experience hotter drier summers and milder wetter winters, with more intensive rainfall events and more frequent extreme climatic events.

Soil processes are influenced directly by temperature, rainfall and changes in atmospheric carbon dioxide, particularly as these affect soil ecology and organic matter. This in turn affects soil structure, water regimes and plant growth.

Most of the predictions for future cropping patterns under climate change in England and Wales have focused on the climatic suitability of areas to support crops and not necessarily considered other constraints, e.g. soil capability. This project used a proxy for the suitability of soils to support agriculture, the Agricultural Land Classification (ALC), the UK Climate Projections (UKCP09) and soils and site information from the National Soil Inventory (NSI) to explore the impact of climate change on soils and agriculture in England and Wales.

The key finding is that under projected climate change there will be a significant decline in the suitability of land (based on the Agricultural Land Classification system) to support unirrigated agricultural crops across England and Wales.

Agricultural Land Classification

The Agricultural Land Classification (ALC) system provides a framework for classifying land in England and Wales according to limitations placed upon it either through physical or chemical constraints. The purpose of the classification is primarily for land use planning in order to steer urban development away from those areas of land that have the greatest agricultural potential.

The ALC is based on the long-term physical limitations for agricultural use using prevailing climate, site and soil characteristics. The main limiting physical factors are identified as:

- Climate
- soil wetness
- soil droughtiness
- gradient
- flooding
- soil texture
- soil depth
- soil stoniness
- soil chemical properties
- soil erosion

The grade for each of these criteria is determined for an individual location using the published methodology. The final ALC grade given to a location is then the lowest grade from any of the 10 criteria (i.e. the most limiting factor), with Grade 1 being excellent quality and Grade 5 being of very poor quality (Table 1). Grades 1-3a are defined as our Best and Most Versatile land in planning guidance.

Table 1: Generalised Description of the Agricultural Land Classification Grades

Grade	Description of agricultural land	Detail
1	Excellent quality	No or minor limitations on agricultural use. Wide range of agricultural and horticultural crops grown. High yielding and consistent.
2	Very good	Minor Limitations on crop yield, cultivations or harvesting. Wide range of crops but limitations on demanding crops (e.g. winter harvested veg). Yield high but lower than Grade 1.
3 (subdivided)	Good to moderate	Moderate limitations on crop choice, timing and type of cultivation, harvesting or level of yield. Yields lower and more variable than Grade 2.
3a	Good	Moderate to high yields of narrow range of arable crops (e.g. cereals), or moderate yields of grass, oilseed rape, potatoes, sugar beet and less demanding horticultural crops.
3b	Moderate	Moderate yields of cereals, grass and lower yields other crops. High yields of grass for grazing/ harvesting.
4	Poor	Severe limitations which restrict range and/or level of yields. Mostly grass and occasional arable (cereals and forage), but highly variable yields. Very droughty arable land included.
5	Very poor	Severe limitations which restrict use to permanent pasture or rough grazing except for pioneering forage crops.

UK Climate Projections

The UK Climate Projections (UKCP09) is the fifth generation of climate change information for the UK, and its projections are based on a methodology designed by the Met Office. UKCP09 reflected scientists' best understanding at the time of how the climate system operates and how it might change in future. UKCP09 should be seen as providing possible projections rather than absolute predictions or forecasts of future climate.

National Soil Inventory

The field work for the National Soil Inventory (NSI) was carried out between 1978 and 1983, as part of the National Soil Map Project, which produced the 1:250,000 scale soil map of England and Wales. The sampling was carried out on a 5 km grid with the aim of characterising the soils of England and Wales using a statistically valid set of data. Samples were taken of the topsoil (0-15cm), site features recorded and a full soil description made to 1.2 m depth.

Methodology

The project combined the UKCP09 projections with existing soil and site data from the NSI point dataset (on a 5km grid across England and Wales) to generate projections of possible future distributions of all ALC grades (using the published ALC methodology) for each NSI point (site).

The ALC grade was calculated for each of the 10 separate criteria at each site. The climate, soil wetness and drought criteria are all assessed using climate variables and were calculated for the baseline and 12 future emission scenarios (high, medium and low for 2020, 2030, 2050 and 2080); the remaining seven criteria were assessed for each of the NSI sites from the original observed data as surveyed in 1979-1983. The final ALC grade given to a site is then the lowest grade from any of the 10 criteria (i.e. the most limiting factor).

Project Team

The project was undertaken by a team of soil scientists, climate scientists and Geographical Information System (GIS) specialists at Cranfield University, the Met Office Rural Environment Team (MORET) (Met Office staff based at and working in partnership with ADAS) and ADAS (Table 2).

Table 2: Project team

Organisation	Project team members
Cranfield University	Dr Robert Jones (project lead), Caroline Keay
MORET	Dr Victoria Chapman, Ian Barrie, Steve Smith
ADAS	Chris Procter, Isabel Nias, Shaun Astbury

Quality Assurance

The findings of this project have been independently peer reviewed (Table 3) and the report has been revised to address comments received. None of the comments received questioned the conclusions, but suggested improvements in presentation and interpretation of the findings. They also suggested further avenues of research which were either beyond the scope of the current project and/or outside of the current ALC methodology, e.g. the impact of climate change on soil organic matter.

Table 3: Independent Peer Reviewers

Peer Reviewer	Organisation
Dr Iain Brown	James Hutton Institute
Ian Condliffe	Independent consultant
Professor Stephen Nortcliff	Reading University
Dr Willie Towers	James Hutton Institute

Key findings

Under projected climate change there will be a significant decline in the suitability of land (based on the Agricultural Land Classification system) to support unirrigated agricultural crops across England and Wales.

For most of the ALC criteria climate change will have a limited or beneficial impact (Table 4). The potential impact of the projected change in climate only becomes significant when the effect on droughtiness[1] is considered. As the overall ALC grade is the lowest grade from the assessed criteria, the result is a very large area of the country being downgraded to Grade 4 (poor).

The proportion of NSI sites in Grade 4 (considering all criteria) rises from 14% (in 1961-1990[2]) to 70% in 2080 under the high emissions scenario (42% low emissions, 57% medium emissions). The proportion of NSI sites considered Best and Most Versatile land falls from 38% to 4% over the same period for the same scenario (11% low emissions, 7% medium emissions)(Table 5).

Table 4: Impact of climate change on ALC criteria

ALC criteria	Impact of climate change	Change in grade (single criterion)
Annual Average Rainfall	Remains steady throughout the future scenarios	None
Accumulated Temperature above 0°C	Increases. The grading on climate is built on the premise that the warmer and drier the climate the better the grade.	Proportion of England and Wales potentially in Grade 1 increases from 58% in 1961-90 to over 90% in 2070-99 based only on this criterion
Soil wetness (based on the duration of field capacity and natural drainage status of the soil)	Largely unaffected over most of England and Wales mainly because, even though the start and end dates of field capacity are likely to change, the duration remained constant. However, there is an overall drying of the soils resulting in fewer sites being downgraded by being too wet	Proportion of England and Wales potentially in Grade 1 increases from 24% in 1961-90 to over 30% in 2070-99 based only on this criterion.

[1] This is where crop demand for water exceeds the capacity of the soil to satisfy this demand. Crop plants will experience moisture stress and cease to grow, resulting in reduced yields.

[2] The 30-year period 1961 to 1990 has been designated as the international standard reference period for climate averages by the World Meteorological Organization. This period was one of the coldest in the 87 year span and therefore has been chosen as the study baseline to emphasise the predicted changes in climate into the future.

ALC criteria	Impact of climate change	Change in grade (single criterion)
Droughtiness	Increases for the two representative crops used in the ALC assessment (winter wheat and main crop potatoes). All alternative aridity indices evaluated show the same trend.	Proportion of the country potentially in Grade 1 decreases from or 37% in 1961-90 to only 7% by 2070-99 (high emission scenario). Proportion of country potentially in Grade 4 increases from 2% to nearly 66% for the same time periods.

Table 5: Percentage of NSI sites (5829 locations across England and Wales) that are classified as Best and Most Versatile land (Grades 1 to 3a) and non-BMV (applying all 10 criteria) excluding urban and non-agricultural land

	1961-90	Scenario	2020	2030	2050	2080
BMV	38%	low	30%	26%	16%	11%
		medium	29%	24%	11%	7%
		high	29%	22%	9%	4%
Non BMV	62%	low	70%	74%	84%	89%
		medium	71%	76%	89%	93%
		high	71%	78%	91%	96%

Interpretation of maps

The maps presented are intended to show general trends and not specific details; the uncertainty of the input parameters and climate scenarios means that results should not be interpreted at a local scale. They are not projected national maps of ALC grade and should not be used for that purpose.

The modelling of the impacts of climate change has been carried out for 5829 points across England and Wales at 5-km grid intersections where good quality site specific data was collected as part of the original National Soil Inventory between 1978 and 1983. Due to the size of the maps presented in the report the impression is given that projected ALC grades for the whole of England and Wales have been determined. However, this is not the case.

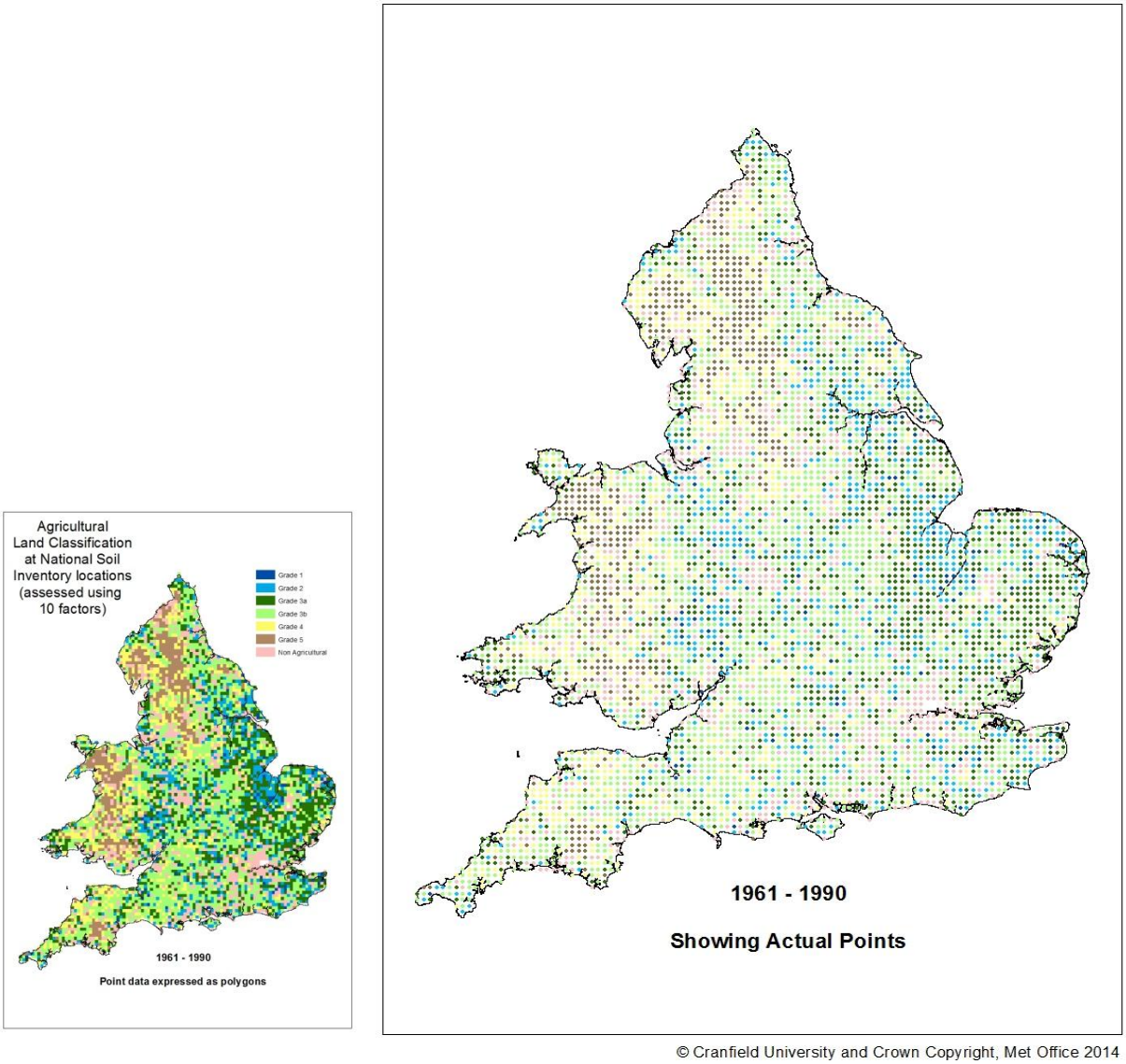
Figure 1 shows a map extracted from the project report (left) and the same map presented at a larger scale (right). The larger scale map clearly shows that it is based on point data only; though with large enough symbols to be visible and which occupy an area greater than the sampling location. However, it would not be possible to fit 13 of these maps on a single page to allow the visual comparisons possible in the project report.

Maps based on a single ALC criterion

These maps do not necessarily show the overall ALC grade projected to be found at the sampling locations, unless the criterion being explored is the most limiting factor at that location. The final ALC grade at any location is the lowest score allocated for any of the ten criteria, i.e. the most limiting factor.

Therefore, while climate change could improve the score for some of the criteria, if one of the other criteria has a lower score at that location, the site's ALC grade is not improved.

Figure 1: Agricultural Land Classification at National Soil Inventory locations (assessed using 10 factors. a) Point data expressed as polygons (left), b) Point data (right)



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Implications for agriculture under climate change

The findings show the potential significant impact of climate change on the capability of land to support unirrigated crops in England and Wales. Arable production in England and Wales may need to be adapted to changing conditions, with the introduction of crops currently found on mainland Europe or changing the management of existing crops. For example, three to four times more irrigation water than is currently applied would be required to maintain production on land currently growing main-crop potatoes in England and Wales. However, water supply for irrigation may become limited in these regions.

Although the ALC model focuses on two arable crops when assessing drought risk (i.e. winter wheat and main-crop potatoes), it should be noted that grassland will also be affected as it has characteristics which make it prone to drought over a large range of conditions, such as shallow rooting. Subsequent low grass yields will affect grazing, increasing the need for supplementary feeding or reduced stocking rates.

There is great potential for adaptation within the agricultural sector. If the aridity zones shift northwards (as predicted by the aridity indices), there may be a geographical shift in the crops grown, including the introduction of crops not currently grown in the UK (and which are not currently represented in the ALC methodology).

Future UK climate projections (periods 2050 and 2080) show that areas of the UK are likely to experience similar climatic conditions to those in present-day Mainland Europe. For example by the 2050 period grain maize, which is currently widely grown in western France, could become an important crop in the UK. By the 2080 period areas of the UK, which currently grow wheat and potatoes, may experience a Mediterranean climate and be able to grow crops such as maize, olives and vines.

Implications for land use planning

ALC Grades 1-3a are defined as our Best and Most Versatile land in planning guidance, and are afforded a greater degree of protection in planning decisions. The findings of this project do not undermine the current use of the ALC system within land use planning. There is a large amount of uncertainty around the input data and climate scenarios used and the results should not be interpreted at a local scale. They do suggest that the greatest impact on the proportion of BMV land in England and Wales will take place after 2030.

Implications for the Agricultural Land Classification system

The purpose of the ALC is to determine the land with the greatest agricultural potential (with least constraints). Under a changed climate agriculture in England and Wales is expected to adapt by growing crops more suited to the new climate. Therefore, in the future, if the ALC is to maintain its purpose of differentiating between land of different agricultural qualities in England and Wales a different set of crop models or revised calibration may need to be considered. In the meantime, there is no indication that the ALC is not fit for purpose under current climatic conditions and cropping systems.

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