Feedback Form

School of Geography
FACULTY OF ENVIRONMENT

UNIVERSITY OF LEEDS

Students to complete all of the following (or work will not be accepted)

Name (optional):

Richard Thomas

Student ID:	Assessment Name (e.g. Essay 2, Group Project etc):
200818341	Assignment 2: Land Capability Mapping
Degree Programme & Level (e.g. BA1 Geog):	Assessment Marker:
MSc Geographical Information Systems (GIS)	Helen Durham
Module Title & Code:	Word Count: (1500 words max)
GEOG5510M Using of GIS	1452

Content, research and reading

Structure and argument

Writing, presentation and referencing

Areas for improvement to prioritise

Marker's signature:	Date:	Provisional mark:

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Land Capability Mapping

INTRODUCTION

This report describes the methodology and results of performing agricultural land analysis for an area of Scotland using 2 different methods: British Land Capability for Agriculture (LCA) Classification and Multi-Criteria Evaluation (MCE). Figure 1 illustrates the location and boundaries of the area studied. The report initially outlines ArcGIS implementation details for LCA and MCE factor maps, followed by a discussion of selection of MCE factors/weights. The results section is then followed by a comparison of the 2 methods.

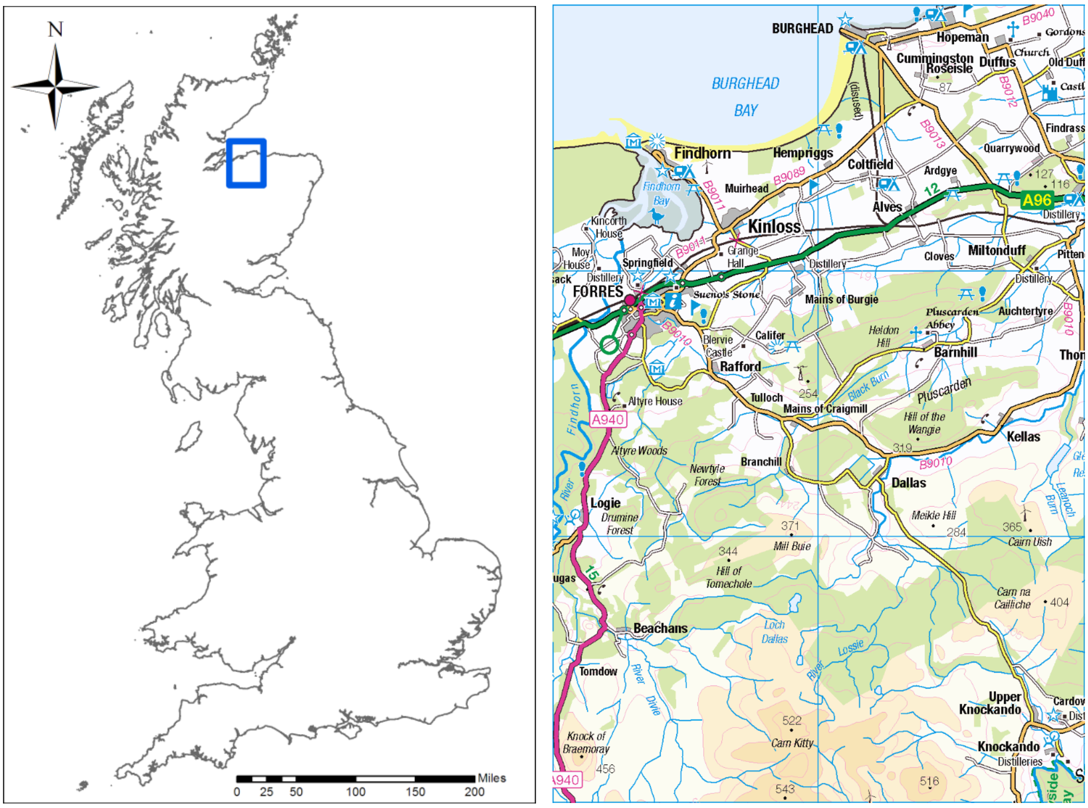


Figure 1: Location of area of analysis (Copyright Ordnance Survey 2014)

METHODOLOGY: LCA FACTOR MAP GENERATION

The methods followed (for both LCA and MCE) map generation were based on instructions provided, so only additional aspects or clarifications will be discussed here. One problem encountered was that the ‘Panorama DTM’ ASC data read directly into ArcGIS was offset from the ‘soil’ raster data by half a pixel (25m) in both X and Y coordinates. This was remedied by instead downloading the NTF files and processing them with MapManager 6.2a.

An analysis mask raster layer was created from the ‘soils’ raster, setting all non-soil pixel locations (sea, lochs, built up areas) to NoData values. When this mask layer was set up in the ‘Environment ->raster analysis’ defaults section, it ensured that the results of most raster operations would also be NoData for those locations. Two other soil types I considered might indicate land unusable for agriculture due to excess water: Saline alluvial soils ("Subject to period marine inundation") and Noncalcareous gleys ("intermittent to permanent waterlogging"). However, it seemed better to leave those to be handled by the LCA ‘Wetness’ (w) subclass.

In the LCA method, the final output map is determined by selecting at each pixel location the worst value (highest number) from all the contributing factor maps. This was achieved using the ‘Cell Statistics’ MAXIMUM’ function, with “Ignore NoData” unticked to ensure that any NoData cells (water and built up areas) would propagate to the output. Figure 9 (in the results section) is the final LCA output map, with each of the factor maps shown in Appendix 1.

METHODOLOGY: MCE FACTOR MAP GENERATION

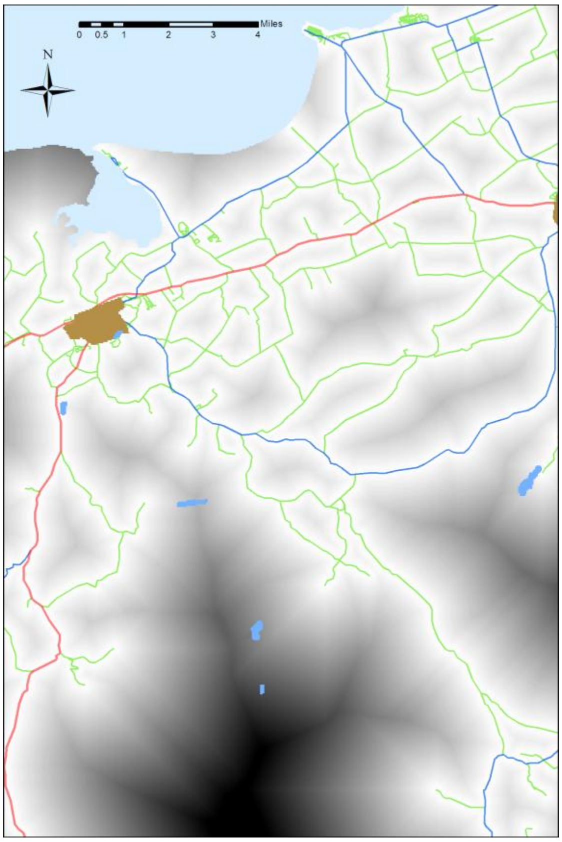


Figure 2: MCE ‘Road Proximity’ factor map

Close proximity to any type of road is important for transport of crops or people by non-off-road vehicles. Although a simple ‘Euclidean Distance’ tool would appear sufficient, this would give misleading results for locations on the other side of water (such as the remote headland on the west side of Findhorn Bay). This was overcome by using the ‘Cost Distance’ tool, with a cost raster that was set to a large value at water locations and to 1 everywhere else – thus making the tool avoid using water-crossing routes.

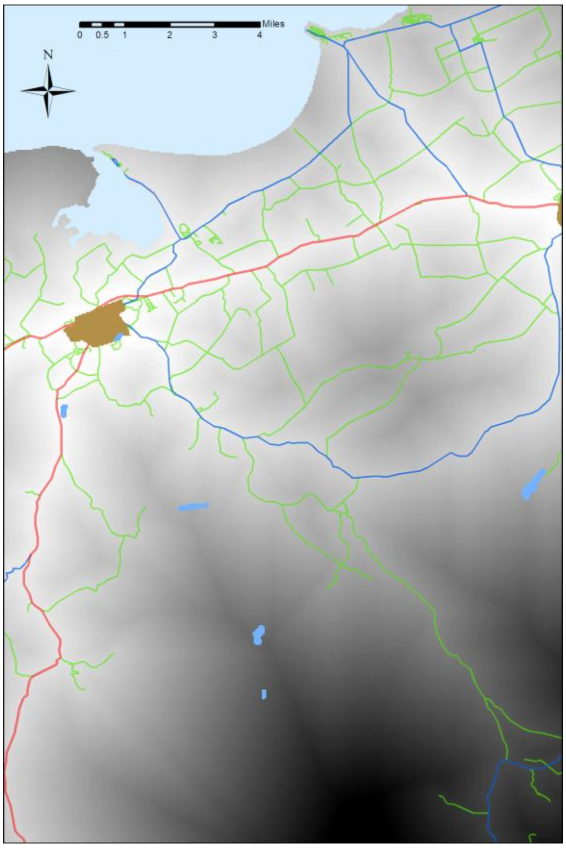


Figure 3: MCE ‘Urban Access’ factor map

The ‘Urban Access’ factor map (figure 3) represents the ease of access by the nearest road to one of the marked ‘built up areas’. For a small-scale farmer this could be an important requirement for selling produce locally.

It was implemented using the ‘Cost Distance’ tool, using a cost raster created to represent the speed and large vehicle-handling capacity of different roads with the following raster values used: A-Road=1, B-Road=2, Minor Road=4, Water=1000, Other=8. The ‘other’ cost represents off-road routing to the nearest road. Although ideally I wouldn’t include this cost (as it is already covered by ‘Road Proximity’), this value could not be too small or the ‘Cost Distance’ tool might take short cuts between roads. Although this map looks similar to the ‘Road Proximity’ map, less weighting is visible given to places further from urban areas and/or reached by more minor roads.

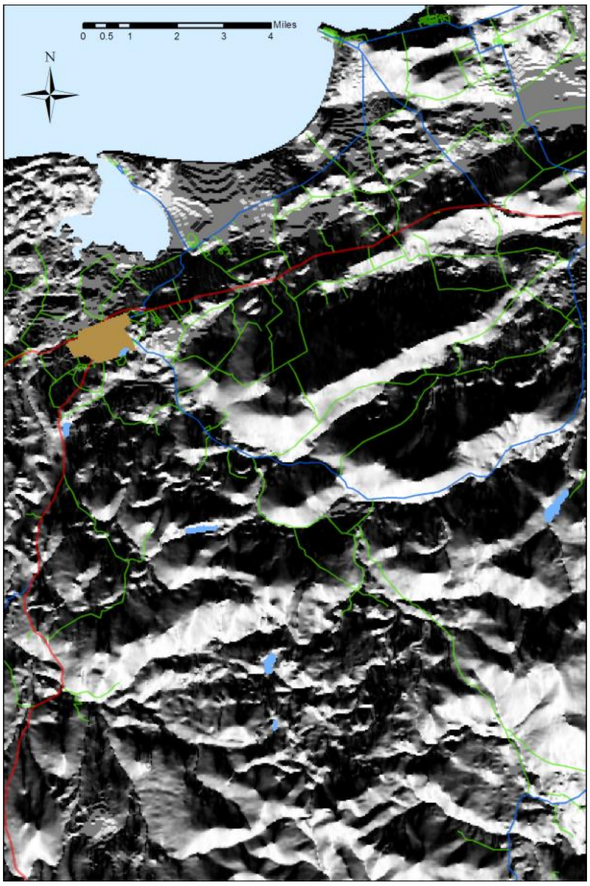
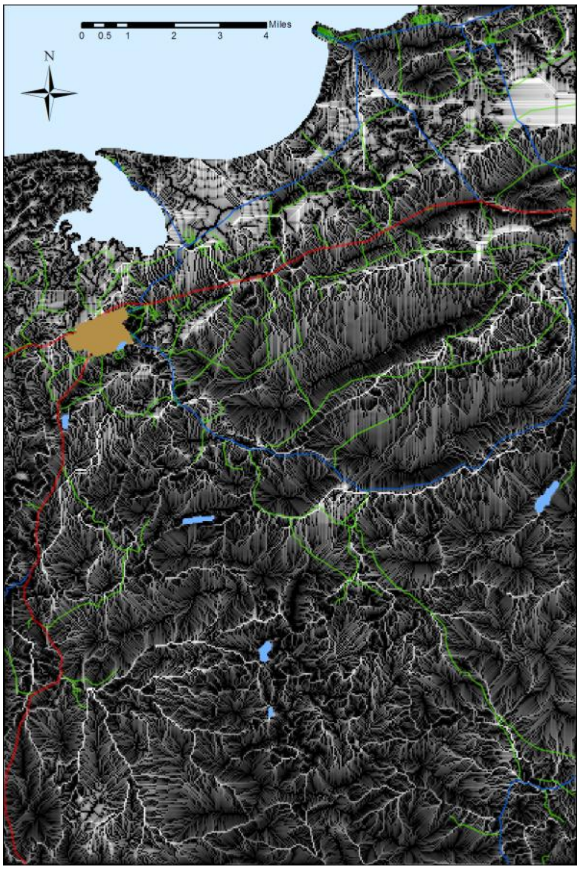


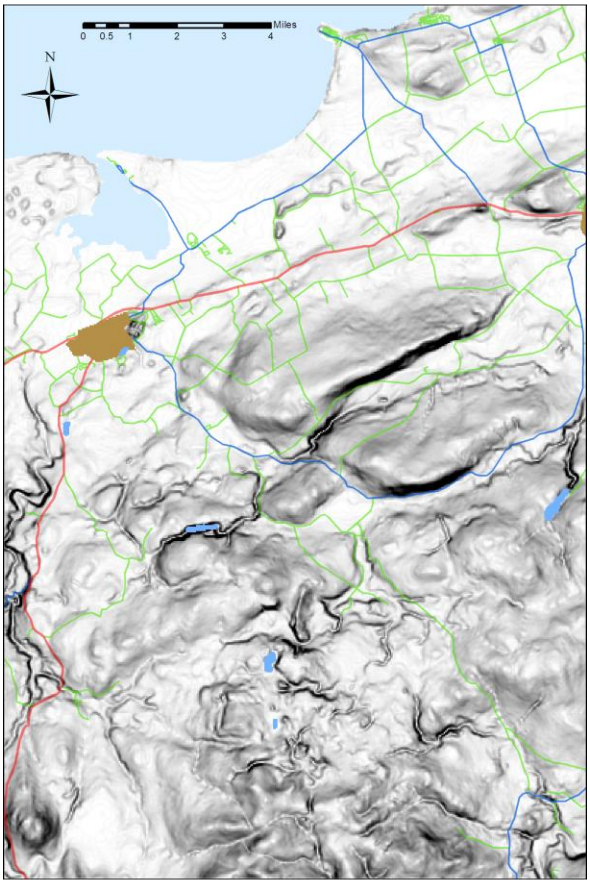
Figure 4: MCE 'South Facing' factor map

As with the other MCE factor maps, the values have been re-ranged to 0..1, with more desirable features being closer to 1.



For the ‘Flow Accumulation’ tool used as part of the Topographic Wetness Index (TWI) calculation, it was essential to exclude the water features (set them to NoData) to prevent the tool treating them as large accumulators of precipitation. Where slope is 0, the factor ‘1/tan(beta)’ would be infinity which gets automatically replaced with NoData. On such occurrences, this was replaced with a value closest to the largest other value before continuing the calculation as such occurrences could be large accumulators of water. In the ArcGIS manual, it recommends that for more accurate flow analysis, DEMs should be pre-processed to make them “depression-less” (i.e. not have zero slope locations), but the proposed method is a quite complicated and iterative.

Figure 5: MCE 'Wetness' factor map



DEM Gradients measured using the ‘Slope’ tool were re-ranged to cover the entire 0..1 range of the gradient map, 0 representing the steepest incline.

Figure 6: MCE 'Gradient' factor map

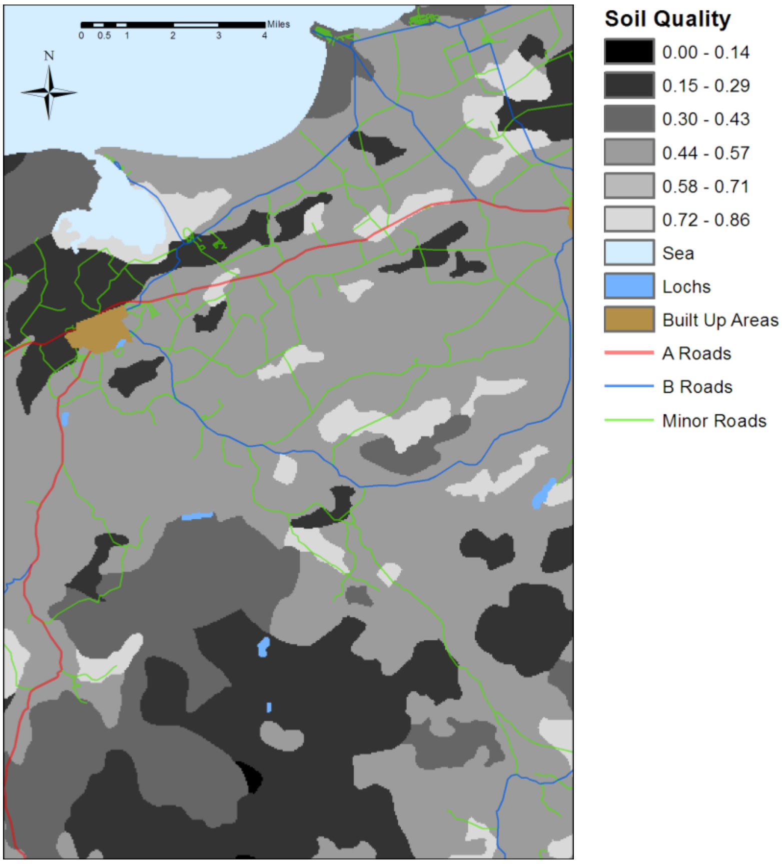


Figure 7: MCE 'Soil Quality' factor map

The 6 different 'Soil Limitations' LCA factor map values for this area were reversed and re-ranged to 0..1, allowing for the 7 possible values in this 'Soil Quality' map. (Hence the range does not go above 0.86).

CHOOSING MCE FACTORS & WEIGHTS

Because of the difficulty in choosing appropriate weights for each factor being combined by the MCE summation, an attempt is made to limit the number of factors to those that seem most relevant and of reliable quality, avoiding correlated inputs where possible:

- **Wetness (No):** although TWI is a widely used indicator of hydrological processes, different methods of calculating the flow accumulation are appropriate to different locations, but are difficult to choose from and widely affect it (Quinn et al, 1995; Sörensen et al, 2008). Additionally, TWI on its own does not directly correlate with land capability: in Scotland soil moisture deficits are only a minor issue (Brown et al, 2008, p53), though conversely waterlogging can be an issue.
- **South-facing (Yes):** plants will only grow when mean daily temperatures are above a certain threshold (5.6C typically quoted) and there need to be enough days of the season above this level to make a crop viable (Brown et al, 2008, p45). Given Scotland's climate, the extra warmth from south-facing slopes could thus be critical.
- **Climate (No):** Although very important, the key climate indicators are accumulated temperature and evapotranspiration estimates (Brown et al, 2008, p45). As we only have altitude as a measure, this is not a very reliable one.
- **Road Proximity (Yes):** given the rugged landscape, transport for agriculture located far from roads may be difficult and expensive to maintain.
- **Urban Access (No):** although small-scale farming may limit its market to local towns, certainly larger commercial operations would need goods transport elsewhere. Also, there will be correlation between this and Road Proximity.

- **Gradient (Yes):** much of the area is rated “strongly sloping” or steeper in the LCA analysis, so gradient is an important consideration in this area. Gradient can seriously restrict mechanization and steep slopes are more prone to erosion (Tenerelli & Carver, 2012, p726).
- **Soil Quality (Yes):** a critical factor, the ‘soil limitation (s)’ LCA sub-class is always the limiting soil factor for the soil groups in this area. It is slightly restricting that unlike the other MCE factors, this one is not continuous (7 levels).
- **Erosion Liability (No):** there will be some correlation between this and the ‘Soil Quality’ and ‘Gradient’ factors, both of which are seen as more important.

In a case study in South Africa, Van der Merwe (1997) selected different weights for different land use purposes. The weights and factors chosen were based on relative proportions of relevant factors in that study when considering the use cases of “small-scale farming” and “commercial agriculture”:

Table 1: MCE factors and weights selected

Multi-Criteria Evaluation (MCE) Factor Map	MCE Weighting
Soil Quality	0.4
Gradient	0.3
South-facing	0.15
Road Proximity	0.15

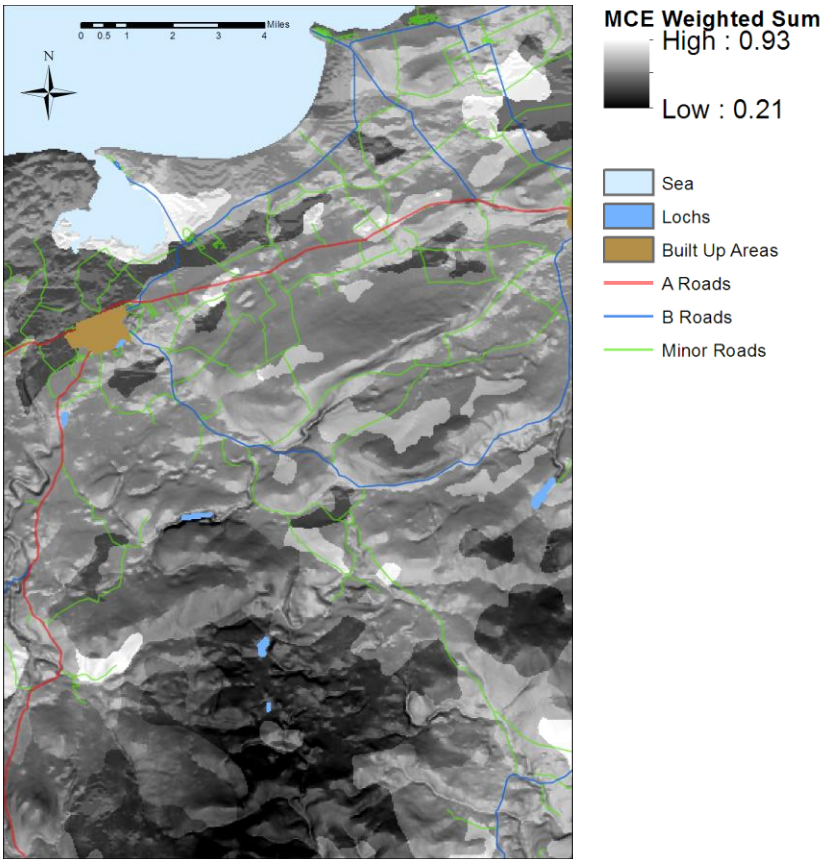


Figure 8 shows the MCE output as a continuous measure, in the style of the other MCE maps.

Figure 8: MCE weighted sum final output

LAND CAPABILITY RESULTS SUMMARY

The MCE map is re-coloured, re-ranged and quantized to 7 levels for direct comparison with the LCA output:

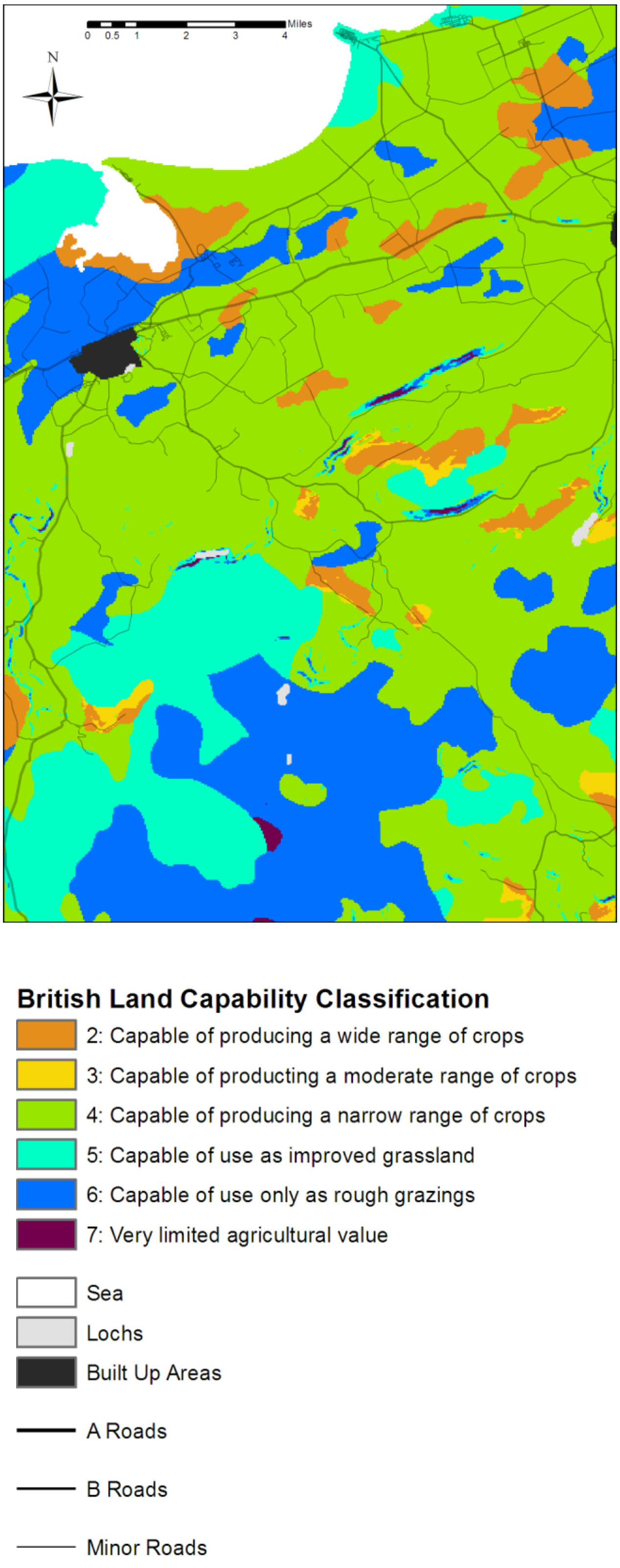


Figure 9: British Land Capability Classification of the area

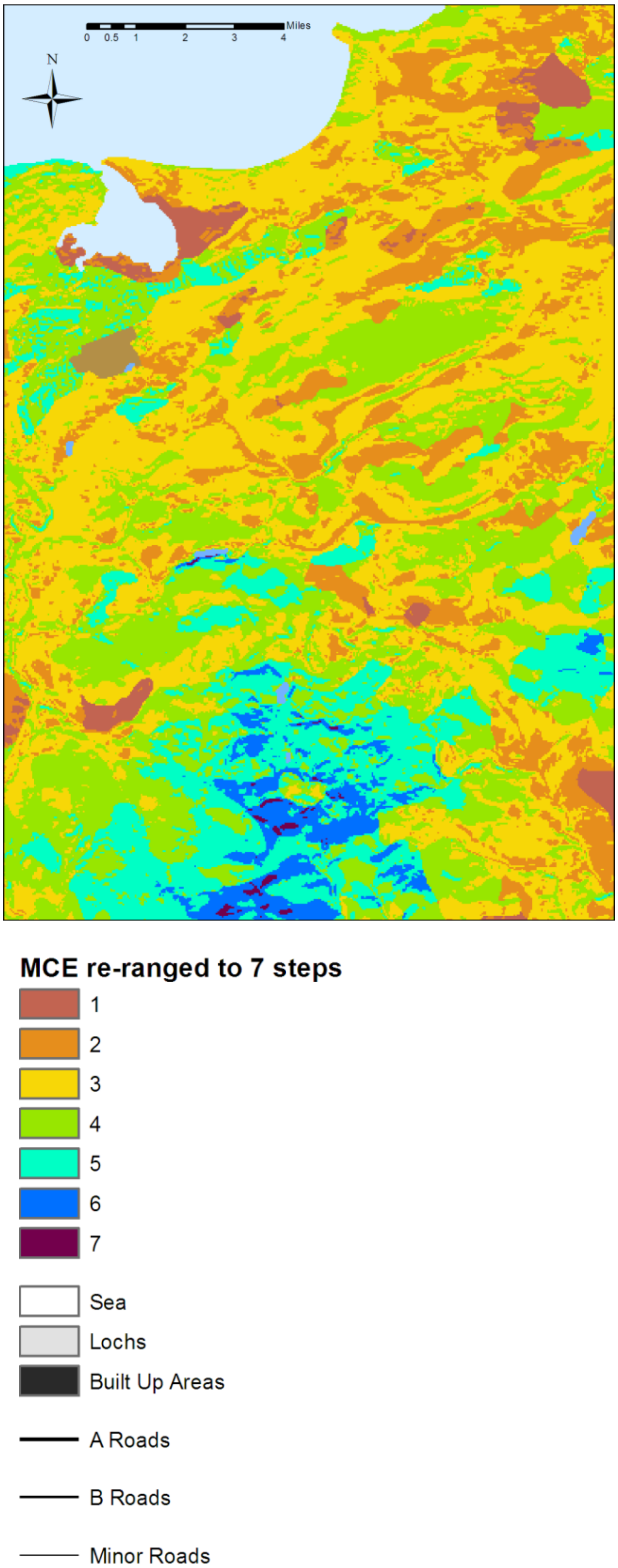


Figure 10: Multi-Criteria Evaluation Weighted Sum

COMPARISON OF METHODS

The key difference is that LCA is fixed, all based on judgements to set levels, whereas MCE looks to take continuous measurable quantities for the factors – it is the weighting that requires decision making.

Brown et al (2008, p43) as designers of an LCA system highlight its strengths as: "intrinsically uncomplicated, … presented in a straightforward and non-technical manner, … has gained wide acceptance and adoption across a range of users" However, they are aware of the very manual nature of generating component factor maps and are increasingly automating aspects with GIS, with results presented online (Macaulay Land Use Research Institute, 2014).

Tenerelli & Carver (2012, p726) demonstrate that for a more in depth study of suitability for specific crops, analysis beyond standard LCA is required for which an MCE is ideally suited. Mendoza (2000) discusses how for land capability MCEs, techniques like Analytical Hierarchical Process (AHP) can be used to simplify and structure choosing of MCE weights.

Table 2: Comparison of various general features between methods

Land Capability for Agriculture (LCA)	Multi-Criteria Evaluation (MCE)
- Specific to agriculture	+ General purpose technique
+ Simple, easy to understand	- Complicated to select factors & weights
+ Standardized: easy to compare	- No standard factors / weights available
- Pessimistic combination method (worst subclass value)	+ Flexible combination method
- Fixed: inflexible in unusual cases	+ Bespoke: can tailor to case and do “what if” experiments
- Unsubtle discrete steps (usually 7) for each factor	+ Continuous measurements, so greater subtlety

CONCLUSIONS

Although there were some similarities in the LCA and MCE final maps, they primarily demonstrate the different factors selected and the more pessimistic output (worst of inputs) of the LCA. Both methods seem well suited to GIS, with a degree of map interchange between them possible.

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Brown, I.Towers, W.Rivington, M. and Black, H.I. 2008. Influence of climate change on agricultural land-use potential: adapting and updating the land capability system for Scotland. *Climate research (Open Access for articles 4 years old and older).* **37**(1), p43.

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Tenerelli, P. and Carver, S. 2012. Multi-criteria, multi-objective and uncertainty analysis for agro-energy spatial modelling. *Applied Geography.* **32**(2), pp.724-736.

Van der Merwe, J. 1997. Gis-aided land evaluation and decision-making for regulating urban expansion: A South African case study. *GeoJournal.* **43**(2), pp.135-151.

Appendix 1: British Land Capability Classification Factor Maps

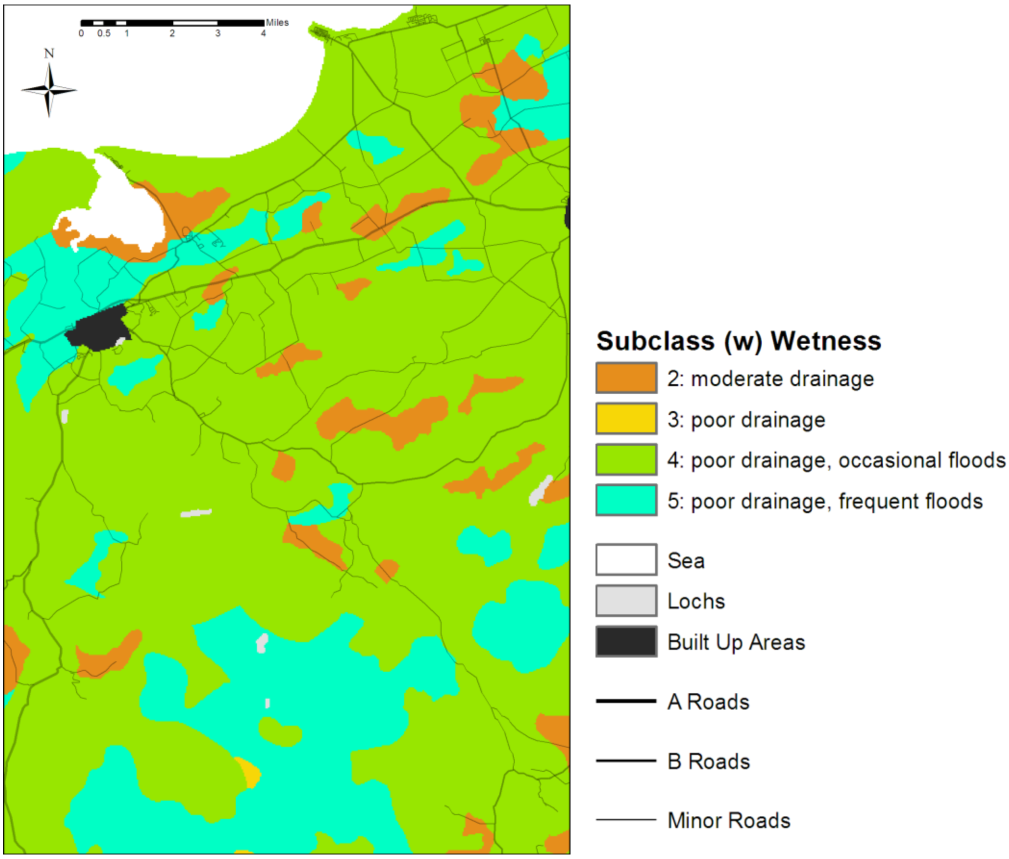

Figure 11: British Land Capability 'Wetness' Classification of the area

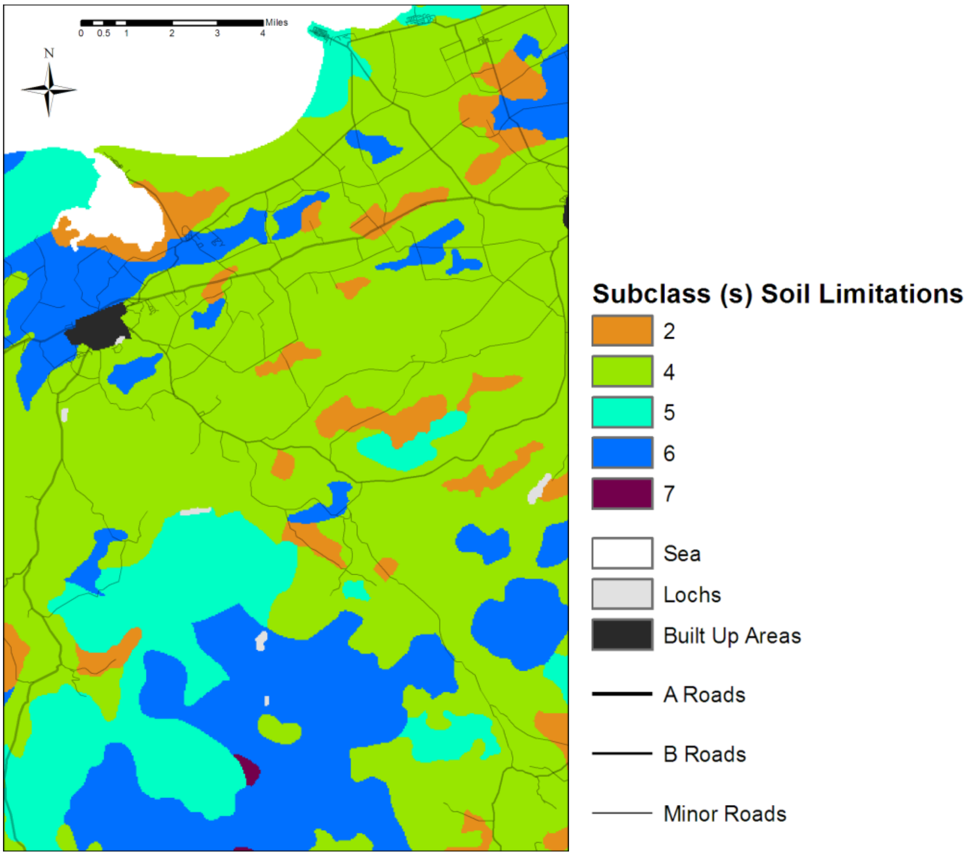

Figure 12: British Land Capability ‘Soil Limitations’ Classification of the area

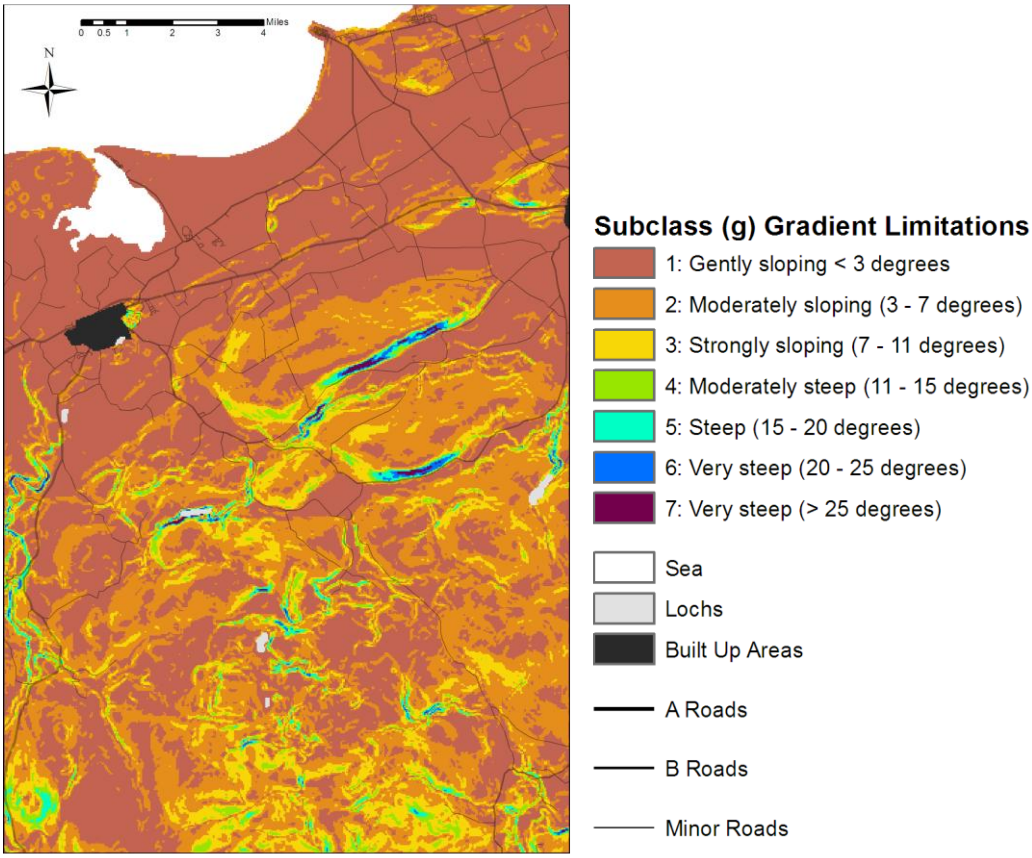

Figure 13: British Land Capability ‘Gradient’ Classification of the area

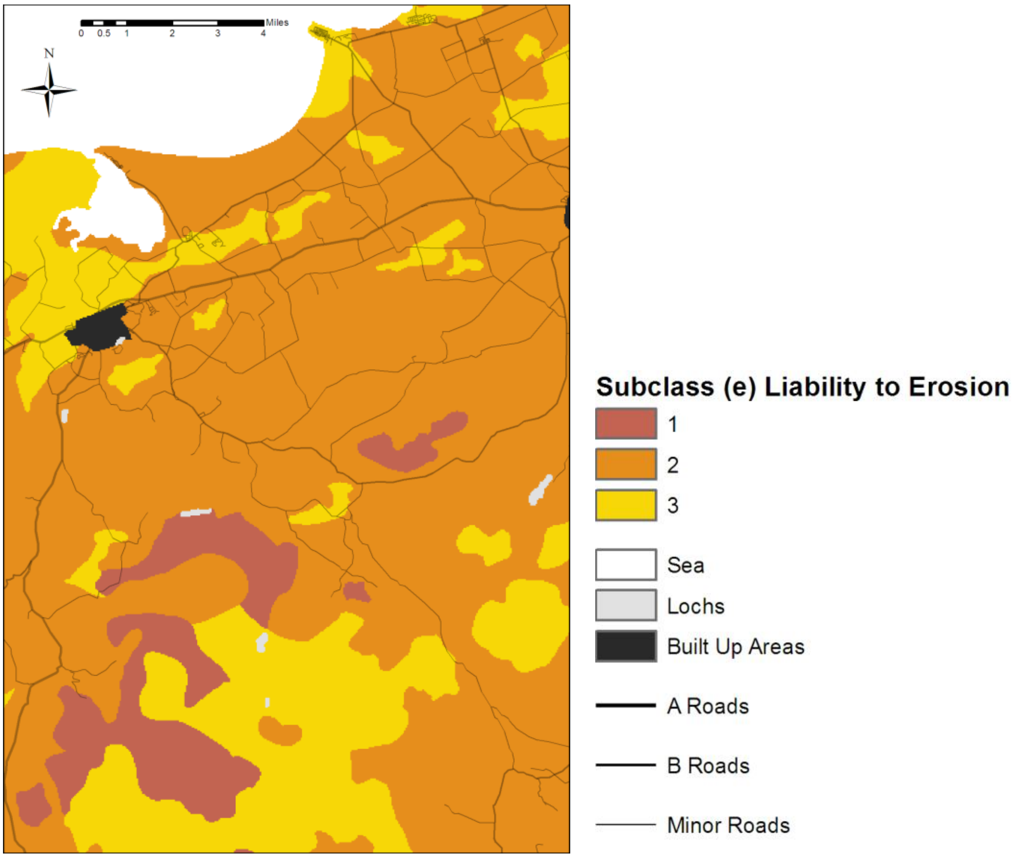

Figure 14: British Land Capability 'Erosion' Classification of the area

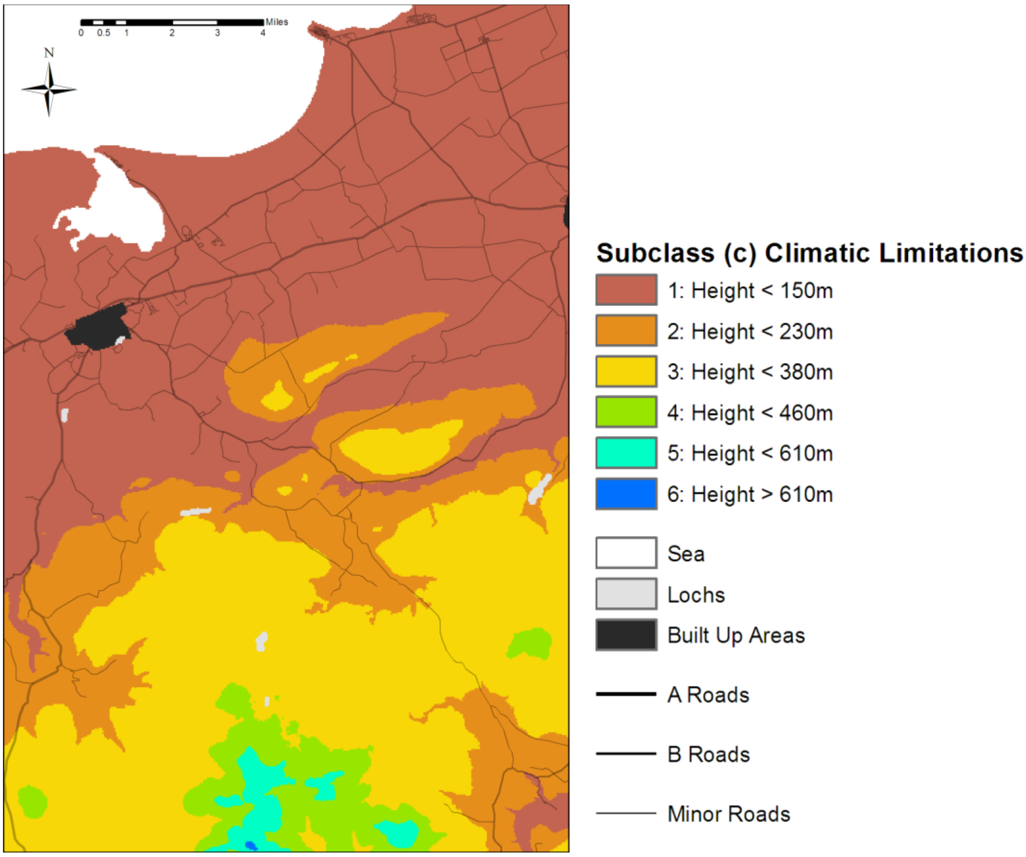

Figure 15: British Land Capability 'Climatic Limitations' Classification of the area