Advanced GIS

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Session 6

GIS Multi-Criteria Decision Analysis

&

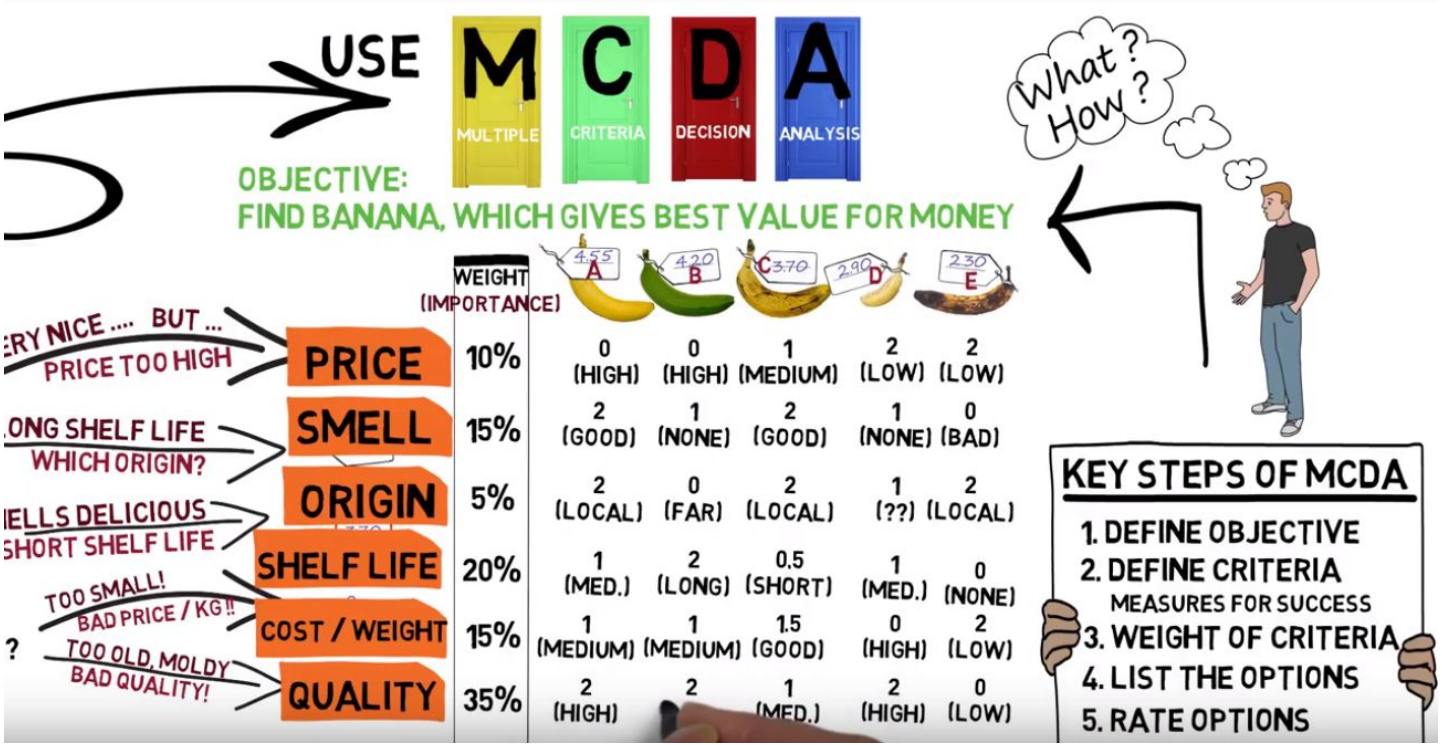
Course wrap-up

Today’s plan

1. Multi criteria decision analysis tutorial
2. Course Q&A
3. Final coursework questions + marking criteria

Multi Criteria Decision Analysis
&
Weighted Overlays

Multi-Criteria Decision Making (MCDM)



GIS Multi-Criteria Decision Making

- Multi-Criteria Decision Making (MCDM), also known as Overlay Analysis, Multi-Criteria Decision Analysis (MCDA) or Multi-Criteria Analysis (MCA), is a framework for taking multiple variables into account when making a decision. It can be applied to spatial decisions using GIS-MCDM methodologies.

- The basic logic is that "*Many decisions depend on identifying relevant factors and adding their appropriately weighted values.*" (Longley, Goodchild et al, 2015). Obviously, different stakeholders will have different perspectives on which factors to take into account and their importance. In policy-making, public consultations can help determine the perspective of each stakeholder, and come up with a set of weights that is acceptable to all parties.

- GIS-MCDM method is especially useful when trying to solve problems such as land use suitability, site selection, etc. Please note that "suitability analysis" can also be carried out using vector geoprocessing (buffers, intersection tools, clipping etc), but typically when we talk about GIS-MCDM or Overlay analysis we refer to a raster data analysis method.

Suitability analysis: Vector vs Raster

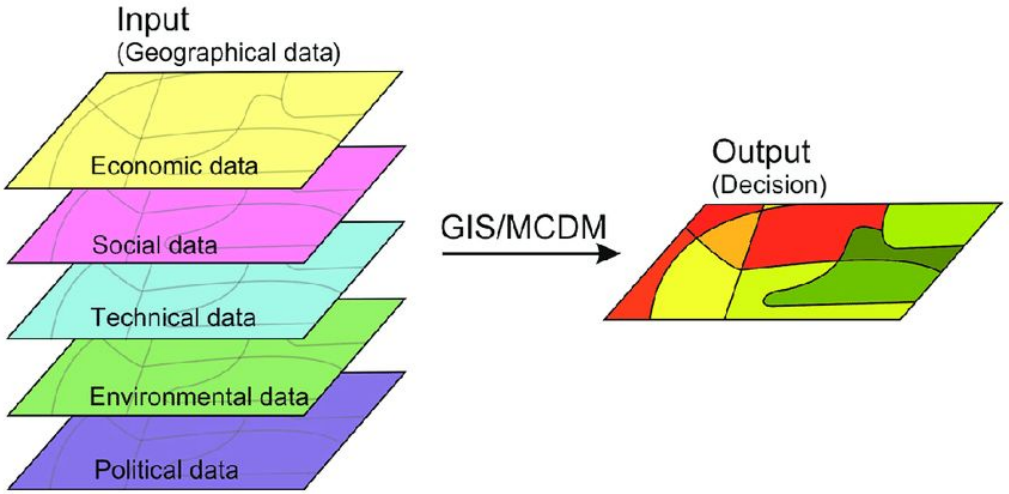
The following table summarizes the main geoprocessing stages, advantages, and pitfalls of suitability assessment with vector and raster data:

	Vector data	Raster data
Main geoprocessing and analysis operations	Buffering Clip overlay Intersection overlay Union overlay	Vector data rasterization Proximity raster creation Raster reclassification Raster algebra addition Raster algebra multiplication Raster algebra subtraction
Advantages	Workflow quickness Workflow simplicity Good representation of man-made features	Simple data reclassification Good representation of continuous features Crisp and fuzzy classes are possible Possibility to weigh different coverages according to their importance Various assessments are possible, such as binary, ranked, and weighted
Limitations	Provide only crisp classes Usually provides binary (yes/no) assessments only	Reclassification and ranking subjectivity Workflow complexity

Source: Bruy, A. and Svidzinska, D., 2015. *QGIS by Example*. Packt Publishing Ltd.

(GIS) Multi-Criteria Decision Making

Applied to GIS, MCDM consists in crossing different variables to determine an output (the decision).



GIS MCDM models: mathematical framework

Let's say you want to identify the zones that are most vulnerable to flooding in a given region.

- A number of factors influence vulnerability **I**, denoted by **X1** through **Xn**. For instance slope, land use, distance from water stream.
- The impact of each factor on vulnerability is determined by a transformation of the factor **f(X)**. For example, the factor distance would be transformed so that its impact decreases with increasing distance, whereas the impact of slope would be increasing.
- Then the combined impact of all of the factors is obtained by weighting and adding them, each factor i having a weight **wi**, which is determined by the GIS specialist, based on stakeholders' inputs.

$$I = \sum_{i=1}^{n} w_i f(x_i)$$

Table 15.1 An example of the weights assigned to three factors by one stakeholder. For example, the entry "7" in Row 1 Column 2 (and the 1/7 in Row 2 Column 1) indicates that the stakeholder felt that Factor 1 (slope) is seven times as important as Factor 2 (land use).

	Slope	Land use	Distance from stream
Slope		7	2
Land use	1/7		1/3
Distance from stream	1/2	3	

GIS MCDM Steps

1. **Define the problem/research objective:** this would typically include literature review to understand the domain and the local context.
2. **Definition of criteria and constraints**, based on literature research, analysis of historical data and potentially interviews with domain experts and stakeholders
3. **Reclassify/Transform the values** onto a relative scale to ensure the criteria can be comparable. For instance, transform a vector layer of a road into a raster layer of distance ranges to the nearest road.
4. **Weight the criteria**: think about each criteria's relevance to the final result, and it's importance compared to the other criteria.
5. **Combine the criteria** into a single layer.
6. **Results analysis** and validation, leading to the decision

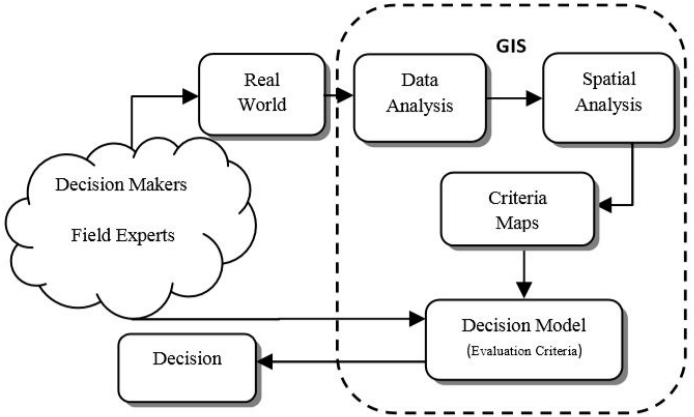
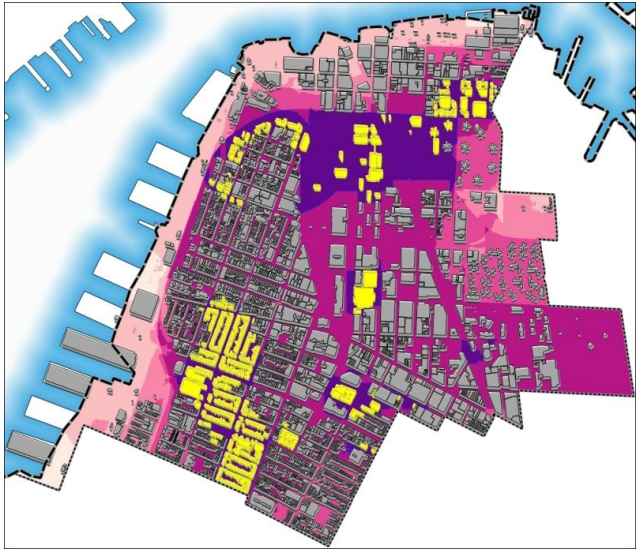


Figure 1. Integrated GIS/ MCDA approach

Extra readings on MCDM / weighted overlays

Please read these three resources to have a better understanding of the MCDM / overlay methodology

1. The ESRI page on overlay approaches
2. This tutorial, which covers an entire workflow for identifying buildings suitable for a family to move in, based on their preferences (close to green spaces, to primary schools, well-connected by public transport, etc.)
3. This research poster on agriculture in Vermont



Weighted Overlays Tutorial

Q&A!

Final Coursework

Final Coursework: Marking Criteria

The marking criteria reflect the learning outcomes expected at the end of this module. Students should be able to:

- Formulate a research question suitable for GIS analysis
- Source relevant data and assess their relevance based on the metadata provided
- Be comfortable working with vector and raster datasets
- Design complex GIS workflows to combine multiple datasets, using at least one technique covered in the Advanced course (bivariate choropleths, raster processing, cartograms, digitization, isochrones, weighted overlays)
- Produce clean map exports that respect cartographic design principles, are colour-blind safe, and are complete with all key cartographic elements (title, legend, north arrow etc.)
- Justify all key methodology choices, focusing on key decisions (choice of datasets, geoprocessing steps, raster processing steps, class breaks chosen for a choropleth, etc.)
- Draw policy insights from their maps and translate those into applicable policy recommendations **or** future research outlooks. Please be very explicit!

Final Coursework: Marking Criteria

Criteria:

- Research question and whether your methodology adequately addresses it (10%)
- Methodology, choice of relevant datasets and design of your workflow (35%)
- Quality of the map outputs (35%)
- Quality of the writing, structure and visual clarity of the report (10%)
- Relevance of the recommendations / insights (10%)