

Multi-criteria analysis techniques to support land-use planning for REDD+

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What is Multi-criteria Analysis?

Multi-criteria analysis:

selecting most appropriate action or suitable locations based on multiple factors

Can be used in a variety of situations and types of decisions (in this instance REDD+ planning)

Multiple types of data, tools and information which can be used

Here we are specifically talking about spatial multi-criteria analysis for REDD+ planning



What is spatial multi-criteria analysis?

- At the simplest level, a **collection of techniques for analysing geographic data** across a range of criteria
- The results of the analysis depend on the **spatial arrangement** of the overlaid data
- Can be carried out as a **string of geo-processing processes** which meet a defined objective
- Different approaches have **different levels of subjectivity**



What is spatial Multi-criteria Analysis?

The quality of the analysis will be dependant upon the information fed in and these can range from:-

- Scientifically-derived hard data
- Subjective interpretations
- Uncertain probabilities
- Inform on the targets to be achieved



What is spatial Multi-criteria Analysis?

- Hard data can also be variable:
 - Simple presence/absence, e.g. Protected area
 - Data spread across a range of values, e.g. Carbon density
- Approaches (ranging from simple to complex) vary in the way they treat the data.
- Two main approaches are:
 - Boolean
 - Weighted Combination



Boolean intersection

- The simplest variant of criteria processing
- Often referred to as constraint mapping
- Prior to the combination, each input criteria is standardised to a certain scale of suitability
 - i.e. Reducing all the factors to Boolean raster datasets of suitable and unsuitable areas (or reclassifying into 2 classes of 1 and 0)
- Factors can then be combined using Boolean algebra
 - In ArcGIS using various tools located under the Spatial Analyst - Math – Logical toolset



Fuzzy Overlay

- In fuzzy logic, knowledge is interpreted as a **collection of elastic or, equivalently, fuzzy constraints on a collection of variables**
- It is a **superset** of conventional(**Boolean**) logic
- Reclassifies or transforms the data values to a common scale (**data are normalised to a scale ranging from 0 – 1**).
- Input rasters are not weighted.



Fuzzy Overlay

- Fuzzy overlay results in **degree of membership**, whereas **boolean or weighted overlay** either belong or don't belong
- The **combining analysis** step in Fuzzy Overlay analysis quantifies each location's **possibility of belonging to specified sets** from various input rasters.



Fuzzy membership tools

- In ArcGIS there are various tools which can be used to normalise the data to a range between 0 – 1.
- Different tools can be used to **spread** the data i.e. determines **how the fuzzy membership values relate to the true value.**

The simplest of these is a linear relationship which divides the values in the continuous raster by the maximum number



Weighted Combination

- Gives varying levels of ‘importance’ or weight to the different input layers
- Additive overlay analysis
 - Weighted overlays
 - Weighted sums



Weighted Overlays

- **Input rasters** have to be **integers**
- Continuous data need to be **reclassified prior to analysis**
- Scales the input data on defined scale (the default being 1 to 9) with the most favourable locations for each input data being given the maximum value e.g. 9.
- Each input layer is assigned a weight (relative percentage) and all weights must sum to 100 percent
- Each input layer is then multiplied by the appropriate weight and all of the resulting values are added together for each cell.
- Weighted Overlay makes **more favourable factors** have the **higher values** in the output raster, therefore identifying these locations as being the **priority**.



Weighted Sum

- Similar to weighed overlay but allows continuous data.
- Does not automatically scale input data
- Also unlike weighted overlay, weights assigned to the input rasters can be any value and do not need to add to a specific sum
- Output values are a direct result of the summation of the multiplication of each value by the weights.
- Maintains the attribute resolution of the values entered in the model (unlike Weighted Overlay, values are not rescaled back to a defined scale)



Reclassifying data

- Need to identify thresholds for suitability in input layer to Boolean analysis and for class breaks in inputs to overlay analysis
- Try to reduce subjectivity by choosing appropriate thresholds informed by literature, policy or expert consultation.
- Understand the data and ensure that the values chosen are appropriate for the data being used.
- Do the values make sense for the question you are trying to answer? How do they inform questions about REDD+ planning?



- Need to identify what weight to put on different input layers within weighted analysis
- Should consider:
 - Policy aims
 - Political priorities
 - Stakeholder needs
- Consultations can be important



Two possible approaches

Ranking approach

- Simple ranking of criteria in order of importance

Advantage: simple to understand and explain

Disadvantage: subjective

Analytical Hierarchy approach (AHP) -

- Pairwise comparison of each of the variables against each other and used to calculating a mean weight for each criteria

Advantages: simple approach, that can easily involve wide range of stakeholders, more difficult to rank according to a predetermined preference

Disadvantages: subjective, difficult to explain the values for the ranking, can be difficult to get agreement between different groups for the pairwise comparisons



- Have been looking at specific REDD+ actions and the objectives that need to be achieved
- Then working out what are the most important factors to consider as well as input data and methods needed
- So cannot predefine exactly which tools or approaches to use at this stage
- As develop workflows will select most appropriate methods depending on priorities (which may vary between provinces)



Summary

- Important that analysis addresses objectives
- Several approaches to spatial multi-criteria analysis
- The question and objectives should determine the analysis undertaken (rather than preselecting a method)
- Important to link closely with stakeholder consultation
- Clearly presenting the inputs that feed a multi-criteria analysis can support understanding and interpretation of results (and preferably present them spatially in addition to the combined output).



Thank You!

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