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

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September 2015

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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

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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 overlayed 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

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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

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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 vaious tools located under the Spatial Analyst - Math – Logical toolset

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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.

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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

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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**.

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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)

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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?

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An example of weighted approach for mapping drivers using ranking method

10	0	0	2
9	5	4	3
7	4	0	0

Driver 1

0	0	9	10
1	0	8	7
0	2	1	1

Driver 2

Each commune (squares in this case) are ranked on a common scale of 0-10 of how much impact that driver has in the commune

Before summing the drivers each driver may be further weighted according to it's influence (e.g. it's effect on forest – i.e. 100 being total removal and 75 being highly degraded etc. or weighted according to likelihood of intervention success on the driver

Determining weights

- 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

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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).

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Thank You!

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