GEOG 413/613

LECTURE 14

1

Data and Tools For Decision Support

- This was a cardinal objective in the development of GIS
  - Computers are effective at processing large amounts of data
  - Multiple alternatives and perspectives are part of the decision making process
- Effective use of data and GIS functionalities is essential
  - Spatial data to be misused and functionalities misapplied. Caution is essential.

2

2

Data and Tools For Decision Support

- Putting the temporal component of data aside, GIS help answer two types of questions
  - What attribute or feature or spatial object is found at a given location
    - Location known, attribute unknown
  - Where a given attribute or spatial object can be found
    - Location unknown, attribute known

3

3

Data and Tools For Decision Support

- For example:
  - assigning residential zones to fire halls represents an allocation problem
    - creating service areas
  - finding a site for a new fire hall is a location problem of optimizing travel distances
  - The combination of the two types is known as location-allocation problems.
    - locating a new fire hall will also require reallocating client populations
    - Location-allocation
  - The solution algorithms for these problems are well-developed
    - Reaching a decision is still requires specialized computer assistance

4

4

Data and Tools For Decision Support

- Specialized decision support depends on the elements of the decision problem that are explicitly spatial
  - decision alternatives are typically locations and therefore spatially explicit
  - decision criteria and decision models are often aspatial and therefore in non-spatial databases and model inputs

5

5

SDSS Decision Problems

- Problem-specific SDSS
  - designed and implemented for one specific decision problem
- Domain-level SDSS
  - addresses multiple problems within an application domain
- Generic SDSS
  - Problems solved with generic GIS-software based

6

6

Decision Problems

- A decision is the selection of a specific option from among a set of decision alternatives or options
  - Deciding which swimming pool to go to, doesn't require decision support. This is a routine activity
  - Decision problems can be operational, tactical, and strategic in scope
    - Operational: typically short term; repeated on a day to day or weekly basis. E.g garbage collection, snow removal
    - Tactical: typically short to medium term; e.g fleet and logistics management, timber harvest planning
    - Strategic: typically long term, complex in nature, most consequential, made at the highest level of the organisation

7

7

Decision Problems

- Decision problems can be classified as structured to unstructured
  - For structured decision problems, parameters are known and the solution (decision) can be computed.
  - For unstructured problems, information available cannot be formalized for the decision-making process

8

8

Decision Problems

- Decision problems are typically characterised by
  - multiple of decision alternatives
    - each evaluated on the basis of multiple criteria
    - may be qualitative or quantitative
  - spatially variability
  - multiple stakeholders in a decision making process
    - stakeholders have competing/conflicting/differing preferences
  - inherent uncertainty

9

9

Spatial Decision Support Systems

- Spatial Decision Support Systems (SDSS) aid in making decisions in geospatial applications.
- SDSS
  - "an interactive computer-based system designed to support a user or group of users in achieving a higher effectiveness of decision-making while solving a semi-structured spatial decision problem."
- SDSS evolved alongside decision support systems
  - DSS a field of study with roots in the 1960s

10

10

Spatial Decision Support Systems

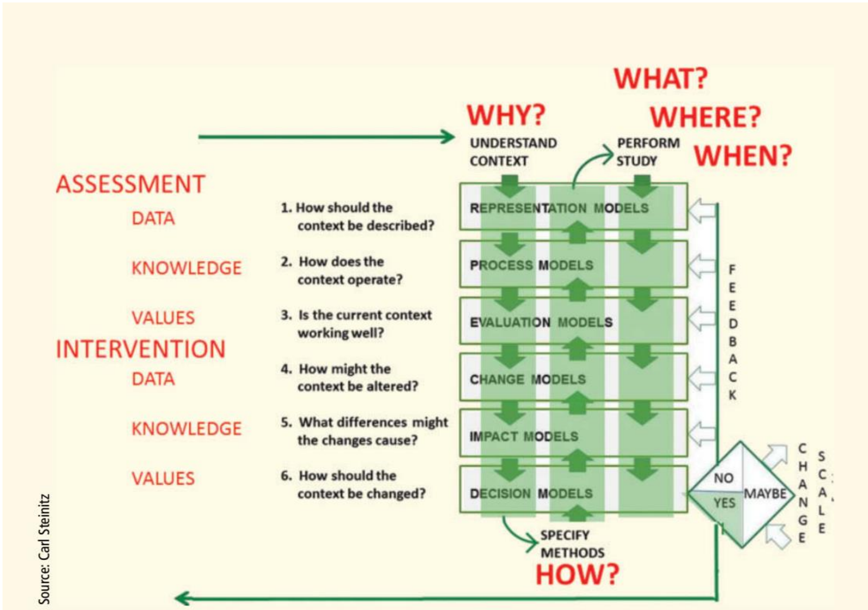
- The main or primary components of an SDSS
  - Database management system
    - spatial and non-spatial data collection, storage, and retrieval
  - Dialog component
    - user interface, visualization, report generator
  - Modeling toolkit
    - spatial models, spatiotemporal models, decision models, GIS functionality

11

Decision Support

- Intelligence
  - Exploration of the decision situation
  - GIS plays an important role: data assembly, initial analysis and problem presentation
- Design
  - Develop a model that generates decision alternatives for the user
  - GIS used to generate alternatives using connectivity, contiguity, proximity and the overlay methods
- Choice
  - Selection of a particular choice by evaluating the different alternatives in relation to the other
  - GIS generally do not easily incorporate the decision makers preferences

12



A schematic model of the geodesign process, developed by Carl Steinitz to capture the various stages used in his practical applications of geodesign principles.

13

Source: Longley, Paul A.; Goodchild, Michael F.; Maguire, David J.; Rhind, David W.. Geographic Information Science and Systems

13

Multi-criteria Evaluation for the Design Stage

- MCE
  - The implementation of decision-making rules to identify and enable the combination of many criteria, in the form of data layers in a GIS, into a single map (Lopez-Marrero et al, 2011)
  - The combination of information from several criteria to form a single index of evaluation
  - AKA
    - Multi Criteria Analysis
    - Multi Criteria Preference Analysis
    - Multi Criteria Decision Making
    - Multi Objective Evaluation

14

14

Multi-criteria Evaluation

- Two basic types of criteria
  - Boolean Criteria
    - Boolean Logic (application of logical AND (intersection); logical OR (union))
    - Referred to as Constraints
  - Quantitative Criteria
    - Continuous variables (e.g. 0–1, 0–100, 0–255)
    - Express varying degrees of suitability for the decision under consideration
    - Referred to as Factors

Binary Criterion

Continuous Criterion

Lopez-Marrero et al, 2011

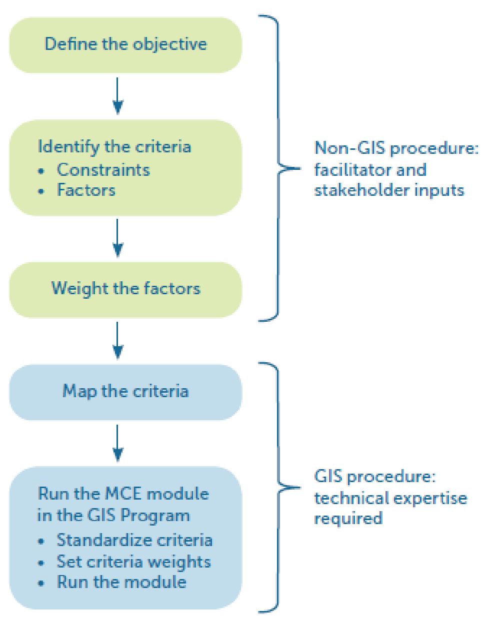
MCE Process

What	How	Who
Decision Making	Criteria	Stakeholders Government Policy Makers Researchers
	Weighing Criteria	

17

17

MCE Process



Lopez-Marrero et al, 2011

18

18

MCE Process

- Decisions:
  - a choice between alternatives
- Criteria:
  - Factors: *enhances* or *detracts* from the suitability of a land use alternative (e.g. distance from a road)
  - Constraint: limits the alternatives
- Objective:
  - some characteristic that the solution must possess (a positive constraint)

19

19

MCE Process

- Determine criteria
  - Oversimplification of the decision problem could lead to too few criteria being used
  - Using a large number of criteria reduces the influence of any one criteria
  - Often proxies must be used since the criteria of interest may not be determinable

20

20

MCE Process

- Determine the weights
  - A decision is the result of a comparison of one or more alternatives with respect to one or more criteria that we consider relevant for the task at hand.
  - Among the relevant criteria we consider some as more important and some as less important; this is equivalent to assigning weights to the criterion according to their relative importance.

21

21

Six factors were identified as being important to include in the analysis and production of the map to identify areas to protect from urban expansion around El Yunque: distance from rivers (D River), distance from El Yunque National Forest boundaries (D EYNF), forest land cover (Forest), northeast portion of the study area (NE Quad), landscape connectivity (Land Conn), and wetland cover (Wetland). Among pairs of factors, the factor in each cell was considered more important by participants in the indentification of such areas.

The final matrix showing the factors' pairwise comparisons and the resulting score for each factor is shown below:

FACTOR	D RIVER	D EYNF	FOREST	NE QUAD	LAND CONN	WETLAND	SCORE
D RIVER		D River	D River	D River	D River	Wetland	4
D EYNF			D EYNF	NE Quad	D EYNF	D EYNF	3
FOREST				NE Quad	Land Conn	Forest	1
NE QUAD					Land Conn	NE Quad	3
LAND CONN						Land Conn	3
WETLAND							1

Lopez-Marrero et al, 2011

22

22

The weight for a factor was calculated by dividing the score of that factor by the total score of all factors. In this study, the sum of all the scores was 15. To calculate the weight for the factor "distance from river," the score of that factor (4) was divided by 15. The weights for all other factors were calculated by using the same prodecure. All weights should add up to 1. The calculated weight for each factor was as follows:

FACTOR	WEIGHT
Distance from rivers	0.2667
Distance from El Yunque	0.2000
Forest land cover	0.0667
Northeast quadrant	0.2000
Landscape connectivity	0.2000
Wetland cover	0.0667
Total	**1.00**

Lopez-Marrero et al, 2011

MCE Process

- Sensitivity Analysis
  - Adjust the weights of the factors to determine the sensitivity of the solution to minor changes
    - Consider the choice of the criteria (e.g. why included?)
  - Assesses the reliability of data: how stable is the final result / solution?
    - Often the choice for weighting factors is subjective
    - Will the overall solution change if you use other weighing factors?