

GIS Models (with a side of ArcCatalog)

ArcCatalog

- GIS data explorer
(like Windows Explorer, but understands GIS data)
 - e.g., “shapefile” is single item instead of multiple files
 - like “Add Data” in ArcMap
 - graphical previews
 - metadata
- ArcToolbox execution environment
(like ArcMap without a map...)
- Metadata editor

Why ArcCatalog?

- Only in ArcCatalog
 - Browse/examine GIS data
 - without having to add it to a map
 - Copy/move GIS data
 - without having to keep track of component files & folders
- (Maybe) more convenient in ArcCatalog
 - Create/edit metadata
 - Geoprocessing
 - individual tools
 - complete models

ArcCatalog vs ArcMap: gotcha!

- They don't play well together
 - A change you make in one won't always be visible immediately in the other
 - Crashes more likely when both are running
- Work-around: Only run one at a time
 - Quit ArcCatalog before starting ArcMap, and vice versa
- NB: ArcMap “Catalog” window is not ArcCatalog

What's a Model?

- an analysis pattern
 - step-by-step implementable strategy

Developing a GIS Model

1. identify goals

- phenomena
- scales
- parameters vs. variables

2. identify elements

- data
- operations

3. implement

- layers
- functions/tools

GIS Models for Decision Support

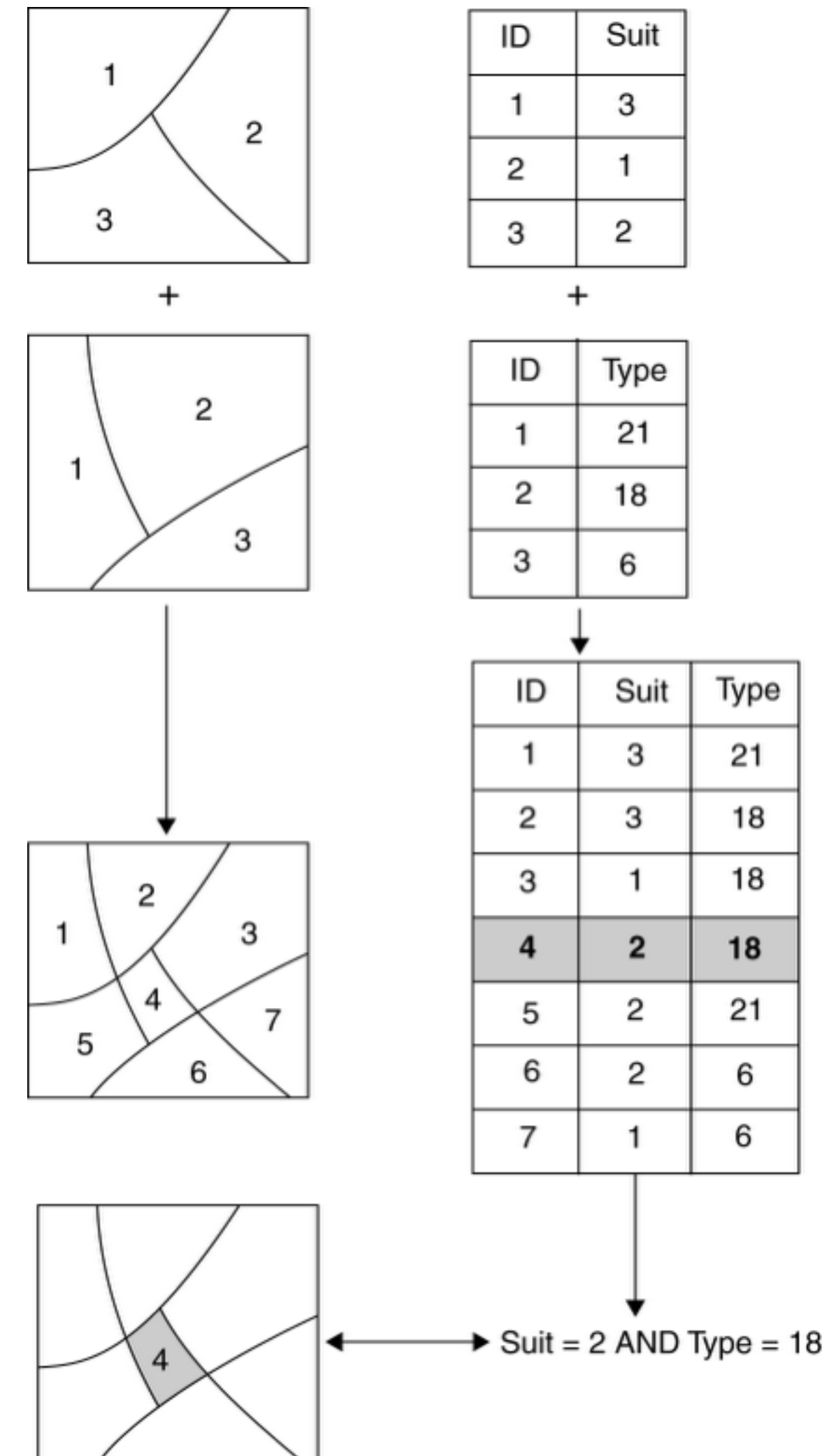
- Analytical
 - Reducible to computational workflow
- Repeatable
 - Same conditions + same assumptions = same answer
- Transparent
 - “it is better for stakeholders to argue in principal about the merits of different factors and how their impacts should be measured, than to argue in practice about alternative decisions.”
 - » Longley et al, Geographic Information Systems and Science, 2nd ed.

Multi-Criteria Models

- output = $f(\text{multiple inputs})$
 - spatial overlay
 - composite feature layer
 - multiple rasters
 - attribute combination
- binary models
 - logical expression \rightarrow feature/cell yes/no
 - common application: siting analysis
- index models
 - combination formula \rightarrow feature/cell index (rank) value
 - common application: suitability analysis

Vector-Based Binary Model

- Combine layers
 - UNION
- Query
 - all relevant attributes pass logical test



Raster-Based Binary Model

- Query
 - all relevant attributes pass logical test
 - no need to combine: cells already line up

1	1	1	4
3	2	4	4
3	3	3	4
4	4	4	4

Raster 1

1	1	1	3
3	2	2	3
3	3	4	4
3	3	4	4

Raster 2

([Raster 1] = 3)
AND
([Raster 2] = 3)

=

Multi-Criteria Analysis (aka Index Modeling)

1. Identify criteria: What will decision be based on?
 - Geographic datasets
2. Standardize factors
 - Interval or ratio scales
3. Establish relative importance: How much does each factor matter?
 - Numeric weights
4. Combine constraints and weighted factors
 - Decision score

MCA Step 1. Identify Criteria

- What measurable geographic phenomena affect the decision?
 - NB: Different objectives \Rightarrow different criteria
- Constraints
 - combine: Boolean logic \rightarrow result: yes/no
- Factors
 - combine: weighted sum \rightarrow result: numeric score
- **Result:** GIS layers

MCA Step 2. Standardize Factors

- All factors must be
 - Same interval (or ratio) scale
 - must be possible to add them together
 - Same ordering
 - \uparrow value \Rightarrow \uparrow score (e.g. "more suitable")
- Example: *linearized* score
$$\text{score} = ((\text{raw} - \text{raw}_{\min}) \div (\text{raw}_{\max} - \text{raw}_{\min})) \times (\text{std}_{\max} - \text{std}_{\min}) + \text{std}_{\min}$$
- **Result:** Reclassified GIS layers

MCA Step 3. Assign Weights

- Simple case
 - few factors
 - stakeholder consensus
 - overall weighting "obvious"
 - (yeah right...)
- Manually assign weights that sum to 1
- **Result:** numeric weights
- Not-so-simple case
 - many factors
 - stakeholder conflict
 - overall weighting *not* obvious
- Use analytical framework (e.g., AHP)

MCA Step 4. Combine

- $\text{score} = \sum(\text{weight}_i \times \text{factor}_i) \times \prod(\text{constraint}_j)$
- Easily implemented with map algebra
- **Result:** “score” layer

MCA Weights: Saaty's Analytic Hierarchy Process (AHP)

1/9	1/7	1/5	1/3	1	3	5	7	9
extremely less important	very less important	strongly less important	moderately less important	equally	moderately more important	strongly more important	very more important	extremely more important

less important \longrightarrow more important

(a)

	Proximity to roads	Proximity to labour force	Slope gradient	Distance from wildlife reserves
Proximity to roads	1			
Proximity to labour force	1/3	1		
Slope gradient	1	4	1	
Distance from wildlife reserves	1/3	2	1/2	1

(b)

Factor	Derived weight
Proximity to roads	0.3770
Proximity to labour force	0.0979
Slope gradient	0.3605
Distance from wildlife reserves	0.1647

(c)

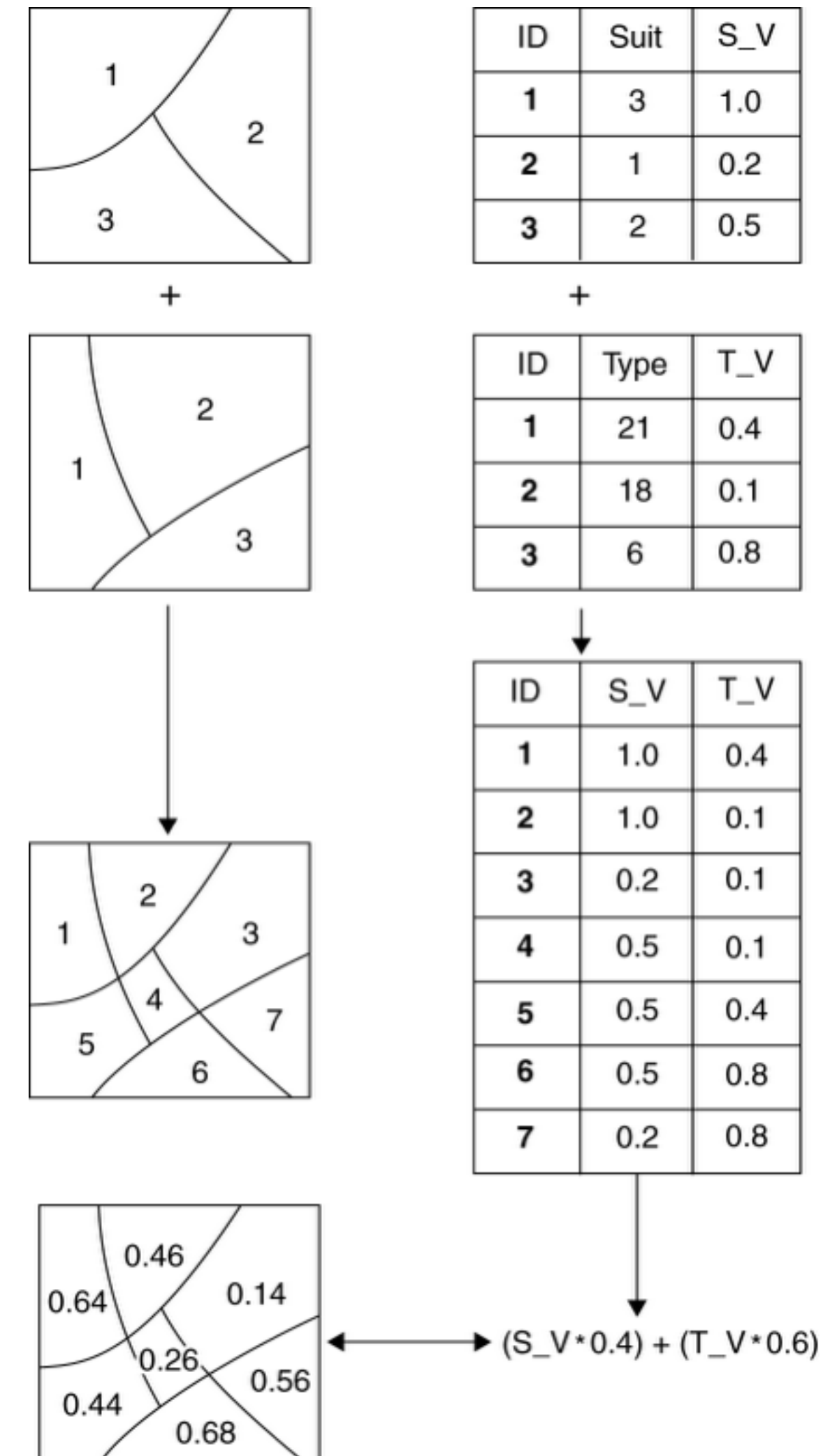
Fig 4. Saaty's pairwise comparison procedure for the derivation of factor weights. Using a 9-point rating scale (a) each factor is compared to each other factor for its relative importance in developing the final solution (b). The principal eigenvector of this matrix is then calculated to derive the best-fit set of weights (c).

MCA Weights: AHP Calculation Shortcut

1. Fill in missing reciprocal scores
2. Normalize score columns
3. Sum normalized score rows \rightarrow weight vector
4. (optional) Normalize weight vector

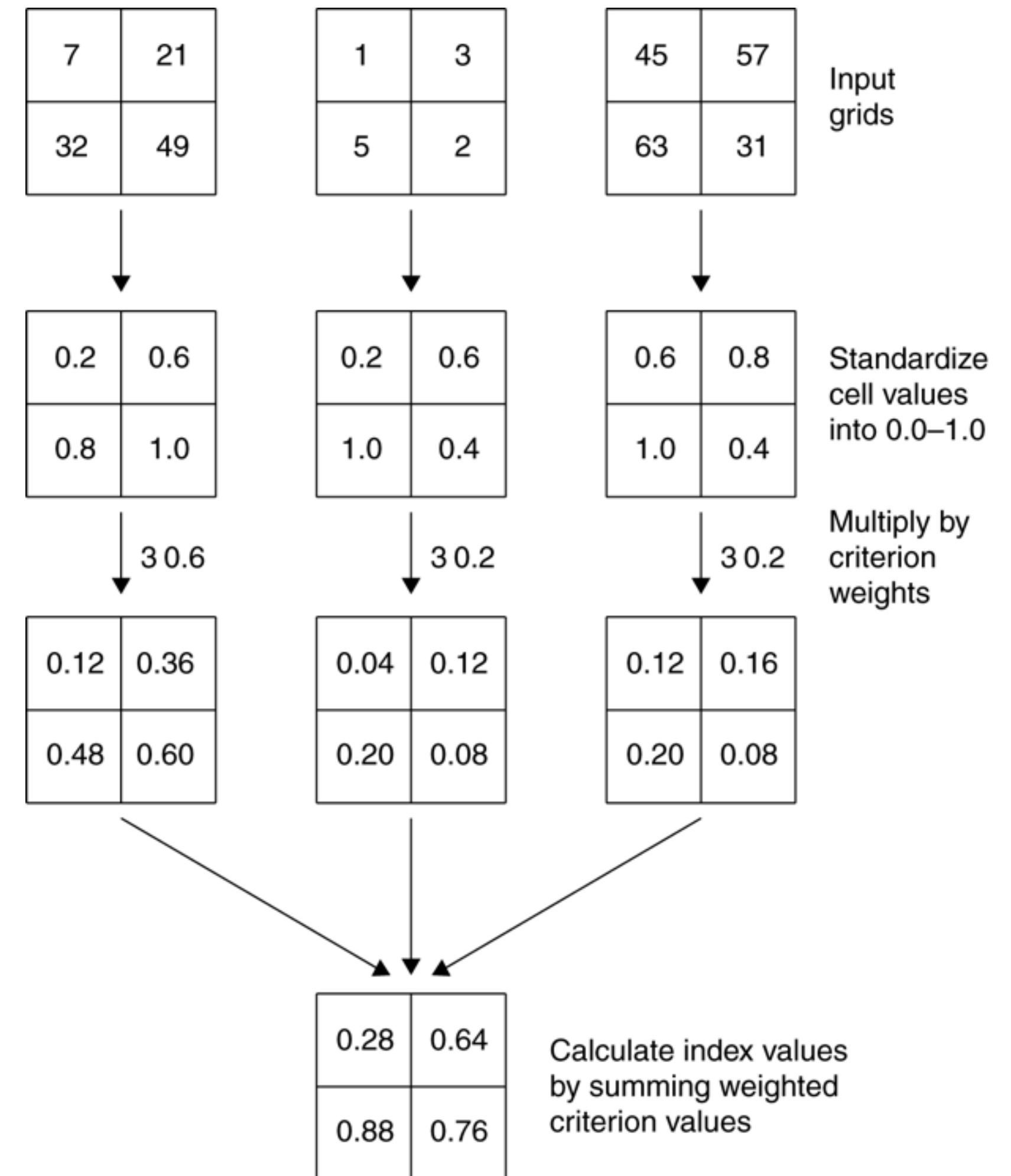
Vector-Based Index Model

1. Standardize relevant attributes
2. Combine layers
 - UNION
3. Weighted sum of standardized attributes



Raster-Based Index Model

1. Standardize cell values
2. Multiply by criterion weights
3. Sum weighted criteria



Figure/Quote Credits

- Introduction to Geographic Information Systems, 4th ed.
– ISBN 978-0-07-305115-2
- Geographic Information Systems and Science, 2nd ed.
– ISBN 978-0470870013
- Geographical Information Systems: Principles, Techniques, Management and Applications, 2nd ed.
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