AGRC 3025 – Module 6

Decision Analysis and Multi-Criteria Analysis

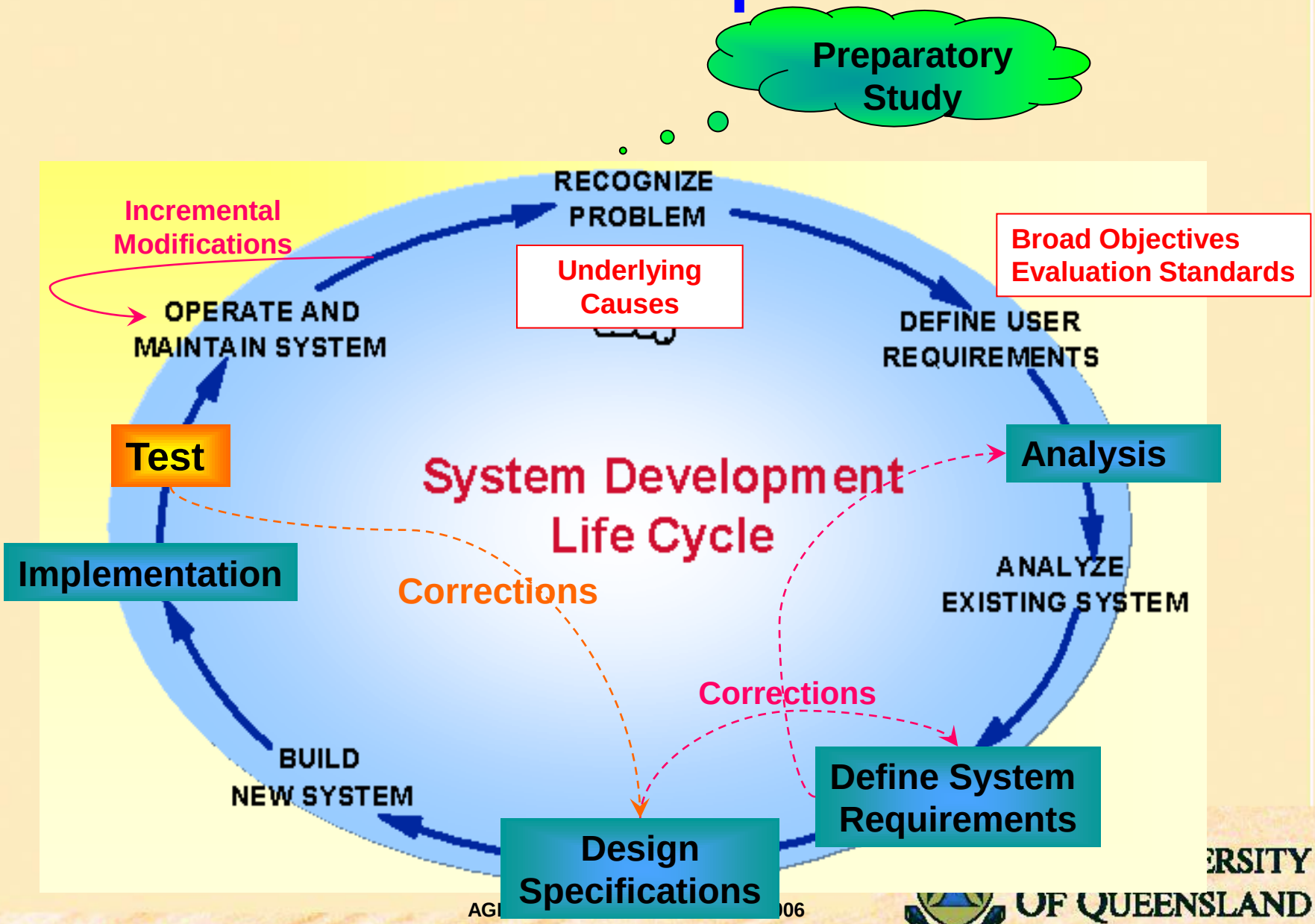
Outline

- **Assessment**
  - Discussion Board Report due this week
- **Today's Lecture**
  - Revise Module 5
  - Decision Theory
  - MCA
- **Practical**
  - MCA Using Catchment Decision Assistant (CDA)

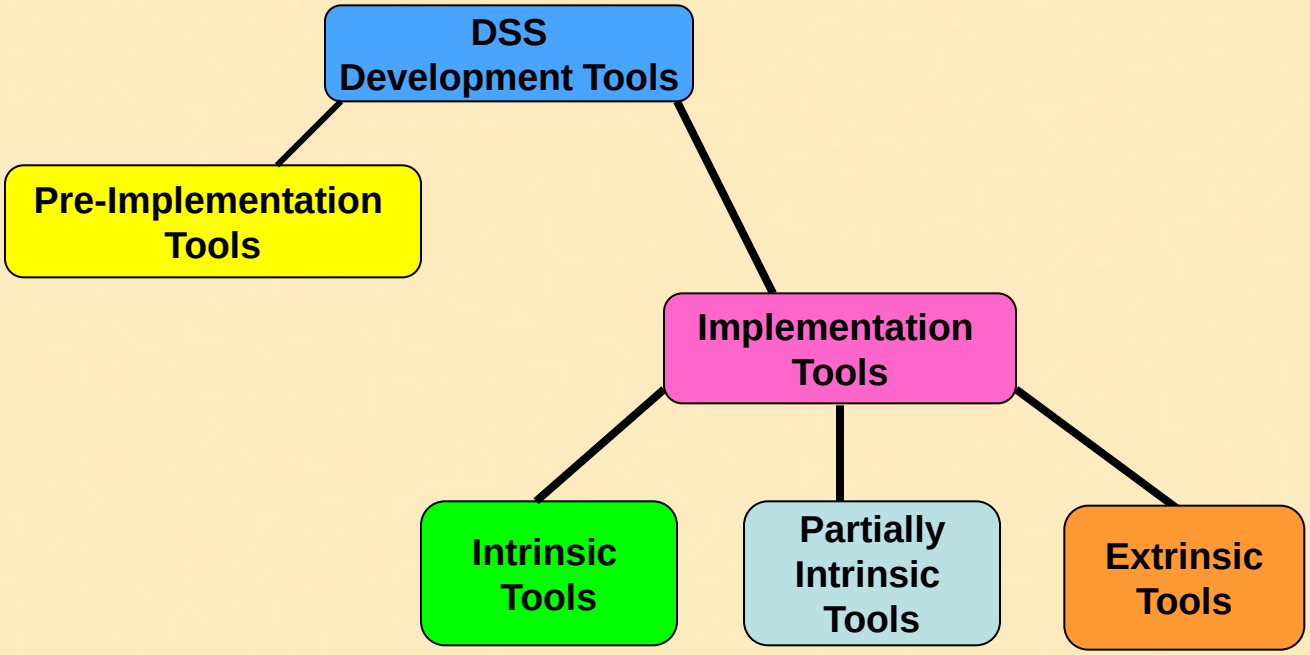
DSS Design

- User Needs
- Data & Data Management
  - Adequacy and Availability, Flexibility, Usability, Security
- Models & Model Management
  - Functionality, Flexibility, Appropriateness, Ease of Use
- User Interface
  - User Friendliness
- Connectivity
  - Integration with existing systems, Searching capabilities (Spiders)
- Hardware & Software
  - Compatibility with existing systems
  - Preferred hardware/operating system/networking configuration
- Cost considerations
  - Initial purchase/licence fee, Maintenance costs, Documentation
- Vendor Considerations

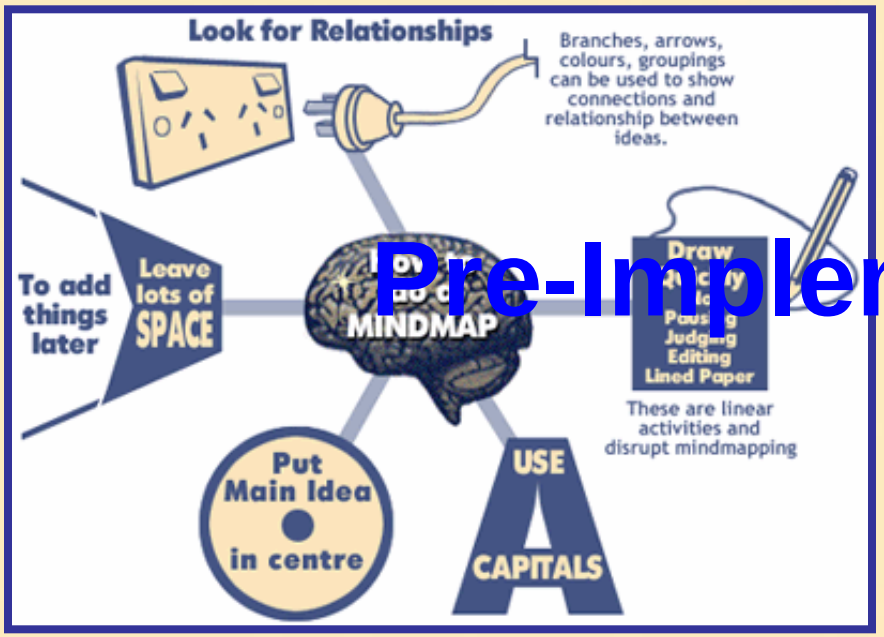
DSS Development

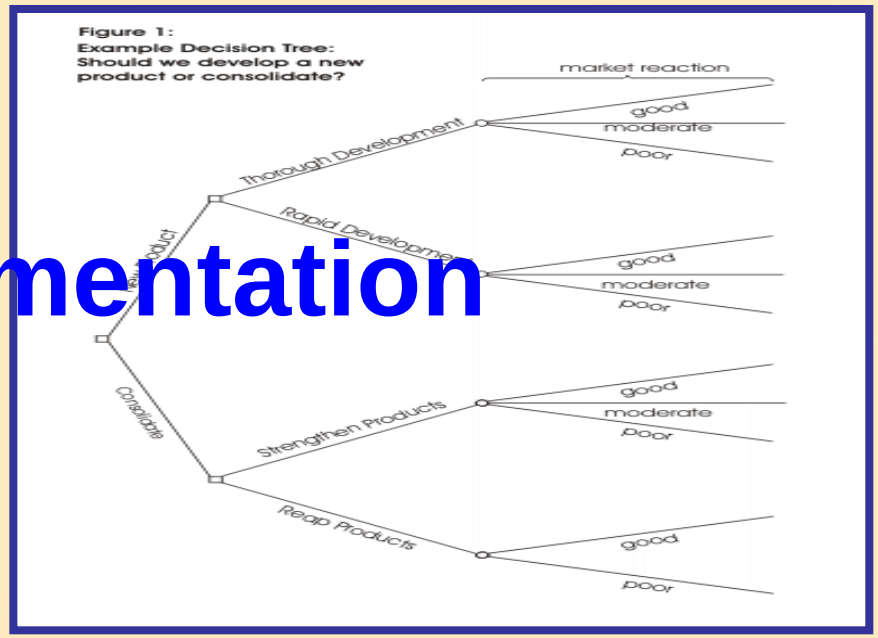


Development Tools



Tools





Pre-Implementation

Creation and Operational Tools

- Intrinsic – Serves as problem processor of the DSS
- Extrinsic – Used to implement the DSS but not part of the problem processor (eg a compiler)

Interface tools - User Friendliness & Task dependency

- Language system
- Presentation System

Integration tools

- Between programs

Implementation

Decision Analysis and MCA

- Decision Theory
- Decision Analysis
- Decision Making (MCA)

Decision Theory

Four things to remember:

1) Coherency

Based on the assumption that decision makers wish to be coherent (consistent) in making decisions

2) Transitivity

If A is preferred to B, and B to C, then A should always be preferred to C - which is a requirement if "preference" is to be treated numerically *(which it has to be in a computational environment)*

Decision Theory

3) Probabilities & Utilities

- If preferences/decisions are coherent – then there are two logical forms of measurement – Probability and Utility – both of which are associated with the consequences of decisions.
  - Probabilities - are numbers that capture the likelihood that consequences will occur.
  - a quantitative estimate of the likelihood that a given outcome depicted will occur. (10% likelihood of rain)
  - Utilities - are numbers that express the subjective value of the consequence and the decision maker's risk attitude.
  - a quantitative expression of the desirability of a particular outcome. Good = $500,000, Medium = $100,000, Poor = $1000

❖ *e.g. Last Week's Practical on Decision Trees*

Decision Theory

4) Expected Utilities Rule

- **Provides a guide to taking decisions**
  - **Choose the course of action with the greatest sum of probability weighted utilities**
  - **Assess the probability and utility for each possible consequence to a course of action, multiply these two figures for each consequence and then add the results to give the expected utility for that course of action**
  - **Repeat for each course of action and then finally choose the largest expected utility.**
  - **Example**

Decision Analysis

- **Offers a set of structured procedures/techniques that assist decision-makers in:**
  - **Structuring decision problems and developing creative decision options**
  - **Quantifying their uncertainty**
    - **includes combining available statistics with expert judgments, and their own beliefs to arrive at estimates of the probabilities of various outcomes**
  - **Quantifying their preferences**
    - **includes structuring their own value tradeoffs and examining their attitude towards risk**
  - **Combining their uncertainty and preferences to arrive at optimal decisions**
  - **Example**

Multi-Criteria Analysis and Decision Making (MCA/MCDM)

MCA/MCDM

- **Both an approach and a set of techniques**
- **Approach – has the goal of providing an overall ordering of options, from the most preferred to the least preferred. Can be used:**
  - **retrospectively to evaluate something to which resources have already been allocated**
  - **prospectively to appraise things that are as yet only proposed.**
- **Set of Techniques to look at complex problems that are characterised by any mixture of monetary and non-monetary objectives.**
  - **Allows the breaking down of the problem into more manageable pieces**
  - **Then allows the reassembling of the pieces to present a coherent overall picture to decision makers.**

Approach

Describing a problem with 6 elements:

1. **VALUES** - things people care about in a bio-physical, economic and socio-cultural sense
2. **GOAL** e.g increase habitat
3. **OBJECTIVE** e.g. increase habitat by 25% over current level
4. **DECISION MAKER** – single/group
5. **DECISION ALTERNATIVES** – feasible options & solutions
6. **OUTCOMES** – evaluation of alternatives against values

Definitions

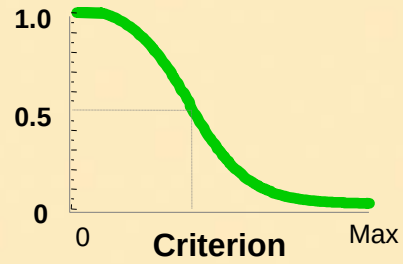
- **Criteria**
  - A criterion is a descriptive variable , e.g. soil type, slope, proximity to roads, or development cost.
- **Decision Tables/Matrices**
  - Criterion scores or ratings are stored in a Decision Table or Matrix that stores values representing each alternative's score or rating for each criterion
  - Also called a Performance Matrix

Decision/Performance Matrix

Alternative	Decision Criteria		
	Biophysical (t/ha soil loss)	Economic ($/ha)	Social (Jobs)
A	100	100,000	2
B	50	200,000	4
C	20	150,000	6

More is Worse

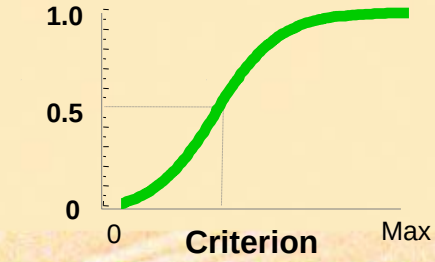
Rating



Score Graphs are used to bring different units of measure to a common measure, i.e., 0 to 1 rating

More is Better

Rating



Weighting

- **Multiple criteria typically have varying importance**
  - **A criterion can be assigned a specific weight that reflects its importance relative to other criteria under consideration**
  - **Weights are normalised to sum up to 1**
    - **e.g. in a set of weights ($w_1, w_2, \ldots, w_n$), $\sum w_i = 1$.**

Weighting

- **Ranking**
  - involves establishing importance orders for the criteria e.g., x = most important, y = second most important etc, and determining all possible weights that satisfy that importance order (used in Facilitator)
- **Categories**
  - involves categorising importance of criteria, e.g., High, Med, Low, and calculating weights for each criterion that reflect their importance categories (used in LUIM)
- **Pairwise Comparison**
  - involves comparing the importance of each criterion against all other criteria
  - Analytical Hierarchy Process (used in CDA)
  - See O'Kane (2000) reference under Section 4, Module 7 (CDA) for simple explanation of AHP

Weighting using Ranking

Criteria Ratings – Biophysical = 0.8, Economic = 0.3, Social = 0.6

Importance Order = Biophysical ≥ Economic ≥ Social

Weights

Biophysical	Economic	Social	Score (∑Rate×Weight)
1.0	0.0	0.0	0.80
0.9	0.1	0.0	0.75
0.8	0.2	0.0	0.70
0.8	0.1	0.1	0.73
0.7	0.3	0.0	0.65
0.7	0.2	0.1	0.68
0.6	0.4	0.0	0.60
0.6	0.3	0.1	0.63
0.6	0.2	0.2	0.66
0.5	0.5	0.0	0.55
0.5	0.4	0.1	0.58
0.5	0.3	0.2	0.61
0.4	0.4	0.2	0.56
0.4	0.3	0.3	0.59
0.33	0.33	0.33	0.56

Weighting using Categories

Importance Category	Numerical Importance
None	0
Weak	1
Medium	2
Strong	3
Very Strong	4

Weighting using Categories

Criterion	Importance Category	Numerical Importance	Criterion Weight
A	Strong	3	3/7 = 0.429
B	Medium	2	2/7 = 0.286
C	Weak	1	1/7 = 0.143
D	Weak	1	1/7 = 0.143
		Total = 7	

Weighting using Pairwise Comparison (AHP)

See O'Kane (2000) reference under Section 4, Module 7 (CDA)

Steps in MCA/MCDM

1. Establish the decision context: What are the aims of the MCA, and who are the decision makers and other key players (stakeholders)?
2. Identify the options/alternatives.
3. Identify the objectives and criteria that reflect the value associated with the consequences of each option.
4. 'Rating' - Describe the expected performance of each option against the criteria. i.e. create a Decision Table or Performance Matrix and score each option against each criterion.
5. 'Weighting' - Assign weights for each of the criteria to reflect their relative importance to the decision.
6. Combine the weights and scores for each of the options to derive and overall value.
7. Examine the results.
8. Conduct a sensitivity analysis to see how the results change with varying ratings and weightings.

Deciding on Alternative Jobs

Multi-F. Evaluation Process

In considering amongst alternative actions, determine the factors that are important to you.

Weightings

Rank these factors, putting weights on each.

Factor	Importance (Weight)
Salary	0.4
Career Advancement	0.5
Location of employer	0.1
TOTAL	1.0

Next for each factor, evaluate how the alternatives satisfy your important factors on a scale from 0 to 1.

Ratings

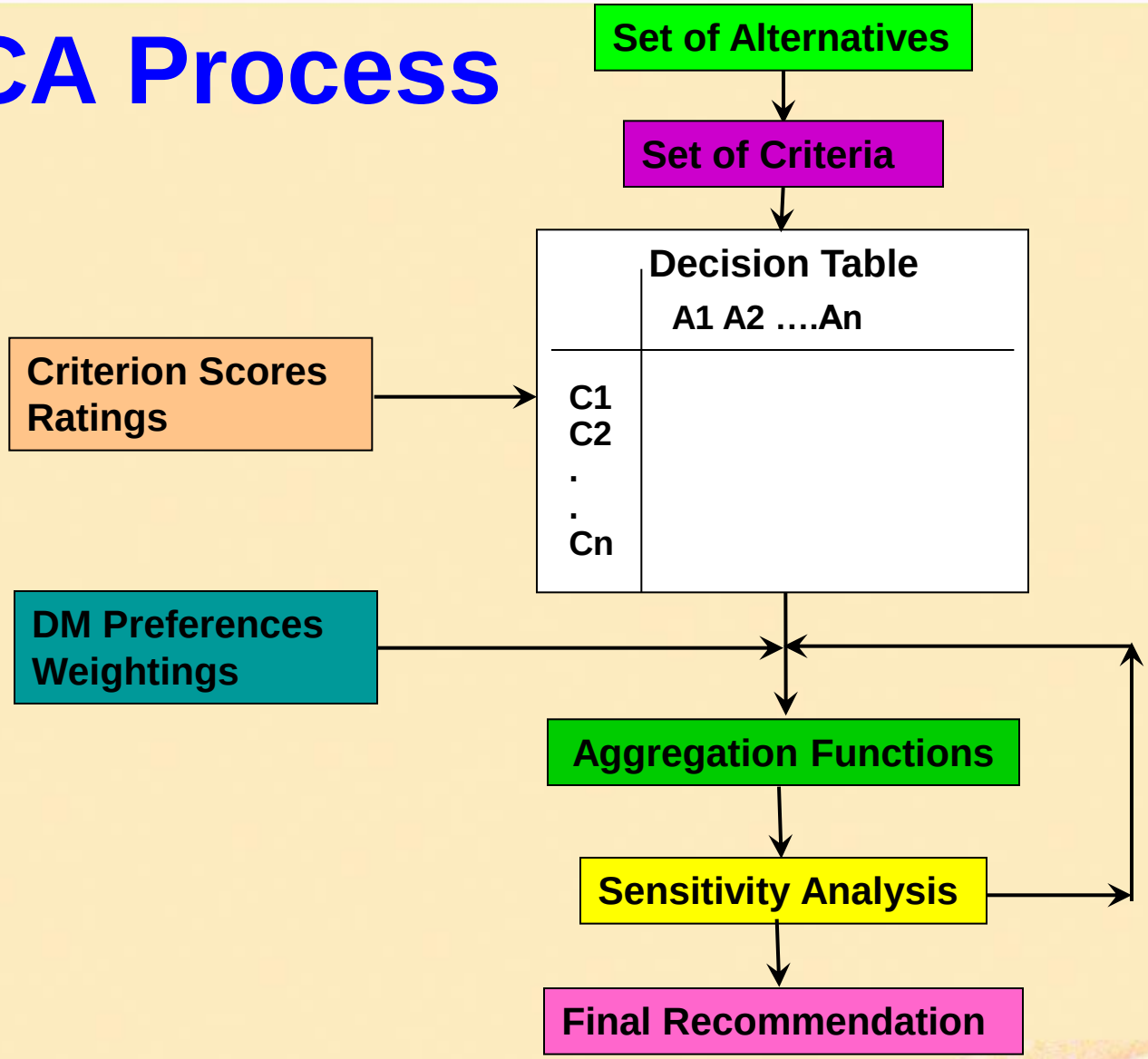
Factor	Company 1	2	3
Salary	0.6	0.7	0.8
Career Advancement	0.9	0.6	0.5
Location	0.5	0.8	0.9

One can now evaluate the different options:

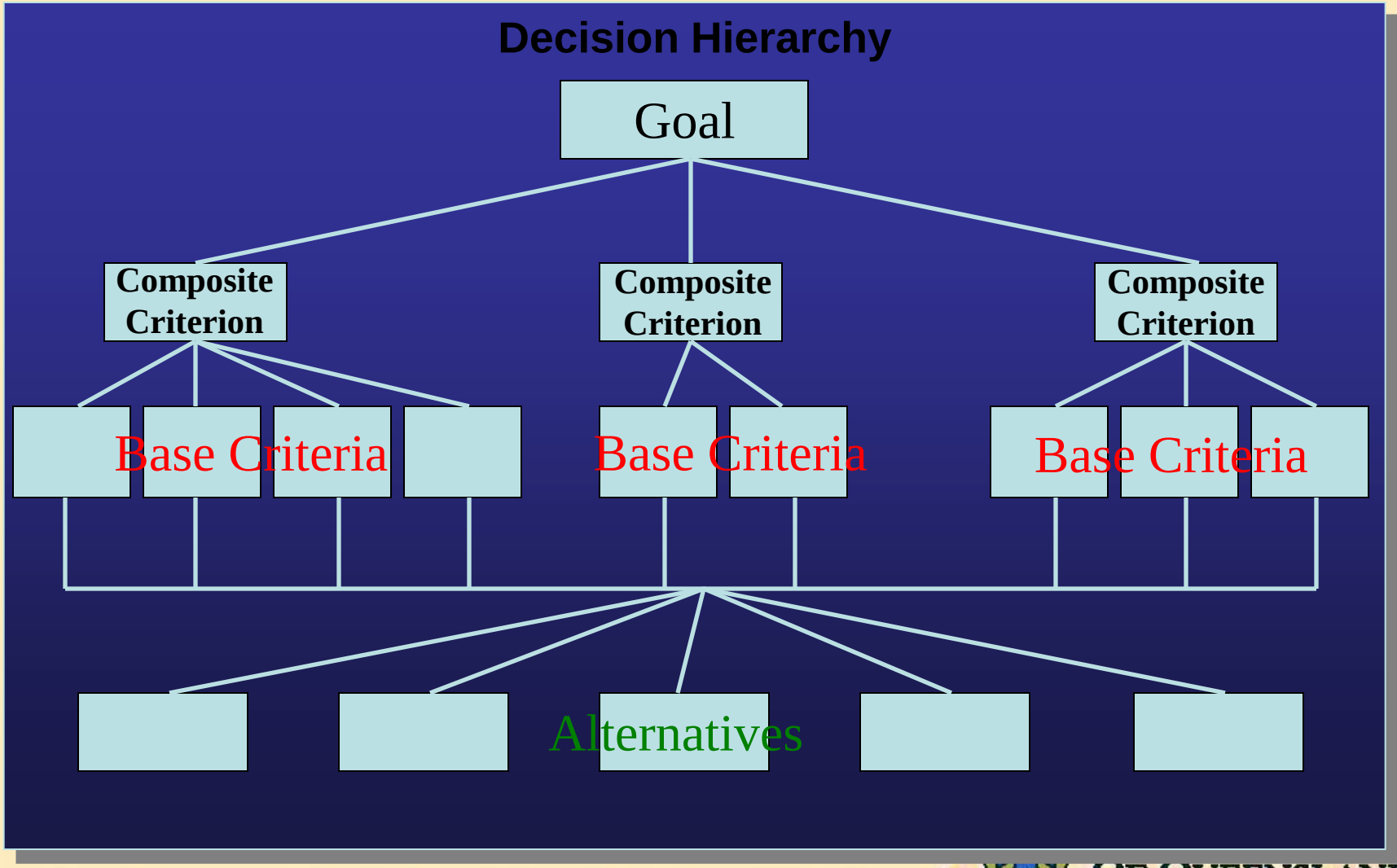
Company 1: 0.4*0.6 + 0.5*0.9 + 0.1*0.5 = 0.74
Company 2: 0.4*0.7 + 0.5*0.6 + 0.1*0.8 = 0.66
Company 3: 0.4*0.8 + 0.5*0.5 + 0.1*0.9 = 0.66

Overall Score = ∑(Rate x Weight)

MCA Process


Set of Alternatives
Set of Criteria
Decision Table
A1 A2 ….An
C1
C2
.
.
Cn
Criterion Scores
Ratings
DM Preferences
Weightings
Aggregation Functions
Sensitivity Analysis
Final Recommendation

Criteria Hierarchy



Practical

- **MCA Using Catchment Decision Assistant (CDA)**
  - **Uses AHP**
  - **Uses MSExcel to perform MCA**