



# Application of Multi-Criteria Decision Analysis Tools



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# 1



## *Presentation -- Overview*

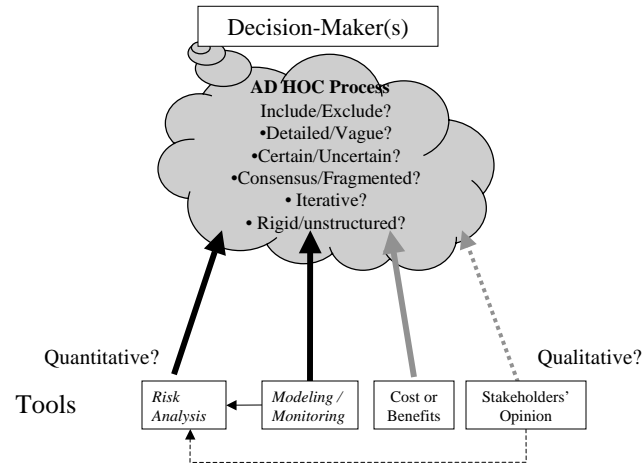


- **Brief Intro to Multi-Criteria Decision Analysis**
- **Examples of Decision Analysis**
  - **Different decisions ...different software ... different approaches**
  - **Estimating weights for multi-criteria**
- **Discussion**

# 2



## Challenges in Current Decision-Making Processes



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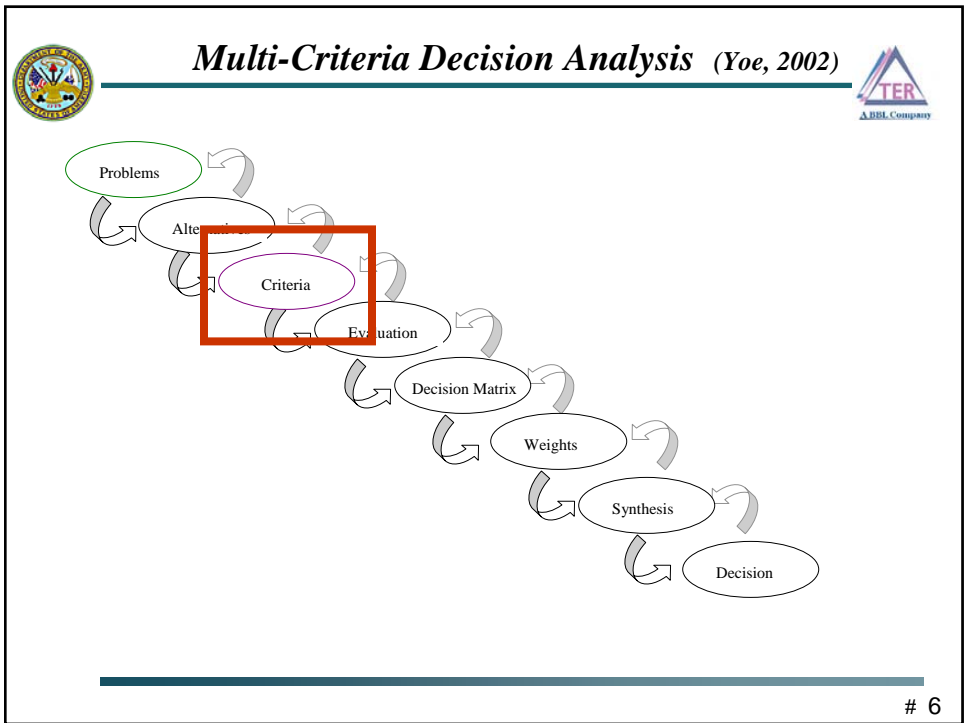
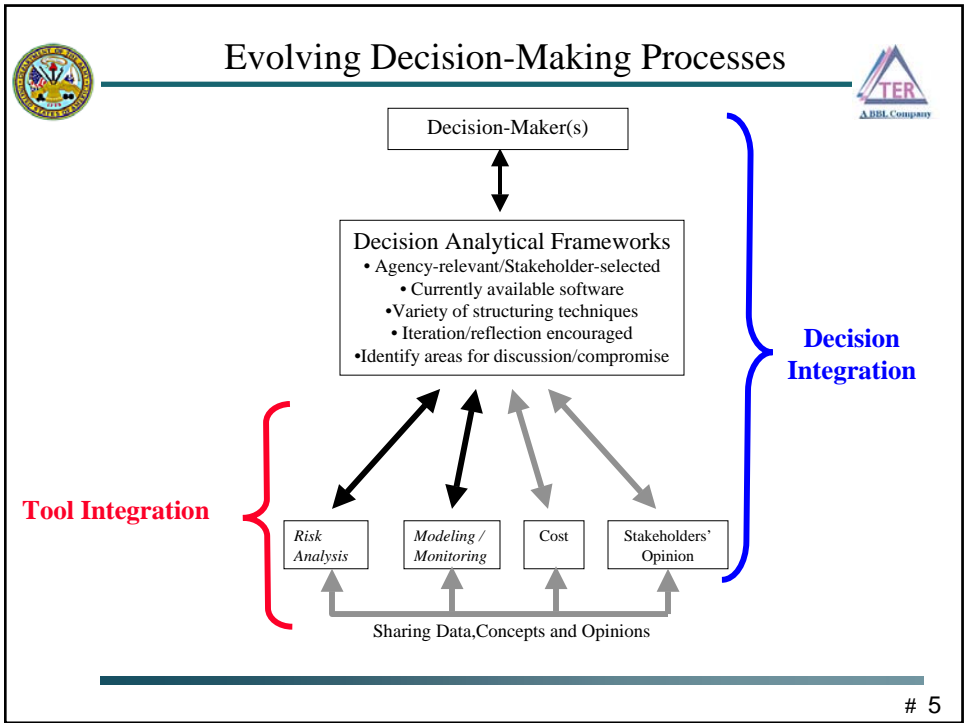


## Challenges to Complex Decision-making



- “Humans are quite bad at making complex, unaided decisions” (Slovic et al., 1977).
- “There is a temptation to think that honesty and common sense will suffice” (IWR-Drought Study p.vi)
- Individuals respond to complex challenges by using intuition and/or personal experience to find the easiest solution.
- Groups can devolve into entrenched positions resistant to compromise

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## Requirements for Decision Criteria



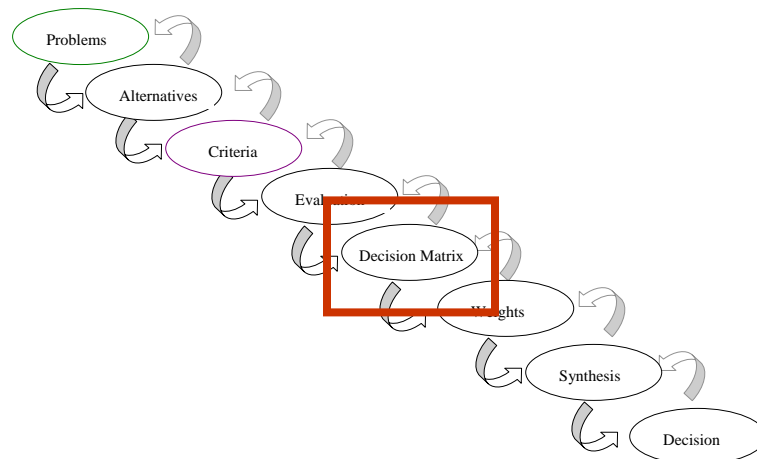
- A coherent criteria set is: (Roy, 1985)
  - Exhaustive (nothing important left out)
  - Consistent (no secret preferences)
  - Non-redundant (no double counting)
- Effective criteria are: (Yoe, 2002)
  - Directional (maximum, minimum or optimum)
  - Concise (smallest number of measures)
  - Complete (no significant impact left out)
  - Clear (understandable to others)
- Criteria are often correlated but can still be acceptable
- Criteria should be tested throughout the decision process



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## Multi-Criteria Decision Analysis (Yoe, 2002)



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## Example Decision Matrix



How to combine these criteria?

	Criteria 1	Criteria 2	Criteria 3	Criteria 4
Alt. 1	How to interpret these results?			
Alt. 2	Monitoring Results	Stakeholder Preference	Economic Cost	Non-monetary benefit
Alt. 3		Stakeholder Preference	Economic Cost	Non-monetary benefit
Alt. 4		Stakeholder Preference		Non-monetary benefit

How to compare these alternatives?



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## Trade-Offs: Giving up one thing to get another



- **Explicit trade-offs**
  - Flood control vs hydropower
  - More of one means less of the other
- **Implicit trade-offs**
  - “Habitat cohesion” vs “enhancing aquatic ecosystems”
  - Terms of trade are not following physical laws
- **Value trade-offs**
  - 100 acres of woodland vs 100 acres of inaccessible wetland
  - Choice may depend on what each person “values”
- *Good trade-off analysis makes the “implicit” things into “explicit” things*



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## *Weights for Multi-Criteria DA*



- **Function =**  
 $a X$  (human health benefit) +  $b X$  (Cost)
- How do we estimate and interpret a, b ?
- Derived from marketing research and environmental economics
- Choice of a method is context dependent
- Process is as valuable as the results
  - Systematically clarifies values
  - Identifies areas of consensus/disagreement

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## *Composite Example*



- **PRP Group developing set of potential remedial actions and a recommendation:**
  - Dredge, off-site
  - Dredge, CDF on-site
  - Cap
  - Monitored natural attenuation
- **Alternative must satisfy regulators, PRP members, outside stakeholders**
- **Conduct a probabilistic cost estimate & multi-criteria decision analysis**

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## Framing Meeting for DA



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## Qualitative Stakeholder Summary

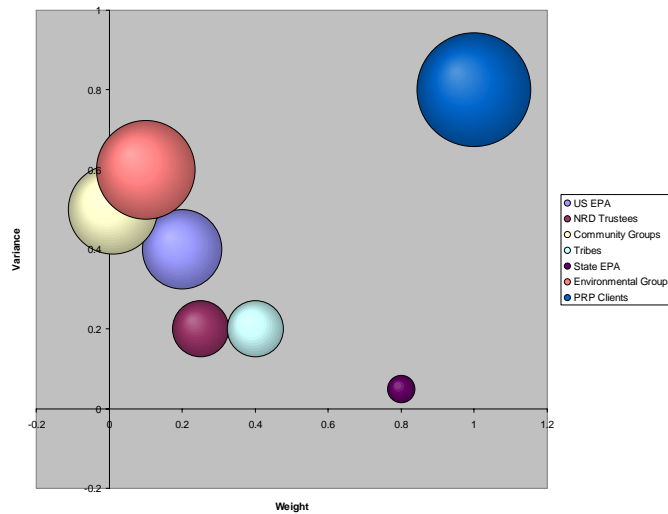


Stakeholder	Specific Stake	Strengths	Weaknesses	Expected Behavior
EPA				
State EPA				
NRD Trustees				
Native American Tribes				
PRP Clients				
Environmental Groups				
Community				

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## Stakeholder Weights



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## Explicit Weights Estimates



Attribute	Weight
Business Impacts	0.1
Stakeholder Acceptance	0.2
3 <sup>rd</sup> Party Lawsuit	0.3
Remediation cost	0.4
<b>Total</b>	<b>1.0</b>

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## *Explicit Weights*



- **Can incorporate many attributes and levels.**
- **Good for estimating absolute weights**
- **Very context dependent (i.e. the current relationship among attributes and their levels)**
- **Respondents tend to overweight non-decision attributes**
- **May incorporate yea-saying**
- **Fatigue can affect results**
- **Good for indicating attribute levels that have the same weight**
- **May have “units” problem**

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## *Rank Based Weights*



- **Focus on differences in levels between pairs, not the absolute levels themselves**
- **Respondents give more weight to quantitative variables (e.g. cost)**
- **Tends to give more weight to negative items (e.g. risk averse)**
- **Values tend to be more abstract and free from experience and reference point bias**
- **Respondents most prone to use simplification, only a few attributes will be important**

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## Trade-off Question



	Alternative A	Alternative B
Business Impacts	None	Local, temporary negative effect (4)
Stakeholder Acceptance	Low (1) – contentious, frequent public meetings	Low (1) – contentious, frequent public meetings
3 <sup>rd</sup> Party Lawsuit	60% chance – expected costs \$2,000,000	20% chance – expected cost \$500,000
Remediation cost	\$75,000,000	\$10,000,000

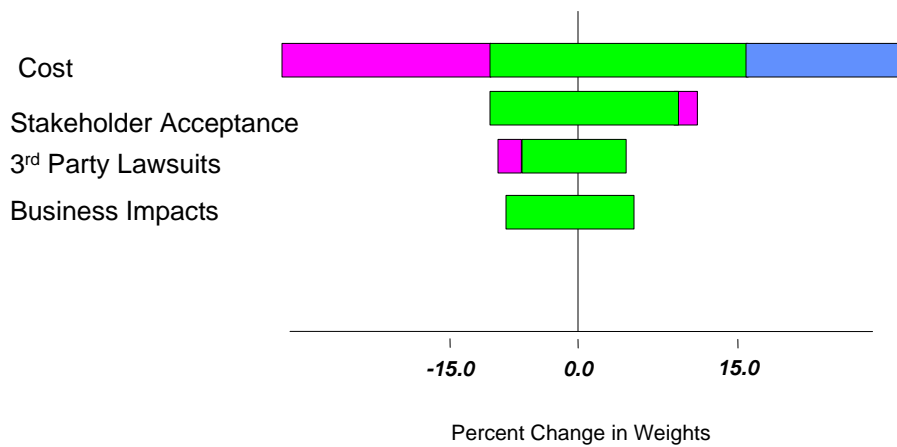
Which strategy has an outcome that is best for the PRP Group?

A is much better than B	A is better than B	A and B are about the same	B is better than A	B is much better than A
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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## Weight Sensitivity Analysis



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## Summary: Essential Decision Ingredients



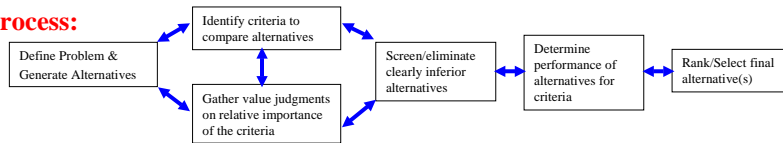
### People:

Policy Decision Maker(s)

Scientists and Engineers

Stakeholders (Public, Business, Interest groups)

### Process:



### Tools:

Environmental Assessment/Modeling (Risk/Ecological/Environmental Assessment and Simulation Models)

Decision Analysis (Group Decision Making Techniques/Decision Methodologies and Software)

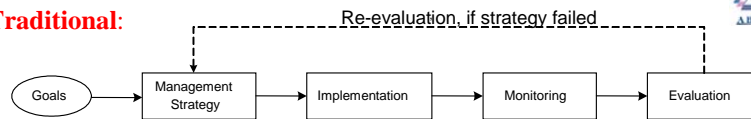
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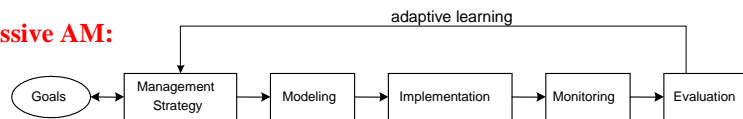
## Upcoming Research: MCDA & Adaptive Management



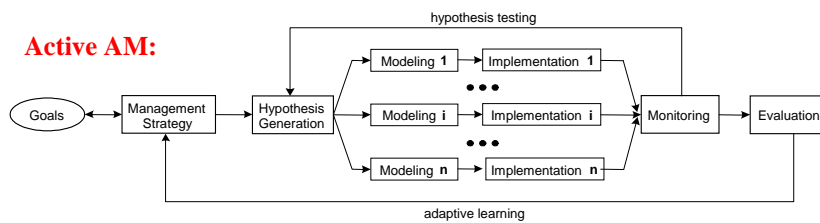
### Traditional:



### Passive AM:



### Active AM:



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## *Discussion/Summary*



- **Ongoing Risk and Decision Analysis Research in USACE-ERDC**
  - **Dredging Operations and Environmental Research**
    - ◆ **Linking comparative risk assessment and decision analysis**
    - ◆ **Environmental Windows for Dredging**
  - **“System-Wide” Integrated Water/Sediment/Ecological Modeling**
    - ◆ **Risk and decision analysis for ecological restoration**
  
- **Including multiple criteria can improve decision making**
  - **Provides a systematic approach**
  - **Makes explicit what had been implicit**
  - **Approach varies with decision problem**