

Decision Analysis: Components, Tools and the Interface with Science

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Components of Decision Analysis

1. Stakeholder Values, Preferences and Objectives

→ MCDA: Multiple Criteria and their Elicited Weights

→ Environmental, economic, ethical-equity . . . *often hierarchical*

2. Decision Options: Alternative Management Plans

3. Models to predict Decision Options → Outcomes

→ Statistical, mechanistic, conditional probability (*expert judgment*)

→ Scientific validation, sensitivity and uncertainty analysis

4. Preferred Decision Option(s) *e.g., portfolio*

→ Sensitivity to (a) scientific uncertainty and (b) stakeholder values & weights

(a) Value of Information for new science (*obtained through adaptive management?*)

(b) Deliberation & further option exploration among stakeholders (*on Pareto surface?*)

5. Ongoing analysis, deliberation and adaptive management

→ Monitoring, scientific study, stakeholder deliberation

VOI for consensus building

Selected Tools of Decisions Analysis

1. Risk Assessment: Risk \sim Scenario \rightarrow Consequences \rightarrow Likelihood

2. Environmental Health Risk Assessment

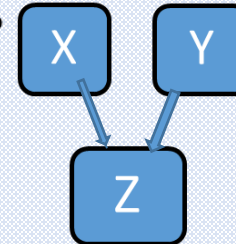
Source \rightarrow Fate & Transport \rightarrow Ambient Impact \rightarrow Exposure (Dose) \rightarrow Response \rightarrow Risk Characterization

Ecological Risk Assessment focuses on vulnerability, resilience and sustainability of populations and ecosystems

3. Systems Modelling

How are relationships among components specified?

How do X and Y affect or influence Z?



1. Empirical equations, $z = f(x, y)$

(e.g., regression equations: $z = a + b_1 \cdot x + b_2 \cdot y$)

2. Mechanistic models and equations (e.g., energy, mass or cash flow balance)

a. analytical, numerical, optimization-based: deterministic or probabilistic

b. parameterized based on first-principles, fit to observations, expert judgment

3. Conditional probability relationships for $\text{Prob}(z | x, y)$

a. Fit using models from 1 and 2 above or elicitation/survey results

4. Scenario Analysis: Identify plausible outcomes for system variables, not sure which will occur, but are the proposed management plans robust to which does?

Tools of Decisions Analysis (Cont.)

5. Event and Decision Trees: Identify scenarios of what could happen (given alternative management options), their probabilities, and valuation. Best decision maximizes expected (net present) value.

→ Provides a bases for VOI

6. Human Behaviour and Economic Valuation

→ Normative Models: what rational people should do (with perfect information, and math skills) to maximize their expected value

→ Behavioural (or “positive”) Models: what people actually do, with limited information and bounded rationality

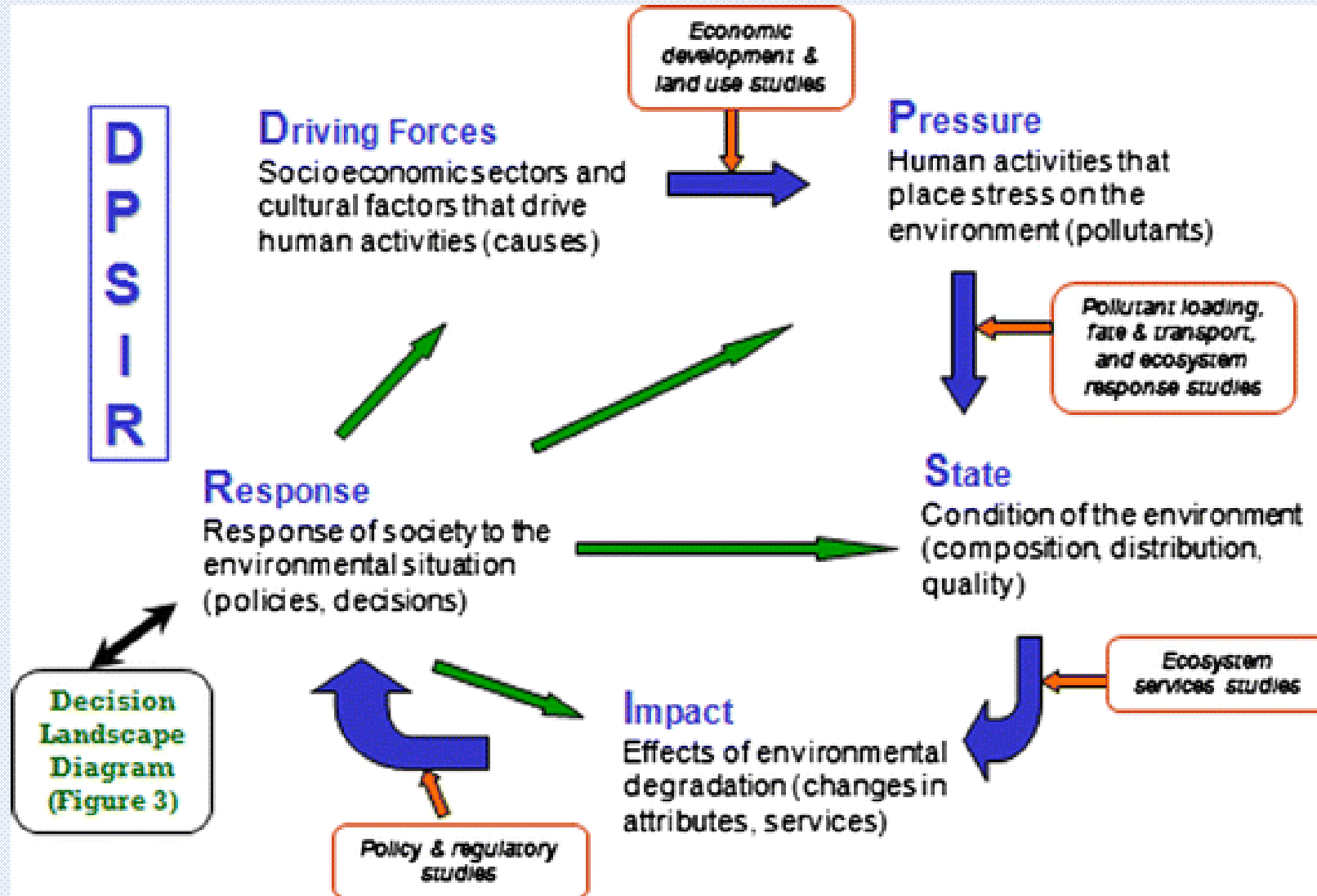
→ Benefit-Cost or Cost-Effectiveness Analysis

→ Monetization of Outcomes: Hedonic (market), ecosystem services, contingent valuation, willingness to pay

7. Multicriteria Decision Analysis

8. DPSIR . . . with scientific input and VOI explicitly addressed

Consider DPSIR, with Scenarios and Scientific Studies (VOI)



Value of Information (VOI)

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(1) Scientific: *Knowledge*↑ *Uncertainty*↓

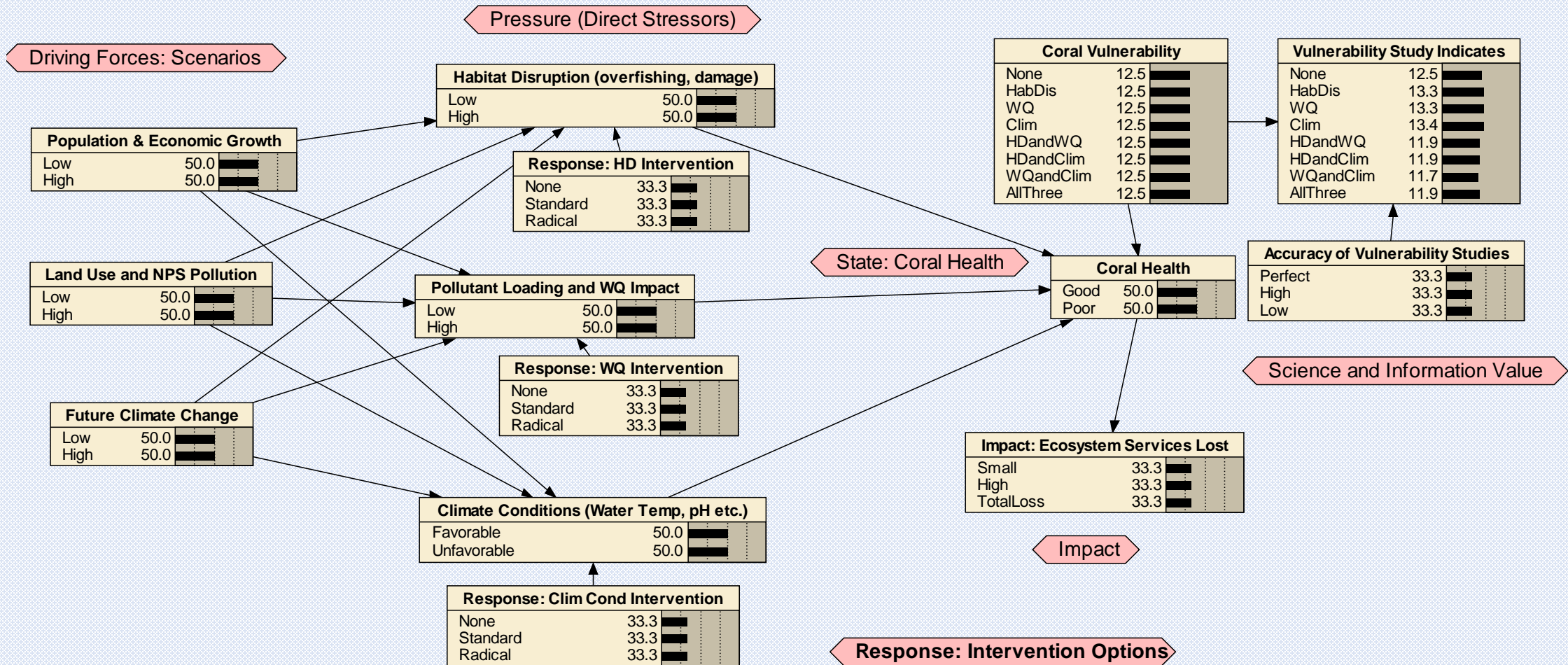
→ Variance of predicted outcome decreases

(2) Decision Analytic: Uncertainties *that matter* to choices among decision options:

Expected increase in value of optimal decision informed by information, compared to choice made under pre-information (prior) state

(3) In a scientific-stakeholder analytic-deliberative process
Value of Information for Conflict Resolution

DPSIR BBN

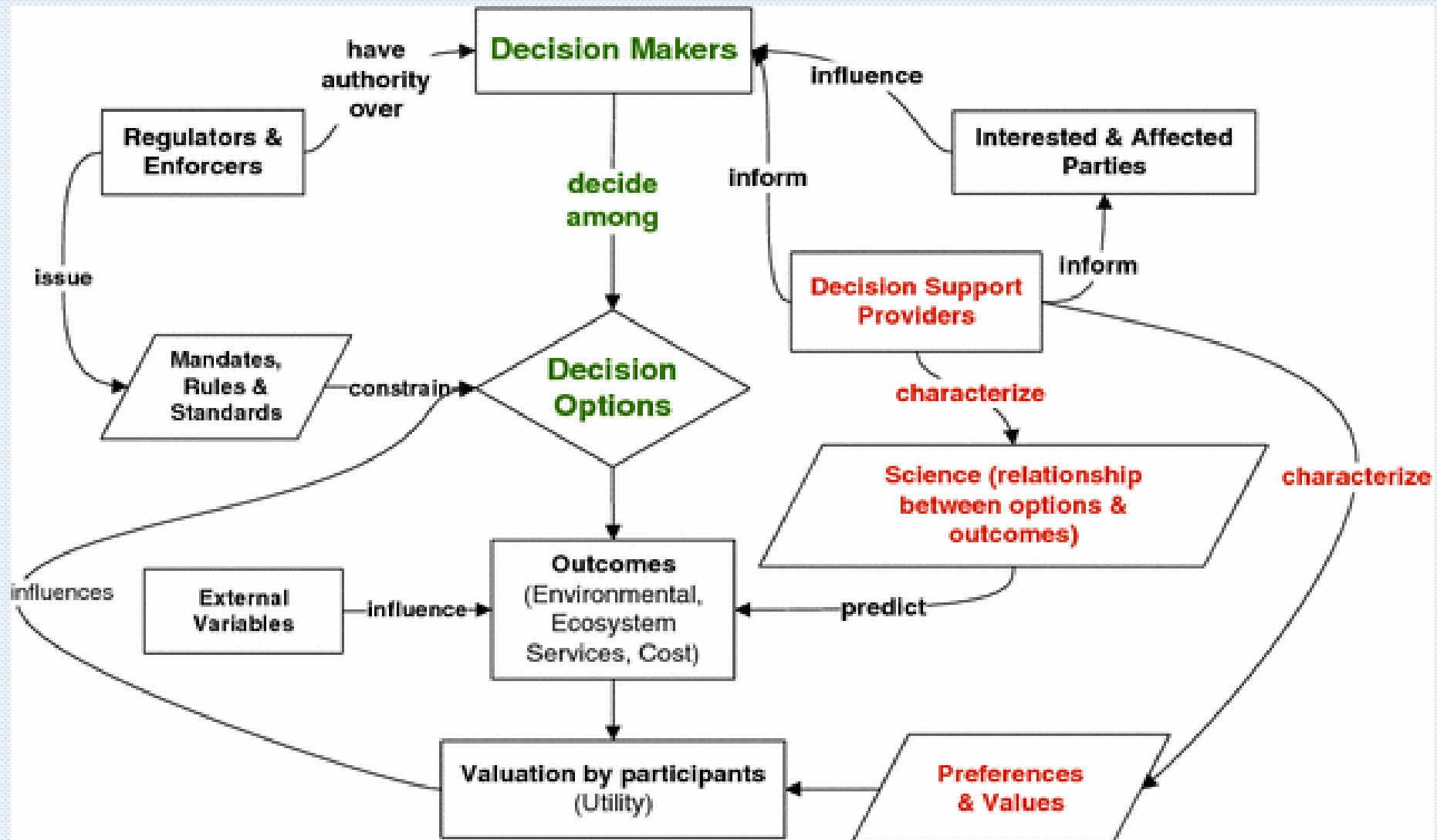


Scientific Studies of Different Accuracy

(Load Network)

BACKUP SLIDES

DPSIR Decision Landscape Diagram



Sensitivity and Uncertainty Analysis

Modelling tools - SA/UA

❖ **Sensitivity analysis**

determining the amount and kind of change produced in the model predictions by a change in a model parameter

❖ **Uncertainty analysis**

an assessment/quantification of the uncertainties associated with the parameters, the data and the model structure → calculated uncertainty for model predictions