Decision Support and Integrated Modelling Approaches for Assessing Climate Change ‘Impacts’

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Main points of the talk

- About DSS
- Modelling frameworks versus Tools
- Guiding selection of an integrated modelling framework
- Examples
- Hydrological needs for ‘impact’ assessment
What is a DSS?

- A computer based system that **supports** decision making
- Three main components:
  - Data base
  - Model base
  - Interface plus
  - Simulation/optimisation engines
  - Visualisation tools
  - Documentation esp. assumptions
Will a DSS help you?

- An ideal Environmental DSS should:
  - assist in decision making for unstructured and semi-structured tasks
  - explore and explain tradeoffs
  - facilitate integration, understanding and adoption – build trust
  - help identify gaps
  - be flexible, adaptable and easy to use
Developing a DSS: essential steps

• Identification of use and users
• Resource specifications
• Design and function specifications
• Technical specifications
• Prototype system
• Delivery points
• Implementation support inc training
Integrated Assessment (IA) is the interdisciplinary process of integrating knowledge from various disciplines and stakeholder groups in order to evaluate a problem situation from a variety of perspectives and provide support for its solution.

IA supports learning and decision processes and helps to identify desirable and possible options.

It therefore builds on two major pillars: approaches to integrating knowledge about a problem domain, and understanding policy and decision making processes.

» www.tias-web.info
Simplified Modelling Process

Scenarios
Assumptions
- Climate
- Episodes
- Demography
- Policy drivers
- External drivers

Environmental System

Sustainability indicators
- Economic
- Social
- Environmental
Decision Making Process for NRM Problems

1. Identify Objectives
2. Problem Framing
3. Identify Performance Measures
4. Identify Alternatives
5. Evaluate Alternatives
6. Rank/Select Final Alternative
Model conceptualisation
- issue definition and policy options
- system boundaries and definition of uncontrollable drivers
- human activities
- scales
- nodes and regions
- processes
- interactions
- indicators

Policy environment knowledge and information (stakeholder)

Tradeoffs and impacts

Scientist knowledge and information
- data for calibration and parameterisation
- technical and scientific knowledge
- process skills
- communication skills

Stakeholder system knowledge and preferences
<table>
<thead>
<tr>
<th>Step</th>
<th>Tasks involved</th>
<th>Tools</th>
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| 1. Identify objectives | • Identify issues, concerns  
• Build consensus on the problem(s) to be addressed | • Participatory methods |
| 2. Problem framing | • Understanding the problem(s)  
• Define boundaries/scope | • Exploratory analysis  
• Visualisation tools (e.g. conceptual models, mind maps)  
• Participatory methods |
| 3. Identify performance measures | • Identify criteria to be used to compare and evaluate alternatives  
• Gather value judgments | • Participatory methods |
| 4. Identify alternatives | • Identify potential management options based on objectives | • Participatory methods  
• Scenario tools |
| 5. Evaluate alternatives | • Evaluate each alternative based on how it is predicted to affect the performance measures  
• Explore tradeoffs  
• Narrow options | • Predictive/Simulation models (e.g. disciplinary tools)  
• Integrated models (e.g. Bayesian networks, coupled component models, system dynamics, hybrid expert systems)  
• Expert elicitation  
• Optimisation tools (e.g. heuristic search methods, optimisation models, pareto-optimal tradeoff curves)  
• Decision trees |
| 6. Rank/select final alternative | • Compare and rank different outcomes  
• Select satisficing option | • Multi-criteria analysis  
• Cost-benefit analysis  
• Bayesian decision models  
• Participatory methods |
Main types of integrated models with different strengths and weaknesses in particular situations:

- Systems dynamics
- Bayesian networks
- Coupling complex models
- Agent-based models
- Hybrid expert systems
Bayesian Networks

- A fundamental modelling tool for decision-making and management where wide-scale knowledge integration and uncertainty are key considerations.

- Use conditional probabilities to determine likelihood of different outcomes.

- Conditional probabilities derived from:
  - Many (1000’s) of runs of component models
  - Expert elicitation
  - Stakeholder surveys
  - Observed data – categoric and numeric

Special Issue, Env Mod. & Software, Vol. 22(8), 2007
Bayesian Decision Networks

- Management decisions
- Decision Variable
- State Variable
- Environmental indicator(s)
- Cost/benefit to society &/or environment

- Increase: 0.1
- No change: 0.2
- Decrease: 0.7
Coupling Complex Models

- Direct combination of complex models from different disciplines
- Can be loosely coupled or fully integrated
- Require comprehensive model testing to understand data and model structure uncertainty: ‘single answer’ for each run
- Can facilitate very complex scenarios
- Restricted to a small number of component complex models

Hybrid expert systems

- Component models of different mixed types

- Example types:
  - expert (e.g., linguistic, rule-based, decision trees)
  - Statistical/empirical e.g., regressions
  - BNs
  - complex computational models
  - metamodels

- Flexible but requires broad base of technical competence

- Limited availability of technical platforms
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Integrated Modelling Examples

- **Hydroeconomic tradeoffs and management**
  - Coupled complex – water allocation: ag productions vs env flows (WAdss)
  - Coupled complex – management of water quality (CATCHMODS)

- **Coastal Lakes Assessment & Management (CLAM)**
  - Bayesian Networks for triple bottom line assessment

- **Water Quality Improvement Planning**
  - Hybrid expert system for Catchment Planning and Estuary Response (CAPER)

- **Climate change and Catchment Planning: Central West CMA**
  - Bayesian Network (EXCLAIM) for exploring impacts of climate change on aquatic resources

- **Wetland Allocations: Gwydir and Narran (IBIS)**
  - Hybrid expert system – integrated hydrology and hydrodynamics with BNs & other simple models for ecology
CCI-related work

- DSS Frameworks for economic-social-environmental assessments (CLAM dss)
- DSS for identifying water quality and ecological improvement options (CAPER dss)
The NRCMA CLAM project

- Assessed the sustainability of 16 coastal systems in the Northern Rivers CMA region
- A *Coastal Lakes Assessment and Management (CLAM)* decision support tool was developed for each system
- Aimed to assist decision-making that will maintain, and where possible enhance, the economic, social, cultural and ecological values of these systems
- Capacity built with accredited local consultants

Recognised by Environs - the Local Government Environment Network - with a 2007 Silver Environs Award in Outstanding Sustainability Partnerships; and the 2007 Gold Environs Award in Outstanding Sustainability Leadership.
CAPER – the Great Lakes DSS

- Was used by iCAM and the Great Lakes Council to negotiate water quality improvement plans (WQIPs) for the Great Lakes region of NSW with Federal, State and Local Governments as well as community and environment groups.

- Plans will guide future management of the catchments by identifying what action(s) are required to meet the required ecological condition of the lakes.

- Plans provide a framework for the implementation of water quality improvement actions that are linked to statutory planning and other decision-making processes, and guide investment by all parties.
Great Lakes DSS (CAPER) for CCI

- Catchment Planning and Estuary Response (CAPER) tool
- Integrates outputs from the modelling and management research components of the CCI
  - Summaries of outputs from more complex models
  - Links models and management together to get the “catchment-to-estuary” story
CLAM and CAPER

- Coastal Lake Assessment and Management (CLAM) approach
  - Assess social, economic and environmental trade-offs associated with development, remediation and use options for coastal lakes and estuaries
  - Can be tailored to look at many types of issues: LUMPED HYDROLOGY
  - Provides a platform to share knowledge, discuss management options, understand the wide range of values within a coastal catchment and identify common goals

- Catchment Planning and Estuary Response (CAPER)
  - Relationship between catchment management to nutrient and sediment inputs to estuaries: DYNAMIC HYDROLOGY
  - Links estuary response to catchment inputs
  - Much tighter focus than CLAM

- Although a very different tool to CLAM, there are similarities in the philosophy of the approaches
  - consistent and transparent tool to aid management of coastal estuaries
exploring climate impacts on management
Water flows
- Irrigation and environmental needs
- ‘High’ security requirements

Water quality
- Salinity
- Nutrients

River and wetland ‘health’
- Ecological indicators
  - Algae, Vegetation, Birds, Fish

Bayesian Network fed by flow scenarios: LUMPED
User-friendly interface overlies the models and provides access to supporting information, model documentation and model results.

*Designed to support environmental flow decision-making (short and long term)*

Integrated hydrology-hydrodynamics-BNs & other simple models for vegetation, fish & birds.
Integrated Model Structure: Bird model only

- Continuous daily hydrology model
- Characteristics of ‘event’ passed through discrete probabilistic response models
- For each event: the likely success of an outcome
Hydrologic needs for assessing ‘impacts’

- Scenarios of climate change

- Long time series with realistic properties: inc. cross correlation and autocorrelation, length of dry spells (climate generator?)

- Integrated hydrologic-hydrodynamic-ecosystem response models of varying complexity

- Focus on vulnerability – those plausible scenarios (and related impacts) that inform planning, mitigation and adaptation

- Capture predictive uncertainty better and equilibrate model components concentrating on weakest aspects
Catchment-Scale Management of Distributed Sources (CatchMODS) Model

- Integrated hydrologic, sediment and nutrient export model developed with simple economic costs component
- Scenario-based
- Enables the biophysical and economic trade-offs associated with management of diffuse source pollution to be explored
- Modelling supported by close end-user participation
- Readily accessible via an end-user interface
Assessing Tradeoffs

Lower Campbells River subcatchment
Channel remediation options

- Riparian zone
- Severe gully
- Moderate gully
- Minor gully

Sediment yield (t) vs. Cost ($)

0 20000 40000 60000 80000 100000

Cost ($)

50000 51000 52000 53000 54000 55000 56000