

A Bayesian approach to Participatory Integrated Water Resource Management

Dr John Bromley+, Dr Caroline Sullivan+ and Muriel Bonjean+
 + Water Management and Policy Group, Oxford University Centre for Water

Research

Summary

Integrated Water Resource Management (IWRM) is the key to the sustainable development of water resources. But this approach means that decisions must be considered not only in environment terms but also in the light of their economic, social, and political impacts. The problem is to find a way to link these factors together. To meet the challenge MERIT developed an integrated water resource management with three main objectives:

- To take the concept of Bayesian Networks (Bns) and adapt it for use in IWRM. Networks have been used successfully for many years in other fields such as Medicine and Artificial Intelligence
- To use the Bn as a focus for stakeholder engagement
- To construct demonstration networks in 4 European catchments in the UK, Denmark, Spain and Italy



Stakeholder engagement using Bns

MERIT investigated the way in which Bns could be used to help the process of stakeholder engagement. The strengths of the approach are:

- Graphical nature:** The graphical presentation of the technique means it is easy for stakeholders to visualize the problem
- Focus:** Networks provide a real for stakeholder meetings
- Ownership:** Stakeholders are encouraged to help construct the network identifying factors and links they perceive to be of importance to them; this provides a sense of ownership of the network, making it more likely that subsequent decisions will be accepted
- Transparency:** Networks make the decision making process transparent
- Explicit Representation of Uncertainty:** The uncertainty involved in the decision making process is explicitly represented in a graphical fashion
- Social Learning:** Because the technique is transparent, inclusive and easy to visualize networks provide an excellent way to promote better understanding of the problem by the stakeholder

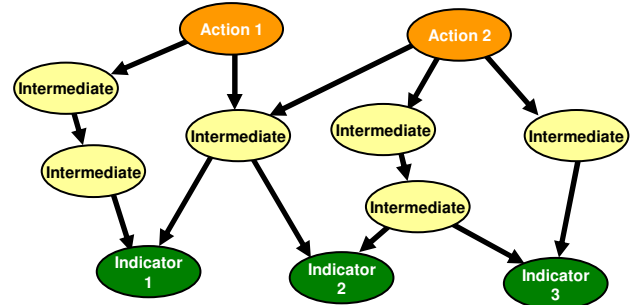


Methodology

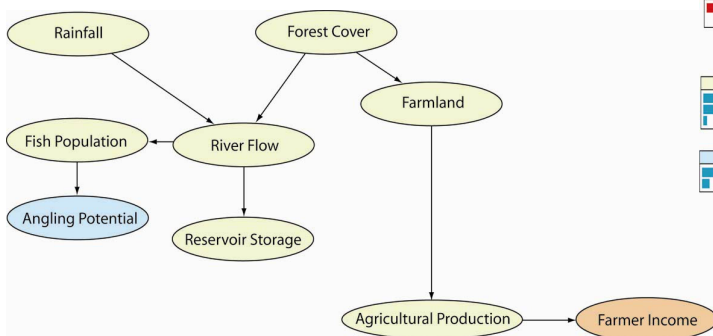
Bayesian Networks can be used to represent an environmental system (e.g. catchment) as a networks of nodes (variables) and links

- Nodes represent variables which are identified by the stakeholders to be relevant to the problem
- Variables can be of any type, environmental (e.g. river flow), economic (e.g. farm income) or social (e.g. amenity value)
- Links connect variables to denote cause and effect; i.e. when the state of one variable is changed those linked to it also change state. The change takes place in the direction of the link
- The states of nodes are represented as probability distributions
- The responses of the network are driven by Conditional Probability Tables (CPTs) constructed for each linked variable
- CPTs are based on the best data available; this may be data sets, model outputs or expert opinion
- Networks usually consist of a set of actions or scenarios and a set of objective (indicator) nodes which respond to changes in the actions or scenarios. Actions and objectives are linked by intermediate nodes that represent the processes being simulated.
- Results are presented graphically as a series of probability distributions for each of the variables

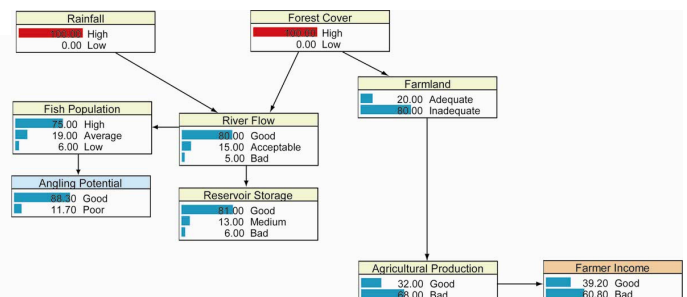
Form of a typical network



Uncompiled



Compiled



Simple Bayesian Network showing (a) Uncompiled and (b) Compiled version.

Note the state of variables in the Compiled version, e.g. Farmer Income is given as a probability distribution, reflecting the uncertainty of the data.

Contact:

Dr. John Bromley, john.bromley@ouce.ox.ac.uk