

Characterize, Incorporate and Communicate the Uncertainty in Climate Change Policy Analysis: a Bayesian Network approach

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FEEM Milan, 25 February 2010 The choice of optimal mitigation and adaptation polices often implies a "hard" decision (Clemen and Reilly, 2001):

Complexity of the issue; Multiple objectives and different perspecitives; Inherent uncertainty in the situation.



Uncertainty and climate change policy (2)



BN approach

Aleatory uncertainty



1.3 Uncertainty and climate change policy (3)

Three-step approach (Morgan, 2008)





BN approach

Probability Chain Rule ("non-graphical"): p(A,B,C,D) = p(D|C,B,A)p(C|B,A)p(B|A)p(A)

Using the BN: p(A,B,C,D) = p(D|C,B) p(C|A)p(B|A) p(A)

Because of the conditional independencies defined by this BN, now: p(D|C,B,A) = p(D|C,B) and p(C|B,A) = p(C|A)





Bayesian network (1)



Predictive or diagnostic probability calculation (eg. P(D=d | A=a))

Updating a prior conditional probability distribution describing a relationship between parent and child nodes, to obtain a posterior probability distribution

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$$P(h \mid e) = \frac{P(e \mid h)P(h)}{P(e)}$$



Bayesian *Decision* network



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Case study: the lagoon of Grado and Marano



Two phases, both built upon processes of <u>expert judgment</u> <u>elicitation</u>

1st phase: Conceptual modelling

Group elicitation of a shared conceptual model of the system (workshop)

Definition of the BN structure (Controlling factor; Decision nodes; Chance nodes; Value nodes)

2nd phase: BN modelling

- Individual elicitation of probabilites (questionnaires)
- Population of the CPTs
- Policy analyses
- Uncertainty analyses

BN approach



BDN (1): Salt Marshes



BDN (2): Beach Nourishment



3.4

Compiled BDN (e.g.1): +30cm No Adaptation



3.5

Compiled BDN (e.g.2): 30cm Salt Marshes



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Compiled BDN (e.g.3): 30cm Beach Nourishment



Analyses

Policy analysis: assessment of adaptation alternatives comparing the aggregate and sectoral expected losses/gains.

Local uncertainty analysis: effects on the outputs of variating one input node at a time; identification of the most influential variables;

Global uncertainty analysis: assessment of the variability of the outputs arising from the simultaneous variation of the nodes' CPTs;

Uncertainty in SLR scenarios: introduction of a likelihood evidence in SLR scenarios, to draw a prevision of the effects on the outputs



BN approach

Policy analysis: aggregate outputs



BN approach

Policy analysis: sectoral outputs



Local Uncertainty Analysis (1)





BN approach

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Global Uncertainty Analysis



Likelihood evidence



Conclusions

The **BN tool** emerges as a **synthesis model**, which helps to:

integrate knowledge and data from different fields in a single framework of analysis

enhance the **interaction** among the experts, and the communication between science and policy

assess alternative "what-if" management approaches structure policy recommendations and identify optimal policy choices

take into account key uncertainties in models' hypotheses and outputs

characterise the uncertainty of the models' hypotheses and outputs in a stochastic framework;

- incorporate the uncertainty into Bayesian models through *sequential* updating processes (ADAPTIVE management) and local/global uncertainty analyses
- communicate the uncertainty to policy makers through the BNs' user-friendly graphical interface.

Thank you

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