

# EX-POST ASSESSMENT OF AGRI-ENVIRONMENTAL MEASURES IN THE VENICE LAGOON WATERSHED

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## Introduction

A new methodological framework was designed to assess the effectiveness of agri-environmental policy measures adopted to reduce diffuse water pollution of agricultural origin. Two already existing methodologies were combined in a new flexible approach for policy assessment: Conceptual Modelling and Bayesian Networks (BNs). The former supported the development of a shared conceptual model (a cognitive map) of the agro-ecosystem; while the latter allowed the development of a probabilistic model coherent with the cognitive map. BNs were selected because they allow analyses with scarce data, can be updated when further information becomes available and are easily understandable by layperson. The paper reports the results obtained in the Venice Lagoon Watershed (VLW) case study, assessing the current agri-environmental measures in order to identify their effectiveness in terms of reduction of nitrogen releases to safeguard the lagoon ecosystem.

## Materials and Methods

The methodological framework set up for the VLW case study follows the scheme presented in Fig. 1. An already existing cognitive map, developed in a previous participatory modelling workshop (Giupponi et al., 2008), provided the conceptual model of pollution phenomena coherent with the DPSIR framework (EEA, 1999). A semi-structured procedure developed by Nadkarni and Shenoy (2004) was applied to transform the cognitive map into the BN structure. This structure was filled with conditional probabilities elicited from experts by means of a structured protocol. Through an ad hoc questionnaire and a face-to-face interview, the involved experts compiled discretised prior conditional

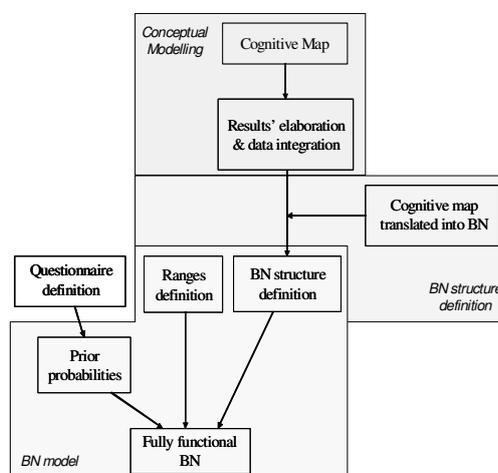


Fig. 1 – Framework built for the application of the innovative approach.

probability tables (CPTs) for each node of the BN. Equal-weighted average aggregation (Clemen and Winkler, 1999) of multiple experts prior probabilities, was followed by an in depth uncertainty analysis to assess the effects of experts' subjectivity on the outputs. The result is a fully functional BN allowing policy assessment through the integration of information about the policy measures and the environment: financial resources and farmers' applications (administrative area of the BN); agricultural and hydrological variables (environmental area). Subsequently the BN was updated including the evidences acquired in a parallel project that applies an hydrological mechanistic model.

## Results

Results obtained seem to contradict the VLW policy assumptions in terms of environmental objectives of the proposed measures, which were indeed ambitious: less than 10 kg N ha<sup>-1</sup> of nitrogen load in surface waters. This level considers the agricultural contribution, 50% of the 3000 Mg N y<sup>-1</sup> that is the target value of the total N load in the Venice Lagoon. Results obtained with experts' judgements (see Tab. 1 – Prior BN) show that agri-environmental measures have limited expected effects to achieve policy objectives: 66% probability to obtain levels of N loads higher than the target. Conditional probabilities updated with the preliminary outputs of mechanistic modelling provide new evidences for the BN showing that the level of N load in surface waters may be even higher and beyond 22 kg N ha<sup>-1</sup> with a high probability, 63% (see Tab. 1 – Updated BN).

In terms of policy effectiveness, the results of the BN model implemented in the VLW support the hypothesis that the current mix of measures and implementation levels do not allow achieving the water quality targets in surface waters. Moreover, results are not influenced in varying probabilities distribution into the administrative area of the model, as deeply studied through the uncertainty analysis, because probability propagation does not reach the target variable (i.e. nitrogen load in surface waters).

Tab. 1. The average probabilities of the nitrogen load in surface waters (target variable): prior and updated BN.

Ranges (kg N ha <sup>-1</sup> )	Prior BN	Updated BN
From 4 to 10	34%	12%
From 10 to 22	38%	25%
More then 22	28%	63%

## Conclusions

Results of modelling support the idea that the proposed framework is a promising tool when only limited data and scientific information are available. BNs confirmed also their potentials for supporting integrated – economic, environmental and social – assessment. It is important to highlight that the obtained results are the outputs of a preliminary methodological test, therefore, they should be considered as exploratory and not yet ready for supporting revisions of current measures or future policy suggestions. Anyway, they could be useful for reflections about current strategies, data availability, and the feasibility of quantitative assessment of expected effects of the measures. At this regard BNs emerge as promising tools for combining various sources of knowledge (models, experts, databases) within the same probabilistic modelling framework. Further investigations are needed regarding the limited probability propagation, which could be due to the high numbers of variables interposed between the administrative nodes and the target, and/or the CPTs of interposed variables that smooth the effects of changing. Both problems show interesting relations with the assessment issue and stimulate discussions about the effectiveness of the measures.

The BN model briefly presented herein shows also potential for future re-use. The model, updated with the evidences emerging from ongoing monitoring and modelling efforts, will indeed allow not only ex-post assessment of policy measures, like this case, but also ex-ante evaluations and, very importantly, with associated documentation of their uncertainty.

## References

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