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# Water Quality Assessment in the Venice Lagoon Watershed with Multiple Modelling Approaches

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**Abstract:**
Over the last 20 years a series of research projects analysed water quality issues of the Venice Lagoon and its watershed (VLW). The policy framework was related to the implementation of the Italian special law for the safeguarding of Venice and a series of European regulations, including the Nitrate and the Water Framework directives and the Common Agricultural Policy (CAP). The main focus was on diffuse pollution from agricultural sources - nitrogen and phosphorous in particular - with the aim of assessing the impacts of current and alternative cultivation and livestock practices. Many different modelling approaches were adopted, ranging from cognitive mapping for expert knowledge elicitation, to deterministic mechanistic models at different scales and Bayesian Belief Networks.
One general evidence of the long term research efforts is that there is not a single or best modelling solution to the water management issues of the VLW. Instead, trade-offs between different approaches are always evident, for example in the data needs, management of complexity and uncertainty, on one side, and knowledge transfer, communication and policy support on the other. Therefore, integration of multiple models is required. In particular a two step procedure is suggested for combining qualitative and quantitative knowledge and tools within a participatory process for policy and decision making.

***Keywords**: agriculture; water quality; modelling; policy support.*

## 1 INTRODUCTION

Any human decision is based upon some sort of model. Conceptual models are in our minds to represent our interpretations of reality, we can use concept maps to represent their main elements and causal links and to communicate them to others. We can also evolve these concepts towards functional representation by means of relational diagrams, using symbolic languages, such as stocks and flows, and convert them into systems of differential equations, which can be used to simulate the behaviour of the system we are interested in.
Following John Sterman [2000] we could say that all those models are wrong in that none of them represent perfectly the reality, but at the same time all of them can be useful if they can help solving specific problems with reasonable efforts and without excessive biases and distortions.
Besides the case of system analysis models described above, many other approaches are available such as expert systems and Bayesian Belief Networks

(BBN), which adopt completely different mathematical formalisms and procedures, while sharing the same objectives of representing the – spatial/temporal – variability of a given system, with the ambition of simulating its behaviour under defined assumptions, constrains, etc.
Agriculture is one domain in which field experiments have "always" been integrated with various models with diverse levels of empiricism and mechanicism. This is due to different reasons, but in particular because the agro-ecosystem represents an emblematic example of complex systems where the capabilities of human cognition, interpretation and decision may easily find limits, whenever the state of the system differs from those experienced before by the decision makers (e.g.: farmers, planners, policy makers). Peculiar of agro-ecosystem is the balance between humans and nature, where, contrary to other socio-ecosystems, natural phenomena – climate, biological organisms, biogeochemical cycles – still play the role of main drivers.
Moreover, not only agro-ecosystems require enhanced capabilities by their competent managers to implement approaches at different scales (from the plot to the whole watershed), but also, given the multiple functions played (production of goods, preservation of the environment, recreation and amenities, etc.), they require that decisions be taken through the collaboration of multiple actors with multiple objectives. These issues complicate things further, because the modelling process is not a simple one in which the decision maker/modeller observes the reality, takes decisions, and subsequently analyses effects (feedbacks) to inform and adapt subsequent decision cycles. We have instead multiple decision makers, operating at different scales, with different competences and roles, but all referring to and acting on the same physical reality.
The above raises problems of communication and participation. In the case referred here communication is seen in particular concerning the relationships between the scientific community and policy/decision makers, while participation is in general amongst researchers, experts, technicians and decision makers.
This paper highlights the findings of more than 20 years of research in the field of agricultural land use and water quality in an area of high environmental relevance [Giupponi 1995]. Many different models have been used and we will drive upon those experiences to discuss issues such as complementarity and/or comparability of different approaches and identify synergies, strengths and weaknesses.

## 2 CASE STUDY

Since the late 1980's a series of research projects analysed water quality issues of the Venice Lagoon and its watershed (VLW). The policy framework was related to the implementation of the Italian special law for the safeguarding of Venice and its lagoon, the agri-environmental measures supported by the Common Agricultural Policy (CAP) and other European regulations and directives. The main focus of the policy framework was on diffuse pollution from agricultural sources - nitrogen and phosphorous in particular - with the aim of assessing the impacts of current cultivation and livestock practices and comparing them with alternative ones, already implemented or to be considered by agri-environmental policies; but more comprehensive multi-sector analyses were conducted too, such as the comparison among different sources of pollution.

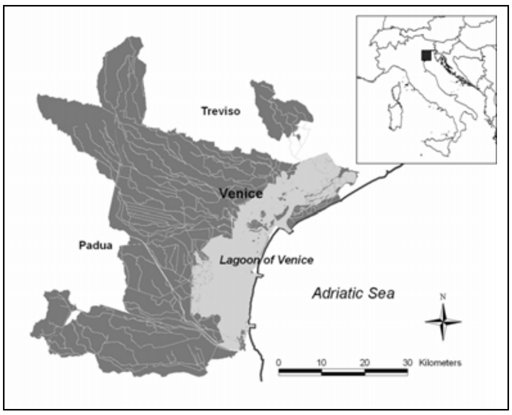

Fig. 1.: The Venice Lagoon Watershed.

The VLW is a portion of the Northern Italy alluvial plain located in the Veneto Region. This area has a surface of about 2038 km$^2$ with 15 sub-basins and around one million inhabitants. The VLW is characterised by a complex and heavily modified hydrological structure of channels and pumping stations. The predominant land use is agricultural (75%), the 65% of which are cultivated lands, and the main crop is maize (56% of the cultivated area). Urban areas represent 15% of the areas while the industrial areas are 5%. Agriculture, with a high level of fertilization, is coupled with an intensive rearing activity, settled in a densely populated area that is also identified as a Nitrate vulnerable zone according to the competent EU Directive (1991/676/EEC).Nutrient loads from agriculture and animal rearing activities are considered to be significant pollution sources: the Master Plan 2000 (DCR n. 24, 2000) estimated the amount of nitrogen from agricultural sources to be about 65% of the total nitrogen generated in the VLW (around 9000 Mg $yr^{-1}$).

National and regional legislations provided financial support to investments for pollution control allowing the building of new sewage systems and treatment plants.

Agri-environmental measures were financed too to support the implementation of good agricultural practices with the overall objective to meet the maximum admissible load of 3000 Mg of nitrogen per year discharged into the lagoon, defined by the competent law.

National and regional policies, legislation and measures, as they evolved over the last decades, provide the framework for assessing the impacts of agricultural activities and the benefits deriving from the planned and implemented actions. Therefore, modelling activities referred herein were in general targeted to the assessment of impacts of agri-environmental measures on water quality as affected by ordinary agricultural management practices and the measures financed.

## 3 METHODS

A long list of approaches and modelling tools have been implemented and can be classified according to eight main categories:

1. Qualitative assessment with expert knowledge elicitation techniques [Giupponi 2006; Giupponi et al 2008];
2. Screening models for nitrogen balance or surplus mapping [Carpani et al. 2008a; Carpani et al. 2009];
3. Whole farm models with nitrogen balance or surplus calculations [Giupponi 2002; Giupponi & Rosato 1998; 2002];
4. Field scale system dynamics and mechanistic models of cropping systems, coupled with multi-criteria analysis methods [MCAM] or agent based [ABM] modelling for integrated assessment of farming systems [Balbi 2012; Giupponi 1998; Giupponi 2004; Giupponi et al. 2004; Giupponi & Rosato 2005; Trevisiol et al. 2006];
5. Field scale system dynamics and mechanistic models of cropping systems, coupled with geographical information system [GIS] for mapping agro-chemical losses [Burigana et al. 2003; Carpani et al. 2008b; Giupponi 1994; Giupponi 2003; Giupponi et al. 1999; Giupponi & Rosato 1999];
6. Basin scale mechanistic models for integrated assessment, coupled with multi-criteria analysis methods [MCAM] for integrated assessment of environmental policies and measures [Salvetti et al. 2006; 2007; 2008; Vale et al. 2006; Zucca et al. 2008];
7. Basin scale expert system modelling, for easer exploration of alternative scenarios [Azzellino et al. 2012];
8. Basin scale Bayesian Belief Networks integrating model simulations with expert knowledge, for the probabilistic assessment of policy measures' effectiveness [Carpani et al. 2010].

Concise details about the various modelling efforts are reported in Table 1.

**Table 1.** Summary table with modelling approaches adopted in the VLW.

| Modelling approach | Modelling tools | Application context | Outputs | Participation level |
|---|---|---|---|---|
| 1. Qualitative assessment | Creative thinker, Decision Explorer, C-Maps, mDSS | Expert knowledge elicitation techniques, utilising cognitive mapping and multi-criteria analysis for assessment purposes: expected benefits, SWOT analysis, etc. | Cognitive models, Concept maps, options' ranking | Exercise entirely carried out in a participatory workshop setting |
| 2. Screening models | RazFert, | Simplified formulas for nitrogen balance extrapolated from local field experiments to identify critical areas | Maps of nutrient loss classes | Collection of inputs from and communication of results to stakeholders |
| 3. Whole Farm Managemen t | Planetor, AGeNDA | Simplified formulas for nitrogen balance or surplus calculations, from literature and local field experiments to identify critical practices or areas | Integrated assessment of alternative farming systems | |
| 4. Field scale system dynamics and mechanistic models coupled with MCAM | Gleams, Cropsyst, Simile, Expert Choice | Models from international literature calibrated to local representative stations to simulate the impacts of crop management and livestock effluents management practices to assess effects of alternative cropping systems | Deterministic performance of agri-environmental measures at the field scale (integrated assessment) | Collection of inputs from and communication of results to stakeholders |
| 5. Field scale models coupled with GIS | Gleams, Cropsyst, ArcGIS, Idrisi | Models as above, coupled with GIS to produce scenario maps of agro-chemical losses at the bottom of root zone and the edge of the field (leaching and runoff, respectively) | Deterministic maps of agri-environmental measures at the field scale | Collection of inputs from and communication of results to stakeholders |
| 6. Basin scale mechanistic models coupled with MCAM | Swat, mDSS | Models from international literature calibrated to local, simulating impacts of the agricultural, civil and industrial sectors, and assess the magnitude of phenomena, effects of scenarios, and routing effects | Deterministic performance of agri-environmental measures at the watershed scale; maps and discharge records | Collection of inputs from and communication of results to stakeholders |
| 7. Basin scale expert system meta-modelling | SPSS Neural Networks module | Neural networks trained on mechanistic models (Meta-model) for easier simulations at the watershed scale | Faster scenario analysis of agri-environmental measures and easier comparison among scenarios | Collection of inputs from and communication of results to stakeholders |
| 8. Basin scale Bayesian Belief Networks | GeNIe | BBN integrating outputs of model simulations and expert knowledge to assess the propagation of effects from farmers' decisions to the quality of the lagoon | Probabilistic performance of agri-environmental measures | Collection of inputs from and communication of results to stakeholders |

## 4 RESULTS

It is practically impossible to report even very briefly on the results of each modelling effort mentioned above, but given the objective of the iEMSs 2012 session to which this paper is submitted, an attempt can be made to report on the observed strengths and weaknesses of the various approaches, with reference to a very broad common purpose of supporting regional policy makers in designing and managing environmental policies and measures. Results of the analysis of strengths and weaknesses are reported in Table 2.

**Table 2.** Summary table with strengths and weaknesses of modelling approaches adopted in the VLW.

| Modelling approach | Main strengths for policy support | Main weaknesses for policy support |
|---|---|---|
| 1. Qualitative assessment | - full involvement of decision makers and stakeholders in the assessment process;<br>- transparency of the process;<br>- elicitation of multiple sources of knowledge feasible;<br>- (quasi) real time results. | - no formal links with the quantitative knowledge available;<br>- skills required for the unbiased management of participatory processes. |
| 2. Screening models | - direct link with local knowledge;<br>- support to confidence of field experts;<br>- "reasonable" results when extrapolations are made within the range of observed phenomena. | - methods based on statistical empiric approaches are not suitable for extrapolations outside the observed ranges;<br>- high costs to acquire a sufficient amount of experimental data;<br>- no mechanistic explanations possible;<br>- scenario analysis impossible. |
| 3. Whole Farm Management | - integration of environmental issues into farm management and economic optimisation;<br>- identification of win-win solutions. | - very intensive burden for data collection on farmers;<br>- no guarantee for innovative solutions. |
| 4. Field scale system dynamics and mechanistic models coupled with MCAM | - understanding of mechanisms and roles of different drivers;<br>- quantitative assessment of the crucial indicators;<br>- mass balances feasible at filed scale;<br>- suitability for integrated assessment with MCAM. | - empiricism hidden in crucial mechanisms;<br>- black box perception possible due to the complexity of models. |
| 5. Field scale models coupled with GIS | - comprehensive picture of the spatial variability of phenomena at their sources;<br>- identification of priority areas for spatially targeted policies;<br>- suitability for integrated assessment with spatial MCAM. | - difficulties in representing crucial phenomena, such as crop rotations;<br>- possible misleading messages regarding the magnitude of impacts on receiving water bodies. |
| 6. Basin scale mechanistic models coupled with MCAM | - mechanistic links set between sources and target;<br>- mass balances feasible;<br>- suitability for integrated assessment with MCAM;<br>- feasibility of trade-off analysis. | - empiricism hidden in crucial mechanisms;<br>- black box perception possible due to the complexity of models;<br>- challenging data requirements. |
| 7. Basin scale expert system meta-modelling | - easier implementation of scenarios;<br>- less intensive burden for data required as input;<br>- faster simulations and quite immediate results;<br>- suitability for integrated assessment with MCAM;<br>- feasibility of trade-off analysis. | - lack of mechanistic links between sources and target;<br>- lower accuracy with respect to the source mechanistic models<br>- black box perception. |
| 8. Basin scale Bayesian Belief Networks | - communication of uncertainty affecting the effectiveness of measures;<br>- integration between hard science and experts' knowledge;<br>- a theoretical framework to manage expert knowledge;<br>- accommodate missing data;<br>- weighting each information source according to its reliability;<br>- readily interpretable as they represent conditional probability relationships among information sources. | - communication of uncertainty raising issues of confidence among decision makers regarding the effectiveness of measures;<br>- difficult to get experts agreements on the structure of the model;<br>- difficult in defining the conditional probabilities of linked events with expert opinion need of continuous data;<br>- scarce confidence with knowledge expressions as conditional probabilities. |

## 5 CONCLUSIONS AND RECOMMENDATIONS

One general evidence emerging from the long experience with diffuse pollution from agricultural sources in the VLW is that there is not a single or best modelling solution to approach the water quality management issues of the watershed and its lagoon. Instead, trade-offs between different approaches are always evident, for example in the data needs and the management of complexity and uncertainty, on one side, and in the knowledge transfer and the communication and support to policy on the other. Therefore, integration of multiple models is required, and synergies are evident when exchanges amongst the various approaches are set up.

The will of policy makers is evident in theory, and it is also prescribed by European and national legislations, asking for the assessment of the effectiveness of public expenditures through investments on environmental infrastructures and supported voluntary measures offered to farmers. In practice, not necessarily policy makers are always interested for example in knowing and communicating to others the uncertainty affecting the effectiveness of measures. Ex post assessment could bring disillusion and disappointment, while ex ante assessment bringing clearer views about expected effectiveness could collide with the multiple objectives that are usually combined with the primary ones of (agri-)environmental policies: typically the will of providing financial support to the vastest majority of farmers (and voters) is often in contrast with the optimisation of effectiveness, which would ask for fine tuned and carefully targeted measures to be implemented only where effects can be maximised.

In our experience an issue to be always considered when dealing with water resources lays in their spatial distribution and dynamics. Such features challenge any research and decision making effort, and require specific capabilities to track the fate of pollutants all along the route, from the application of chemicals to a multitude of cultivated fields managed by numerous farmers, to the discharge in the target water body – in this case the Venice Lagoon.

Field scale analyses tended to bring to excessive optimism about expected results, overestimating the benefits of measures as compared to counterfactual situations, because cascade phenomena (e.g. in-stream biochemical dynamics) are not considered. On the contrary, basin scale analyses tend to deliver a message that uncontrolled drivers such as weather can easily overcome the expected beneficial effects of measures: e.g. a dry spring is much more effective than the implementation of challenging best practices to be implemented by all the farmers of the watershed.

Varying balances can be observed between the required efforts – in particular in terms of data acquisition – and obtained results. The complexity of agro-ecosystems is such that, in order to obtain the desired level of precision, the efforts and costs can easily become unjustifiable to the use that we can make of the results obtained for decision making. Typical case is the collection of information about farmers behaviour (e.g. fertilisation practices in this case), which can be extremely challenging in terms of experimental design, data acquisition, data quality assurance, etc. and thus not necessarily better than the use of "ordinary" behaviours elicited from local experts' opinion without any support of robust statistical analysis.

A general recommendation, which emerges from the experiences reported above, useful whenever modelling is used in support to policy makers, and thus when the participation of multiple actors is relevant, is to adopt a two-step approach as follows:

- firstly, a qualitative approach should be implemented, based on participatory techniques for problem exploration and formalisation and for the development of shared conceptual models, making use of workshop techniques including brainstorming and structured interaction with the support of cognitive mapping;
- secondly, quantitative approaches should be designed within the conceptual framework and the structuring of problems defined in the first phase, in which

integrated models (environmental, economic, technical ones) provide the required quantitative bases for the assessment at the most important scale(s).

The proposed approach can significantly and positively contribute in particular to the following most relevant issues: effectiveness of stakeholders involvement; level of understanding of complex methodological frameworks; effectiveness and efficiency of communication within and outside work groups; sense of ownership of the methods and tools by competent administration.

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## REFERENCES

Azzellino A., Giupponi C., Parati P., Salvetti, R., Vismara, R. 2012. Meta-modeling of a physically-based model for predicting the nutrient load discharged to the Venice Lagoon. Proceedings of SIDISA 2012, 9th International Simposium of Sanitary and Environmental Engineering.Balbi, S., S. Bhandari, A. Gain, C. Giupponi, Future dynamics of irrigation water demand in the farming landscape of the Venice Lagoon Watershed under the pressure of climate change, this conference, 2012.

Burigana, E., C. Giupponi, and G. Bendoricchio, Nitrogen surplus as indicator of agricultural pollution impact in the Venice Lagoon Watershed, Diffuse Pollution and River Basin Management, In Bruen, M., Proceedings of the 7 th IWA International Conference, Dublin, pp 171-176, 2003.

Carpani, M. and C. Giupponi, Ex-post assessment of agri-environmental measures in the Venice Lagoon Watershed, In Grignani, C., M., Acutis, L., Zavattaro, L. Bechini, C. Bertora, P. M. Gallina, and Sacco, D., Proceedings of the 16th Nitrogen Workshop: Connecting different scales of nitrogen use in agriculture, June, 28th – July, 1st 2009, Turin, Italy, pp 575-576, 2009.

Carpani, M. and C. Giupponi, Construction of a Bayesian Network for the Assessment of Agri-Environmental Measures – The Case Study of the Venice Lagoon Watershed, *Italian Journal of Agronomy 5*, pp 265-274, 2010.

Carpani, M., C. Giupponi, and P. Trevisiol, Evaluation of agri-environmental measures in the Venice Lagoon Watershed. Nitrogen budgets and surplus indicators, *Italian Journal of Agronomy 3*, pp 167-181, 2008.

Carpani, M., A. Zucca, C. Giupponi, M. Acutis, R. Salvetti, A. Azzellino, R. Vismara, and P. Parati, Modelling Agricultural Diffuse Pollution and Water Quality in the Venice Lagoon Watershed (Italy): I - A Method for Building Spatially Distributed Scenarios of Agricultural Systems, *Italian Journal of Agronomy (3)1 suppl.*, pp 761-762, 2008.

Giupponi, C., Integration of simulation model and geographical information system for the assessment of agricultural pollution, In Giupponi, C., A., Marani, and F., Morari, Modelling the fate of agrochemicals and fertilizers in the environment, Venezia (I), pp 133-152, 1994.

Giupponi, C., Modelling agriculture and the environment: crop production and non-point source pollution, *European Journal of Agronomy 4*, pp 403-412, 1995.

Giupponi, C., Environmental evaluation of alternative cropping systems with impact indices of pollution, European Journal of Agronomy 8, pp 71-82, 1998.

Giupponi, C., AGeNDA: a new tool for sustainable farm management, integrated in the agri-environmental policy of the EU, Proceedings of the 8th Joint Conference on Food, Agriculture and the Environment, Mikana, Wisconsin, (USA), p 11 pp, 2002.

Giupponi, C., Climate change and agricultural land use: scenario simulations in the Venice Lagoon Watershed, In Parks, B.O., K.M., Clarke, and M.P., Crae, Proceedings of the 4th International Conference on Integrating GIS and Environmental Modeling: Problems, Prospects, and Needs for Research (CdRom), 2-8/09/2000 Banff (CAN), pp 44-49, 2003.

Giupponi, C., Bridging environmental models and decision making: a conceptual framework for water resources management, In Jacobsen, S. E., C. R., Jensen, and J. R.,Porter, VIII ESA Congress: European agriculture in a global context. Book of Proceedings, Copenhagen (Dk), pp 749-750, 2004.

Giupponi, C., Bridging scientific knowledge and stakeholders' visions for agri-environmental assessment: Editorial, *Italian Journal of Agronomy 1*, pp 643-645, 2006.

Giupponi, C., B. Eiselt, and P. F. Ghetti, A multicriteria approach for mapping risks of agricultural pollution for water resources: the Venice Lagoon watershed case study, *Journal of Environmental Management 56*, pp 259-269, 1999.

Giupponi, C., A. Fassio, and A. Sgobbi, Evaluation of agri-environmental measures in the Venice Lagoon Watershed. Expert knowledge elicitation and multi-criteria analysis, *Italian Journal of Agronomy 3*, pp 147-165, 2008.

Giupponi, C., J. Mysiak, and A. Fassio, An Integrated Assessment Framework for Water Resources Management: A DSS Tool and a Pilot Study Application, *FEEM Working Paper*, p 29 pp, 2004.

Giupponi, C. and P. Rosato, Simulating impacts of agricultural policy on nitrogen losses from a watershed in northern Italy, *Environment international 21*, pp 577-582, 1995.

Giupponi, C. and P. Rosato, A farm multicriteria analysis model for the economic and environmental evaluation of agricultural land use, in Beinat, E. and Nijkamp, P. eds.) Multicriteria evaluation in land use management, Kluwer Academic Publishers, p^pp 115-138, 1998.

Giupponi, C. and P. Rosato, Agricultural land use changes and water quality: a case study in the Watershed of the Lagoon of Venice, *Water Science and Technology 39*, pp 135-148, 1999.

Giupponi, C. and P. Rosato, Multi-criteria analysis and decision-support for water management at the catchment scale: an application to diffuse pollution control in the Venice Lagoon, FEEM Working Paper, p 22 pp, 2002.

Salvetti, R., M. Acutis, A. Azzellino, M. Carpani, C. Giupponi, P. Parati, M. Vale, and R. Vismara, Modelling the point and non-point nitrogen loads to the Venice Lagoon (Italy): the application of water quality models to the Dese-Zero basin, *Desalination* 226, pp 81–88, 2008.

Salvetti, R., A. Azzellino, G. Gardoni, R. Vismara, M. Carpani, C. Giupponi, M. Acutis, M. Vale, and P. Parati, Application of SWAT Model on Three Watersheds within the Venice Lagoon Watershed (Italy): Source Apportionment and Scenario Analysis, In Avanzini, C., 4th International Swat Conference 2007, 4-6/07/2007 Delft (NL), p Proceedings DVD, 2007.

Salvetti, R., A. Azzellino, R. Vismara, C. Giupponi, P. Parati, M. Vale, and M. Acutis, Modelling point and non point nitrogen loads to the Venice Lagoon Watershed (Italy): the application of water quality models to the Dese-Zero Basin, 10th Int. Specialised Conf. on Diffuse Pollution and Sustainable Basin Management. 18-22/09/2006, Istanbul, p 8, 2006.

Sterman, J., Business Dynamics. System Thinking and Modeling for a Complex World, 2000.

Trevisiol, P., M. Carpani, and C. Giupponi, Assessment of agri-environmental measures in the Watershed of the Venice Lagoon with the Agenda-NBoxes software, In Fotyma, M. and B.,Kaminska, IX ESA Congress - European education and research in agronomy, Warsaw (PL), pp 727-728, 2006.

Vale, M., P., Parati, A., Azzellino, R., Salvetti, R., Vismara, M., Carpani, C., Giupponi, and M., Acutis, First application of the Soil and Water Assessment Tool (SWAT) to different subbasins discharging into the Venice Lagoon, In Avanzini, C., MWWD 2006 - 4th International Conference on Marine Waste Water Disposal and Marine Environment. 6-10/11/2006, Antalya (TR), p Proceedings DVD, 2006.

Zucca, A., M. Carpani, C. Giupponi, M. Acutis, R. Salvetti, A. Azzellino, R. Vismara, and P. Parati, Modelling Agricultural Diffuse Pollution and Water Quality in the Venice Lagoon Watershed (Italy): II - a Spatial Decision Support System for the Evaluation of Alternative Scenarios, *Italian Journal of Agronomy (3)1 suppl.*, pp 827-828, 2008.