Development of an information technology tool for the management of Southern European lagoons under the influence of river-basin runoff

(DITTY Project)
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DELIVERABLES D17-D18

Towards Sustainable Management of Southern European Lagoons.

Editors: C.N. Murray, T. Do Chi, J.M. Zaldívar Comenges

Book proposal to SPRINGER

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1. Title: Towards Sustainable Management of Southern European Lagoons.

Authors: each chapter will be written by the group that undertook the work that is presented in the individual work packages of this European project, see outline

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2. Aims, scope and market: The development of management tools for coastal lagoons is a complex task requiring interdisciplinary research and active interaction with the end-users. Mathematical models of the biological, physical and chemical processes are fundamental tools for analyzing disruptions in the ecosystem due to abnormal conditions. However, the successful management of such complex systems requires the integration of the information provided by mathematical models with other kinds of analysis. Socio-economic analysis assumes for instance great importance in coastal lagoons, especially where various kinds of anthropogenic pressures (aquaculture, fishery, tourism, etc.) are sources of conflicts among different users. Information tools such as Decision Support Systems, i.e. information systems that help decision-making, represent a suitable framework for the implementation of multi-criteria approaches.

The objective of the present book is to present the results of a European project (Development of an Information Technology Tool for the Management of European Southern Lagoons under the influence of river-basin runoff- DITTY) whose aim as been the development of the scientific and operational bases for a sustained and rational utilisation of the available resources in Southern European Lagoons. The project took into account all relevant impacts from agriculture, urban and economic activities that affect the aquatic environment, by developing information technology tools tailored for these types of ecosystems. The development of reliable information tools required that the underlying integrated model approach be benchmarked across a wide range of catchment-coastal lagoon ecosystem process description.

In order to cover a wide geographical range of southern European coastal lagoons, representing a extended series of ecosystems, conflicting water use needs, and management resource requirements, five lagoons were chosen covering the Southern European arc from Portugal, through Spain, France and Italy to Greece.

The underlying modelling techniques and methodology will be described in detail along with the results of the application of the Decision Support System implemented by Local Authorities to specific problems facing the managers of each of the five coastal lagoons: Ria Formosa (Portugal), Mar Menor (Spain), Etang de Thau (France), Sacca di Goro (Italy) and Gera (Greece).

Rational: Coastal zones play a key role in Earth System functioning providing a significant contribution to the life support systems of most societies. Goods and services derived from coastal systems depend strongly on multiple trans-boundary interactions with the land, atmosphere, open ocean and sea bottom. Human habitation, food

production, growing tourism and transportation accelerate the exploitation of the coastal landscape and resources.

Changes in the hydrologic cycle coupled with changes in land and water management alter fluxes of materials transmitted from river catchments to the coastal zone having a major effect on coastal ecosystems.

In order to maintain a sustainable delivery of goods and services for humankind, science needs to better inform society, decision-makers and planners about:

- global changes that are part of natural cycles of change, such as climate, and those due to changes in the global economy/trade and policy.
- regional (trans-boundary and supra-national) changes as a result of regional and national drivers and pressures in the coastal zone.
- regional changes at the river catchment level which affect the downstream coastal zone and the near-shore marine environment.

In this context European transitional waters, and especially coastal lagoons, are increasingly recognised as representing a highly diversified series of ecosystems reflecting the wide range of climate conditions and geo- and hydro-physical processes of the region. They also are often systems of important economic value to local communities, and as such are often strongly impacted by anthropogenic pressures.

EU Water Framework Directive. In Europe a major effort is already underway towards these goals through the implementation of the EU Water Framework Directive (WFD). The objective of this Directive is to ensure all European surface waters (rivers, lakes, transitional/coastal) and ground water bodies are effectively protected, and remediation is carried out where needed, so attaining good ecological status by 2015. Twenty-eight countries with a population of around 450 million people are collaborating towards this common goal.

Information Needs: There are thus considerable management and policy needs and scientific interest, focussed on better understanding the ecological functioning of lagoons and the external pressures such as agriculture, industry, tourism and aquaculture etc. The recent first and second international conferences on European Coastal Lagoons held in Ferrara, Italy, November 2003, and Klaipeda, Lithuania, October 2005, as well as LOICZ II Inaugural Open Science Meeting, Egmond aan Zee, Netherlands, June 2005, The Netherlands, and earlier ELOISE and LOICZ conferences have clearly highlighted the information gaps that still need addressing.

Specifically, Southern European lagoons are subjected to large variations in temperature and rainfall (climatic variations), to strong anthropogenic pressures due to tourism causing conflicting requirements for local and regional authorities (responsible for their administration) on the best use of limited land and water assets, as well as of safeguarding major renewable resources such as aquaculture and fish farming activities (sustainable development).

The efficient management of coastal lagoon areas with strong anthropogenic exploitation is thus a particularly difficult task for local and regional authorities. Socio-economic interests and environment preservation are typically contrasting objectives between which a suitable trade-off must be achieved. The solution to this problem

requires the development of interdisciplinary and multi-criteria approaches. The proposed decision support system has been developed as a model-driven DSS, which integrates the different kinds of mathematical and analytical models (e.g., biogeochemical, hydrodynamic, ecological, socio-economic models, etc.) developed in the project. Data and information obtained from the models are used to accomplish the decision task through an Analytic Hierarchy Process which has been shown to be a powerful and flexible tool to make decisions in situations where multiple and conflicting objectives/criteria are present, and both qualitative and quantitative aspects of a decision need to be considered.

Networking: Using the southern European arc sites as a specific example, the development of a number of regional/national networks on coastal lagoon ecosystems has been shown to be a pragmatic way of focussing regional scientific and management interests at an effective scale, and allowing collaboration between different regional/national networks, local and regional Authorities to develop as mutual interests and concerns are identified.

The fact that local and regional authorities are also responsible for the monitoring (WFD and other national and EU Directives) of coastal-lagoon ecosystems involved in the networks has clearly helped making available long-term data and the testing of advanced predictive modelling approaches and information technology support systems (DITTY project) for coastal-lagoon management purposes.

3. Special features: A CD ROM of the entire model including a complete case study including DSS and socio-economic study. Material could be used for advanced teaching courses, or use by lagoon Administrators.

4. Preliminary list of contents, objectives of each chapter and lead Authors:

Preface – Watershed-lagoon management, climatic change and anthropogenic pressures
Author (lead): Prof. Steven Eisenreich, Joint Research Centre, Italy.

***Objective of Preface*:** Set-out the objectives of the book of reporting the results of a European project that has developed practical tools for the management of southern European lagoons, based on sound environmental data, biogeochemical assessment models, socio-economic techniques, including decision support systems.

Chapter 1. Introduction

1.1. Management needs for integrated watershed-lagoon-coastal assessments (P. Viaroli and L. Loubersac)
1.2. Physical processes (A. Fiandrino and A. Norro)
1.3. Biogeochemical cycles (P. Viaroli et al.)
1.4. Changes in coastal lagoons (P. Viaroli et al.)
1.5. Socio-economic elements (F. Valette et al.)

Author (lead): Prof. Pierluigi Viaroli, Dept. Environmental Sciences, University of Parma, Italy.

***Objective of chapter 1*:** Synthesize the knowledge about coastal lagoon ecosystems (also using prior investigations from ELOISE) including socio-economic aspects, and analyse data in the form of long-term spatio-temporal time series that supports this knowledge.

Chapter 2. Role of databases and GIS in environmental management

2.1. Monitoring ecosystems and collecting data (L. Loubersac et al.)

2.2. Data structure and large environmental data sets (J.F. Boyer and G. Giordani)

2.3. Data for economic analysis (F. Valette et al.)

2.4. Spatial databases and spatial analysis in environmental management (D. Kitsou and T. Nitis)

2.5. The role of WebGIS in coastal management (D. Kitsiou)

2.5. GIS applications to environmental crises in Thau lagoon (T. Do Chi, A. Lemsanni and M. Troussellier)

Author (lead): Dr. J. Francois Boyer, Dr. D. Kitsiou, Dr. G. Giordani

Objective of Chapter 2:Provide an overview of Database Management systems and Geographic information systems (GIS) as well as their application for the management of coastal lagoons.

Chapter 3. Watershed processes and Water quality modelling

3.1. Hydrological processes in Mediterranean watersheds (M.G. Tournoud and J.L. Perrin)

3.1.1. Rainfall-runoff characteristics

3.1.2. Land phases processes

3.1.3. River dynamics

3.2. Water quality processes (M.G. Tournoud and C. Salles)

3.2.1. Diffuse versus point-source pollution impact in Mediterranean catchments

3.2.2. Land phase processes

3.2.3. River transfer

3.3. Water quality models (F. Somma and S. Payraudeau)

3.3.1. Catchment models

3.3.2. River models

3.4. Application in study sites (M.G. Tournaud et al)

3.4.1. Ria Formosa watershed case study (M. João Guerreiro and P. Duarte)

3.4.2. Gulf of Gera catchment (G. Tsirtsis et al.)

3.5. Intercomparison of models: Thau lagoon case study (F. Somma, M. Plus and M.G. Tournoud)

Author (lead): Prof. Marie George Tournoud, Laboratoire “Hydrosciences Montpellier”, UMR.5569 CNRS-UM.II-IRD, France.

Chapter 4. Lagoon Hydrodynamics

4.1. Hydrodynamic processes (A. Norro and P. Luyten)

4.2. Modelling approaches and existing tools (A. Fiandrino and A. Norro)
4.3. Hydrodynamic modelling of coastal lagoons: Specific issues (A. Norro et.al.)
Duarte)
4.4. COHERENS application to Sacca di Goro (D. Marinov et al.)
4.5. Model-intercomparison for Thau lagoon (A. Norro and A. Fiandrino)
4.6. Model-intercomparison for Gera gulf (A. Norro and G. Tsirtsis)
4.7. Ria Formosa case study (P. Duarte et al.)

Author (lead): Drs. Alain Norro and P. Luyten, Royal Belgian Institute for Natural Sciences, Brussels, Belgium.

Chapter 5. Lagoon Biogeochemical processes

5.1 Introduction (A. Chapelle and P. Duarte)
5.2. Nutrients (M. Plus, A. Chapelle)
5.3. Sediments (A. Chapelle)
5.4. Ecosystem modelling (P. Duarte, M. Plus)
5.5. Contaminants (S.Dueri et al., JRC-IES)
5.6. Object oriented approach to ecological modeling (A. Pereira et al.)
5.7. The ecological model of Mar Menor: the role of jellyfish (S. Rodríguez, J. Martínez, M.A. Esteve)
5.8. Ecological model in Ria Formosa using an object oriented approach (P. Duarte et al.)

Authors (lead): Dr. Annie Chapelle, IFREMER, France; Prof. Pedro Duarte, Univesidade Fernando Pessoa, Porto, Portugal.

***Objectives of chapters 3-5*:** Develop modelling techniques for the watershed basin, the coastal lagoon, and the coastal zone, as well as the aquatic ecosystems, and design and validate benchmarking. Included will be techniques for assessing socio-economic processes and their integration into the assessment methodology.

Chapter 6. Application of indicators for the analysis of coastal lagoons

6.1. Introduction (G. Tsitsis and J. Martinez)
6.2. Environmental indicators for transitional waters (P. Viaroli et al.)
6.3. Socio-economic indicators (F. Valette et al.)
6.4. LOICZ budgets in coastal lagoons (G. Giordani et al.)
6.5. Indicators of ecosystem functioning, alterations and quality in coastal lagoons (P. Viaroli et al.)
6.6. Indicators from Qualitative modelling: Network and loop analysis (A. Bodini et al.)
6.7. Application of IFREMER's approach for assessing the status of coastal lagoons (M. Austoni et al.)
6.8. The application of specific exergy for coastal lagoon ecosystem health evaluation (J.M. Zaldivar et al.)

Authors (lead): Prof. Giorgos Tsirtsis, Dept. Marine Sciences, University of the Agean, Greece;
Dr. Julia Martinez-Fernandez, Facultad de Biologia, Universidad de Murcia, Spain.

***Objectives of chapters 6*:** Analyse and study the application of ecological indicators in transitional waters as well as the results obtained in their application to several sites. This is a crucial chapter and will help managers for the implementation of the WFD on transitional waters.

Chapter 7. Socio-economic approaches in coastal lagoon management

7.1. Introduction (F. Valette, H. Rey, T. Do Chi)

7.2. Objectives and methods (F. Valette and H. Rey)

7.2. Analysis of stakes for the main actors: Gainers and Loosers. Application to bivalve farming economic value in Ria Formosa (F. Perna)

7.3. Analysis of the value of "out of market" goods and acts, context-related valuations of externalities, and valuation transfer (G. Enjolras)

7.4. Micro-economic and macro-economic modelling. Application to Thau lagoon (F. Valette)

7.5. Negotiation and decision, in interaction with simulation models (P. Rio, M. Willinger)

7.6. Socio-Economic analysis of the Sacca di Goro lagoon (L. Torsello and M. Federici)

7.7. Cost-effectiveness analysis of main management options in Mar Menor (J.M. Martínez-Paz, J. Martínez, M. Ruiz, M.A. Esteve

7.8. The specific role of socio-economic sciences, and the benefits of their interaction with natural sciences. (F. Valette et al.)

Authors (lead): Dr. Francois Valette, Laboratoire Montpelliérain d'Economie Théorique et Appliquée, Montpellier, France.

Objectives of Chapter 7 : The goal of this chapter is to show generally (rather than depending on specific DITTY's sites) the diversity of the possible approaches that "socio-economic sciences" may propose to answer the questions put by the principal actors of the development at the level of a territory (politicians and other representatives of authorities, private actors, associations...). This exercise should show the links between these approaches (in the field of the social sciences), as well as their links to the other approaches (in the field of natural sciences) which were undertaken to face the same problems of management (in the short and medium term) and durable development (in the medium and long term) of the territories.

Chapter 8. Integrated modelling in coastal lagoons

8.1. Towards integration of concepts and tools for coastal lagoon management (J.M.
Zaldivar and A. Bodini)

8.2. Integrated COHERENS version for coastal lagoons (A. Norro et al.)

8.3. Surface-subsurface modelling in Burana-Po di volano watershed (L. Galbiati et al.)

8.4. Integrating environmental and socio-economic processes in watershed models: the Mar Menor case (Martínez, J.; Alonso, F.; Martínez-Paz, J.M.; Carreño, F.; Ruiz, M.; Miñano, J.; Esteve, M.A.)

8.5. 3D modelling of contaminats in Sacca di Goro (R. Carafa et al., JRC-IES)

Authors (lead): Dr. Jose-Manuel Zaldivar-Comenges, Joint Research Centre, Italy; Dr. Antonio Bodini, Dept. Environmental Sciences, University of Parma, Italy.

Objectives of Chapter 8: To demonstrate how integration between the different tools and approach can be developed and which results can be expected. Introducing the integrated modeling tool that will be provided in the CD and showing case studies

Chapter 9. Scenario Analysis

9.1. Coastal lagoons of Southern Europe: recent changes and future scenarios (C. Aliaume, J.M. Zaldivar, P. Viaroli, T. Do Chi)
9.2. Scenatio Analysis in the Gulf of Gera (G. Tsirtsis et al.)
9.3. Scenario Analysis in Sacca di Goro (P. Viaroli et al.)
9.4. Scenario Analysis in Etang de Thau (C. Aliaume, A. Fiandrino, N. Mazouni, L. Loubersac, M. Troussellier, T. Do Chi)
9.5. Management options for the control of nutrient loadings into the Mar Menor lagoon (J. Martínez, M.A.Esteve)
9.6. Scenario analysis in Ria Formosa (M. Falcão et al.)
9.7. Scenario Analysis from Qualitative modelling: Network and loop analysis (A. Bodini et al.)

Authors (lead): Prof. Catherine Aliaume, Laboratoire Ecosystèmes Lagunaires, CNRS-UMII,

***Objective of chapter 9*:** Develop scenario analysis for each site taking into account the end-user priorities. One of the most important challenges regarding coastal ecosystems is to develop predictive tools able to anticipate the ecological changes, and to propose management solutions for avoiding the extension of environmental crises both in intensity and frequency. In this chapter several scenarios concerning, e.g., the effects of nutrient loads, changes in resource exploitation, adoption of early warning detection systems for anoxic crises, effects of global climate variability, etc., are tested and evaluated.

Chapter 10. Decision Support System (DDS) development

10.1. Decission Support Systems: concepts and terminology (C. Mocenni, M. Casini, S. Paoletti, M. Pranzo and A. Vicino)
10.2. Review of DSS tools for coastal lagoons (S. Paoletti, M. Casini, C. Mocenni and M. Pranzo)
10.3. A model-based DSS architecture (M. Casini, C. Mocenni, S. Paoletti and M. Pranzo)
10.4. Tools for multicriteria analysis (M. Pranzo, A. Agnetis, M. Casini, P. Detti, C. Mocenni and S. Paoletti)
10.5. Application of the DSS to Sacca di Goro (C. Mocenni, M. Casini, M. Federici, P. Viaroli, G. Giordani, S. Paoletti, M. Pranzo, L. Torsello and J.M. Zaldivar)
10.6. Application of the DSS to Etang de Thau (M. Pranzo, M. Casini, A. Fiandrino, M. Jouan, L. Loubersac, C. Mocenni, S. Paoletti)
10.7. Application of the DSS to Mar Menor (S. Paoletti, F. Carreño, M. Casini, M.A. Esteve, J. Martínez, C. Mocenni, M. Pranzo)
10.7. Application of the DSS to Gulf of Gera ()

Author (lead): Dr. Chiara Mocenni, Universita degli Studi di Siena, Italy.

Objective Chapter 10: Develop the basis of common information technology tools for the development of Decision Support Systems for the management of coastal lagoons. The final result is a tested prototype that integrates the different tools and approached developed. This is the basis of an integrated, interdisciplinary DSS relating existing coastal zone use to its ecological consequences, and also providing a framework in which innovative management options can be analyzed as regards their social acceptability, economic evaluation and ecological outcomes.

Chapter 11. Conclusions

Appendices

A. COHERENS version for coastal lagoons + CD, including one complete case
Author (lead): Dr. Alain Norro, Royal Belgian Institute for Natural Sciences, Brussels, Belgium.

B. Detailed model descriptions (including analysis and comparison of currently available tools) + models on CD-Rom
Author (lead): Prof. Pedro Duarte, Univesidade Fernando Pessoa, Porto, Portugal

C. Implementation of the DSS (**M. Casini**, C. Mocenni, S. Paoletti, M. Pranzo)
Author (lead): Dr. Marco Casini, Universita' degli Studi di Siena, Italy