LAGOONS project - Integrated water resources and coastal zone management in European lagoons in the context of climate change

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ABSTRACT

The main objective of the LAGOONS project is to develop science-based strategies and a decision support framework for the integrated management of lagoons in the context of climate change. The LAGOONS methodology is based on an increased understanding of land-sea linkages processes and the science-policy-stakeholder interface. This approach combines knowledge and insights from an interdisciplinary team, working together to apply dynamic models of drainage basins for a range of scenarios and quantitative models of lagoons. In management terms, the project will seek to contribute to interface between the EU WFD, the Habitat Directive, the EU's ICZM, and the EU MSD. In addition, LAGOONS will propose actions foreseen in the goals of the Europe 2020 strategy. To fulfil the proposed objectives, 4 "hot spot" case study lagoons have been selected. These lagoons will provide a support for Pan-European integration through a bottom-up approach, showing that it is possible to enhance connectivity between research and policy-making in a lagoon's context using a proactive approach to water issues, which assures more efficient use of existing research results. Moreover, integrated scenarios will be formulated using also a participative approach to develop strategies and methodologies for integrated decision support for stakeholders, as well as with a special focus on recommendations of suitable use of ecosystem services.

In this paper, we introduce the main challenges and objectives of LAGOONS, which is one of two EU-FP7 funded projects on issues related to coastal lagoons. We will also present the current knowledge followed by a knowledge gap analysis.

KEY WORDS: *climate change, science-policy-stakeholders, river basin, modelling, coastal lagoons.*

INTRODUCTION

LAGOONS – "Integrated water resources and coastal zone management in European lagoons in the context of climate change" is an EU funded FP7 research project in the theme ENV.2011.2.1.1-1 "Lagoons in the context of climate change". The consortium is formed by nine partners from eight countries (Figure 1), with backgrounds in Integrated water resources management (IWRM), legal policy and institutional analysis, climate change scenarios, hydrological and ecological modelling, impact assessment, ecology, toxicology and ecosystem services.

The basic concept of the LAGOONS project is that knowledge produced by these different scientific disciplines needs to be combined and integrated with local knowledge and the views of stakeholders using a participative approach in order to propose reliable integrated scenarios of future possible economic development and environmental conditions in the coastal lagoons.

The continued availability of ecosystem goods and services is a consequence of a complex combination of climatic, social, economic, political and environmental drivers. Exploitation and conservation of critical ecosystem goods and services is influenced by societal needs, development priorities and current state of knowledge. In this context, scenario-building and modelling have been recognised as useful tools for estimating and predicting likely states of the resource base and environmental conditions in future.

Starting from four case study lagoons, selected to represent a set of different "hotspot" coastal lagoons with a wide and balanced geographical distribution and different characteristics, the LAGOONS project aims to assess environmental and social responses under different climate change scenarios, river basin management scenarios and coastal zone management scenarios.

The selected lagoons are:

- Vistula Lagoon in the Baltic Sea (Poland/Russia);
- Tylygulskyi Lagoon in Black Sea (Ukraine);
- Ria de Aveiro Lagoon in Atlantic Ocean (Portugal);
- Mar Menor in the Mediterranean Sea (Spain).

The geographic location and major characteristics of the LAGOONS case studies are shown in Figure 1 and Table 1, respectively.

The main objective of the LAGOONS project is to develop science-based strategies and a decision support framework for the integrated management of lagoons, based on an increased understanding of land-sea processes and the science-policy-stakeholder interface. To this end, the project will seek to enhance the integration of the EU Water Framework Directive, the Habitat Directive, the EU's integrated coastal zone management (ICZM) recommendation, and the EU Marine Strategy Directive.

More specifically, the sub-objectives of the project are:

- To share responsibilities between partners and complement each others main individual expertises to better understand and manage the dynamics of the relationships between humans and the coastal lagoons;
- To create a knowledge base of existing knowledge and data on environmental conditions in the four case study coastal lagoons, which include Poland/Russia transboundary waters;
- To create a knowledge base of relevant laws and policies governing coastal lagoons in the European context;
- To create a transboundary platform for the determination of common agreements between national legislation and international conventions.
- To identify knowledge gaps in the IWRM and ICZM knowledge base;
- To conduct quantitative drainage basin modelling and to create scenarios for future developments in land-water interactions in coastal lagoons;
- To use the outputs of the drainage basin modelling as input for quantitative lagoons modelling and scenario analysis;
- To present and evaluate these modelling scenarios through a series of three stakeholder workshops in each case area. These workshops will enable participation and will provide local knowledge and input into the refinement of the scenarios;
- To develop strategies and decision support frameworks for pan-European dissemination and application. These will be based on the results of the scenarios as well as on the analysis of legal and policy frameworks, and of the actors and institutions active in the coastal lagoon management. They will build upon the results produced in the four case study coastal lagoons, but will, with some adjustment and modifications, be applicable on other European coastal lagoons as well.

METHODOLOGY AND ASSOCIATED WORK PLAN

Scenario-building and modelling

Four case study lagoons overlaying interconnected Work Packages (WPs) should enable to fulfil the LAGOONS project objectives (Figure 2).

The LAGOONS team will use scenario-building and modelling approaches to project the states of the four case study lagoons and their drainage basins in future, taking into account anticipated changes in climate and land use.

In essence, the specific scenario-based approach in the project is based on the creation of alternative hydrological and environmental scenarios driven by selected climate and land use change scenarios that combine inputs from various
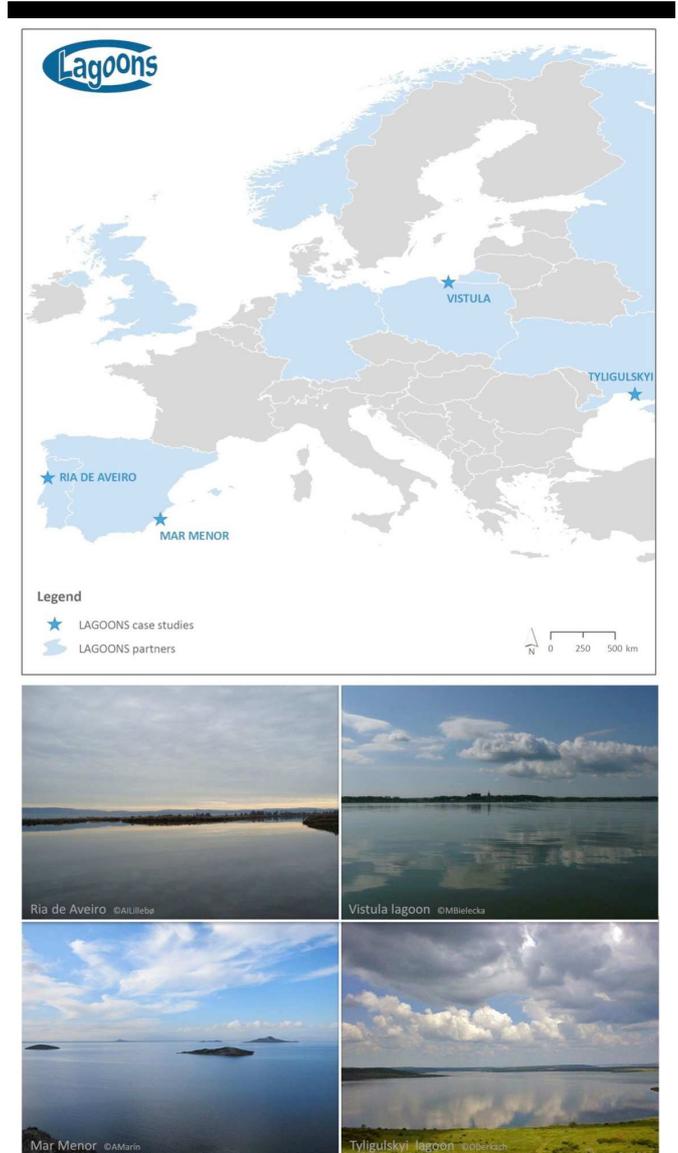

Figure 1. The geographic distribution of the LAGOONS partners and the LAGOONS case studies.

scientific disciplines. Figure 2 illustrates the sequential step-wise procedure in the project, namely:

- The creation of a mutual disciplinary respect and a basic understanding of all scientific approaches (WP2&3);
- The definition of 3-4 qualitative story-line scenarios jointly with stakeholders (WP4);
- The translation of the qualitative story-line scenarios into quantitative form (W5&6);
- The modelling of the hydrological and environmental conditions in the lagoons (WP6) and their drainage basins (WP5);
- The Analyses of the policy and socio-economic implications of the modelling results (qualitative scenario impacts), including an analysis of the value of scenarios from an information perspective (WP4);
- The results of the qualitative scenarios proposed in WP4 will be used as inputs into quantitative models in WP5 (drainage basins) and WP6 (lagoons). Afterwards, these

quantitative model-based scenarios will be used for discussion with stakeholders and policy-makers in WP4 using participative approach, where integrated scenarios should be developed. The integrated scenarios will be used to provide policy recommendations in WP7.

Figure 2. Schematic representation of LAGOONS methodology and interconnection between Work Packages.

Climate change and modelling

Regarding the Integrated water resources and coastal zone management in the lagoons in the context of climate change, different sets of regional climate scenarios produced by Regional Climate Models (RCMs) until 2100 for Europe will be applied in the project.

In LAGOONS, the SWIM model (Krysanova *et al.*, 1998) is being used for ecohydrological modelling of the catchment areas of lagoons. SWIM is a continuous-time spatially distributed model, integrating hydrological processes, vegetation growth (agricultural crops and natural vegetation), nutrient cycling (nitrogen, phosphorus and carbon), and sediment transport at the river basin scale.

Depending on specifics of the lagoon (location, physical conditions, dimension, depth, hydrodynamic and water quality conditions, specifics of water exchange, ice conditions, etc.) and environmental problems that will be investigated, different mathematical models may be applied in order to assess response of the lagoons to different climate, hydrological, hydrochemical and hydrobiological pressures. Usually 2D and 3D hydrodynamic and water quality models are used for calculation of water current velocities, salinity and temperature distributions as well as for simulation of influence of anthropogenic factors (nutrient loads from drainage area, local sources and atmosphere) on seasonal changes in concentrations of nutrients, detritus in water and sediment, oxygen concentrations in water and biomass. These models may be used to evaluate the climate change effects on several system variables at different scales.

FIRST RESULTS AND DISCUSSION

Knowledge base and knowledge gap analysis

One of the first tasks within LAGOONS was to collect, document and make available the current knowledge, data and information on the status of the four case lagoons and their river basins regarding climate, hydrology, water quality, water demand, land use, water and land user conflicts, political structures, institutions and policies. This information is now available on the LAGOONS website (lagoons.web.ua.pt) in the form of full reports (LAGOONS 2012, D2.1 a-d) and in the form of short technical briefs, both in English and in each lagoon local language.

The data and information gathered (qualitative and quantitative) allowed identifying the knowledge gaps of the LAGOONS case studies. The identified knowledge gaps related issues are presented in Table 2. It can be seen that most of these knowledge gaps are common to the four case study lagoons, and can be summarized as: i) Improve the number of meteorological and/or eco-hydrological monitoring stations in the lagoons and/or in the respective catchment area; ii) Application of effective methods for environmental management, including its resilience and adaptability to human and natural stressors; iii) Increase the knowledge about the evolution of the lagoons as social-economic and ecological systems; iv) Application of mechanisms for active participation of stakeholders including "ordinary citizens", in the decision-making process. This analysis highlights the importance of science-stakeholder and the policy-stakeholder interface in the present-future management of these coastal zones. Within LAGOONS project, the gathered knowledge base information and this knowledge gap analysis will be further discussed with stakeholders, and has also been used to refine the problem based science analysis.

Science-policy-stakeholder interface and combined scenarios

Science-policy interface is only a part of the challenge facing integrated lagoon management. The demands made for increased stakeholder and public participation provide other important interactions, the science-stakeholder and the policy-stakeholder interfaces. Therefore, in the LAGOONS project a series of three stakeholder workshops in each of the case basins are planned. At these workshops, scenarios at different stages of their development will be presented and discussed. In this way scientific knowledge and the quantitative modelling results produced by the LAGOONS team will be combined with the local knowledge and opinions of the stakeholders at all stages of the project.
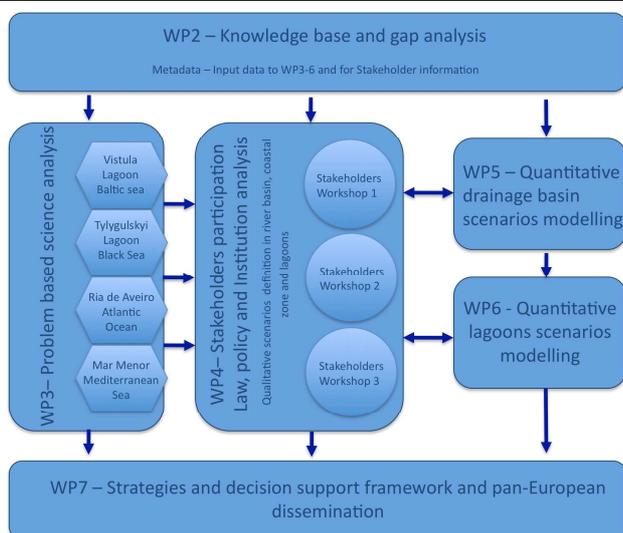
Table 1. Summary of the major characteristics of the case study lagoons.

Lagoon	VISTULA	TYLIGULSKYI	RIA de Aveiro	MAR MENOR
Lagoon area & drainage basin area (km^2)	838	170	83	135
	23,870	5,420	3,645	4,800
Population in the watershed area	~700,000 (1998)	160,000	353,688 (2011)	99,447
Major land uses	Agriculture, industry, recreation, urban settlements	Agriculture, recreation, tourism (landscape park), coastal suburban housing estates	Agriculture, urban settlements	Agriculture, recreation, tourism (landscape park), urban settlements
Major activities in the lagoon	Port facilities, naval base, industry, agriculture, fishing, limited recreational activities	Recreational activities, tourism, aquaculture, fishing, agriculture	Port facilities, tourism, industries, fishing aquaculture, salt-production, agriculture, recreational activities	Port facilities, salt-production, fishing, agriculture, recreational activities, tourism
Major fresh water sources (Rivers)	Pregola (RU) (41%), Elbląg (PL), Pasłęka (PL), Nogat (PL), Prokhladnaya (RU), Mamonovka (RU), Bauda (PL), Primorskaya (RU) and Szkarpawa (PL)	Tyligul (65%), Balaichuk,Tsarega	Vouga (67%), Antuã, Boco	Albujón and Ponce wadis
Major water uses in the basin	Fishing, transportation, limited recreational use, drinking water supply from surface waters	Recreation, tourism, aquaculture, fishing, agriculture, agricultural industry, municipal water consumption	Hydropower, agriculture, domestic use, irrigation, tourism, industry	Recreation, tourism, fishing, agriculture
End users	Regional Inspectorates for Environmental Protection, Sea Fisheries Inspectorate in Gdynia, IMGW, RZGW, Associations of Marine Cities and Communes. Federal and regional environmental authorities Centre for Hydrometeorology and Environmental Monitoring	MEPU & SAEPO, SCUWE & OPIAWE, Provincial Adm., Administrations of regional landscape park 'Tyligulskyi', sectoral associations (e.g. farming, fishing, tourist)	ICNB, INAG, ITP, Natural Reserve S. Jacinto Dunes, Municipalities, APA-ARHc, sectoral associations (e.g. farming, fishing, saltpans producers)	Ministerio de Medio Ambiente y Medio Rural y Marino, Estación Náutica del Mar Menor, Autonomic and local administrations, sectoral associations (e.g. tourist, saltpans producers)

Table 2. Summary of the major knowledge gaps of the case study lagoons.

Lagoon	VISTULA	TYLIGULSKYI	RIA de AVEIRO	MAR MENOR
Hydrological	Hydrological monitoring is not sufficient for modelling. Not synchronized with ecological monitoring and over the border	Lack of hydrological and hydro-chemical data for the rivers and the lagoon	Need to identify the impacts resulting from the changes in the system's tidal prism and water velocity in the Ria biotopes with recognized high biological diversity	Hydrological monitoring is not sufficient for modelling. Not synchronized with ecological monitoring.
Environmental	Historical data gaps; lack of sediment/water interactions studies; improve synchronized catchment and lagoon monitoring; clarify the role of deep navigation canal in lagoon internal water exchange.	Hydroecological observations were sporadic, their number substantially differed from year to year and some of the years no observations were at all	The protection of Ria de Aveiro's natural and cultural capital is considered insufficient given its biodiversity and the ecosystem value and benefits	A better understanding of the interactions between changes in the watershed and their consequences on the lagoon environment is still necessary
Ecosystem services	Need to enhance a more holistic approach regarding eutrophication, fisheries and natural protection. Enhance recreational potential.	Need to enhance model's ability to describe the lagoon ecosystem under natural and anthropogenic forcing.	Need to enhance the collaborative research in order to identify and value the provided ecosystem services; particularly on the topic of ecology and socio-economy.	The consequences of global climate change in the area and the possibility of aggravated eutrophication in the Mar Menor lagoon needs to be addressed

Lagoon	VISTULA	TYLIGULSKYI	RIA de AVEIRO	MAR MENOR
Social	Solutions to unemployment and outflow of young people problems need to be proposed and urgently implemented.	The residents, state authorities, and local autonomous bodies are ecologically unconscious and uninformed in respect of environmental protection and conservation.	Increase the knowledge and the understanding about the evolution of the lagoon as a social-ecological system.	Seasonal increase of the tourist population without the understanding about the evolution of the lagoon system.
Management	Effective methods for local and cross border environmental management ensuring conflicts solving are absent.	Modern environmental management systems are lacking	Need to integrate on the lagoon management system its resilience and adaptability to human and natural change	Need to integrate on the lagoon management system its resilience and adaptability to human and natural change.
Stakeholders involvement	Application of mechanisms for active participation of stakeholders including "ordinary citizens", in the decision-making process.	The location of the lagoon in the territories of two administrative units (Odessa and Mykolaiv regions) is on of the problems of natural resources protection and conservation at the Tyligulskyi Lagoon.	Incentivise and enhance the application of mechanisms for active participation (not only of stakeholders, but also ordinary citizens, as users of the Ria de Aveiro) in the decision-making process	Incentivise and enhance the application of mechanisms for active participation of stakeholders in the decision-making process.
Equipment & data	Insufficient number of meteorological and eco-hydrological monitoring stations; knowledge gaps in soils properties; knowledge in catchment land-use is not harmonized; CORINE Land Cover database does not cover Russian territory.	There are no stationary hydrometeorological (hydroecological) stations or monitoring sites on the lagoon coast. The census data are old.	There are data gaps regarding the catchment area and the lagoon; There are no stationary hydroecological stations in the transition between freshwater to the lagoon transitional waters.	Insufficient number of stationary hydroecological monitoring stations in the main wadis.

FINAL REMARKS

European policy context and LAGOONS impact

The main policy context of relevance for the LAGOONS project is the EU Water Framework Directive (2000/60/EC) and the activities related to its implementation in the Member States and candidate countries.

The novel approach proposed by the LAGOONS, i.e., the Pan-European integration aspect, ensures that project results will be particularly useful, since it is devoted to the enhancement of the connectivity between research and policy-making exploiting the recently developed concept of SPSI (science-policy-stakeholder interface) (Gooch & Stålnacke, 2010) and SPI-CIS (science-policy interface – common implementation strategy).

In the management terms, LAGOONS will contribute to the decision-support methodologies for a coordinated approach to the Water Framework Directive and the Marine Strategy Directive. In addition, LAGOONS will propose actions to tackle bottlenecks in the context of climate change, i.e., LAGOONS will propose actions foreseen in the goals of the Europe 2020 strategy - A strategy for smart, sustainable and inclusive growth.

ACKNOWLEDGEMENT

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