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ECOMANAGE

Integrated Ecological Coastal Zone Management System

Deliverable 4.8: First report on index assessment strategy

Deliverable 4.9: Criteria for index application in the scenarios to study

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1 FOREWORD

This short document aims to make a first step forward in delineating a strategy to select ECOMANAGE indicators. The underlying basic ideas are explained hereinafter. Feedback from the partners is expected. This is a working document in the sense that the indicators proposed need to be evaluated by each partner for other suggestions or, eventually, for acceptation. Furthermore, after reaching an agreement in what concerns the indicators to be selected, the reference values (or, perhaps better, significant changes) need to be proposed for each component, as explained in section 5.

2 INTRODUCTION

An indicator is defined as "a statistic or measure, which facilitates interpretation and judgment about the condition or an element of the world or society in relation to a standard or goal" (USEPA, 1995).

"Indicators help to reflect and communicate a complex idea […]. We use them to observe, describe, and evaluate actual states, to formulate desired states or to compare an actual with a desired state. These simple numbers, descriptive or normative statements can condense the enormous complexity of the world around us into a manageable amount of meaningful information. […] It aims to communicate information on the system or process. The dominant criterion behind an indicator's specification is scientific knowledge and judgement." (WWDR, 2003).

Within the water-related field, indicators must be used to manage and systemize information due to the large amount of data available and the increasing complexity of policy problems, providing information for political decision-making processes, and also information for the public.

The type of indicators proposed for ECOMANAGE project are "basic indicators", defined in Chapter 1 of the WWDR (2006) as to "provide fundamental information not directly linked to policy goals (e.g. water resources, GNP and population), well established, widely used and corresponding to data generally widely available around the world".

The use of an indicator depends on the objectives for which they are used. In the following sections, a proposal for ECOMANAGE indicators will be explained based on the 3 project case-study areas needs.

3 OBJECTIVES

The use of indicators within ECOMANAGE Project has the objective of connecting the driving forces of the watershed activities to the coastal ecosystems and resources, through pressures and pathways, using the conceptual index framework of DPSIR (driver-pressure-state-impact-response) initially proposed by OECD (1993).

The indicators proposed will serve two main purposes within the Project: 1) reflect the present state of waters (inland and estuary) due to the existing pressures; and 2) evaluate effects deriving from new scenarios to be modelled regarding various environmental management measures of land use - land cover changes. Their final purpose is to help choosing the watershed scenarios that better contribute to a sustainability integrated management of the selected coastal zones.

The indicators in this project will be **'state' indicators** (DP**S**IR), meaning indicators that describe the actual conditions of the systems. These indicators will be divided in quantity and quality, and proposed for groundwater, surface water and estuary water. Sonak *et al*. (2003) refer a set of other type of indicators for coastal ecosystems analysis, also using the DPSIR framework such as: 'Pressure' indicators, which refer to the stresses created by different drivers on the coastal area; and 'Impact' indicators which can be described by the effect on coastal ecosystems and resources as reflected by changes in the characteristics of the ecosystem. 'Pressure' and 'impact' indicators are not proposed to be used for ECOMANAGE project.

Once ECOMANAGE project scenarios will be centred in land use - land cover changes, 'state' indicators will directly attempt to reflect mainly the effects of these changes, both in the watershed and in the estuary waters:

- In the case of **Santos estuary**, these aspects will concern essentially social changes: movement, increase and density of population and their effects in water demand and water pollution and the sustainability of mangrove.

- In the case of **Bahía Blanca estuary**, it will be the changes in land use for agriculture and for livestock, as well as the placement of city sewage treatment plant that will be considered.

- In the case of **fiord Aysen**, it will be the effects of intensifying and extending the salmon fish farming that will be predicted for several scenarios and the results assessed using the corresponding indicator values.

4 INDICATORS PROPOSAL

4.1 Quantity

'State' quantity indicators will be defined only for inland waters, as the changes in pressures are not expected to be reflected in the quantity of the water in the estuary. Quantity indicators will assess the changes in water amount due to the different scenarios of pressures for each case-study. As in fiord Aysen the scenarios are proposed for changes in the fish farming, directly in the estuary waters, 'state' quantity indicators are not proposed for this case-study.

For groundwater, the quantity 'state' indicator proposed is the piezometric level. Additional pumping, either due to scenarios of growth of population consumption or to agriculture demands, will result in a decrease in this level. Note that if the source for irrigation water comes from surface water, it is possible that an increase in the groundwater level is observed.

Aiming the assessment of aquifer vulnerability to sea-water intrusion in coastal aquifers, that may affect the mangrove health, **GALDIT index** (originally done in the framework of the EU-India INCO-DEV COASTIN project, see Chachadi and Lobo Ferreira, 2005 for further details) describes the most important factors controlling seawater intrusion: ***G***roundwater occurrence (aquifer type; unconfined, confined and leaky confined); ***A***quifer hydraulic conductivity; Depth to groundwater ***L***evel above the sea; ***D***istance from the shore (distance inland perpendicular from shoreline); ***I***mpact of existing status of sea water intrusion in the area; and ***T***hickness of the aquifer, which is being mapped. The acronym GALDIT is formed from the highlighted letters of the parameters for ease of reference. These factors, in combination, are determined to include the basic requirements needed to assess the general seawater intrusion potential of each hydrogeologic setting. GALDIT factors represent measurable parameters for which data are generally available from a variety of sources without detailed examination. A numerical ranking system to assess seawater intrusion potential in hydrogeologic settings has been devised using GALDIT factors. The system contains three significant parts: weights, ranges, and ratings. Each GALDIT factor has been evaluated with respect to the other to determine the relative importance of each factor.

For surface water, the chosen indicator is the flowrate discharge of rivers into the estuaries. Flowrate changes reflect the seasonal availability, the climatic changes and also reflect the extra demands (Pressures) due to urban and agriculture activities. A decrease in the flowrate will be expected in scenarios of population and agriculture growth. Moreover, the water quality is expected to be worsening due to these activities, as can be seen in the next section. Salt water intrusion can also affect the possibility of using surface fresh water of upstream reservoirs.

4.2 Quality indicators

'State' quality indicators will help assessing the current status of water quality (due to existing pressures) and to further weigh up the effects of the different scenarios to be modelled.

As stated before, the scenarios for the 3 case-study areas are focused on changes due to population changes, to land use changes due to agriculture and livestock, and to changes in fish farming. All these activities have analogous effects in what concerns the main type of pollutants associated. Therefore, the selection of common indicators is possible and, therefore, hereinafter proposed. The main types of pollutants expected are described in Table 1.

Table 1 - Principal activities potentially causing water pollution (adapted from CHAPMAN, 1996)

Activity	Category	Main types of pollutants				
	P Point; D Diffuse; L Line	Faecal pathogens	Nutrients	Organic micropollutants	Heavy metals	Salinity
Urbanisation						
Unsewered sanitation	P-D	X	X	X		
Land discharge of sewage	P-D	X	X	X		X
Stream discharge of sewage	P-L	X	X	X		
Sewage oxidation lagoons	P	X	X	X		
Sewer leakage	P-L		X	X		
Landfill, solid waste disposal	P		X	X	X	X
Highway drainage soak-aways	P-L			X		X
Wellhead contamination	P	X	X			
Agricultural						
Cultivation with:						
Agrochemicals	D		X	X		
Irrigation	D		X	X		X
Sludge and slurry	D		X	X		X
Wastewater irrigation	D	X	X	X		X
Livestock rearing/crop processing:						
Unlined effluent lagoons	P	X	X	X		
Land discharge of effluent	P-D	X	X	X		X
Stream discharge of effluent	P-L	X	X	X		

From the main type of pollutants referred, the following indicators are proposed (among other possibilities):

- Faecal and other pathogens coming from livestock and human waste; Indicator: *Escherichia coli* (E-Coli).
- Nutrients such as nitrogen and phosphorus coming from fertilizers, manures, and sewage sludge; Indicator: nitrate (NO_3^-) and phosphate (PO_4^{3-}).
- Organic micropollutants wastes coming from slurries, silage liquor, surplus crops, and sewage sludge. Indicator: chemical oxygen demand (COD) or biologic oxygen demand (BOD) or dissolved oxygen (DO).
- Heavy metals have little expression in this type of pollution, and therefore no indicators are proposed.
- Salinity indicates the freshwater and salt water interactions; Indicator: electrical conductivity (EC) and salinity (Cl^-).
- Total suspended solids (TSS) is also an important indicator of loads, i.e. soil particles (resulting in suspended solids) coming from farming, upland erosion, forestry, urban areas and construction and demolition sites.

Urban, agriculture and livestock can also led to other important indicators that were not chosen for this project since their analyses are frequently unavailable. They are pesticides, veterinary medicines, biocides, and endocrine-disrupting substances (particularly oestrogenic steroids deriving from human contraceptive pills, linked to feminization of male fish). This is a proposal among several other valid possibilities.

4.3 Synthesis of the indicator proposal

Table 2 presents a synthesis of the 'state' indicators for ECOMANAGE project, based on the 'pressure' scenarios that will be modelled for each case-study site, as referred in previous sections.

Table 2 - Synthesis of the 'state' indicators for ECOMANAGE project

Case study	Pressure	'State' quantity indicators			'State' quality indicators		
		Groundwater	Surface	Estuary	Groundwater	Surface	Estuary
Aysen	Fish farming	Piezometric level	Flowrate	-	E-Coli, NO_3^-, DO, BOD, EC, Cl^-	E-Coli, NO_3^-, PO_4^{3-}, COD or BOD, EC, Cl^-, TSS	E-Coli, NO_3^-, PO_4^{3-}, COD or BOD, EC, Cl^-, TSS
Bahía Blanca	Agriculture + population	-	-	-			
Santos	Population + industry in the harbour	Piezometric level	Flowrate	-			

Note that the 8 quality indicators proposed for surface and estuary waters are not all included in groundwater. TSS is a meaningless measure in groundwater since the geological material acts as a natural filter that reduces their value. Phosphorus is usually not a problem in groundwater quality due to its strong retention into the soil particles.

It is our view that it is very important to have as much common indicators as possible between inland and estuary, so as to facilitate communication within the effects of scenarios changes.

5 WORK TO BE DONE BY EACH THEMATIC TEAM

Based on the 'state' quality and quantity indicators referred in Table 2 of the previous section, each thematic team (groundwater, surface, and estuary) must now define the guideline values for the quantity and quality indicators proposed in Table 2, as well as an indication of what should be the changes that can be considered to assess the effects of different pressures.

Table **3** presents a proposal for groundwater 'state' indicators, based on the "natural background level" (NBL) defined in MEUS *et al*. (2006) as "the concentration of a given element, species or chemical substance present in solution which is derived by natural processes from geological, biological or atmospheric sources".

Table 3 - Proposal for groundwater 'state' indicators within ECOMANAGE project

'State' indicator	Maximum natural background level	Significant change
Piezometric level	-	Variation in the yearly average value of the piezometric level
E-Coli	0 N/100 ml	Variation of the values above 5% in a significant period
NO_3^-	10 mg NO_3/l	
DO	8 mg DO/l	
EC	2500 µS/cm	
Cl^-	1000 mg Cl/l	

Values above the maximum natural background level will tell us that an influence of anthropogenic source is occurring. However, *significant changes* might be a better judge for assessing the effects of different land use or land cover changes scenarios and might also prove to be better to compare scenarios effects among different case-studies.

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