THE EUROPEAN CORINE LAND COVER 2000 PROJECT
IGN-FI
October 2005

Xavier Depouilly
Ign France International
xdepouilly@ignfi.fr

KEY WORDS: environment, land cover, digital, interpretation, inventory, updating, change detection, international

SUMARY

Environmental protection has become a major challenge and concern within the European Community. The European Community/Commission introduced environmental action programmes in 1972 (Statement from the Paris Summit 1972). However, the real breakthrough occurred with the Treaty of Amsterdam in 1992, where environmental protection was set as a priority.

In support of environmental assessment, the need for updated information on land cover (LC) has become important both at the European and national levels. The growing interest in such information can be ascribed to the important role of LC in processes taking place on the Earth's surface, such as absorption of solar radiation, utilization of carbon dioxide by plant associations and evaporation. Landscape changes at the national and global levels are becoming even more topical, and their importance acquires new dimensions not only in research, but also in environmental management. That is why harmonized and standardized spatial reference data are considered mandatory in support to the following environmental management in the European Union policies:

- Environmental assessment and sustainable development (European Union Strategy for Sustainable Development COM (European Commission 2001).
- Territorial impact assessment and regional planning (Structural Funds, European Spatial Development Perspective).
- Impact of agricultural policies on the environment.
- Nature Conservation and Environmental Protection (the Natura2000 network and LIFE programme).
- Water Framework Directive.
- Integrated coastal management.
- Strategic environmental assessment of the Trans-European network.

In response to the need for environmental assessment, the IMAGE 2000 & CORINE Land Cover 2000 (I&CLC2000) project was launched by the European Environmental Agency (EEA) and the Joint Research Centre of the European Commission (JRC). The I&CLC2000 project aims to provide a satellite image mosaic of Europe (IMAGE2000), an up-to-date LC database for the year 2000 (CLC2000), and information on general LC changes in Europe between 1990-2000 (Steenmans and Perdigao 2001). The I&CLC2000 is a joint three-year project between the EEA and the JRC, co-funded by the European Commission and the participating countries. Initiated in 2000 in Member States, the project was extended in 2001 to accession countries and currently covers 29 countries.

1. BACKGROUND

1.1. Introduction

From 1985 to 1990, the European Commission implemented the CORINE Programme (Co-ordination of Information on the Environment). During this period, an information system on the state of the European environment was created (the CORINE system) and nomenclatures and methodologies were developed and agreed at EU level. At the Dobris Conference in 1991 the European Environment Ministers requested the application of the programme to the Central and Eastern European countries covered by the EC Phare programme.

Following the European Council decision to set up the European Environment Agency (EEA) and the establishment of the European Environment Information and Observation Network (EIONET), the responsibilities of the CORINE databases, including their up-dates rely now on the EEA. CORINE Land Cover (CLC) is the largest of CORINE databases, providing information on the physical characteristics of the earth surface. Images acquired by earth observation satellites are used to derive land cover information.

The overall aim of updating is to produce the CLC2000 database and the database of CLC-Changes between the 1990's and 2000. To guarantee full coverage and to maximise consistency with the previous inventory, the I&CLC2000 project calls upon existing local expertise and requires access to both the ancillary data and the satellite data used for the first CLC inventory. The I&CLC2000 project consist of two main components, which are interconnected (EEA-ETC/TE, 2002):
• IMAGE2000: covering all activities related to satellite image acquisition, ortho-rectification and production of European and national mosaic and
• CLC2000: covering all activities related to updating of the 1st CLC inventory (called CLC90) based on IMAGE2000 and detection and interpretation of CLC-Changes by using CLC90 and IMAGE90.

1.2 Project organisation

I&CLC2000 is a joint EEA / JRC project in which the JRC has the responsibility for the IMAGE2000 and EEA is responsible for CLC2000. EEA is overall coordinator of the project and the overall responsibility for the CLC2000 component. Therefore EEA establishes an information chain to ensure that all bodies involved have access to information on the ongoing CLC inventory and reports to the European Steering Committee.
JRC is responsible for the IMAGE2000 component and is coordinating the IMAGE2000 team, which involves European organisations specialised in satellite image processing.

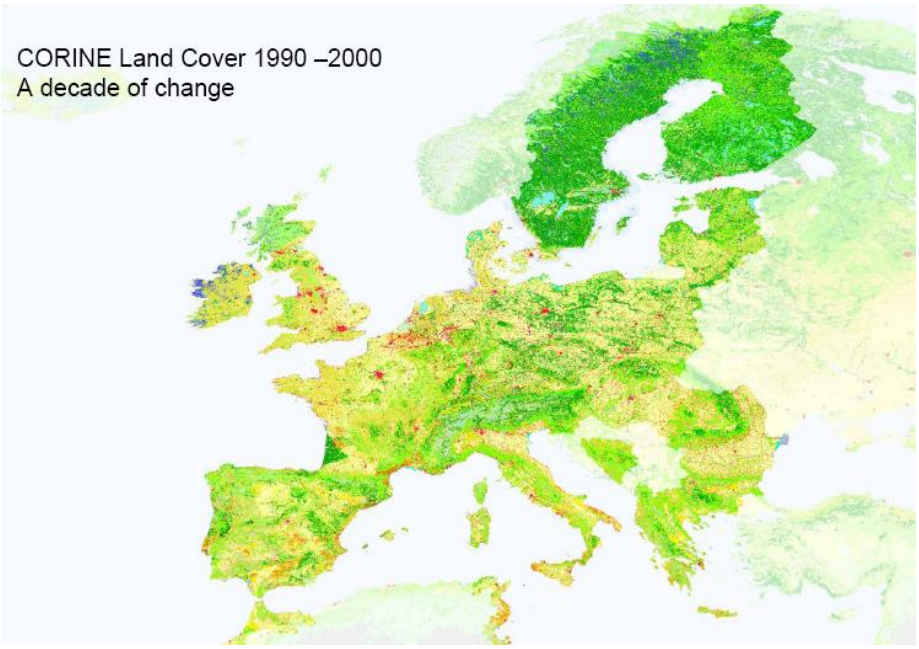
2. THE CLC2000 PROJECT

2.1 From CLC90 to CLC2000

The basic aim of the CLC project is to provide an inventory of the Earth surface features for managing the environment (Heymann et al., 1994). Only features that are relatively stable in time are mapped. CLC is not interested in diurnal changes (tide), seasonal changes (e.g. vegetation cycle) or short-term changes (e.g. flooding). The approach of computer assisted visual interpretation of satellite images have been chosen as mapping methodology. The choice of scale (1:100.000), minimum mapping unit (MMU) to be mapped (25 hectares) and minimum width of linear elements (100 metres) represents a trade-off between cost and detail of land cover information.
These two basic parameters are the same for CLC90 and CLC2000. However, in CLC90 some of the countries had not kept the 25 ha limit, which made comparison among countries difficult.

The standard CLC nomenclature includes 44 land cover classes. These are grouped in a three level hierarchy. The five level-one categories are: 1) artificial surfaces, 2) agricultural areas 3) forests and semi-natural areas, 4) wetlands, 5) water bodies. All national teams had to adapt the nomenclature according to their landscape conditions.

Mapping representation of Corine Land cover in Europe



Although the 44 categories have not changed since the implementation of the first CLC inventory (1986-1998), the definition of each nomenclature element was significantly improved (Bossard et al., 2000).

2.2 Evolution of the methodology

During the first CLC inventory a “traditional” photo-interpretation method was used: a transparent overlay was fixed on top of a satellite image hardcopy and the photo-interpreter drew polygons on it. Later the overlay was digitised, topology was created and the CLC code entered (Heymann, et al., 1994). This procedure often resulted in several types of errors:
• Geometrical errors caused by an imprecise hardcopy image size, distortions of the hardcopy image, improper alignment of overlay and image, errors of digitisation.

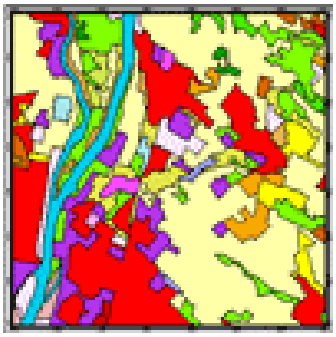
• Thematic errors made by the photointerpreter because of the limited interpretability of hardcopy image and / or because of misuse of the nomenclature. Thematic mistakes could have been introduced also during the database-coding phase.

In CLC2000 the method of drawing on transparencies was rejected, and the use of computer-assisted photointerpretation (CAPI) was required (Perdigão and Annoni, 1997). The improved technology was expected to provide better thematic and positional accuracy.

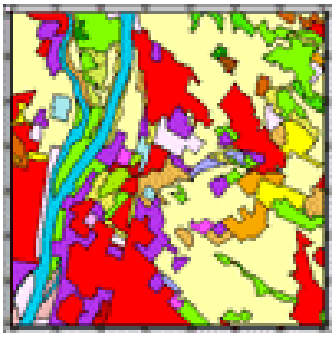
2.3 Land Cover changes

CLC2000 is based on the photo-interpretation of satellite images by the national teams of the participating countries.
The CLC2000 is done by mapping the changes occurred between theCLC90 and the date of updating. The change detection process and the mapping of the CLC-Changes are carried out by means of image comparison, using computer aided visual interpretation tools.
The CLC90 is used as reference data set. The methodology was developed by the JRC in collaboration with the ETC Land Cover (Perdigão, Vanda and A. Annoni, 1997). The method was successfully applied within the LACOAST Project (Perdigão, V. and S. Christensen, 2000) and by the Phare Topic Link on Land Cover Project (Feranec et al., 2000).
The MMU of the LCC database was set to 5 ha. The 100 meter minimum width is also valid for the LCC polygons from practical reasons. Changes should refer to real evolution processes, and not to different interpretations of the same subject. Therefore amendments of CLC90 and real changes have to be clearly distinguished.

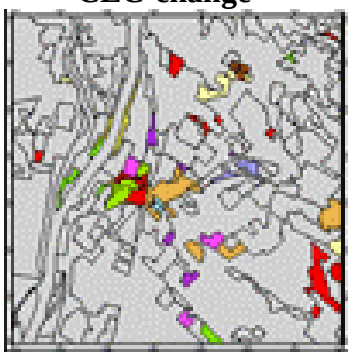
CLC90



CLC2000



CLC-change



CLC2000 shows the land cover change in ecosystems such as forest, lakes, pasture etc and the impact of human activities (such as housing, food production, transport etc.) on land use. Forty four land cover classes are used to map changes aver time all of which tell their own story of how decisions made across Europe have led to alternation in the landscape.

2.4 Products of the CLC2000 project

The CLC2000 project creates a number of defined standard output products. All vector products should be in ArcInfo format. National products are created in national projection, while European vector data are provided in geographical coordinates (ETRS89 system). European raster products are delivered in Lambert Azimuthal Equal Area projection.
The dissemination and use of the I&CLC2000 products is defined in an agreement between the EEA, the European Commission and the participating

3 Applications

The CORINE land cover database 1990 is still the second most downloaded data set from the EEA data service with more than 3500 downloads for the different versions. Looking at country statistics a similar picture is available – close to 5000 copies of the CLC90 database have been distributed by the national authorities.
The database has served a wide range of application sectors apart from the environment, such as agriculture, forestry, physical planning, transport or education and research. This variety is even expected to grow with the arrival of the CLC2000 and land cover change databases.
Environmental applications have focussed in their majority on nature conservation and biodiversity related issues, as well as water and soil management (including modelling of diffuse contamination) or air pollution and climate change.

Several applications are also foreseen within the European Commission Services, such as DG-Regional Policy, DG-Environment and DG-Agriculture, as well as in EEA and its European Topic Centres (ETCs). The work plan includes European-wide computation of agri-environmental indicators (IRENA project), assessment of fragmentation by urban and transport infrastructures, mapping urban sprawl, mapping forests within 1, 25 and 50 km from major urban agglomerations, and coastal zone assessment (Kleeschulte, 2004a).

31 Applications at different scales

To make plans, you need information. And to make effective plans you need accurate, objective information. CLC is a planner’s tool and provides land cover information that actually helps people to visualise the area of interest, what they look like and how they have changed over time.

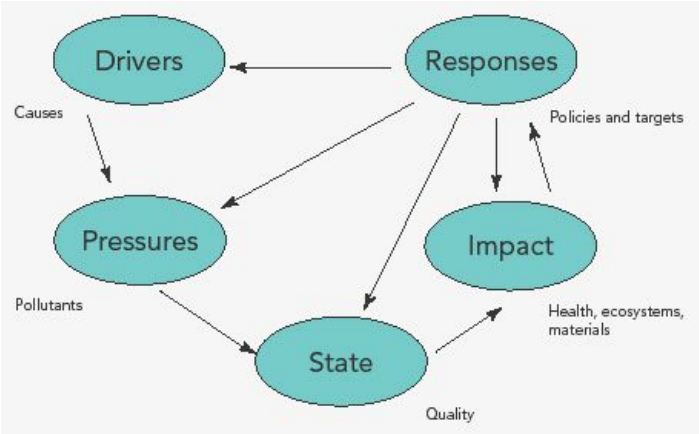
The CLC database can be used as an analytical tool supplying statistics about land use or the development of land use and management in a specific area. It can be compared to other databases such as nature reserve or regions under economic development, their city centres and their surroundings.

32 Definition of Environmental indicators

Indicators synthesize and compile information collected through different databases, providing a useful tool to measure environmental performance. The main objective of the ETC is to develop a core set of indicators to provide policy relevant information on Europe's terrestrial environment, to review and evaluate the effectiveness of existing policies, and to provide the basis for a better integration between environmental and sectoral policies.

Integrated assessment:
The complexity of terrestrial environment must be addressed by putting together a broader set of areas than an assessment of the same issue within the bounds of a single topic.
One approach is to analyse the causal chain that joins human actions to valued consequences for the environment.

The EEA has defined the **DPSIR** framework to assist in the development of indicators [Driving forces - Pressure - State - Impact - Response].



CLC can support the development of environmental indicators for nature conservation. For example it is possible to show where an endangered habitat is intense pressure from factors such as transport, urban expansion or agriculture. If the habitat is reduced or fragmented by human influence, the resulting isolation of individuals and groups of species can lead to species decline. Some of these indicators can be used for research while others can have a direct use in policy formation.

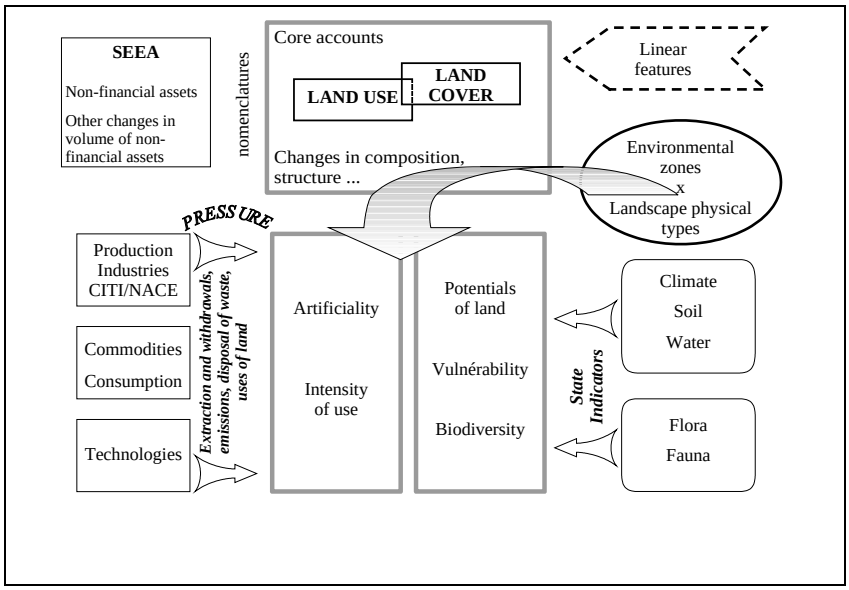
33 The Land Ecosystem Account LEAC

Environmental accounting and modelling aim at describing the interactions within the environment and between the environment and the economy. To some extent, the environmental account are a model, very simple and of a general nature. The accounts aim is to check the consistency and the quality of data coming from various sources, to organise them in a systematic way and to calculate a first set of indicators (costs, results, availability of a resource etc.). To some extent also, the accounts help in organising the statistics for modelling purposes.
In the continuation of the work initiated by the UN-ECE, Eurostat is leading a working group on land accounting. It is therefore too early to describe precisely what the land accounts will look like. However, some key points can be stated.

First land cover (what is seen from the sky) has to be clearly distinguished from land use (what the people do). The accounts of the habitats (what the use of land by Nature) have to be distinguished as well. For land cover, the CLC inventory is accepted as the basic source in Europe. Land use is a more complex issue an no obvious answer is available. In particular, the current classifications of land uses avoid the key issue of the possible multiple use of a land. They miss therefore the description of the conflicts resulting from these multiple uses. The classification of habitats will be based on the classifications defined by the biologists; these classifications can be bridged with the land cover types, at least an aggregated level.

It is also agreed that land use should be put in relation with the economic accounts through appropriate tables. The so-called input-output tables and the NAMEA model (developed by the Central Bureau of Statistics of the Netherlands) seems a relevant solution.

Another area of agreement is that a distinction has to be made between core accounts, which production could be recommended for all the countries and supplementary accounts developed for specific policy issues. This position is the continuation of the approach proposed by the UNECE task force[1].
It can be summarised in the following scheme :



34 Digitised analysis of geographical information

In many cases, it is possible to obtain the information required by policy makers simply by using systematically the GIS resources.

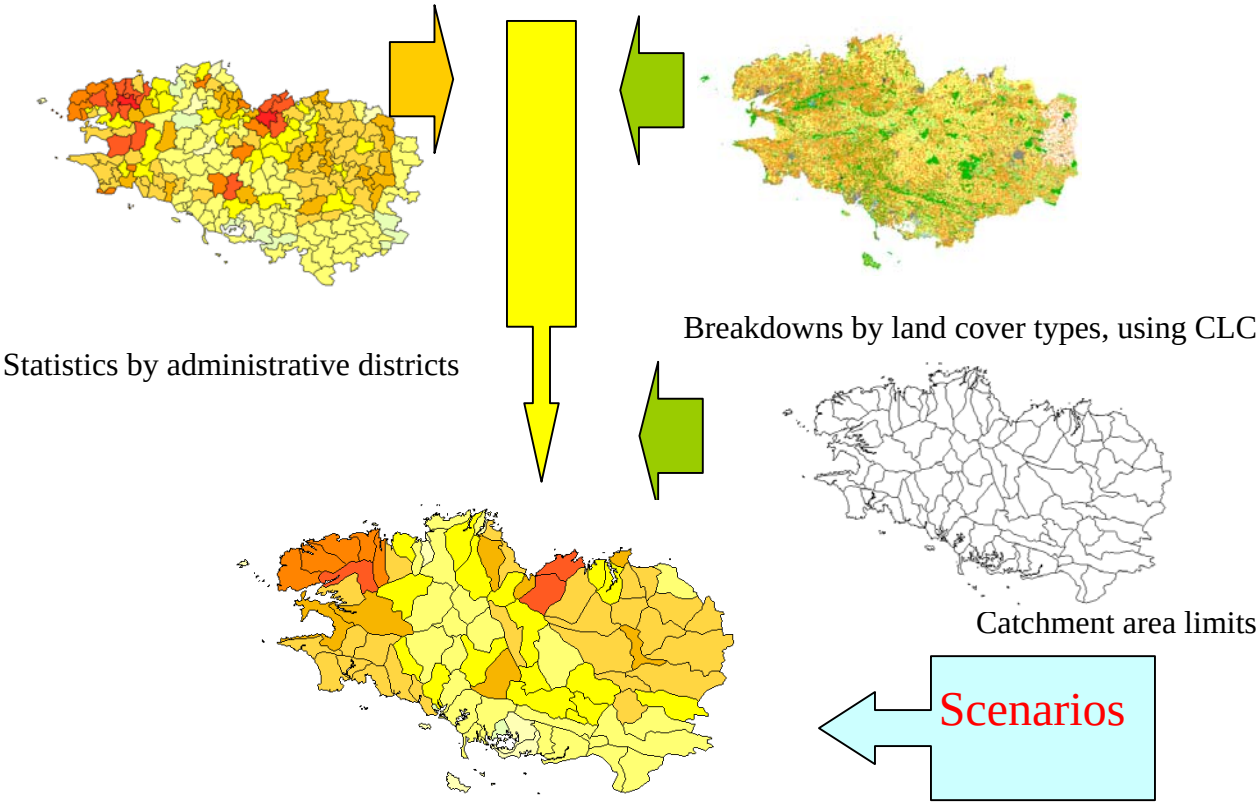
For example, it is no need spending time and money in photo-interpreting linear (roads, rivers…) and point features when these data are available from other sources. It is therefore easier to overlay these geographic data with CLC. The only possible difficulty lays in the geometric compatibility between CLC and other geographic databases. This point has to be tackled in an early stage of the CLC process of production. The minimum is a high standard in the geometric correction of the satellite images. When an official national cartographic database exists, the best compatibility with it has to be obtained.

Another way of producing details with a GIS is by dint of breakdowns of CLC classes according to various zoning. Typically, the overlaying of CLC with the Digital Elevation Model (DEM) is an easy way of producing maps, e.g. of forests according to their altitude or to the magnitude of the slope (for mapping the so-called “protection forests”). Coastal wetlands or rocky land can be identified in the same way, without changing anything to CLC.

Many overlays can be produced for taking into account the geology, the pedology, or the climate, when it matters.

Example:
Physical modelling is essential in the development of the environmental information systems. Basically, most important purpose of physical modelling is not the production of forecasts or outlooks. These one can only be developed in the context of a broader system analysis, integrating socio-economic factors and scenarios and relate to what is called analytical modelling. Indeed, physical modelling is important for the understanding of the interactions, in particular in the DPSIR chain. A major difficulty is that the equations of the local models (even simplified) cannot be fed with the current statistics, which are either too much aggregated or collected in a non-appropriate framework. The example below shows the calculation of the leakage of nitrogen to rivers due to the use of fertilisers. Modelling is obviously the only way of assessing the exceeding quantities of nitrogen and obviously, the calculation has to be done river basin by river basin, taking into account the agriculture land in each river catchment area. Unfortunately, the current statistics on crops and on sales of fertilisers are not available with the appropriate breakdown. They are collected in an administrative framework when data are required for physical units. The difficulty can be partly solved with CLC and the HYDROSOL model. The example below comes from a comparative study of the flows of Nitrogen in the Loire and Elbe basins, realised by Ifen, Beture and a group of German research institutes, WRc and Gisat for the Joint Research Centre[2].

An illustration of the methodology is given by the figure below (region of Bretagne, France) :



APPENDIX A

CORINE LAND COVER NOMANCLATURE (Heymann et al., 1994)

LEVEL 1	LEVEL 2	LEVEL 3
1. ARTIFICIAL	SURFACES 1.1. Urban fabric	areas 1.1.1. Continuous urban fabric 1.1.2. Discontinuous urban fabric
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units 1.2.2. Road and rail networks and associated land 1.2.3. Port areas 1.2.4. Airports
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites 1.3.2. Dump sites 1.3.3. Construction sites
	1.4. Artificial, non-agricultural vegetated	1.4.1. Green urban areas 1.4.2. Port and leisure facilities
2. AGRICULTURAL	AREAS 2.1. Arable land	2.1.1. Non-irrigated arable land 2.1.2. Permanently irrigated land 2.1.3. Rice fields
	2.2. Permanent crops	2.2.1. Vineyards 2.2.2. Fruit trees and berry plantations 2.2.3. Olive groves
	2.3.Pastures	2.3.1. Pastures
	2.4. Heterogeneous agricultural areas	2.4.1. Annual crops associated with permanent crops 2.4.2. Complex cultivation patterns 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4. Agro-forestry areas
3. FOREST AND SEMI-NATURAL	AREAS 3.1. Forests	vegetation 3.1.1. Broad-leaved forest 3.1.2. Coniferous forest 3.1.3. Mixed forest
	3.2. Scrub and/or herbaceous associations	3.2.1. Natural grassland 3.2.2. Moors and heathland 3.2.3. Sclerophyllous vegetation 3.2.4. Transitional woodland-scrub
	3.3. Open spaces with little or no	3.3.1. Beaches, dunes, sands 3.3.2. Bare rocks 3.3.3. Sparsely vegetated areas 3.3.4. Burnt areas 3.3.5. Glaciers and perpetual snow
4. WETLANDS	4.1. Inland wetlands	4.1.1. Inland marshes 4.1.2. Peat bogs
	4.2. Marine wetlands	4.2.1. Salt marshes 4.2.2. Salines 4.2.3. Intertidal flats
5. WATER BODIES	5.1. Inland waters	5.1.1. Water courses 5.1.2. Water bodies
	5.2. Marine waters	5.2.1. Coastal lagoons 5.2.2. Estuaries 5.2.3. Sea and ocean