Information on integrated management of water and territory. International proposals for balances and indicators

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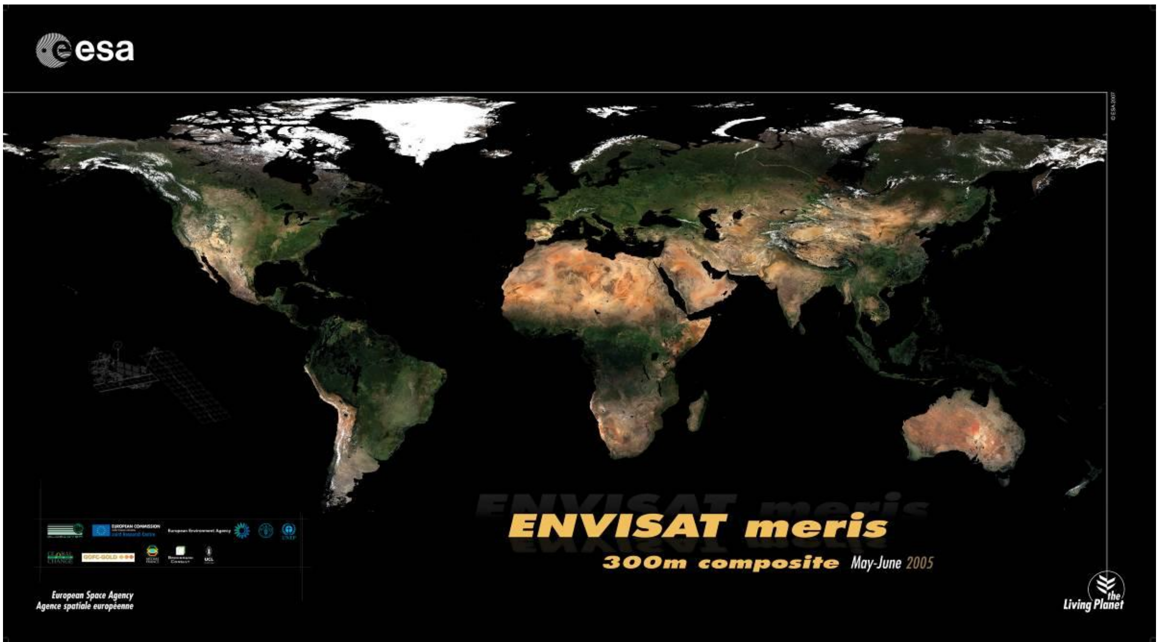
1. SOME ISSUES WHERE GEOGRAPHY MATTERS FOR WATER POLICY // WHERE WATER MATTERS FOR LAND PLANNING



Source: European Space Agency (2007) [1]

At a glance, a satellite image of the world like the "Tapisserie de Montreux", the sharpest ever satellite map of Earth – presented in the Envisat Symposium

[1] http://esamultimedia.esa.int/images/EarthObservation/globcover/globcover_MOSAIC_H.jpg and http://www.esa.int/esaEO/SEMGSY2IU7E_index_0.html

2007 shows the broader picture of water and land. Water in all its states, in particular in soil and vegetation; dryness sprawling from Northern Africa to Southern Europe….

The number of subject matters involving interactions of water and land is very high but a few points capture most of the story.

a. The natural Net Primary Production (NPP) potential of a territory depends on solar energy received, soil, land use, and water. Droughts which affect more or less, more or less frequently nature, agriculture and the people are overcome with irrigation, which leads to storage and transport of water over or between territories.

b. As well as a resource, water is a risk when floods occur; a natural hazard worsened by deforestation and soil sealing by artificial development, as well as with excessive construction in well known flood risk areas. A risk expected to increase with climate change.

c. Water covers land with rivers and lakes but water makes as well land cover in some cases. An example is with temporary wetlands, a rich ecosystem which role is important in turn in water cycle as a natural buffer against floods and a denitrification system protecting coastal water from eutrophication. Another example of the production of territory by water are the phenomenon of accretion of coasts by rivers' sediments and oppositely coastal erosion when large dams sequestrate these sediments.

d. The conservation of ecological networks is the indispensable complement of nature protection, recognised in Art.10 of the Habitat Directive. These networks are made of favourable landscapes and rivers, which are natural corridors for fishes as well as, on their banks, for many other species. When fragmentation by large dams is responsible of sediment sequestration, small dams have a strong impact on fishes.

e. Regarding pollution of rivers, as much as the amount of residuals, the localisation of their emissions matters.

f. Access to clean water means availability of water altogether in quantity and quality (ies), at a given place, when needed, at a cost affordable for different uses by various social groups. Access to water is one the most serious source of inequality in the world, a strong message of the Johannesburg conference of 2002. In a better position, Europe is not free of inequalities regarding access to water.

g. The European Water Framework Directive, which asks altogether for good ecological quality of water ecosystems, full recovery of costs and sustainable use of water is based on territorial units: the river basin districts and the river sub-basins. It reflects the need for an ecological-economic integration of resource management: the cost of water service should include the full procurement cost plus the cost of maintaining/restoring water ecosystems – all these costs being to a large extent entangled. The river basin – an hydrological territory is becoming a management unit of responsibility (payment for the full costs) and solidarity (access of all to clean water).

These issues – and several others not mentioned here – have lead the EEA to a more integrated vision of its own information system, elaborating on the concept of "Integrated platform for land, water and biodiversity" and to focus on ecosystems. Accordingly, spatial analysis has been given a central role in assessments and has been integrated to economic-environmental accounting.

2. INFORMATION INPUT TO DECISION MAKING: SPATIALLY EXPLICIT ACCOUNTS OF LAND COVER, LAND USE, ECOSYSTEMS AND WATER.

In practical terms, integrating data and information on land, water and biodiversity requires:

- Assimilating geographic and statistical data sets. In Europe, this is in particular achieved via the implementation of the Shared European Environmental Information System (SEIS) on the one hand and by implementing procedures for sampling and modelling monitoring data and statistics. SEIS goes beyond the INSPIRE directive which streamlines the harmonisation of the basic geographical data with the perspective of facilitation of access and interoperability of databases at the various levels. SEI is collecting as well thematic data on the main environmental items. The task is distributed between 3 European bodies: EEA (air, climate change, water, land use and biodiversity), Eurostat (resource use and waste) and JRC, the Joint Research Centre (soil, forest). Other items will be progressively assigned to one or the other organisation. The process is coordinated by a group of 4 directors, which includes in addition DG Environment.
- Developing a conceptual model showing the linkages between the various realms and supporting the development integrated indicators and aggregates. At the macro level, the development of this conceptual model takes place in the framework of the UN integrated system of economic environmental and economic accounting [2].
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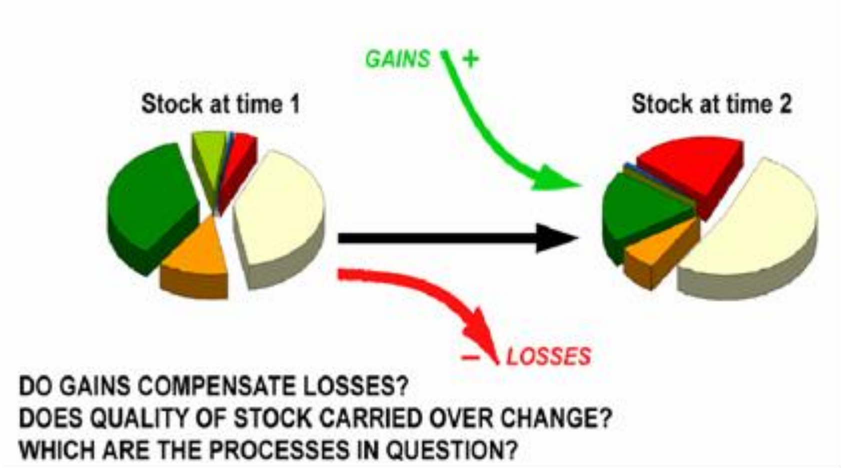
[2] **UN, European Commission, OECD, the World Bank and IMF**, SEEA2003, http://unstats.un.org/unsd/envaccounting/seea2003.pdf

Figure 1: Principle of stock and flows accounts



The SEEA covers:

- Physical and hybrid (physical x monetary) flow accounts
- Economic accounts and environmental transactions
- Asset accounts in physical and monetary terms
- and an overview and discussion of possible techniques for the extension of SNA aggregates to account for depletion, defensive expenditure and degradation

Issues regarding land and water are in particular covered in the chapters relating to "assets accounts", altogether with subsoil, fisheries and forests. Land is sketched as land and ecosystem accounts. Water accounts are built upon a systemic description of the hydrological and use systems, in reference to territories.

2.1. Land and Ecosystem Accounts (LEAC)

The European Environment Agency has started the implementation of a programme of land use and ecosystem accounts, following the System of Environmental and Economic Accounts (SEEA) guidelines of the United Nations. The purpose is to integrate information across the various ecosystem components and to support further assessments and modelling of these components and their interactions with economic and social developments. This programme reflects the increasing demand for environmental policy integration in Europe, both vertically through thematic policies as well as horizontally across policies in those sectors that contribute most to environmental impacts. The construction of land and ecosystem accounts is now feasible due to continuous improvements in monitoring, collecting and processing data and progress with the development of statistical methods that facilitate data assimilation and integration. The accounts are based on explicit spatial patterns provided by comprehensive land cover accounts that can be scaled up and down using a 1 km^2 grid to any type of administrative regions or ecosystem zones (e.g., river basin catchments, coastal zones or bio-geographic areas).

2.1.1. Land cover accounts

Land cover accounts 1990-2000 have been produced for 24 countries in Europe and will be updated for year 2006. They record stocks of land cover, defined from the 44 classes of the Corine land cover classification and land cover flows which summarize the 44 time 43 elementary changes measured in the CLC matrix into 50 processes, grouped in 10 at level 1. Therefore the accounts tell how much “consumption” of hectares of the initial year and “formation” of hectares of the final year has taken place for a given land cover (urban, agriculture, forests, wetlands, water bodies) and according to which processes (Urban residential sprawl, sprawl of economic activities, conversion to agriculture, forest management, water body creation and management…).

The table below, from the EEA report[3], gives a general overview of the processes which have taken place in Europe. Methodology and commented results are presented in the report.

[3] **EEA** (2006) Land accounts for Europe 1990-2000, EEA Report No 11/2006 prepared by **Haines-Young, R.** and **Weber, J.-L**. – http://reports.eea.europa.eu/eea_report_2006_11/en

Table 2.2 A flow account describing processes of land cover change in 24 countries in Europe, 1990–2000

Corine land cover types	1	2A	2B	3A	3B	3C	4	5	
Land cover flows	Artificial areas	Arable land and permanent crops	Pastures and mosaics	Forested land	Semi-natural vegetation	Open spaces/ bare soils	Wetlands	Water bodies	Total, km²
LCF1 Urban land management	737	15	19	0	8	0	0		780
LCF2 Urban residential sprawl		1 924	1 867	200	145	8	3	2	4 149
LCF3 Sprawl of economic sites and infrastructures	77	2 728	1 595	665	451	35	22	53	5 627
LCF4 Agriculture internal conversions		17 252	10 062						27 314
LCF5 Conversion from other land cover to agriculture	273		935	1 796	1 734	155	96	50	5 039
LCF6 Withdrawal of farming		2 393	2 860						5 253
LCF7 Forests creation and management	254			35 803	5 166	1 048	1 063	3	43 337
LCF8 Water bodies creation and management	191	252	253	117	190	17		21	1 042
LCF9 Changes due to natural and multiple causes	311	44	15	1317	1323	1 041	229	252	4 534
Total consumption of 1990 land cover, km²	**1 843**	**24 608**	**17 607**	**39 899**	**9018**	**2 304**	**1 413**	**381**	**97 074**
No change	160 016	1 149 717	802 502	990 736	255 914	50 289	45 502	45 473	3 500 149
Total land cover 1990, km²	**161 860**	**117 4325**	**820 109**	**1 030 635**	**264 932**	**52 593**	**46 915**	**45 854**	**3 597 223**
LCF1 Urban land management	780								780
LCF2 Urban residential sprawl	4 149								4 149
LCF3 Sprawl of economic sites and infrastructures	5 627								5 627
LCF4 Agriculture internal conversions		15 695	11 619						27 314
LCF5 Conversion from other land cover to agriculture		2 450	2 590						5 039
LCF6 Withdrawal of farming			1 124	2 792	1 244	23	70	0	5 253
LCF7 Forests creation and management				42 547	766	24			43 337
LCF8 Water bodies creation and management						21		1021	1 042
LCF9 Land cover due to natural and multiple causes				4	2 167	1 790	313	260	4 534
Total formation of 2000 land cover, km²	**10 556**	**18 144**	**15 333**	**45 343**	**4 177**	**1 858**	**383**	**1280**	**97 074**
No change	160 016	1149717	802 502	990 736	255 914	50 289	45 502	45 473	3500149
Total land cover 2000, km²	**170 572**	**1 167 861**	**817 835**	**1 036 079**	**260 090**	**52 147**	**45 885**	**46 754**	**3 597 223**

Source: EEA (2006)

2.1.2. Ecosystem accounts

Ecosystem accounts record stocks, resilience, material/energy flows and ecosystem services as well as their counterpart in terms of use of material/energy flows and ecosystem services by the sectors[4].

In the case of ecosystem services, a distinction is made between those services which are entangled in the value of market commodities and the end use non market services enjoyed for free by people. In the latter case, accounts are first established in physical terms, then in monetary terms, using shadow or virtual prices. At this stage, the natural capital is recorded in physical terms only. Instead,

[4] The framework of ecosystem accounts is presented in
Weber, J.-L. (2007) Implementation of land and ecosystem accounts at the European Environment Agency, Ecological Economics Volume 61, Issue 4, 15 March 2007, Pages 695-707.

the full maintenance cost of ecosystem integrity is computed; full maintenance means up to societal stated objectives (International conventions, European regulations and directives, national laws…).

Ecosystem accounts are established at several scales for landscape functional units. Key spatial units are:

- land cover units – for which Corine land cover (CLC) supplies a wide exhaustive picture for 35 European countries; these CLC units are supplemented with the database of river reaches produced for water accounting
- socio-ecosystems dominated by a land cover type;
- functional landscapes such as ecological networks defined by their capacity of supporting exchanges between habitats, river basins and coastal zones
- local ecosystems and habitats

In CLC terms the main classes of ecosystems or socio-ecosystems are: urban systems, intensive agriculture, extensive mosaic agriculture, pasture and natural and semi-natural grassland, forests, wetlands, water bodies.

Stocks and flows are accounted for in terms of

- Land cover
- Water
- N, P, C, CO_2
- Biomass
- Biodiversity

A draft nomenclature of ecosystem services has been established, following the principles of the Millennium Ecosystem Assessment. The main difference is a clarification of the status of the so-called "support services" which correspond to internal ecosystem functions, not an output to people. Therefore, ecosystem services will be made of "provisioning services" (almost all incorporated in market commodities), socio-cultural and regulating services (which can be either market or non-market services).

2.2. Spatial accounting of water quantities, qualities and costs

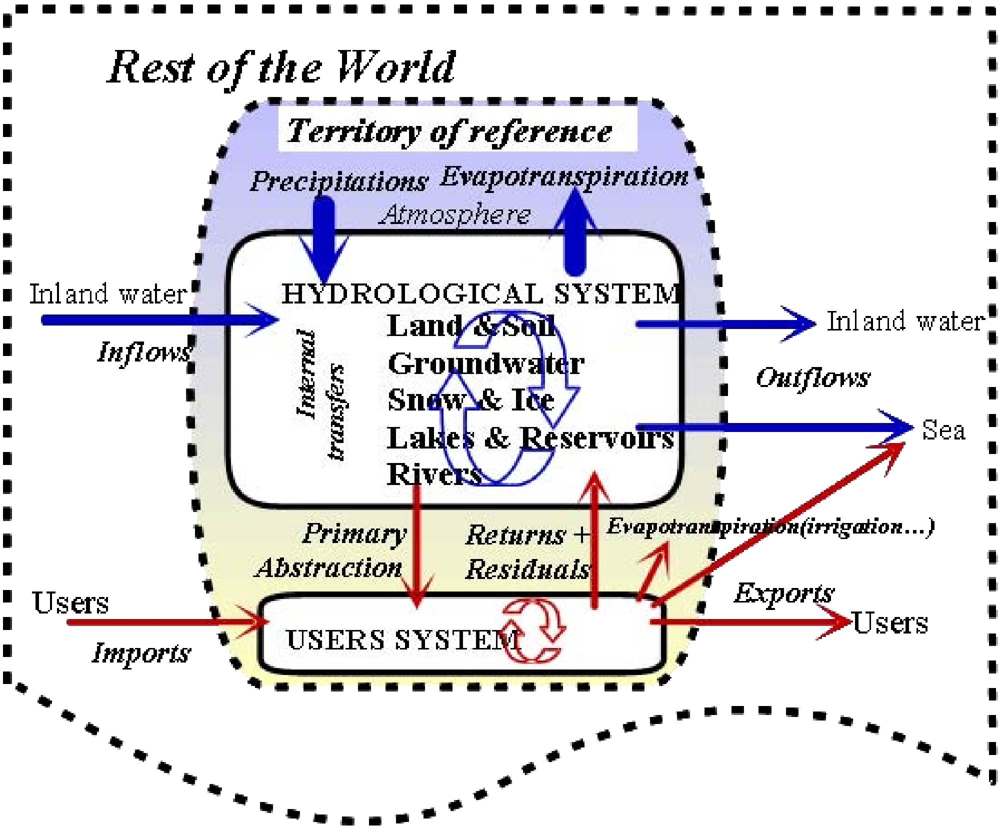
Pilot water accounts have been produced for France and Spain in the 1980s and more recently for Chile, Moldova, Turkey, Australia, and the Netherlands. The experience gained has resulted in the drafting of an implementation handbook for water accounting, in addition to the water chapter of SEEA. The purpose is to support the implementation of water accounts in particular in the UN context. Tests are currently done by Eurostat and the EEA to assess the possible contribution of water accounts to the information system of the Water Framework Directive and in turn their feasibility considering data availability.

Water accounts are based on a comprehensive framework based on a system analysis of water assets and use. It can be described as a system made of two sub-systems:

• The water system (or hydrological system) made of water bodies (rivers, lakes, aquifers) and soil/land/vegetation and

• The use system restrictively defined within the limits of abstraction and returns of water. According to these conventions, in situ uses of take place in the water system. The overall system is bounded by the atmosphere and upstream inflows on the one side, by evapo-transpiration, and downstream outflows to other basins or the sea on the other side.

Figure 2: System analysis of water accounts



Source: Tafi J. & Weber J.-L. (2000)

Accounts are established for spatial units. These units can be water bodies and functional units such as basins, sub-basins; in this case, water accounts feed in hydrological modelling. Basins are as well the appropriate units for water managements and economics in general. Because the accounting framework records inflows and outflows, accounts can be established for any other zoning, in particular for administrative units such as regions or countries; in this case, the relevance of hydrological modelling is generally low but the match with general budget management may be easier.

Within each of the sub-systems, internal transfers of water are recorded. Within the water system, transfers take place between land/soil, surface water bodies and subsoil – they result in a characterisation of the state of the water resource and its location. Within the use system, the breakdown will be done according to the economic sectors of the UN System of National Accounts (ISIC nomenclature). In aggregated tables, a highlight is kept on water distribution and sewerage. The supply and use table integrates transfers between sectors and the various uses by industries and households. This is currently the most standardised part of water accounts, for which test applications are lead by the UN Statistical Division.

The table below is an example of aggregated asset account for water quantities.

Table 8.7 An asset account for water — Million cubic metres

		EA.131.Surface water			EA.132	Land & soil	Total
		EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers	Groundwater		
Opening Stocks			**2743.5**	**500**	**150000**	**5000**	**158244**
Abstraction (-)	Total abstraction			2453	265		2717
	Sustainable use						
	Depletion						
Residuals (+)	Returns from irrigation (lost water)						0
	Wastewater			315	81.1		396.3
	Treated waste water						0
	Untreated waster water						0
	Cooling water			1448			1448.2
	Water used for hydroelectricity						0
	Lost water in transport				218		218
	Others						0
Consumption by irrigation (+)						621	621
Precipitation (+)			210.2	168		13636	14014
Inflows (+)				9000	1100		10100
Net natural transfers (+,-)		0	0	2013	-135.5	-1878	0
Evapo-transpiration (-)			416	333		12723	13472
Outflows (-)	To other country			10150	1379.1		11529
	To the sea						0
Other volume changes	Due to natural disaster						
	Discovery (+)						
	Others						
Net accumulation		***0***	***-206***	***9***	***-380***	***-344***	***-921***
Closing Stocks		**0**	**2538**	**509**	**149620**	**4656**	**157323**

Source: Water Data Centre, Moldova 1994, Provisional results, courtesy Jana Tafi

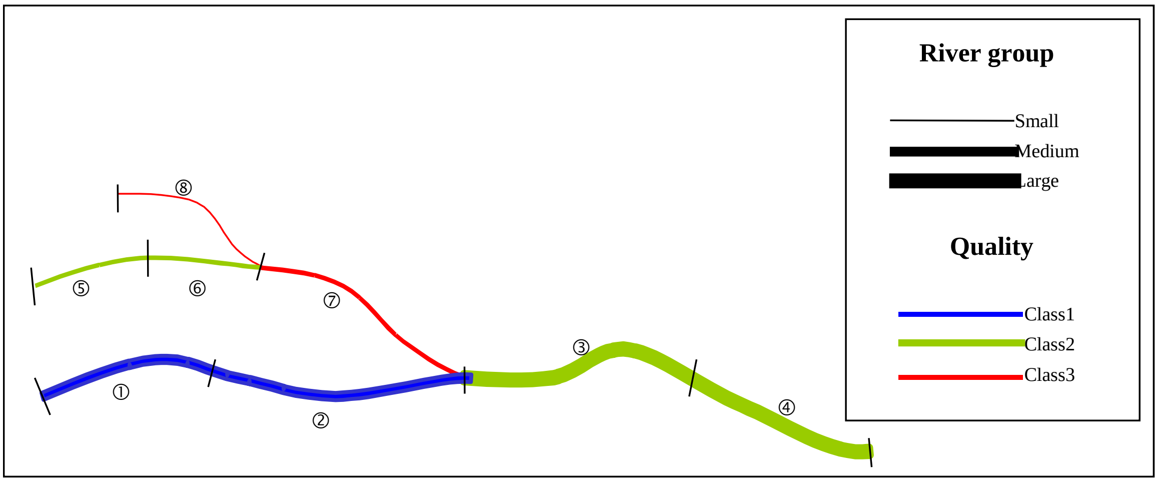
The assets accounts of water cover more than the economic assets of the SNA: rivers (and canals), lakes (and reservoirs), aquifers as well as water in snow and ice and land/soil/vegetation. This last category can be, if requested subdivided according to the CLC categories used for land accounting – for example for assessing the contribution of land covers (irrigated vs. non irrigated cropland, rangeland vs. cropland, forest plantations…) to evapo-transpiration.

The assets accounts include as well accounts for the biochemical and ecological quality of the water. In the case of rivers – where the quality “flows” with the water, an additional analysis of rivers sub-systems is done in homogeneous reaches (segments with the same discharge). These reaches are then measured by their length times discharge or standard river kilometres:

1 srkm = 1 km x 1 m3 / second

This measurement tells first where (in which type of river or sub-basins or regions) is the available water resource from rivers. Second, quality attributes can be assigned according to various methodologies combining chemical-physical and/or biological parameters. This gives an integrated measurement of the “quality of the quantity” of water available in rivers.

Figure 3: Principle of the subdivision into river reaches



(Each segment is given a weight in srkm)

The thermodynamic eco-integrated accounting (exergy synthesis) of water quantity, quality and maintenance/restoration costs developed in Spain is the most integrated development of water accounts. Based on the water quality accounts framework (with in particular rivers spatially assessed and measured in srkm), the water accounts produced in Spain are tools for operational management of territories. Recognising the entangling of quantity and quality aspects of the resource (the quality of a river can be degraded by polluting discharges as well as by excessive abstraction), connected to the territory and the ecological objectives assigned by the society (e.g. in policy documents such as WFD, Natura2000 and the CBD objectives, Kyoto Protocol…), the water accounts are the practical basis of the calculation of the full cost of meeting these objectives and their translation into market prices.

The last dimension of water accounts is precisely related to monetary flows of water protection and management. This is a particular building block of the SEEA, which records actual expenditures by “characteristic activities” of environmental protection and management. These current and capital expenditures are analysed form the point of view of the producers of the environmental service (water business, municipal services), the financing (by central, regional and local government, companies and households) and the beneficiaries. As a consequence the full cost of water management (the full recovery of costs recommended by WFD) can be decomposed into actual expenditures and additional maintenance and restoration costs (Gasco & Naredo[5] 1994 and Naredo 2007[6]).

From a management perspective, the spatial integration of water accounts allows, last, addressing other issues like social inequalities in the access to water and compensatory measures to be taken. From a social perspective, the finalisation of the integration of water accounts in the framework of ecosystem accounts will lead to a complete description of the other ecosystem services linked to water bodies, in particular amenities, angling or climate regulation…

[5] **Gascó, J. M.** y **Naredo, J. M.** (dirs.) (1994) *Las Cuentas del Agua en España*, 6 vol. (CAE 94) (trabajo contratado por la D.G. de la Calidad de las Aguas, MOPMA. English summary in **Naredo, J.M.** (1997) "Spanish water accounts (sumary report)", in San Juan, C. y Montalvo, A. (eds.) *Environmental economics in the European Union,* Mundi-Prensa y Universidad Carlos III, Madrid, pp.369-443.

[6] **Naredo, J. M.** (2007): "Costes Y Cuentas Del Agua – Propuestas Desde El Enfoque Ecointegrador", *Workshop on water costs and accounts in Catalonia in relation to the Water Framework Directive*, Catalan Water Agency, Barcelona, 18-19 June 2007