23rd Meeting of the London Group on Environmental Accounting

San Jose', 17-20 October 2017

Proposal for additional accounts to assess sustainability and to track the causality nexus

Alessandra La Notte

European Commission Joint Research Centre

Directorate D – Sustainable Resources

[Please refer to the paper La Notte, Maes, Dalmazzone et al. (2017) for the case study application]

Abstract:

The possibility to work with biophysical models allows the compilation of the basic Supply and Use tables presented in the SEEA-EEA and of complementary information where a further extended production boundary can be tested. There are in fact some ecological concepts that require further developments of the current frame: by keeping the strict rules that regulate the accounting mechanism of SNA we attempt to extend the production boundary to allow a more active role to be played by ecosystem types as full accounting units. Specifically, ecosystem types as accounting units should be able to produce, "accumulate" and consume (being aware that we deal with ecological processes). The very first implication of considering ecosystem types as accounting units is that what should be assessed on the supply side is what ecological types are able to offer independently of how much of it will be used. Two different kinds of flows should thus be reported in accounting: the potential flow that relevant ecosystem types are able to generate for each individual service and the actual flow that is currently used/consumed by economic sectors and households; being the former the supplementary supply table to be added to the traditional set of accounts. The second implication of considering ecosystem types as accounting units requires to explicitly separate them from benefits and to address the issue of how to combine 'products' (SNA) and environmental assets (SEEA-AFF, SEEA Water) with what in the SEEA-EEA is called SNA benefits and non-SNA benefits. The importance of specifically reporting benefits in a combined presentation is to clearly separate the service flow generated by ecosystem units from the final benefit perceived. There might be cases (third implication) where the enabling actor of the service differs from those who perceive the final benefit (beneficiaries). This is true especially for sink-related services. In the case of polluters, enabling actors are those who activate the service: without them the service would not be there. One purpose we need from the accounting tool is to establish the causality nexus between the behavior of human actors (economic sectors and households) and sustainability. The three implications are here tested on the pilot application on water purification across Europe.

1. Introduction

The 7th Environment Action Programme (EAP) and the EU Biodiversity Strategy include objectives to develop natural capital accounting (NCA) in the EU, with a focus on ecosystems and their services. The Knowledge Implementation Project on the Integrated system of Natural Capital and ecosystem services Accounting (KIP-INCA) aims to design and implement an integrated accounting system for ecosystems and their services in the EU. KIP-INCA builds on the first phase of the EU initiative on Mapping and Assessment of Ecosystems and Services (MAES), which aims to map and assess ecosystems and their services in the EU, and supports the second phase of MAES which aims to value ecosystem services and integrate them into accounting and reporting systems by 2020. The starting point of our application is the UN System of Environmental-Economic Accounting- Experimental Ecosystem Accounts, which includes: accounts of ecosystem extent, ecosystem condition, ecosystem services and thematic accounts as well as monetary accounts which should help to integrate the results of ecosystem accounting with the System of National Accounts (SNA).

The SEEA-EEA supply and use tables are for KIP-INCA the starting point to develop pilot applications. It provides us with the basic structure to start a comprehensive and consistent accounting for ecosystem services. However, few issues mentioned in the SEEA-EEA require practical applications to be addressed and solved.

Firstly, to consider only the actual flow of ecosystem services can be not sufficient to analyse the issue of sustainability; for this, we need to measure whether the service has been overused. To report what is actually used can be misleading especially for sink-related service since a higher actual use implies a higher impact (in this case the more the worse, but this does not show). Strictly linked with the notion of sustainability is the notion of capacity, which is still debated. By being the ability to generate the ecosystem service, capacity is intended as the critical ecological functioning basis needed to sustain the yearly flows of each service.

Secondly, the complementarity with the SEEA-CF should be reinforced in order to avoid: (i) the risk of overlapping provisioning services and natural inputs. Although the ecosystem services use table by also including 'products' is structured to provide the first hint to link with the national accounts datasets, still the major ambiguity generates from mixing services with benefits; (ii) the role of residual flows. Although it is acknowledged that ecosystems play a regulating and filtering role in reducing the impact of residual flows on humans, there is no clear indication on how to combine the physical flows from economic units into the environment (i.e. pollutant emissions) with the flow of regulating services (sink-related services) from ecosystems to economic units. The definition of SNA and non-SNA benefits should be further explored: the notion of benefit should be integrated as much as possible with the definition of goods and services provided by the SNA and the SEEA-CF.

Thirdly, by separating service from benefits might imply different categories of users. This is especially true for sink-related services, such as air filtration, water purification, carbon sequestration. A crucial role for these services is played by enabling actors: those services exist because there are economic sectors and/or households who pollute. The service of 'cleaning' generate benefits who will be likely used by different categories of users. The allocation of the sink-related services to one category (enabling actors) or the other (beneficiaries) requires further thinking and analyses.

We are going to use a first pilot application (La Notte et al., 2017) to screen all these implications and find out relevant features.

2. Application

The application we here report concerns a regulating ecosystem service characterized by being a sink-related service. The empirical objective of this case study is to value the water purification service that take place in inland waterbodies in Europe. In-stream nitrogen retention is used as proxy for the actual flow of water purification. We define N retention as the process of temporary or permanent removal of nitrogen taking place in the river. This includes the processes of denitrification, burial in sediments, immobilization, and transformation or simply transport. Please refer to the published paper (La Notte et al., 2017) for a detailed description of the biophysical and valuation models' description and procedure.

2.1 Standard tables: the transactions

In the current SEEA-EEA, the standard frame requires to report in the supply and use tables the actual flow. This represents in fact what in economic accounts is referred as 'transactions' between ecosystem units (in our case "inland waters") and economic sectors and households. The more nitrogen is emitted, the higher is the actual flow.

Table 1. Monetary flow (constant price 2000) for in-stream nitrogen retention at national scale (EU 27)

Country	Actual river nitrogen removal (euro km^{-1} $year^{-1}$)		
	1985	1995	2005
Austria	20,542	20,612	20,649
Belgium	44,390	42,487	41,798
Bulgaria	11,297	11,646	11,828
Croatia	16,227	16,175	16,144
Cyprus	6,149	6,131	6,001
Czech Republic	19,276	19,009	19,181
Denmark	60,580	60,218	60,201
Estonia	40,097	40,039	39,715
Finland	74,929	74,920	74,619
France	44,389	44,816	44,063
Germany	32,196	32,756	31,659
Greece	26,127	25,769	25,492
Hungary	5,212	5,164	5,163
Ireland	40,970	41,083	40,894
Italy	45,253	45,609	45,251
Latvia	39,898	39,416	39,325
Lithuania	32,564	31,950	32,372
Luxembourg	50,247	50,661	48,853
Netherlands	34,595	34,176	33,725
Poland	25,478	25,144	25,232
Portugal	17,513	17,219	16,600
Romania	5,709	5,673	5,761
Slovakia	7,913	7,777	7,759
Slovenia	25,749	25,399	25,047
Spain	19,539	19,288	17,622
Sweden	79,913	80,159	80,073
United Kingdom	45,209	44,887	44,685

Table 1 shows us how important (from one country to the other) is water purification, but does not provide any information on the ability of inland water to keep on providing this service in the short, medium and long run. This ability depends in fact on how degraded inland waters are: the actual flow alone is not the proper measurement to assess overuse and degradation.

2.2 Additional tables: building the capacity

To enlarge the production boundary implies that ecosystem types can be treated as accounting units in the same ways it happens for other institutional sectors. It should thus be possible to consider the flow that relevant ecosystem units are able to provide independently of how much of it will be used. This does not mean that the transactions change (i.e. actual flow), but it implies that additional information is added on the potential flow and on the difference between the potential and the actual flows.

For some ecosystem services, it is possible to assess the maximum potential flow supplied. For other ecosystem services (i.e. sink-related services) any attempt to calculate a maximum potential is either impossible or useless; for them it makes sense to establish and properly justify a sustainability threshold and to measure the sustainable flow.

Table 2. Monetary flow (constant price 2000) for in-stream nitrogen retention at national scale (EU27)

Country	Sustainable river nitrogen removal (euro km^{-1} $year^{-1}$)		
	1985	1995	2005
Austria	12,657	12,856	14,640
Belgium	318	64	478
Bulgaria	1,923	1,130	774
Croatia	1,822	2,378	2,940
Cyprus	277	662	407
Czech Republic	14,161	19,435	21,862
Denmark	0.09	3.05	52.88
Estonia	32,738	11,421	45,349
Finland	178,935	156,191	206,894
France	7,628	5,139	7,592
Germany	20,356	21,418	33,449
Greece	1,044	708	746
Hungary	80	155	171
Ireland	22,948	20,276	25,136
Italy	8,581	8,211	9,964
Latvia	3,404	13,232	22,569
Lithuania	143	3,119	3,809
Luxembourg	204	46	1,114
Netherlands	58	69	253
Poland	21,714	23,299	25,525
Portugal	2,728	2,538	8,197
Romania	578	930	399
Slovakia	319	1,187	1,228
Slovenia	7,519	11,639	12,029
Spain	4,570	4,649	3,863
Sweden	208,661	223,885	344,206
United Kingdom	19,069	20,707	20,638

By comparing tables 1 and 2 we find out how in most cases actual flow goes above the sustainability threshold; we also find out that the unsustainability trend is decreasing from 1985 to 2005. To calculate the Net Present Value (NPV) of the actual flow for most countries would consider higher values and a decreasing trend over time; the same calculation for sustainable flow for the same countries would consider a lower value with an increasing trend over time. Very different messages to be passed to policy makers.

Strictly linked with the notion of sustainable flow is the notion of capacity. By being the ability to generate the ecosystem service, capacity is intended as the critical ecological functioning basis needed to sustain the yearly flows and should be calculated for each individual ecosystem service. In order to be measurable and applicable for supply and use tables, capacity might be assessed not for the ecosystem as a whole but for each ecosystem service individually. Capacity might thus be considered in terms of ecological processing as what the stock represents in terms of physical assets.

In the case of water purification (Table 3) capacity has been calculated as the Net Present Value (NPV) of the sustainable flow, i.e. what the ecosystem is able to provide now and in the future for that specific ecosystem services. Once the sustainable flow is confronted with the actual flow, degradation might occur if the latter is higher than the former and that will affect the capacity opening stock value for the following time period. This virtual process-based setting allows consistency in accounting terms.

Table 3 - Total capacity of the European river network (EU27) to generate in-river nitrogen retention services at sustainable level expressed in monetary terms (constant price 2000).

Monetary terms	Net present value of the stock (billion €)
1985	233.66
1995	233.72
2005	335.58

The remarkable shift from 1995 to 2005 can be explained by the Nitrates Directive, a regulation on the reduction of N emissions entered into force in 1991. Information on whether and how the Directive has increased (or decreased) the value of natural capital in terms of water purification can be relevant and serve many other linked analyses.

3. The combined presentations

To enlarge the production boundary and to treat ecosystem types in the same ways it happens for other institutional sectors implies that a magnifying glass is placed on them as producer units: the production process should not to be mixed with the outcome it generate if relevant relationships have to be tracked.

3.1 Embedded services and benefits

In the current presentation of ecosystem services supply and use tables, benefits are not explicitly separated from services and this facilitate the allocation of the flow to final beneficiaries that in this (simplified) example are water companies.

supply table

ecosystem services	Type of economic unit: agriculture	forestry	fisheries	mining and quarrying	manufacturing	construction	trasportation and storage	accomodation and food service activities	electricity, gas supply	water collection, treatment and supply	professional scientific and technical activities	other industries	households	accumulation	rest of the world - exports
provisioning															
regulating and maintenance															
water purification (blln euro/year)															
1985															
1995															
2005															
cultural															

ecosystem services	Type of ecosystem unit: artificial surfaces	herbaceous crops	woody crops	multiple or layered crops	grassland	tree-covered areas	mangroves	shrub-covered areas	regularly flooded areas	sparse natural vegetated areas	terrestrial barren land	permanent snow and glaciers	inland water bodies	coastal water and inter-tidal areas	sea and marine areas
provisioning															
regulating and maintenance															
water purification (blln euro/year)															
1985													16.20		
1995													16.22		
2005													16.04		
cultural															

use table

ecosystem services	Type of economic unit: agriculture	forestry	fisheries	mining and quarrying	manufacturing	construction	trasportation and storage	accomodation and food service activities	electricity, gas supply	water collection, treatment and supply	professional scientific and technical activities	other industries	households	accumulation	rest of the world - exports
provisioning															
regulating and maintenance															
water purification (blln euro/year)															
1985										16.20					
1995										16.22					
2005										16.04					
cultural															

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provisioning															
regulating and maintenance															
water purification (blln euro/year)															
1985															
1995															
2005															
cultural															

Figure 1 – SEEA-EEA standard supply and use tables in monetary terms

The principle here applied is the “receiver-based allocation” that does not consider the causality between the causes of increasing/decreasing flow, but only the gain/cost that the change in the flow will provide to the final beneficiaries.

3.2 Disentangled services and benefits

In this section, we present and comment services separated from benefits. This implies to include in the Supply table the SEEA-CF non produced good section, and in the Use table the SNA benefits (that corresponds to what is currently included in the SNA), and the non-SNA benefits (currently included neither in the SNA nor in the SEEA-CF). We also included the residual section, which is part of the SEEA-CF. The environmental asset more closely related to water purification is surface freshwater. The reason to look at the water asset is justified by the non-SNA benefit generated by water purification, i.e. clean water. It should in fact be calculated as the fraction of N cleaned freshwater abstracted by water supply companies.

<table>
<tr><td>supply table</td><td colspan="15"></td></tr>
<tr><td>SEEA-EEA</td><td colspan="15">Type of economic unit</td></tr>
<tr><td></td><td>agriculture</td><td>forestry</td><td>fisheries</td><td>mining and quarrying</td><td>manufacturing</td><td>construction</td><td>trasportation and storage</td><td>accomodation and food service activities</td><td>electricity, gas supply</td><td>water collection, treatment and supply</td><td>professional scientific and technical activities</td><td>other industries</td><td>households</td><td>accumulation</td><td>rest of the world - exports</td></tr>
<tr><td>ecosystem services</td><td colspan="15"></td></tr>
<tr><td>provisioning</td><td colspan="15"></td></tr>
<tr><td>regulating and maintenance</td><td colspan="15"></td></tr>
<tr><td>water purification (blln euro/year)</td><td colspan="15"></td></tr>
<tr><td>1985</td><td colspan="15"></td></tr>
<tr><td>1995</td><td colspan="15"></td></tr>
<tr><td>2005</td><td colspan="15"></td></tr>
<tr><td>cultural</td><td colspan="15"></td></tr>
<tr><td>SEEA-CF</td><td colspan="15"></td></tr>
<tr><td>non-produced assets</td><td colspan="15"></td></tr>
<tr><td>SEEA-CF</td><td colspan="15"></td></tr>
<tr><td>residuals</td><td colspan="15"></td></tr>
<tr><td>N input (mlln tons/year)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1985</td><td>57</td><td></td><td></td><td colspan="9">1.3</td><td></td><td></td><td></td></tr>
<tr><td>1995</td><td>55</td><td></td><td></td><td colspan="9">1.2</td><td></td><td></td><td></td></tr>
<tr><td>2005</td><td>82</td><td></td><td></td><td colspan="9">1.3</td><td></td><td></td><td></td></tr>
</table>

SEEA-EEA: sustainable flow	artificial surfaces	herbaceous crops	woody crops	multiple or layered crops	grassland	tree-covered areas	mangroves	shrub-covered areas	regularly flooded areas	sparse natural vegetated areas	terrestrial barren land	permanent snow and glaciers	inland water bodies	coastal water and inter-tidal areas	sea and marine areas
	Type of ecosystem unit														
ecosystem services															
provisioning															
regulating and maintenance															
water purification (blln euro/year)															
1985													22.57		
1995													22.02		
2005													30.84		
cultural															
SEEA-CF															
non-produced assets															
water													X		
SEEA-CF															
residuals															

Figure 2 – Combined presentation reporting the complementary supply table on sustainable flow

To have residuals in the frame greatly help to see the linkage with the service flow: higher/lower nitrogen input have an impact on water purification flow. It also shows which part of nitrogen is retained in soil (that is not part of the water purification service) and which part flows into the inland waters.

By adding data on sustainable flow, we are able to assess whether degradation is occurring. Negative signs show that overuse is taking place. For EU27, although most countries record an actual flow higher than sustainable flow (ref. Table 1 and Table 2), the positive remarkable amount of sustainable flow in Finland and Sweden is able to counterbalance the negative outcome of the other member states. For policy purposes, it does matter how countries are aggregated.

use table

SEEA-EEA: actual flow	Type of economic unit: agriculture	forestry	fisheries	mining and quarrying	manufacturing	construction	trasportation and storage	accomodation and food service activities	electricity, gas supply	water collection, treatment and supply	professional scientific and technical activities	other industries	households	accumulation	rest of the world - exports
ecosystem services															
provisioning															
regulating and maintenance															
water purification (blln euro/year)															
1985	16.02							0.18							
1995	16.06							0.16							
2005	15.88							0.16							
cultural															
SEEA-CF & EEA: benefit flow															
SNA benefits															
water	X	X		X	X	X			X	X		X	X		X
SEEA-CF & EEA: non-SNA benefit flow															
non-SNA benefits															
clean water (less tons N/cbm water)															
1985										X			X		
1995										X			X		
2005										X			X		
SEEA-CF															
residuals															
N input (mlln tons/year)															
1985															
1995															
2005															

SEEA-EEA: (sustainable flow - actual flow)	Type of ecosystem unit: artificial surfaces	herbaceous crops	woody crops	multiple or layered crops	grassland	tree-covered areas	mangroves	shrub-covered areas	regularly flooded areas	sparse natural vegetated areas	terrestrial barren land	permanent snow and glaciers	inland water bodies	coastal water and inter-tidal areas	sea and marine areas
ecosystem services															
provisioning															
regulating and maintenance															
water purification (blln euro/year)															
1985													6.4		
1995													5.8		
2005													14.8		
cultural															
SEEA-CF & EEA															
SNA benefits															
SEEA-CF & EEA															
non-SNA benefits															
SEEA-CF															
residuals															
N input (mlln tons/year)															
1985			51.6										6.7		
1995			49.8										6.6		
2005			77.9										5.5		

Figure 3 – Combined presentation reporting the use table complemented with sustainable flow information

In the Use table, it is possible to allocate the flow of the service to their enabling actors: for water purification diffuse sources concern agriculture, while point sources concern wastewater discharge collected by Waste Water Treatment Plants (WWTP). These are in fact the actors who are able to modify the actual flow of water purification: any policy whose intent is to reduce inland water degradation needs to track this kind of information in order to establish a causality nexus and monitor effects and impacts of regulation, taxes, subsidies and incentives.

The benefit generated by the service is then allocated to the final beneficiaries that cannot modify on the actual flow, but can provide evidence of the need for the society to act.

4. Elements for discussion

The importance of an integrated accounting framework that links together economy and ecosystem services is acknowledged and fully accepted and supported by many scientists active on ecosystem service mapping, assessment, and valuation. From an ecological perspective, it is important to switch on a magnifier lent on the role of ecosystem units in providing ecosystem services. This implies to measure and account for:

- the total flow they provide,
- the effect of transactions with human activities on this flow,
- their long term ability to provide the service flow.

It also implies to:

- disentangle the ecosystem services from the benefits they generate,
- to allocate services to their enabling actors,
- to allocate benefits to their final beneficiaries.

In order to proceed in this direction, it is possible to add supplementary information to the system of tables already in place and harmonize it accordingly. The supplementary information should however consider what is consistent with ecological notions and principles: the accounting mechanism is kept and applied rigorously, but the ecological meaning becomes the operational logic underneath it all.