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Policy applications: a consumption-based indicator for water purification

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1. Introduction

Sustainably managing ecosystem services is critical to guarantee the well-being of current and future generations. To do so it is essential to take into consideration that there might be a spatial disconnection between the place where the service is supplied and the place where the service ends up. We use recently developed production-based water purification accounts to compute water purification consumption-based accounts and therefore measure the international flows of ecosystem services. The water purification service is enabled by agricultural activities, and flows embodied in agricultural products. In this work we quantify for the first time a time-series of consumption-based accounts for the water purification services enabled by agriculture in Europe. Consumption-based accounts refer to the upstream, indirect or embodied (these worlds are often used as synonyms) resources or environmental impacts associated with a consumption activity, for example the total water purification service required by a certain country's consumption of agricultural commodities. The paper is structured as follows. In the next section we summarize the water purification service accounts (production-based) by presenting some of outcomes. The third section presents consumption-based accounts and the water purification services embodied in international trade. The following sections discusses the results and the implications for policy making.

2. Production-based water purification accounts

A first pilot application for water purification accounts was undertaken in EU for the time series 1985 -2005 (La Notte et al. 2017, La Notte and Dalmazzone 2018). From the obtained results we can summarize:

- the main driver of changes in water purification is the agricultural sector – the more nitrogen is emitted through crop production and livestock, the higher the need for water purification;
- having established a sustainability threshold to check the ecological status toward the risk of eutrophication, it is possible to track over time which countries are moving toward a sustainability path;
- considering that an important phase in nitrogen removal is undertaken by soil, we are able to separate which amount from nitrogen total emissions is effectively purified by rivers and lake and thus avoiding double counting or underestimations.

Table 1 reports a simplified version of water purification supply and use tables in 2005, considering that here only actual flows are reported.

Table 1 - Supply and Use table for water purification (mlln of euro, year 2005)

(a) Supply table

water purification *mlln euro year 2005*	Primary sector	Secondary sector	Tertiary sector	Households	Rest of the world - exports	Green urban areas	Cropland	Grassland	Heatland and shrub	Woodland and forest	Sparsely vegetated land	Wetlands	Rivers and lakes	Coastal and intertidal areas
	Type of economic unit					**Type of ecosystem unit**								
AT													153.95	
BE													106.16	
BG													114.51	
CY													2.71	
CZ													135.74	
DE													1,024.53	
DK													118.50	
EE													139.27	
EL													189.05	
ES													749.12	
FI													1,989.50	
FR													2,118.36	
HR													79.01	
HU													50.21	
IE													174.21	
IT													1,108.30	
LT													207.87	
LU													18.61	
LV													234.15	
NL													96.83	
PL													708.07	
PT													123.71	
RO													135.57	
SE													3,097.06	
SI													47.09	
SK													33.49	
UK													726.44	
EU													13,682.03	

(b) Complementary use table

water purification *mlln euro year 2005*	Primary sector	Secondary sector	Tertiary sector	Households	Rest of the world - exports	Green urban areas	Cropland	Grassland	Heatland and shrub	Woodland and forest	Sparsely vegetated land	Wetlands	Rivers and lakes	Coastal and intertidal areas
	Type of economic unit					**Type of ecosystem unit**								
AT	140.28			13.67										
BE	96.93			9.23										
BG	104.45			10.06										
CY	2.50			0.22										
CZ	123.65			12.09										
DE	929.73			94.80										
DK	109.99			8.51										
EE	128.17			11.11										
EL	172.28			16.77										
ES	682.69			66.43										
FI	1,821.26			168.24										
FR	1,926.37			191.99										
HR	71.21			7.79										
HU	44.94			5.28										
IE	160.78			13.44										
IT	1,007.26			101.03										
LT	187.44			20.43										
LU	16.65			1.96										
LV	211.60			22.56										
NL	87.50			9.33										
PL	643.59			64.48										
PT	112.53			11.18										
RO	122.24			13.33										
SE	2,815.40			281.67										
SI	42.76			4.33										
SK	30.55			2.94										
UK	666.68			59.76										
EU	12,459.40			1,222.63										

(a) Supply table (b) Complementary use table

From the supply table we are able to read which ecosystem asset provide the service flow (in this case: rivers and lakes); in the complementary use table we are able to read where the service goes to. As explained in La Notte and Marques (2017) the actual in the Use table has been allocated to sectors and households who (i) create the need for the service and (ii) have the power to modify the amount and availability of the service (i.e. the enabling actors).

3. Consumption-based water purification accounts (multi-regional input-output analysis)

Multi-regional input-output analysis has been widely used to quantify the environmental impacts associated with consumption activities and international trade by tracing all the impacts occurring throughout the supply chain. The main feature of a multi-regional input-output model is the coverage of the world economy and the interrelationships between the different sectors, from different countries. In this work we used the 2013 Release of the World Input-Output database (WIOD), with a disaggregation level of 40 countries one Rest of the World region, 35 industries, covering the time period between 1995-2011. We have extended the database with the production-based water purification accounts, described in the previous section, linked to the agricultural sector. The computation of the consumption-based water purification accounts followed the standard environmentally extended input-output model, as follows:

$$\mathbf{E} = \mathbf{f}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{Y}$$

Let *m* denote the number of countries, *k* the number of industries and *j* the number of environmental resources or impacts under analysis. **E** is the (*j* x *m.k*) matrix of total (direct and indirect) environmental impacts associated with the consumption activities of each country. **f** is a (*j* x *m.k*) matrix of the direct environmental resources required to supply one unit of industry output . The $\mathbf{(I\text{-}A)}^{-1}$ is the (*m.k* x *m.k*) Leontief inverse matrix, which informs on the total (direct and indirect) environmental resources required to supply one unit of industry output. **Y** is (*m.k* x *m*) the final demand (or consumption activities) matrix.

4. Results

The comparison between the production-based water purification accounts and the consumption-based water purification accounts informs about the reliance of a country on external ecosystem services to fulfil its consumption. This is important because consumption is the ultimate driver behind production processes; to tackle overexploitation of ecosystem services requires knowledge of who in the end uses them or benefits from them.

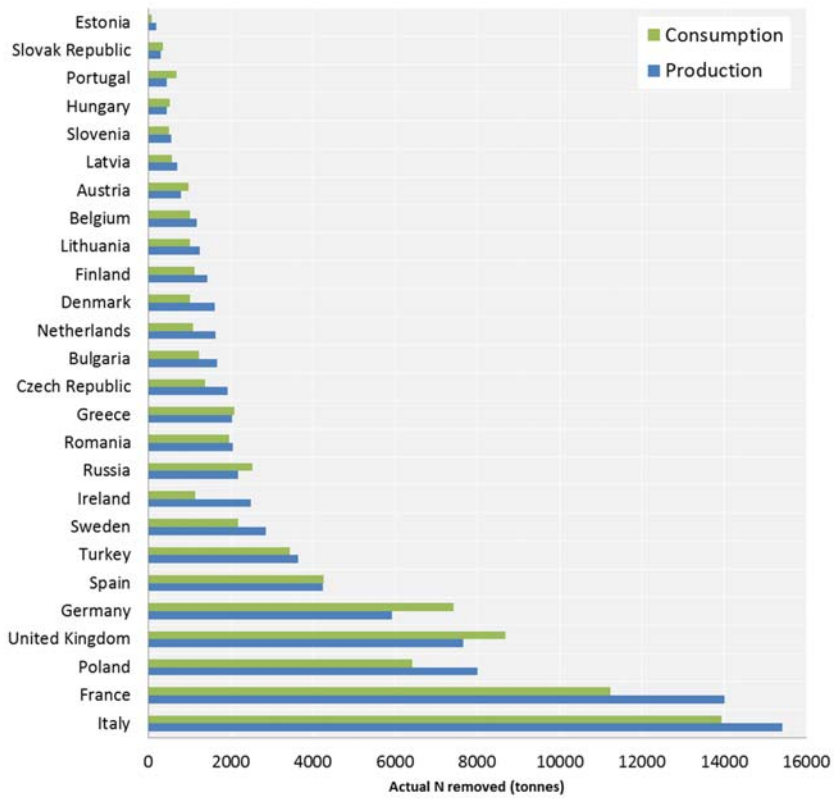

Figure 1 – Comparison between production-based and consumption-based water purification accounts for 2005.

In Fig. 1 we present a comparison between the production-based and consumption-based water purification accounts for 2005. Italy and France, two of the biggest producers of agricultural products in Europe, were the countries which enabled the highest values of water purification service (removal of nitrogen from water bodies). These were also the countries whose consumption of agricultural products enabled the highest values of water purification services in Europe; these were nevertheless lower than the values from production indicating that water purification ecosystem services are being exported elsewhere embodied in agricultural products. France, Poland, Italy and Ireland are the biggest net exporters of the water purification embodied in agricultural products. In France and Poland the majority of the water bodies are in less than good ecological conditions, nevertheless these countries are net exporters of water purification ecosystem service (EEA, 2015). Germany and United Kingdom on the other hand are the European countries whose consumption is most dependent on water purification services elsewhere.

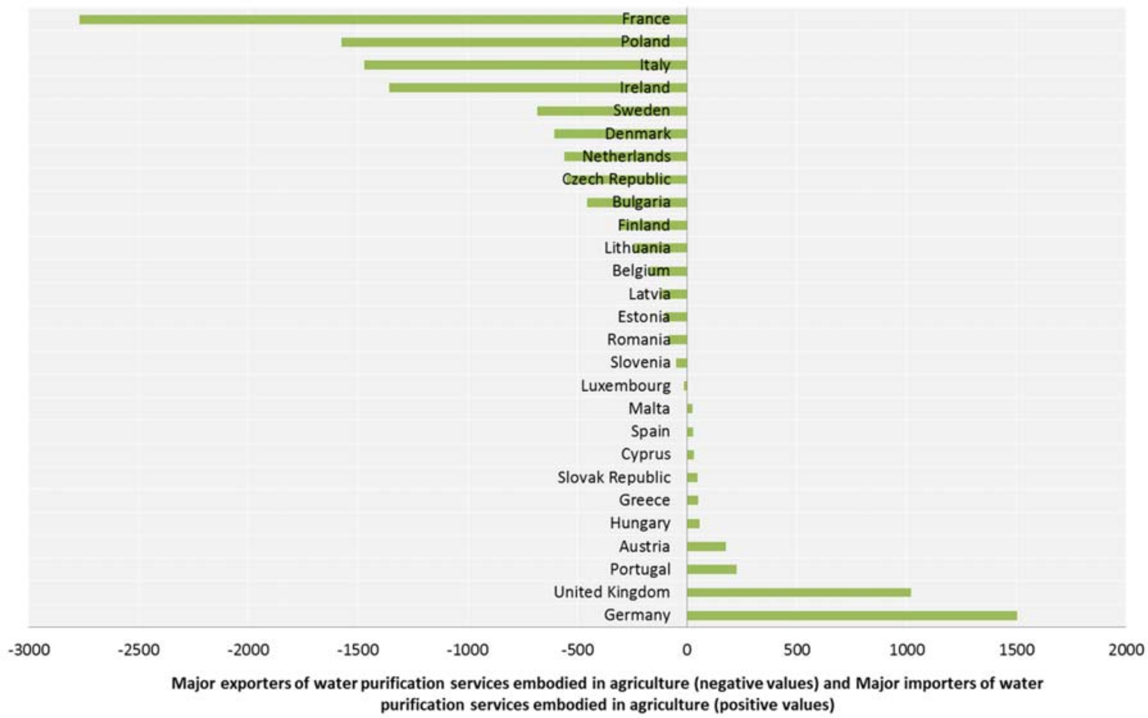

Figure 2 – Major net exporters and net importers of water purification ecosystem services in 2005 (tons of N removed).

In Fig. 3 is shown the countries from which Germany is exporting water purification services. We see that Germany's consumption relies on water purification services mainly from Italy, France, Poland and the Netherlands. These countries water bodies' are highly affected by nitrogen pressures therefore our results show that Germany's consumption is contributing to the degradation of water bodies in these countries. United Kingdom's consumption is dependent on water purification services from Ireland, France, Italy and the Netherlands and as for Germany is it possible to say that United Kingdom's consumption patterns are contributing to the depletion of natural capital in these countries.

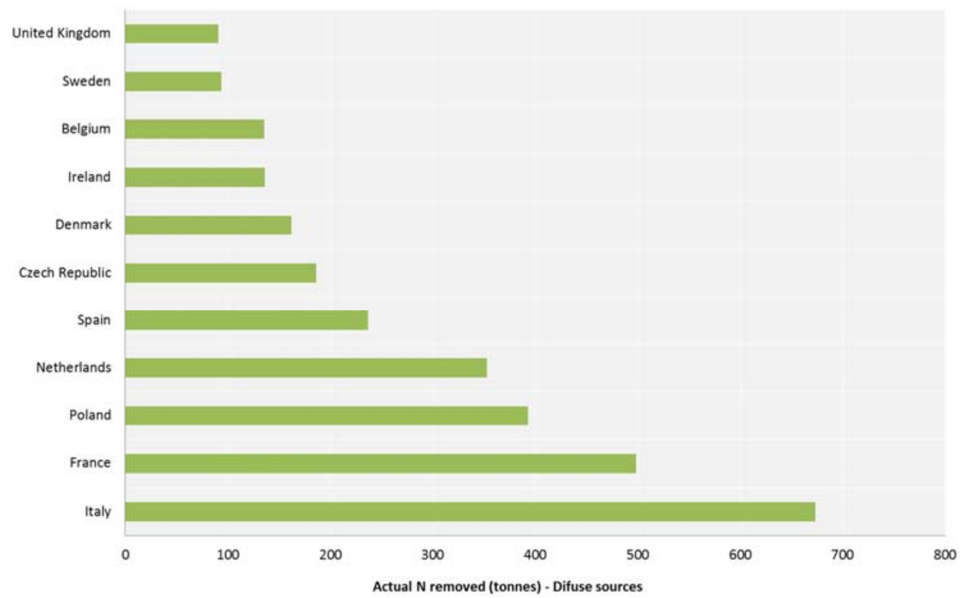

Figure 3 – Germany's imports of water purification ecosystem services in 2005.

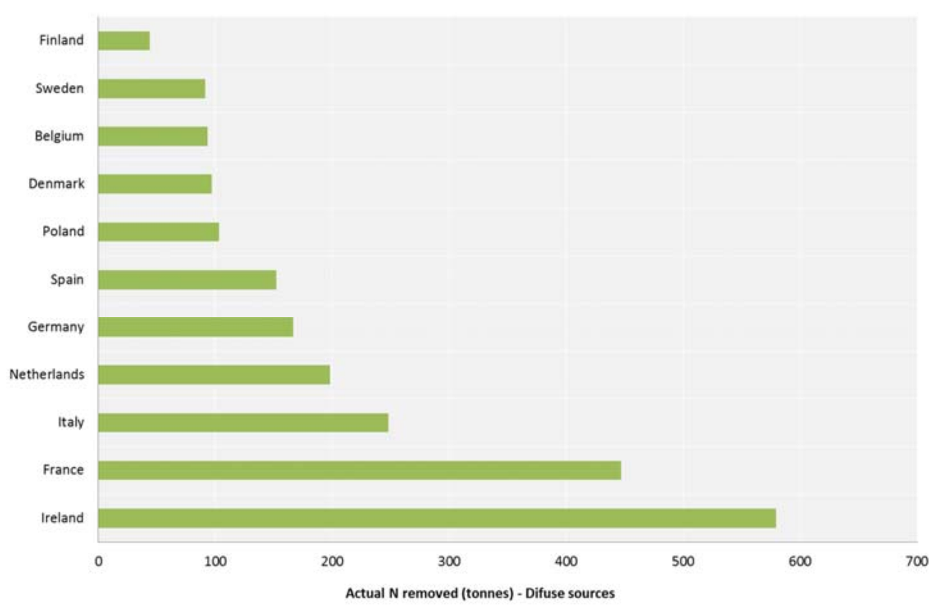

Figure 4 – United Kingdom's imports of water purification ecosystem services in 2005.

5. Final remarks

Consumption-based accounts allow understanding how consumption in a certain country might be driving environmental resources' use or environmental impacts in other countries. Our work is the first attempt to present consumption-based accounts for a regulating ecosystem service - water purification. We show that the intra-European trade of agricultural commodities allows countries to access the ecosystem services of other countries. We show that the biggest importers of water purification ecosystem services are importing these services from countries whose water bodies are highly pressured by nitrogen pollution. The majority of actions to improve the good ecological status of water bodies in Europe are planned at the River Basin level, nevertheless our work shows that taking a systems perspective that considering the benefits from nature as well as the flows of ecosystem services between different countries is possible and may provide new alternatives to tackle degradation and overexploitation of natural capital.

This kind of assessment can be replicated for all ecosystem services accounts that ends up (directly or indirectly) in an SNA product and would represent a useful source of information for the SDG # 12 concerning "Responsible Production and Consumption". It would in fact allow to assess and monitor the amount of ES embedded in traded goods.

Reference material:

La Notte A., Marques A. (to be published soon) Linking Integrated ecosystem Services and Benefits to Economic models THrough bridging functions (LISBETH). JRC Science for Policy Report.

Questions for the London Group

1. Do you see as viable to standardize this footprint-type indicators for ecosystem services accounts?
2. Do you think it woud be possibile to assess such an indicator considering sustainability issues? How?
3. What would be the most effective way to communicate this kind of information? To whom?