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How EU27 is outsourcing the vast majority of its land and water footprint

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ABSTRACT

Water consumption and scarcity problems are mainly caused by agricultural production. Highly populated and economically developed regions such as the EU27 import a large share of their products from other regions. Thereby they induce environmental impacts in these regions and put the resource availability at risk, affecting their future food security. In order to trace the water consumption and related impacts of EU27 final demand, we combine multi-regional input-output data with detailed water consumption estimates of crop production. This allows tracing back the water consumption through the full supply chain of final demand to the originating watersheds. In a second step, impact assessment methods are applied to evaluate water scarcity effects on this level of spatial detail. The results show that the EU27 states are outsourcing the majority of their water scarcity impacts (25-35%) to other regions. While different methods draw a variant picture, they consistently show the high dependency on other regions, which leads to responsibilities of the EU27 in these regions in order to comply with the polluter pays principle and also secure future food supply.

Keywords: Agriculture, international trade, environmental outsourcing, life cycle impact assessment

1. Introduction

Global agriculture is responsible for ~85% of water global consumption (Shiklomanov and Rodda 2003) and therefore the main driver water scarcity and related impacts, while its products are traded in a highly globalized market. This has been shown in several studies, indicating the tele-connections of producer and consumer regions (Hubacek et al. 2014). In order to connect impacts of producer to final consumption, we applied the EXIOBASE multi-regional input output (MRIO) dataset, which is accounting for water consumption and trade of 43 individual countries (~95% of the global GDP) and 5 rest-of-the-world (RoW) regions (Wood et al. 2014). Each region has 163 industrial sectors and for agriculture, 8 different crop sectors are available in Exiobase.

Water footprints have emerged as an area of high public interest, which finally lead to the creation of an ISO standard (ISO 2014) as a result of international consensus building. Many methods exist (Kounina et al. 2013), while most methods use either a water scarcity index (WSI) (Pfister et al. 2009) or an approach from the NGO "water footprint network" (Mekonnen and Hoekstra 2011). More recently, an international working group was formed to harmonize the different approaches and recommend a method. The preliminary recommendation is the so called Aware method, which combines natural water scarcity and water stress induced by humans in one single number through land use equivalents required to regenerate the water consumed sustainably (Boulay et al. 2015).

MRIO facilitates a more complete water footprint assessment of final consumption than bottom-up approaches using trade data (Feng et al. 2011). Therefore, this work builds upon a recently published study that combines EXIOPOL data and detailed information on water consumption of 160 related to final consumption by the EU27 states (Lutter et al. 2016), which only reported water consumption and impacts in terms of the water footprint network approach.

2. Methods

Since water consumption and impacts vary regionally, we created a spatial disaggregation matrix that allows allocating the consumption of a crop group in each region to >10'000 watersheds as a function of the production pattern and subsequently the application of water scarcity characterization factors (Figure 1). Water consumption estimates of 160 crops on high spatial detail is taken from (Pfister and Bayer 2014) and combined with MRIO data EXIOBASE (Wood et al. 2014). Details on how these results are calculated is available (Lutter et al. 2016).

In this work we present and extended this analysis in terms of LCIA by using Aware (with a range from 0.1 to 100) and WSI ranging from 0.01 to 1) on top of the blue water scarcity (BWS) method which ranges from 0-12 months per year (count of months under water scarcity). Everything is calculated on watershed level.

3. Results

Figure 1 shows “green water” (rain-fed water; as a land use indicator) and “blue water” (irrigation) footprints of EU27 final consumption. The “blue water” footprint of EU27 final consumption of products is mainly located in Europe, the US, China, India, Pakistan and Brazil, while scarce water originates mainly from Europe, India, Pakistan, the US, China, and Egypt. For green water, Sub-Saharan Africa and Latin America have a much higher contribution, indicating high land use impacts caused by EU27 production, since green water is a potential proxy for land use impacts.

The share of green, blue and scarce water consumed within the EU27 for its final consumption is between 25 and 35% of the total, reflecting the high dependency of EU states on foreign land and water resources. This is supported by the fact that different water scarcity methods, including the recommended method from the recent UNEP-SETAC Pellston workshop on LCIA methods, identify Indus as the highest contributor to water scarcity impacts, followed by the Guadalquivir (shown in figure 1 for BWS). However, different stress indicators result different hotspots, such as shown for the relevance of Nile and Mississippi river, where a high discrepancy is observed among the methods (Table1). Other rivers of high relevance and high discrepancy include Tagus, Danube, Po, Ganges, Ebro and Gaudiana.

The differences among the methods become also visible when comparing the total amount of scarcity covered by the top 15 watersheds presented in Table 1: while BWS and Aware attribute 71% and 67%, respectively, of all scarcity to these rivers, WSI only attributes 50% to these rivers. A large portion of this difference can be attributed to relevance of the Indus watershed for water scarcity in EU27 final demand.

While the origins are of most interest, it is also relevant through which product group the impacts are caused. Water footprint is mainly caused by agricultural products, which are mainly imported as processed bio-based products through other sectors, incl. processed food and leather.

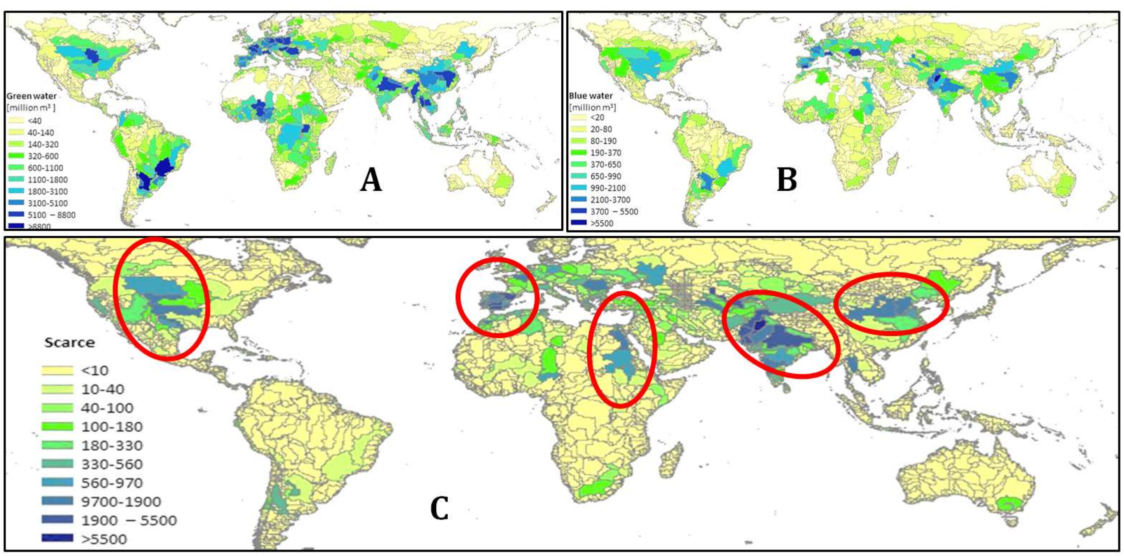

Fig. 1: Water consumption in million m3 (Mm3) per year and watershed from EU27 final consumption: (A) Green water consumption (rain-fed); (B) blue water consumption (irrigation); (C) Scarce water consumption representing midpoint impacts for water scarcity based on Mekonnen and Hoekstra (2011). Red circles indicate water scarcity hotspot (cf. Table 1). Adjusted from (Lutter et al. 2016)

Tab. 1: Top 15 producer watersheds for EU27 final consumption, sorted by blue water consumption. The shares are also presented in terms of impact after characterization with three different methods (incl. CFs): Blue water scarcity (BWS, Mekonnen and Hoekstra 2011), Aware (Boulay et al. 2015) and WSI (Pfister et al. 2009).

Watershed	Water consumption		Blue water scarcity		Aware		WSI	
	[Mm3]	Share	CF [month/year]	share	CF [-]	share	CF [-]	share
Indus	25'107	12%	12	40.2%	60.8	32.9%	0.83	20.9%
Danube	9'485	5%	0	0.0%	1.2	0.2%	0.07	0.7%
Mississippi	8'895	4%	4	4.8%	11.2	2.2%	0.24	2.1%
Quadalquivir	5'459	3%	7	5.2%	60.2	7.1%	1.00	5.5%
Nile	4'850	2%	2	1.3%	100.0	10.5%	0.98	4.8%
Parana	4'472	2%	0	0.0%	0.5	0.0%	0.01	0.0%
Po	4'276	2%	2	1.2%	1.1	0.1%	0.05	0.2%
Amu Darya	4'040	2%	5	2.7%	37.3	3.2%	1.00	4.0%
Ganges	3'658	2%	7	3.5%	17.9	1.4%	1.00	3.7%
Ebro	3'478	2%	3	1.4%	42.6	3.2%	0.26	0.9%
Guadiana	3'259	2%	7	3.1%	22.6	1.6%	0.99	3.2%
Douro	2'732	1%	5	1.8%	24.4	1.4%	0.17	0.5%
Tagus	2'584	1%	5	1.7%	4.3	0.2%	0.53	1.4%
Hai river	1'853	1%	12	3.0%	80.9	3.2%	1.00	1.9%
Chao Phraya	1'512	1%	7	1.4%	3.5	0.1%	0.48	0.7%
Other rivers	115'531	57%		28.7%		32.5%		49.6%

4. Discussion

The results show the effect of our globalized markets: the majority of food impacts is occurring outside the consumer region in the case of EU27. Many reasons might exist, but clearly affluent countries import from less affluent countries, with the main exception of the US. One reason is the low economic revenue of the agricultural sector but also the high population density and competition for land in Europe. However, the vast dependency on imported products and high share of external impacts highlights the need for policy actions to mitigate impacts in producer countries.

Several limitations need to be highlighted. First of all, the MRIO data includes high sector aggregation of the 160 crops into 8 groups. Furthermore, aggregation outside Europe combines many important producers in Africa, Asia the Middle East and Latin America into large regions. While only ~5% of total GDP is affected, a large fraction of water scarcity is located in such areas. Therefore, the level of detail is hampered, since water consumption of aggregated sectors and countries is traced back by the relative production shares, which might not be representative for actual trade.

Additionally, water consumption estimates have high uncertainty (Pfister et al. 2011), as well as the model to estimate water scarcity do (Laura and Stephan 2016; Scherer et al. 2015). Therefore also the results of this analysis are highly uncertain. However, the results are largely consistent among the different stress indicators applied.

Another limitation is that we applied the current water scarcity indicators to total water consumption. Since the indicators are showing current scarcity suitable for assessing marginal changes, the impacts are overestimated. In Theory, the non-marginal water consumption of EU27 final demand needs to be assessed by integrating the water scarcity indicators from water consumption without EU demand to current water consumption (Pfister and Bayer 2014). However, since the correlation is very high between marginal and non-marginal index, this effect is assumed to be lower than those mentioned above.

5. Conclusions

The study shows, that EU27 is outsourcing the vast majority of water scarcity related to its consumption to other regions. A high share is originating from highly water stressed river systems, many situated in poor countries. It is therefore concluded that the EU27 has a high responsibility to improve the situation in these regions to comply with the polluter pays principle, but also to ensure future supply of its agricultural products. For robustness of result it is recommended to use more than one method to assess water scarcity.

6. References

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