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Virtual water:Which perspective for the Mediterranean water management and distribution?

In the Mediterranean rim countries, water resources are limited and very unevenly distributed over both space and time. Among anthropogenic water uses, agriculture accounts for over 80% of the total water use in the Southern and Eastern rim countries.

Agricultural products, unlike water, can be easily exchanged over long distances. This visible trade masks an invisible exchange in water resources tied to the production of the various goods. Therefore, through international trade, agricultural products are increasingly weighing in the water balance of countries and regions.

Quantifying the invisible or "virtual" water flows contained in the agricultural products traded by the Mediterranean countries, and comparing them to the resources available in these countries, is a useful addition to the array of decision-making tools designed to manage water rationally and face up to problems of scarcity.

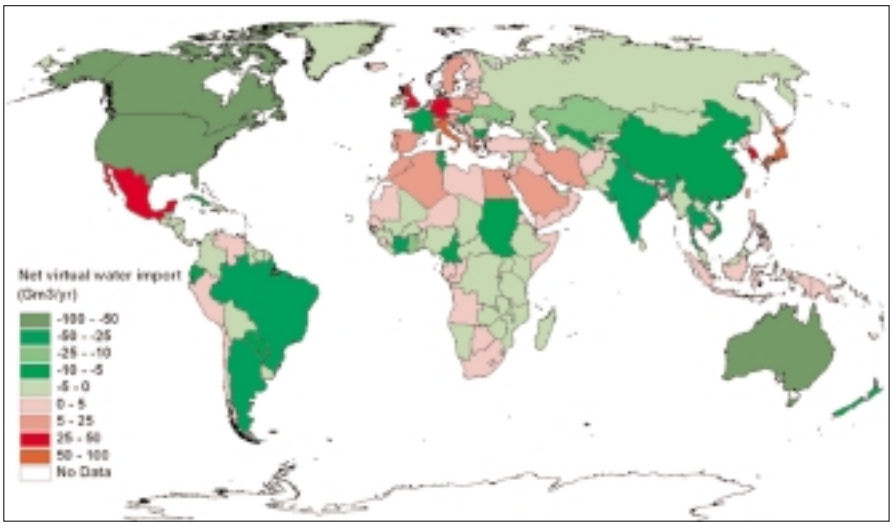
A metaphor to discuss the relevance of food self-sufficiency

Virtual water is a concept that was first used by J.A. Allan (1993) to show how, especially in the Middle East, the growing pressures on a country's water resources has been partly offset by trade in agricultural products. This trade, in reality, provides a virtual, flexible and relatively cheap access to water resources elsewhere. The concept also illustrates the progressive shift from food self-sufficiency to food security.

Thus, through trade, water transfers occur from exporting to importing countries, as the production of such goods required, in the exporting country, the consumption of substantial amounts of water. The "virtual water" embedded in an imported or exported good can be estimated by measuring the quantity of water consumed during the production process of the given good.

For agricultural products, which account for about 90% of the virtual water exchanges world-wide, virtual water is equal to the water evapotranspirated during crops growth. Two components of

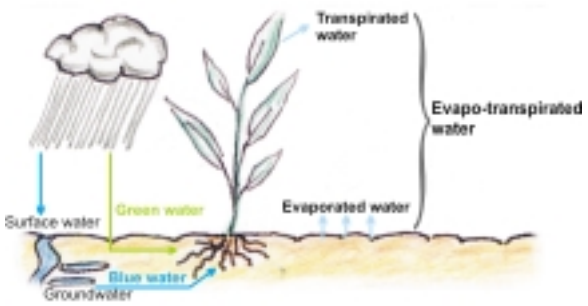
Figure 1 : Net balance per country of virtual water exchanges related to international trade in agricultural and industrial products over the period 1997-2001



Source: A.K. Chapagain and A.Y. Hoekstra, 2004
Note: The red-colored countries have net virtual water import. The green colored countries have net virtual water export.

virtual water can be distinguished: the amount of water generated by rainfall and naturally stored in the soil (called "green water") and the amount of water that is withdrawn from surface water or groundwater through irrigation (called "blue water") (Figure 2). The relative importance of green and blue water within the overall crops water consumption may vary significantly. Mobilising blue water aims at ensuring independence vis-à-vis the insufficiency and variability of rainfall, but it incurs far higher costs than the use of green water.

Figure 2 : Green water, blue water and evapotranspirated water



After a development within a circumscribed geographical area, international research centres and bodies (such as the Delft University, IWMI, FAO, the World Water Council) invested themselves in the "virtual water" concept. Important research works were undertaken to quantify virtual water and its flows in the world (Figure 1). The objective pursued was not only to quantify these "silent" water transfers, but also to assess their impacts on water resources management at both local and global levels. Several definitions and methods for quantifying virtual water were developed, according to different visions of the concept and its implications.

Between 400 and 8000 litres of water to produce one kilogram of wheat in the Mediterranean

A first attempt to quantify the flows of virtual water contained in the agricultural products imported and exported by the different Mediterranean rim countries was undertaken over the period 2000-2004 (Fernandez, Plan Bleu 2007). The products considered for this analysis were selected according to two criteria: their quantitative importance in the global virtual water flows for the Mediterranean countries and their strategic importance for food security. Thus, the selected products – namely wheat, barley, soya bean, olives and bovine meat, and crops specific to certain given countries (as an example: dates for Algeria) – account for about 70% of the total virtual water volumes exchanged through agricultural products trade from and to the studied Mediterranean countries.

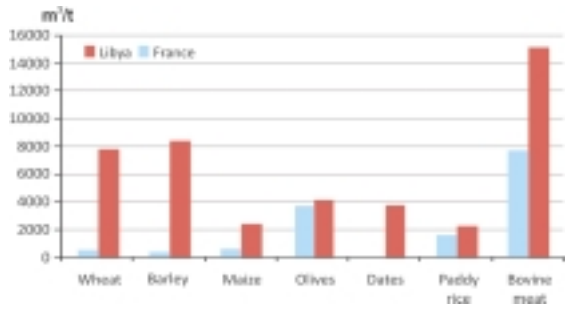
The virtual water content of crop products was estimated using the CropWat water balance model (FAO, 1992). Such a model makes it possible to distinguish between blue water contribution and green water contribution.

The virtual water content of bovine meat was estimated by taking into account the water consumed for producing the crops for cattle feed. The definition of a typical diet for each country is particularly complex. For the purposes of the present exercise, the quantification of the virtual water flows linked to trade in bovine meat was based on Hoekstra's studies about the virtual water content of beef, specified for each country (Hoekstra, 2004).

The amount of water consumed during the production process of a given agricultural good varies significantly according to the good itself, on the one hand, and to the producing country, on the other hand (Figure 3). Indeed, climatic conditions have a significant impact on the crops evapo-transpiration. Crop yield also depends on various factors that are of physical, technical and socio-economic nature. Accordingly, the amount of water needed for producing one ton of wheat ranges from 450 m^3 (in France) to 7850 m^3 (in Libya). The amount of water that is required for producing one ton of bovine meat is, on average, ten times higher.

The calculation of the virtual water flows linked to the trade in the selected agricultural products was based on trade exchange statistics (from and to the Mediterranean countries) produced by FAO, as well as on the virtual water content calculated for each product. Imports were estimated by taking into account the amounts of water that would have been needed by the importing countries to produce what they actually imported. This approach allows analysing virtual water flows impacts on water resources exploitation and on

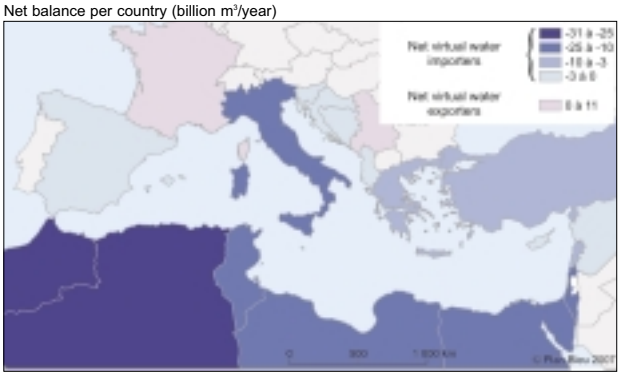
Figure 3 : Virtual water content per product (France and Libya)



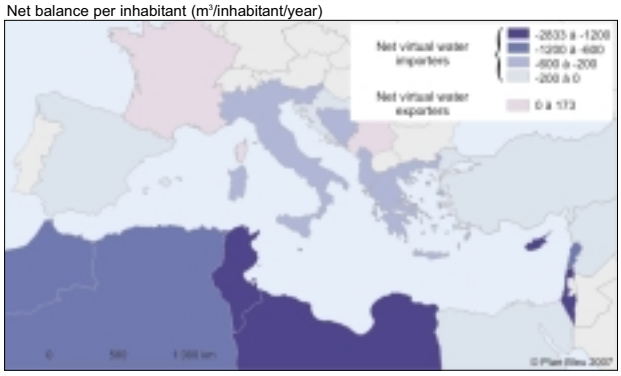
Sources of data: FAO, Hoekstra

Figure 4 : Net balance per country (total and per inhabitant) of virtual water exchanges related to international trade in grain, soya bean, olives, specific crop products and bovine meat, average over the period 2000-2004

Net balance per country (billion m³/year)



Net balance per inhabitant (m³/inhabitant/year)



Sources of data: FAO, Hoekstra & al.

food security for the importing countries. It can also help evaluating "water savings" made by the importing countries when they import agricultural goods instead of producing them themselves.

The Mediterranean, a large virtual water importing region

The Mediterranean region (considering the twenty-one rim countries) has been, since 1990, a net virtual water importer, with respect to the rest of the world, considering the selected products trade. Virtual water flows generated by crop products trade (220 billion m³/year) are by far higher than those that are associated to animal products trade (50 billion m³/year for bovine meat). If we consider all the selected products, only France and Serbia-Montenegro are net virtual water exporters over the period 2000-2004 (Figure 4). All the Southern and Eastern Mediterranean countries are net virtual water importers, with Libya being the largest net importer per inhabitant (2800 m³/inhabitant/year).

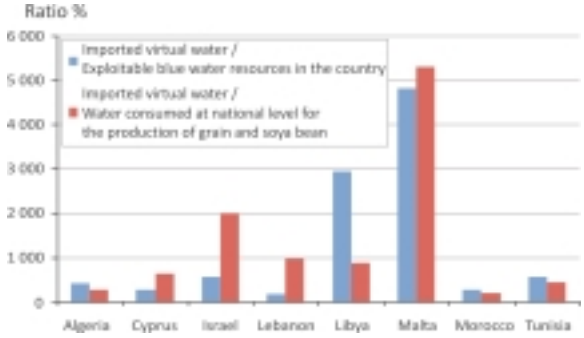
The overall virtual water importing nature of the Southern and Eastern countries, which is strengthened by the selected approach for evaluating virtual water imports, is strongly correlated with their water scarcity level. Indeed, for some countries – such as Malta, Libya, Israel, Tunisia, Algeria and Cyprus –, virtual water imports associated to grain and soya bean imports are far larger than, on the one hand, their national exploitable water resources and, on the other hand, the amount of water consumed for their national production of these same products (Figure 5). However, some countries facing water stress situations also export a significant part of their irrigation water (Syria, Israel) (Figure 6).

There is a stark contrast between the Northern and the Southern and Eastern Mediterranean countries regarding their virtual water exchange profiles. However, there are some exceptions by and large determined by factors that are not only physical, but are rather related to trade and food security policies impacting water uses and virtual water flows.

Thus, in Syria, a large-scale programme for the development of irrigation, mainly based on the exploitation of external surface water resources originating from Turkey, together with an intensification of the use of groundwater, has resulted in a high growth of agricultural production and exports over the period 1990-2000. In spite of the smallness of its internal water resources, "green water" in particular, Syria has become the 5th virtual water exporting country via grain and soya bean exports, although the net balance remains negative over the period 2000-2004. The virtual water gross exports associated to these exports (equivalent to 160 m³/inhabitant/year) consist for as much as 90% of blue water, which highlights the extent of irrigation (this rate being of 50% at the Mediterranean level).

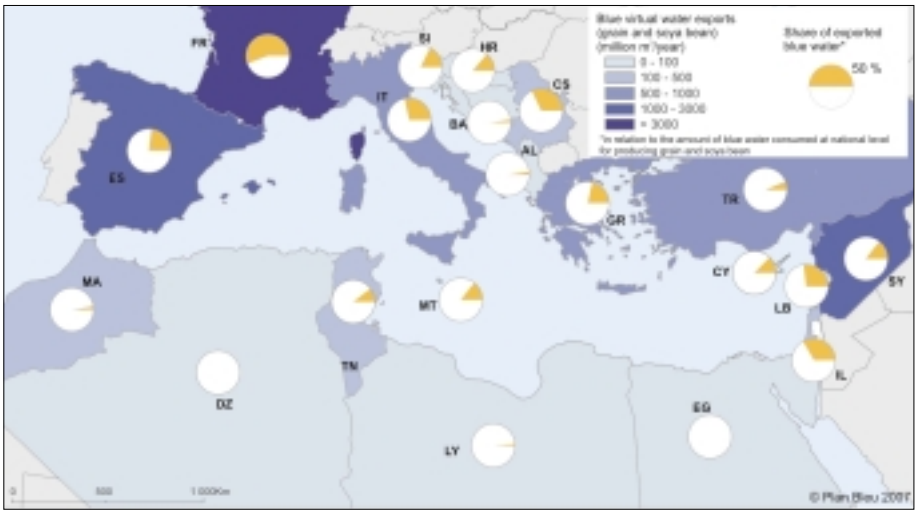
Spain and Italy are net virtual water importers, on the whole, while their water resources per inhabitant are fairly high (of 2700 and 3340 m³/inhabitant/year, respectively) and close to those of France (3350 m³/inhabitant/year). Spain is, however, the Mediterranean country that is the largest net exporter of virtual water linked to trade in bovine meat, a large part of this virtual water being generated by imports of grain for animal feed.

Figure 5 : Virtual water imports linked to grain and soya bean imports



Sources of data: FAO, Plan Bleu

Figure 6 : Share of the Mediterranean countries' irrigation water exported through grain and soya bean gross exports, average over the period 2000-2004



Source of data: FAO

Virtual water, an additional decision-making tool

This preliminary study conducted in the Mediterranean aimed at testing the available tools for evaluating virtual water flows and understanding the scale of such flows. It calls for an in-depth analysis to be carried out at country level.

The quantification of virtual water flows has, first of all, an analytical scope, its prescriptive value depending on the selected analysis framework. For agricultural products, it illustrates the interactions between agricultural policies and water policies, and their impacts on water resources exploitation. The level of integration of agricultural policies within regional policies, as well as the objectives pursued for food security, trade and the environment, highly differ from one country to another. These objectives define the type of indicators to be chosen as decision-making tools.

Virtual water flows and their impacts should be analysed within the context specific to each country and at appropriated scales. The virtual water concept shows, in this regard, that water management and distribution issues don't exclusively lie at the catchment area level. Some explaining factors of water use within a watershed are external to this watershed and they are of a "hydro-economic" nature (Allan, 2003).

When analysing virtual water flows, it is also worth distinguishing green water from blue water since they have different financial, economic and environmental implications, even though they are physically interrelated. Thus, the virtual water concept also adds to the debate on the distribution between rainfed agriculture and irrigated agriculture.

The virtual water concept illustrates how trade in agricultural products reallocates water between countries, especially in Mediterranean countries where water resources are unevenly distributed. Quantifying and analysing virtual water flows could be an interesting tool to assist policy in the management of water resources and weigh up the true costs and benefits of competing uses.

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