CHAPTER 6

Water footprint and virtual water trade in Spain

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1 INTRODUCTION

As the most arid country in the European Union, water resources management in Spain is an issue as important as controversial. In this country, even if water resources are unevenly distributed and, in some regions drought conditions are increasing, the crisis is one of water governance rather than physical scarcity. The estimation and analysis of the water footprint of Spain, from a hydrological, economic and ecological perspective, is very useful to facilitate an efficient allocation of water and economic resources. This analysis can provide a transparent and multidisciplinary framework for informing and optimising water policy decisions, contributing at the same time to the implementation of the EU Water Framework Directive (2000/60/EC) (WFD). This is particularly relevant since Spain is the first country that has included the water footprint analysis into governmental policy making in the context of the WFD (Official State Gazette, 2008).

The water footprint (WF) is a consumption-based indicator of water use (Hoekstra & Chapagain, 2008). The WF of an individual or community is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community (ibid.). Closely linked to the concept of water footprint is the virtual water. The virtual water content of a product (a commodity, good or service) refers to the volume of water used in its production (Allan, 1997). Building on this concept, virtual water 'trade' represents the amount of water embedded in traded products. International trade can save water globally if a water-intensive commodity is traded from an area where it is produced with high water productivity (resulting in products with low virtual-water content) to an area with lower water productivity (Hoekstra and Chapagain, 2008). Nevertheless, just a small amount of international virtual water trade is due to water scarcity (Yang & Zehnder, 2008). International trade in agricultural commodities mainly depends on factors such as availability of land, labour, technology, the costs of engaging in trade, national food policies and international trade agreements (Hoekstra & Chapagain, 2008). At national or regional level, a nation can preserve its domestic water resources by importing products instead of producing them domestically. This is particularly relevant to arid or semi-arid countries with scarce water resources such as the case of Spain. Spain imports water-intensive low-economic value crops (mainly wheat, maize and soybeans) while it exports water-extensive high-economic value commodities adapted to the Mediterranean climate, essentially olive oil, fruits and vegetables. Apart from stressing its potential contribution to water savings, it is also important to establish whether the water used in the production of a given crop proceeds from rainwater stored in the soil as soil moisture evaporated during the production process (green water) or from surface water and/or groundwater evaporated as a result of the production of the crop (blue water) (Falkenmark & Rockstrom, 2004). Compared to blue water, the opportunity cost of green water use is lower since it cannot be easily reallocated to other uses besides natural vegetation or alternative rain-fed crops (Hoekstra & Chapagain, 2008).

The present chapter analyses the water footprint and virtual water trade in Spain assessing both green and blue water of the different socioeconomic sectors from a hydrological and economic perspective. The analysis aims to contribute to achieve a more efficient allocation of water resources. First of all, it provides a general overview of the water footprint and economic value of the different sectors in Spain, focusing afterwards on the agricultural sector, which is the main water user. Second, the virtual water trade and policy implications are analysed. Finally, it concludes that the current idea of water scarcity in Spain is mainly due to mismanagement in the agricultural sector providing interesting lessons for arid and semiarid countries. This mismanagement is due to several reasons such as the persistence of the former idea of food self-sufficiency, the still imperfect World Trade Organization (WTO) regulations, the absence of appropriate economic instruments for water management, national policies that promote irrigated agriculture to contribute to regional stability and agricultural commodity prices.

2 AN OVERVIEW OF THE WATER FOOTPRINT AND ECONOMIC VALUE OF THE DIFFERENT SECTORS IN SPAIN

Spain is the most arid country in Europe and the one that consumes one of the largest volumes of water per capita after the US and Italy, amounting to about 2300 m^3/capita/year (Chapagain & Hoekstra, 2004). According to Chapagain & Hoekstra (ibid.), total water requirements (green and blue) by the different economic sectors in Spain are about 100 km^3/year, that are distributed as shown in Table 1.

These figures, based on national averages, are taken as a first approximation. More detailed studies provide more accurate data as shown in the next section.

According to Chapagain & Hoekstra (ibid.), urban water supply amounts to 5% of the total water used with a value of 4.2 billion euros (MIMAM, 2007). The industrial sector represents 15% of the total water use (from which more than half corresponds to virtual water 'imports'), 14% of the Gross Domestic Product (GDP) (123 billion euros; INE, 2008) and 16% of the economically active population (3.1 million jobs; INE, 2008). Urban water supply and industrial sector figures refer to blue water uses—not necessarily consumptive—and are in line with the values given by official statistics (MIMAM, 2000; 2007).

The agricultural sector, considering green and blue crop consumption and livestock water use, represents about 80% of the total water use in line with Chapagain & Hoekstra (2004) (2/3 with national water and 1/3 with 'imported' virtual water) (Table 1) and Rodríguez Casado *et al*. (2008). According to this author, Spain is a net virtual water 'importer' concerning agricultural products, whereas a net virtual water 'exporter' when considering livestock products (fish water footprint has not been included as there are no estimates available yet). The agricultural sector, however, just contributes with about 3% of the GDP (about 26 billion euros, including livestock and fisheries, according to INE, 2008) and employs 5% of the economically active population (1 million jobs, following INE, 2008). Since agriculture is by far the main (green and blue) water user in Spain, this sector is at the centre of the present study. Thanks to factors such as globalization, availability of cheap and fast transport, guaranty of groundwater irrigation against climate variability and environmental regulation among others, the Spanish farmers are moving rapidly from a policy of 'more crops and jobs per drop' towards 'more cash and nature per drop'.

3 AGRICULTURAL WATER USE

Concerning the crop water consumptive use (or evapotranspiration) of agriculture in Spain, there are remarkable differences between the results of the first and more recent estimations (Table 2). On the one hand, crop water consumptive use estimated by Chapagain & Hoekstra (2004) is higher than that of Rodríguez Casado *et al.* (2008) probably because of the greater detail of the more

Table 1. Virtual water flows and water footprint of Spain, Italy, US and India (period 1997–2001).

	Spain	Italy	US	India
Population (10^6)	40.5	57.7	280.3	1007.4
Urban water supply				
km^3/year	4.2	8.0	60.8	38.6
m^3/cap/year	105.0	136.0	217.0	38.0
Crop evapotranspiration				
National consumption (km^3/year)	50.6	47.8	334.2	913.7
Idem (m^3/cap/year)	1251.0	829.0	1192.0	907.0
For export (km^3/year)	17.4	12.4	139.0	35.3
Idem (m^3/cap/year)	430.0	214.0	495.0	35.0
Industrial uses				
National use (km^3/year)	5.6	10.1	170.8	19.1
Idem (m^3/cap/year)	138.0	176.0	609.0	14.0
For export (km^3/year)	1.7	5.6	44.7	19.1
Idem (m^3/cap/year)	42.0	97.0	159.0	6.0
Virtual water 'import'				
Agricultural products (km^3/year)	27.1	60.0	74.9	13.8
Idem (m^3/cap/year)	671.0	1039.0	267.0	14.0
Industrial products (km^3/year)	6.5	8.7	56.3	2.2
Idem (m^3/cap/year)	1605.0	150.8	208.9	21.8
Re-export of imported products	11.4	20.3	45.6	1.2
Idem (m^3/cap/year)	281.0	351.0	163.0	1.0
TOTAL WATER FOOTPRINT				
km^3/year	94.0	134.6	896.0	987.4
m^3/cap/year	2325.0	2332.0	2483.0	980.0

Source: Modified from Chapagain & Hoekstra (2004) in Llamas (2005).

recent study. The latter uses regional level climate data and differentiates between rainfed and irrigated farming for the water consumption estimations, whereas the former assumes that every crop water requirements are satisfied. This assumption, however, is not always fulfilled in Spain where rainfed farming covers an area of more than 80% of the total utilised agricultural area. On the other hand, official numbers from the Spanish Ministry of the Environment are the lowest (MIMAM, 2007) (Table 2), probably due to the fact that official figures focus on the blue water consumption, that is, the total amount of irrigation water that is lost to crops' evapotranspiration, without taking into account green water evapotranspiration. Incorporating the concept of green water into the bigger picture makes it possible to understand water implications of land cover change and water scarcity problems of rainfed agriculture (Falkenmark & Rockstrom, 2004). In order to achieve an effective land use planning, green water analysis should be considered within an integrated land and water resource approach.

Within the agricultural sector, irrigated agriculture uses about 80% of blue water resources (MIMAM, 2007). Concerning the economic aspects, however, irrigated agriculture is a vital component of the agricultural sector. Even if it just occupies about 20% of total crop area, it produces 60% of the total Gross Value Added (GVA) of this sector (MIMAM, 2007) (Figure 1). This fraction is higher than the global average. Worldwide, the Gross Value of irrigated agricultural production is 46%, which makes up 28% of the harvested cropland (Comprehensive Assessment of Water Management in Agriculture, 2007). The economic productivity (€/ha) in irrigated agriculture in Spain is about five times higher than that of rainfed agriculture (Plan Nacional de Regadios, 2009).

Table 2. Estimated values of internal or domestic water consumptive use in Spain's agricultural crop production after different sources.

Source	Agricultural water consumption[1] (Mm^3)	Blue water consumption[2] (Mm^3)	Green water consumption[3] (Mm^3)
MIMAM (2007)[4]	–	11,897	–
Chapagain & Hoesktra (2004)[5]	50,570	–	–
Rodríguez Casado *et al*. (2009)[6]	26,824	15,645	11,177

[1] Agricultural water consumption refers to the total crop water evapotranspiration.
[2] Blue water consumption is the total amount of irrigation water evapotranspirated by the crops.
[3] Green water consumption represents the total amount of soil water evapotranspirated by crops.
[4] Average figures for the year 2001 (average rainfall year).
[5] Average figures for the period 1997–2001.
[6] Average figures for the years 1998, 2001 and 2003.

By comparing blue water requirements (consumptive use) and supply, water use average efficiency turned out to be about 65% in 2001 (MIMAM, 2007). This figure has recently diminished since the implementation of the National Irrigation Plan, which is undertaking the modernisation of irrigation systems and improving water use technical efficiency (Plan Nacional de Regadios, 2009). These water savings, however, are possibly relative savings as the irrigated area has also increased, water continues to be priced by area and not by volume consumed in most systems; and the previously water 'lost' due to inefficient irrigation might be used downstream.

4 TOWARDS AN EFFICIENT ALLOCATION OF WATER RESOURCES

Spanish agriculture has comparative advantages as a result of its soil availability, sunshine hours, lower labour costs and its strategic location for the access to the European Union markets. Spain has no barriers to trade with other EU Member States. On the whole, Spain benefits from this advantage producing high value crops adapted to the Mediterranean climate, such as vegetables, citrus trees, vineyards and olive trees (Figure 1).

First of all, it has to be highlighted that rainfed grain cereals in Spain occupy more than 5 million hectares as shown in Figure 1. In the year 2001, grain cereals were the main land and water users in Spain, utilizing 47% of total arable land and 32% of blue water resources (Figures 1 and 2) (MIMAM, 2007). In economic terms, however, they generated the lowest Gross Value Added (GVA) value, which was about 6% GVA of irrigated agriculture according to MIMAM (2007) data. Nevertheless, the analysis should not just focus on economic aspects but also address social and environmental factors. On the other hand, vegetables, citrus trees and fruit trees are very productive in economic terms and require a relatively small amount of land and water. These are, however, mainly grown with blue water resources. The best opportunities and economic yields are obtained when these are grown in areas where blue water resources are less abundant.

Similar trends are obtained when analysing the water apparent productivity (Figure 2). When looking at the productivity per crop type, vegetables (including greenhouse crops such as horticultural, flowers and ornamental plants) present the highest values per water unit (with about 3.5 €/m^3). With lower values, other profitable crops are vineyards and temperate climate trees. It has to be highlighted that vineyards, as well as being one of the most profitable crops, are very well adapted to the Mediterranean ecosystem. Finally, with remarkably lower values, grain cereals, industrial crops and pulses display an average productivity of less than 0.3 €/m^3. Accordingly, the apparent productivity of vegetables is more than six times higher than that of cereals.

A mere 4% of all blue water used in irrigated agriculture accounts for 66% of total Gross Value Added. Conversely, close to 60% of the water used in this sector produces a slight 5% of total GVA in agriculture. This means that Spain is mainly producing blue water-intensive, low-value crops.

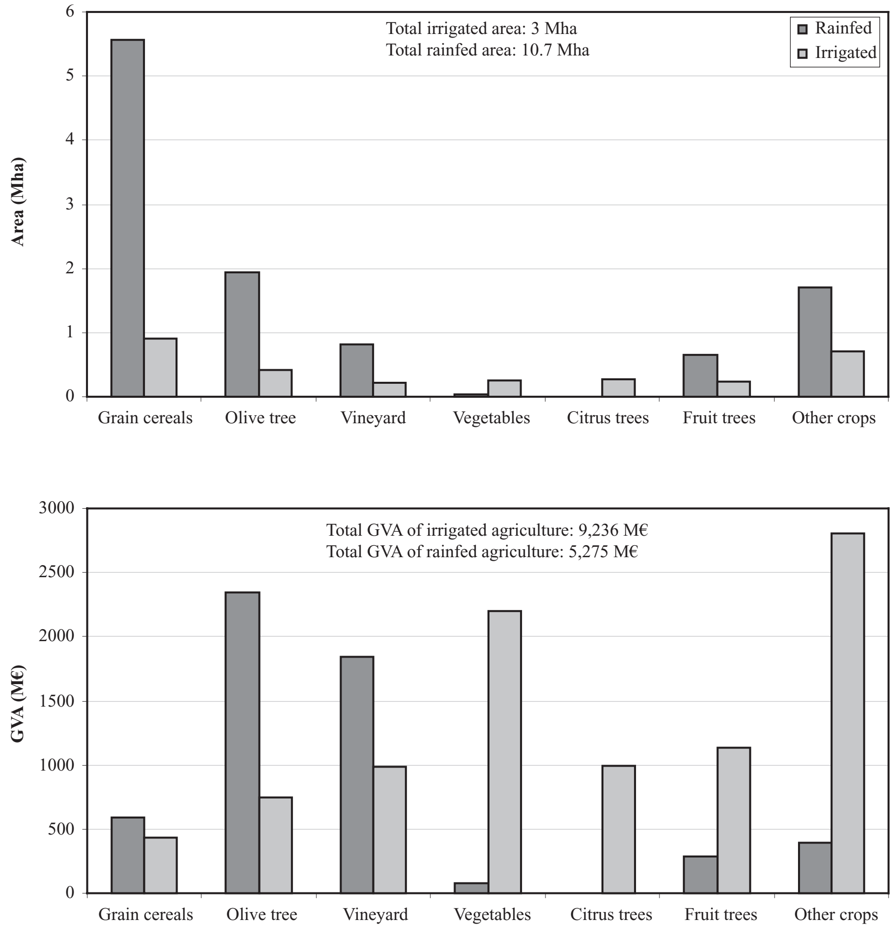

Figure 1. Total area (Mha) and Gross Value Added (GVA) (M€) comparing rainfed and irrigated agriculture per crop in Spain for the year 2001.

Source: Based on date from the Spanish Ministry of the Environment (based on 78% of total irrigation in Spain) (MIMAM, 2007).

In this sense, in order to achieve a win-win solution for increasing productivity, enhance rural employment opportunities and improve the livelihoods of the rural population while protecting the environment, a more efficient allocation of water resources is desirable. Even if Spain has already achieved a fairly high level of accomplishment of the policy of 'more crops and jobs per drop', it still struggles to attain 'more cash and nature per drop'.

Even if not considered in the analysis of the Spanish Ministry of the Environment (MIMAM, 2007), most probably high value crops are watered with groundwater resources or combining ground and surface water (Hernández-Mora *et al*., 2001). This fact of forgetting or ignoring the relevance of groundwater irrigation is a frequent attitude in many countries that only recently is beginning to change (Llamas & Martinez-Santos, 2005; Shah, 2008). In line with existing data, groundwater irrigated agriculture has a higher productivity when compared to irrigation using surface water (Hernández-Mora *et al*., 2001). This difference can be attributed to the greater control and supply guarantee that groundwater provides, which in turn allows farmers to invest in modern and efficient irrigation techniques and cash-crops farming practices without the risk of water shortages during dry periods. Generally farmers who are groundwater users bear all financial costs,

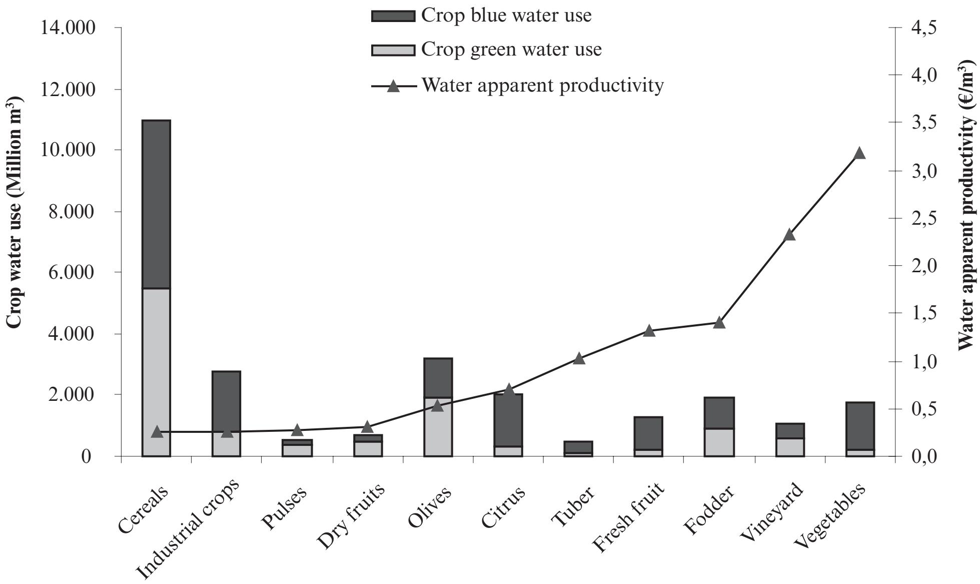

Figure 2. Water apparent productivity (€/m³) and blue and green crop water use in Spanish agriculture for the year 2006.
Source: Garrido *et al*. (2008).

both, operation and maintenance as well as investment costs. In fact groundwater users usually pay a higher price per volume of water used than irrigators using surface water that is, in general, largely subsidized. At the same time, the higher financial costs groundwater-using farmers bear motivates them to look for more profitable crops that will allow them to maximize their return on irrigation investments (Hernández-Mora *et al*., 2001). Along these lines, the groundwater role is significantly different from the surface water role. However, most water footprint studies have not hitherto differentiated between surface and groundwater (e.g. Chapagain & Hoekstra, 2004; Rodríguez Casado *et al*., 2008). This distinction is crucial to inform water policy decisions, and to follow the environmental requirements of the Water Framework Directive (Aldaya & Llamas, 2009; Hernández-Mora *et al*., 2007).

5 VIRTUAL WATER TRADE IN SPAIN: SOLVING WATER SCARCITY PROBLEMS

Agricultural commodity trade in relation to water is an issue that has rarely been dealt with. Overall, Spain is a net virtual water ‘importer’ concerning agricultural commodities. According to Chapagain & Hoekstra (2004) Spain ‘imports’ about 27 km³/year and ‘exports’ 17 km³/year, resulting in a negative balance of 10 km³/year. Spain exports high economic value and low virtual water content crops, such as citrus fruits, vegetables or olive oil, while it imports virtual water intensive and low-economic value crops, such as cereals (Novo *et al*., 2009; Rodríguez Casado *et al*., 2008). This not only has a huge potential for relieving local hydrologic, economic and political stress in Spain (Allan, 2006) but it is also very relevant for the national economy and water balance. Cereal grains can thus be crucial commodities for food security to water scarce importing countries (Yang *et al*., 2006). Spanish cereal production is just 5% of total European production. In this sense Spanish demand would always be supplied by other EU producers or security stocks. This, however, does not imply that importing food is the only response the water scarce countries and regions should and can take. Furthermore, in the real world, even if the potential of trade to ‘save’ water at national level is substantial, most international food trade occurs for reasons not related to water resources (Comprehensive Assessment of Water Management in Agriculture, 2007). In line with Yang & Zehnder (2008), globally, less than 20% of the total virtual water trade is due to water scarcity. In this sense, 80% of the virtual water trade is mainly due to pure commercial factors. International trade in agricultural commodities mainly depends on factors such as availability of land, labour, technology, the costs of engaging in trade, freight costs, national food policies and international trade agreements (Aldaya *et al*., 2008; Hoekstra & Chapagain, 2008).

Figure 3 shows that in Spain the composition of virtual water 'imports' and 'exports' are fairly stable in the period studied (1997–2005). Spain's cereal imports make up about 70% of all water agricultural imports, whereas livestock exports represent 55% (Rodríguez Casado *et al*., 2008). Both are obviously linked and respond to Spanish natural endowments, land and climate, and its intimate integration in the EU economy. Water scarcity as such does not explain why Spain 'exports' virtual water through livestock products. This is explained to a greater extent by lesser enforcement of environmental legislation related to livestock production, more empty territory and a great deal of economic integration. But clearly without the option to import cereals and feedstock, the livestock sector would not have grown to the extent it did in the last 10 years.

6 INCORPORATING THE WATER FOOTPRINT INTO POLICY MAKING

In the last twenty years Spanish water policy has changed dramatically (Garrido & Llamas, 2009). Over the last decades, the priorities of the Spanish society have been changing and, moving away from the traditional supply-enhancing water policy, environmental factors are becoming increasingly important. There is a growing need to integrate nature conservation, social equity and economic growth into the process of decision making. For the time being and almost in the entire world, water footprint analysis has focused on hydrological aspects. A significant innovation of this work is to emphasize the imperative challenge of considering economic and ecological aspects, with the aim of going towards a policy of 'more cash and nature per drop'.

The water footprint analysis, thus, from a hydrological, economic and ecological perspective, differentiating green and blue ground and surface water, provides a transparent and multidisciplinary framework for informing and optimising water policy decisions, contributing at the same time to the implementation of the EU Water Framework Directive (2000/60/EC) (see Chapter 16 for a more detailed analysis).

In this context, Spain was the first country in the EU to adopt the water footprint evaluation in governmental policy making. In September 2008, the Spanish Water Directorate General, under the competence of the Ministry of the Environment and Rural and Marine Affairs, approved a regulation that includes the analysis of the water footprint of the different socio-economic sectors as a technical criterion for the development of the River Basin Management Plans, that all EU Member States will have to accomplish by 2009 (and every six years thereafter) as part of the requirements of the Water Framework Directive (Official State Gazette, 2008).

The Water Framework Directive sets the clear objective of achieving the 'good ecological status' of all water bodies in the EU (surface as well as groundwater) by 2015 and the strong recommendation of full cost recovery for water services including environmental and resource costs. This, theoretically, is going to have a direct effect on irrigation agriculture and agricultural systems. According to Garrido & Varela-Ortega (2008), the implementation of the WFD might result in a regionally-based reduction of irrigated area and, thus, blue water consumption, and a better use of soil and water resources, with important impacts on land planning and management. These expected results may vary considerably across regions and irrigation systems.

Along with the WFD, the Common Agricultural Policy (CAP), has had over the years a clear impact on irrigation agriculture, on cropping patterns and hence on water use. Along the decades of the 80's and 90's the CAP programs encouraged irrigation expansion and intensification as larger production-coupled subsidies were granted to the farmers for their intensively irrigated crops. This coupled aid scheme induced water consumption most acutely in arid and semi-arid regions

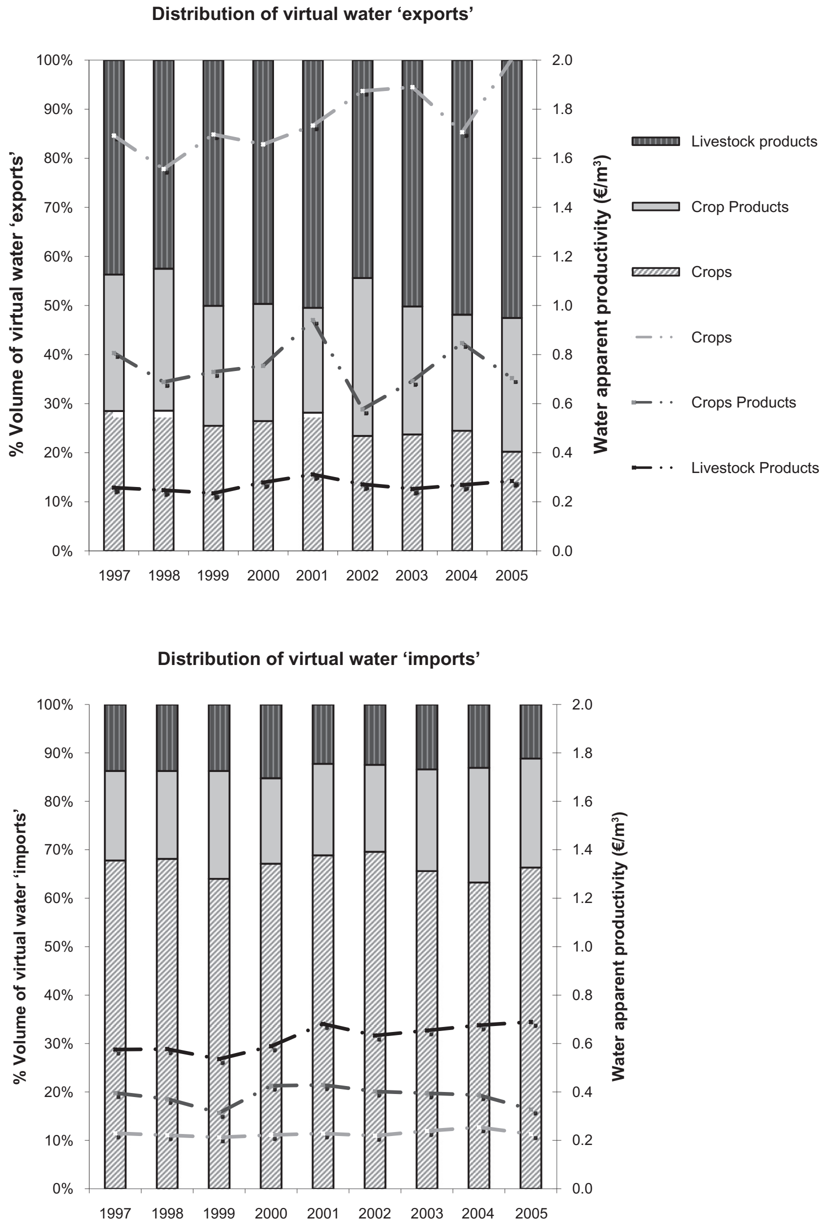

Figure 3. Volume of virtual water 'export' and 'imports' (%) and water apparent productivity (€/m^3) for the years 1997–2005.

across the EU, predominantly along the Mediterranean coastline and its hinterland (Varela-Ortega, 2008; Garrido & Varela-Ortega, 2008). This situation produced clear socio-economic benefits to the rural population but, on the other hand, it engendered negative consequences to aquatic ecosystems (Baldok *et al*., 2000; Martinez-Santos *et al*., 2008; Varela-Ortega *et al*., 2008). Responding to the WTO agreements, the CAP evolved from the Mc Sharry reform of 1992, to the reforms of Agenda 2000 and lastly to the Luxemburg reform of 2003. These two last reforms, have included progressively environmental and nature protection regulations with the aim of achieving a more compatible agricultural production with the protection of ecosystems. The 2003 reform, in force in 2005, makes a step further by establishing a system of subsidies or direct payments, that are decoupled from production (to cereals, oilseeds, protein crops and olives) and substituted by a single farm payment (that also includes livestock support aids) (Spain is still under a 25% coupled scheme except for land set-aside that is fully decoupled). These payments are currently tied to the requirement by all farmers in the Member States to comply with specific environmental regulation as well as specific nature-protection farming and tillage operations under a 'cross compliance' scheme (EC, 2003). Lastly, the CAP has made a step further in the newly proposed reform 'the CAP Health Check' that strengthens environmental requirements and specifically includes water management, climate change and biofuels as the main challenges to be addressed by all member states (EC, 2008). Therefore, this new policy context implies the need for achieving a well-balanced and sustainable integration of agricultural, environmental and water sectors (Varela-Ortega, 2008).

Following the 2003 reform, irrigated acreage of intensive water—consuming crops such as maize and legumes is being reduced in favour of winter cereals and oilseeds of lower water requirements and to olive (under CAP subsidies) and vine (with no subsidies) that are well adapted to specific region-based farming conditions and water-saving modern irrigation technologies as well as market opportunities (Garrido & Varela-Ortega, 2008; Varela-Ortega, 2008). Alongside, other water intensive crops such as tobacco and sugar-beet have also diminished in surface due to their subsequent reduction in their price support schemes and market reforms. Vineyard and olive tree irrigated production is increasing significantly (using more than 800,000 irrigated hectares in 2006) (MAPA, 2008). It is expected that significant changes in crop distribution will continue to occur in the near future. These significant and gradual changes of cropping patterns in irrigated acreage result from several factors, including CAP production-decoupled payments, an increased obligation to comply with environmental requirements, investment in irrigation and water transportation technologies and more market-driven farming decisions.

Significant changes in water demand can occur not only by changing the amount of irrigated area but also by modifying the cropping patterns. In the EU, cropping patterns have been profoundly influenced by farm and trade policies (Varela-Ortega, 2008). This is in line with recent water footprint studies, which recognize that water resources management is intimately linked to the structure of the global economy (Hoekstra & Chapagain, 2008). Currently, due to more decoupled modes of farm income support, EU farmers are responding more to market signals. Most of these originate in the global markets, offering a broader opportunity to enhance the connections and synergies between food markets and farm trade and water policies.

One of the most relevant consequences of the water footprint and virtual water 'trade' knowledge in arid and semiarid countries such as Spain is the change in the water security and food security concepts, paradigms that have hitherto prevailed in the minds of most policy makers. This comes from a food self-sufficiency tradition that will probably change in the near future. Previous works support that water crisis is a problem of water management in relation to various aspects, such as obsolete irrigation systems or excessive blue water use for growing low economic value crops (Llamas, 2005; UNDP, 2006; Comprehensive Assessment of Water Management in Agriculture, 2007). Along these lines, the water footprint analysis is providing new data and perspectives that are enabling to form a more optimistic outlook of the frequently spread looming 'water scarcity crisis'.

7 CONCLUDING REMARKS

Water scarcity in Spain is mainly due to the inefficient allocation of water resources and mismanagement in the agricultural sector, such as the use of large amounts of blue water in virtual water intensive but low economic value crops. Nevertheless, the Spanish water footprint should be analysed in its time and spatial dimension as well as considering the sectorial and geographical standpoints. Furthermore, we cannot forget about the multifunctionality of agriculture.

On the whole, there seems to be enough water to satisfy the Spanish agricultural sector needs, but a necessary condition is to achieve an efficient allocation and management of water resources. This will take some time since crop distribution in Spain is determined by several factors such as the Common Agricultural Policy or the WTO regulations. The mentioned transition will require the action of the Spanish Government by embracing transparency and encouraging an active and effective public participation. This is already happening in Spain in lieu of the application of the WFD.

The water footprint analysis, hydrological, economic and ecological, at a river basin level provides most valuable information to facilitate an efficient allocation of water resources to the different economic and environmental demands. There is no blueprint. The Spanish context is characterized by regional differences on green and blue water resource availability. Along these lines, virtual water studies, taking into account not only green and blue (ground and surface) water systems but also trade policies, can contribute to a better integrated management of water resources.

Finally, this analysis, in industrialized countries such as Spain can help to move forward from a policy of 'more crops and jobs per drop' towards 'more cash and nature per drop'. Achieving this new paradigm would mean a win-win solution to the conflict between farmers and conservationists, allowing the preservation of the environment without damaging the economy of the agricultural sector.

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