Challenging the conventional paradigm of water scarcity through the water footprint: The Spanish example[1]

M.M. Aldaya[a], A. Garrido[b], M.R. Llamas[c], C. Varela-Ortega[b], P. Novo[b] and R. Rodríguez[b]

[a] Corresponding author. University of Twente, Twente Water Centre, P.O.Box 217, 7500 AE Enschede, The Netherlands. Phone: +31 53 4894464, Fax: +31 53 4895377, E-mail: M.M.Aldaya@ctw.utwente.nl

[b] Technical University of Madrid. Department of Agricultural Economics, Avda. Complutense s/n, 28040 Madrid, Spain.

[c] Complutense University of Madrid, Geodynamics Department, José Antonio Novais s/n, 28040 Madrid, Spain.

[1] This is the preprint of an article submitted as a chapter for the EARTHSCAN book “Global Water Governance” A. Hoekstra (edit.)

Abstract

In most arid and semiarid countries, water resource management is an issue as important as controversial. Today most water resources experts admit that water conflicts are not caused by the physical scarcity of water but they are mainly due to poor water management as many authors and institutions recognize. However, scientific and technological advances that occurred in the last fifty years open new paths to solving many water related conflicts, often with tools that a few decades ago seemed unthinkable.

The present chapter deals with the water footprint and virtual water analysis of Spain, both from a hydrological perspective, differentiating the green and blue components, and from an economic point of view. The water footprint study is making traditional water and food security concepts change. According to available data, at a global scale, food production is the main green and blue water user, being agriculture at the centre of the present study. Along these lines, national water policies are going to be increasingly linked to the agricultural policies, not only concerning food production but also in relation to agricultural commodity trade. At the same time, it has to be taken into account that in industrialized countries, such as the case of Spain, environmental determinants are becoming more and more important and, either consciously or unconsciously, the old paradigm ’more crops and jobs per drop‘ is shifting towards ’more cash and nature per drop‘. The relevant role of groundwater in addressing this paradigm is shown.

Keywords: Water footprint, virtual water ’trade‘, water scarcity and security, food security, water apparent productivity, economic production

1. Introduction

The present research analyses the water footprint and its relevance in arid and semiarid countries such as Spain. This study is framed within two projects: 1) the Spanish Water Footprint analysis sponsored by the Marcelino Botín Foundation (www.fundacionmbotin.org/) and; 2) the Guadiana Water Footprint assessment carried out within the EU NeWater proyect (www.newater.info/everyone/1025).

Table 1. Gross Domestic Product and employment in Spain. Year 2005 at current prices.

	Gross Domestic Product		Employment	
	Million €	%	Thousand jobs	%
Agriculture, livestock and fishing	26,473	3	1,033	5
Energy	20,415	2	149	1
Industry	122,844	14	3,130	16
Building industry	94,161	10	2,425	12
Services sector	546,929	60	13,324	66
Total	905,455	100	20,061	100

Source: Modified from Novo (2008), based on INE (2008) data

Conventional view of water for agriculture focuses on withdrawals of water from surface sources (e.g. river, lakes) and groundwater sources for irrigation or processing (Comprehensive Assessment of Water Management in Agriculture, 2007). Rainfall is partitioned into runoff, which contributes to river flow, percolation to groundwater bodies, and water stored temporarily within soils, which is converted to liquid vapour through evaporation and transpiration. We use concepts of blue water and green water to describe this complex of sources and flows. Blue water is water in rivers, aquifers, reservoirs and lakes and is the main water source for irrigated agriculture. Green water refers to the soil moisture generated from rainfall that infiltrates the soil and is available for uptake by plants (Falkenmark, 2003). It constitutes the main water resource in rainfed agriculture or the environment.

At a global level, the main blue water user is the agricultural sector, representing about 70% of the total blue water use (Comprehensive Assessment of Water Management in Agriculture, 2007). This figure is higher in arid and semiarid countries, and even higher if green water is taken into account. In industrialized countries, the economic value of the agricultural sector, including livestock and fishing, is quite low (table 1).

Nevertheless, the agricultural sector analysis cannot just be limited to its economic aspects and forget about the multifunctionality of agriculture. A very important but generally not studied aspect is the role of agriculture as a supplier of raw materials for the Spanish agro-food industry. Available data show that this is an important share of the national industrial sector (Naranjo, 2008). Nevertheless, data about the origin (domestic or imported) of raw materials is not available yet (ibid.).

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». This new knowledge is making traditional water and food security concepts change, concepts that have hitherto prevailed in the minds of most policy makers. 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 (Rosegrant et al., 2002; Benoit and Comeau, 2005; Llamas, 2005; Rogers et al., 2006; UNDP, 2006; Comprehensive Assessment of Water Management in Agriculture, 2007). This comes from a food self-sufficiency tradition that will probably change in the near future. Many people believe that each country needs a basis of minimum production. In any case, Spain is already taking advantage from both, its comparative advantage producing high economic value crops adapted to the Mediterranean climate, such as vegetables, citrus trees, olive trees and vineyards, and from its strategic location concerning trade as there are no trade barriers between the European Union Member States.

The present document highlights two of the more relevant consequences of virtual water ’trade‘ in arid and semiarid countries such as Spain, closely related to the water footprint concept. The first outcome is the change in the water security paradigm and, as a corollary, in food security, which has been many times invoked in the press (Food Ethics, 2008). Secondly, a better knowledge of the water footprint, differentiating green and blue ground and surface water, can be very useful for achieving a more efficient allocation of water resources in Spain. This country has already achieved a good degree of the paradigm ’more crops and jobs per drop‘ but it is still far from achieving ’more cash and nature per drop‘, especially on its second half. 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 the new paradigm ’more cash and nature per drop’. However, in this article the ecological aspects related to ‘nature’ are not dealt with.

2. An overview of the water footprint and economic value of the different sectors in Spain

Spain is the most arid country of the European Union and the one that devotes most water resources to irrigation (MIMAM, 2007). According to Chapagain and Hoekstra (2004), total water requirements (green and blue) by the different economic sectors in Spain are about 100 km^3/year, that are distributed as follows (table 2):

Table 2. 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	2300.0	2300.0	2500.0	980.0

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

a) Urban water supply represents 5% of the total water used (table 2) (about 5 km^3/year, with a value of 4,200 million euros, MIMAM, 2007).

b) The industrial sector amounts to 15% of the total water use (from which more than a half corresponds to virtual water ’imports‘), 14% of the Gross Domestic Product (GDP)

(123,000 million euros, INE, 2008) and 16% of the economically active population (3,100,000 jobs, INE, 2008) (table 1).

Urban water supply and industrial sector figures refer to blue water uses and are in line with the values given by official statistics (MIMAM, 2000; 2007). Frequently the data from the MIMAN do dot consider the consumptive uses, typical of agricultural, but the total water supplied; and usually a certain amount of this water returns downstream to the river basin and can available to downstream users.

c) 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 and Hoekstra (2004) (2/3 with national water and 1/3 with ’imported‘ virtual water) (table 2). A similar proportion was obtained by Rodríguez (2008), amounting to 78% when considering green and blue crop consumption together with livestock water use. 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 Gross Domestic Product (GDP) (about 26,000 million euros, including livestock and fisheries, according to INE, 2008) and employs 5% of the economically active population (1,050,000 jobs, following INE, 2008) (table 1). Even if the present study does not analyse the number of jobs linked to the agricultural sector, it is important to highlight the role of immigration. According to Sancho (2008) immigration labour in irrigated agriculture has increased a 387% during the last 10 years (1998-2007). This requires an assessment of the possible social instability risks in case of a regression of the sector. This is, however, out of the scope of the present paper.

3. The water footprint of agriculture in Spain

Concerning the crop water consumptive use of agriculture in Spain, there are remarkable differences between the results of the different authors (table 3). Statistics from the Spanish Ministry of the Environment (MIMAM, 2007) are lower than those estimated by Chapagain and Hoekstra (2004) and Rodríguez (2008) (table 3). This is probably due to the fact that official numbers (MIMAM, 2007) do not take into account green water. 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 and 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.

When comparing the crop water consumptive use estimated by Chapagain and Hoekstra (2004), and Rodríguez (2008), the calculated volume of the former almost doubles the figures given by the latter (table 3). Methodological variations could explain these great differences. Rodríguez (2008), using regional level climate data, differentiates rainfed and irrigated farming when doing his estimations, whereas Chapagain and Hoekstra (2004) assume that every crop water requirements are satisfied. This assumption, however, is not always fulfilled in Spain. In this country, rainfed farming covers an area of more than 80% of the total utilised agricultural area. Accordingly, Rodríguez (2008) figures seem to be the closest to the real world.

Furthermore, the above studies do not differentiate between surface and ground water. This distinction is crucial to inform water policy decisions, and to follow the environmental requirements derived from the Water Framework Directive (Hernandez-Mora et al., 2007; Lopez-Gunn and Llamas, 2008).

Table 3. 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 and Hoesktra (2004)[5]	50,570	-	-
Rodríguez (2008)[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.

When comparing blue water requirements (consumptive use) and supply, water use average efficiency was about 65% in 2001 (MIMAM, 2007) (table 4). This figure has probably diminished since the implementation of the National Irrigation Plan, which is undertaking the modernisation of irrigation systems and improve water use efficiency (National Irrigation Plan, 2008). This water savings, however, are possibly relative savings as a) the irrigated area has also increased; and b) the water 'lost' for irrigation maybe used downstream.

Considering the final agricultural production, the statistics from the Spanish Ministry for the Environment (MIMAM, 2007) agree with numbers from the Spanish Ministry of Agriculture (MAPA, 2008) and National Statistics Institute (INE, 2008), which are 22,008 versus 22,011 and 22,346 million euros respectively for the year 2001 (table 4).

Concerning blue water irrigated area these data coincide with those of the Water White Book (MIMAM, 2000), which are 3 against 3.4 Mha respectively (table 4).

Table 4. General data on the Spanish agricultural sector.

	Spain, year 2001
Total rainfed area (ha)	10,753,598
Total irrigated area (ha)	3,020,458
Fallow area (ha)	2,385,891
Total crop area (ha)	16,174,905
Total crop blue water requirements (Mm^3)[1]	11,897
Total crop blue water supply (Mm^3)[1]	18,194
Final economic agricultural production (M€)[2]	22,008
Rainfed Gross Value Added (GVA) (M€)[3]	5,275
Irrigated Gross Value Added (GVA) (M€)[3]	9,236
Total Gross Value Added (GVA) (M€)[3]	14,512
Average rainfed Gross Value Added per hectare (GVA/ha)[3]	491
Average irrigated Gross Value Added per hectare (GVA/ha)[3]	3058

Source: based on data from the Spanish Ministry for the Environment (MIMAM, 2007)

1 Ground and surface water systems are not differentiated in the MIMAM (2007) report.
2 Final economic agricultural production is defined as the total economic value received by the agricultural sector of the region for the commodities sold in the market without taking subsidies into account (total €). This figure just includes crop and fodder production. According to AgroNegocios (2008) based on MAPA data, the final value of the agricultural sector was greater than 40,200 million euros in 2007, where crops represent 24,300 and animal production 14,300.
3 Gross Value Added is the value of goods and services produced in a given country at different stages of the productive process (million €). It is obtained by deducting intermediate consumption from final agricultural production. In a sense, GVA is equivalent to the return of the labour and capital inputs.

Within the agricultural sector, irrigated agriculture uses about 80% of blue water resources (INE, Cuentas del agua, 2002; 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 agriculture (MIMAM, 2007). This benefit is higher than the global average. Worldwide the gross value of rainfed agriculture is 55% amounting to 72% of the world’s harvested cropland (Comprehensive Assessment of Water Management in Agriculture, 2007). Along these lines, the economic productivity (€/ha) in irrigated agriculture in Spain is about five times higher than that of rainfed agriculture (Berbel, 2007; Hernández-Mora et al., 2007; MIMAM, 2007) (figure 1).

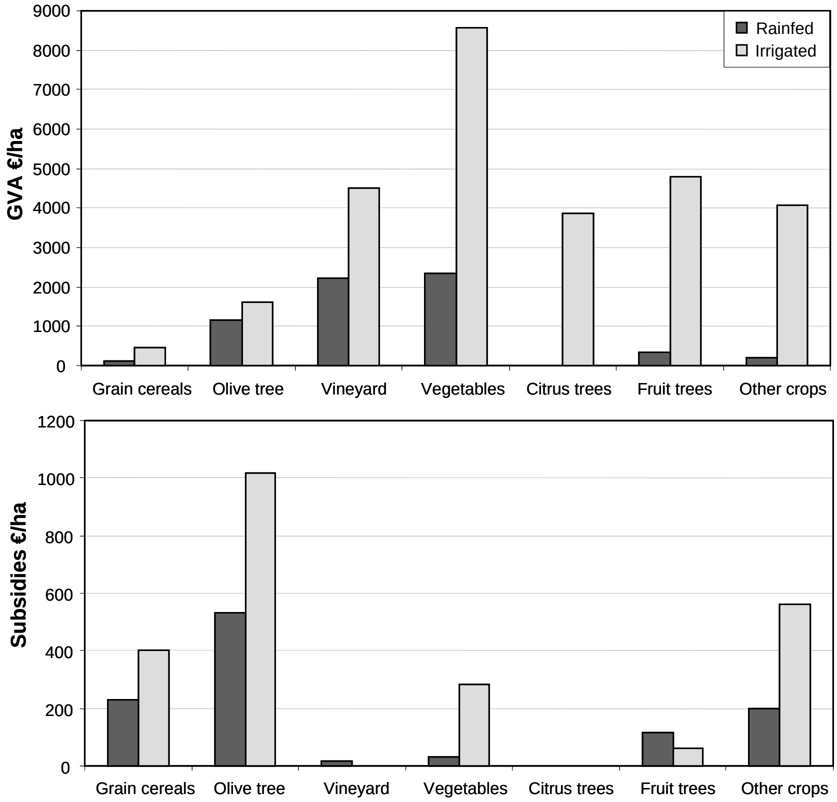


Figure 1. Gross Value Added (€) per hectare and subsidies per hectare comparing rainfed and irrigated agriculture in Spain for the year 2001/2002. Be aware of the different ordinate scales. *Source:* based on data from the Spanish Ministry for the Environment (MIMAM, 2007) It is noteworthy that the subsidies for irrigated olive groves are very high, almost equivalent to the GVA. This is commented later.

Different policy implications

Being more productive per hectare, irrigated agriculture received up to 70% more subsidies per hectare than rainfed farming in 2001/2002 according to MIMAM (2007). This is because in 2001/2002 EU farm support programmes, although already connected to farmed land, were set in correspondence to average yields. Also in 2001/2002 some payments were still connected to production. As of 2007/08 most measures of farm income support are based on decoupled payments. Both rainfed and irrigated subsidies, however, are a small fraction representing about 18% of the final agricultural economic production and 28% of the total Gross Value Added (GVA), even if in some types of continental agriculture (mainly cereals) and in terms of employment these can be very important.

In a context of crop production for the year 2001, before the CAP reform and commodity price increases, there is a great difference between the average final agricultural production per hectare of vegetable (26,600 €/ha) and cereal (587 €/ha) production (figure 1) (MIMAM, 2007). These numbers are in line with those of Albiac et al. (2005) calculating average values between 900 €/ha for cereals and 40.000 €/ha for greenhouse crops in the Júcar, Segura and Sur river basins. Similar figures can also be found in the Andalusian Regional Government Irrigation Inventory (2003) and Vives (2003). Generally, high economic production corresponds with market-driven crops, whereas low values are largely linked to important institutional help. An exception to this is the case of drip irrigated olive trees, which are very productive and receive CAP subsidies at the same time. The production of market-driven crops, such as vineyards, fruit trees and mainly greenhouse agriculture, does not depend on subsidies or just to a small extent, and is less dependant on agricultural policy changes.

The way the EU supports its farm sector dramatically changed with the Common Agricultural Policy (CAP) reform in 2003. Up to 2003, CAP support direct payments were coupled to production and, as a result, farmers' incentives to grow certain crops (cereals, oilseeds, protein crops and olive) were driven by relative subsidy differences as well as production quotas and other acreage limitations (Garrido and Varela-Ortega, 2008; Varela-Ortega, 2008). The CAP 2003 reform established a system of direct payments decoupled from production defined by a 'single farm payment' making EU farmers more competitive and market orientated (European Commission, 2008). Furthermore, these new 'single farm payments' are linked to the respect of environmental, food safety and animal welfare standards well as to comply with good agricultural and environmental conditions (cross-compliance scheme). In the case of Spain, however, direct payments are not fully decoupled from production and still maintain a 25% coupled rate.

This CAP reforms, together with the Common Market Organization of fruits and vegetables, wine, cotton, tobacco and sugar, and the agricultural market liberalization have indirect implications on agricultural water demand (Garrido and Varela-Ortega, 2008). Currently, cereal price increases and subsidies for biofuel production could also have an influence but it is difficult to predict which is going to be the result in the mid term.

On the other hand, the Water Framework Directive (WFD) sets the clear objective of achieving the 'good status' for all water bodies in the EU (surface as well as groundwater) by 2015 and the requirement 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 and Varela-Ortega (2008), the implementation 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.

Currently, water management in Spain is evolving towards the implementation of the WFD and the CAP reform, which require a more integrated, flexible, adaptable and participative land and water planning and management (Garrido and Varela-Ortega, 2008). This new policy context implies the need for achieving a well-balanced and sustainable integration of agricultural and environmental sectors (Varela-Ortega, 2008).

Recently, Garrido and Varela-Ortega (2008) showed that the irrigated acreage of intensive water –consuming crops such as sugar beet, cotton, tobacco or maize, are losing importance in favour of winter cereals, vine and olive, well adapted to region-based farming and irrigation technologies. 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 more decoupled farm support measures, investment in irrigation and water transportation technologies and more market-driven farming decisions.

Towards an efficient allocation of water resources

Spanish agriculture has comparative advantages as a result of its soil availability, sunshine hours, reasonable labour costs and location in relation to 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 2).

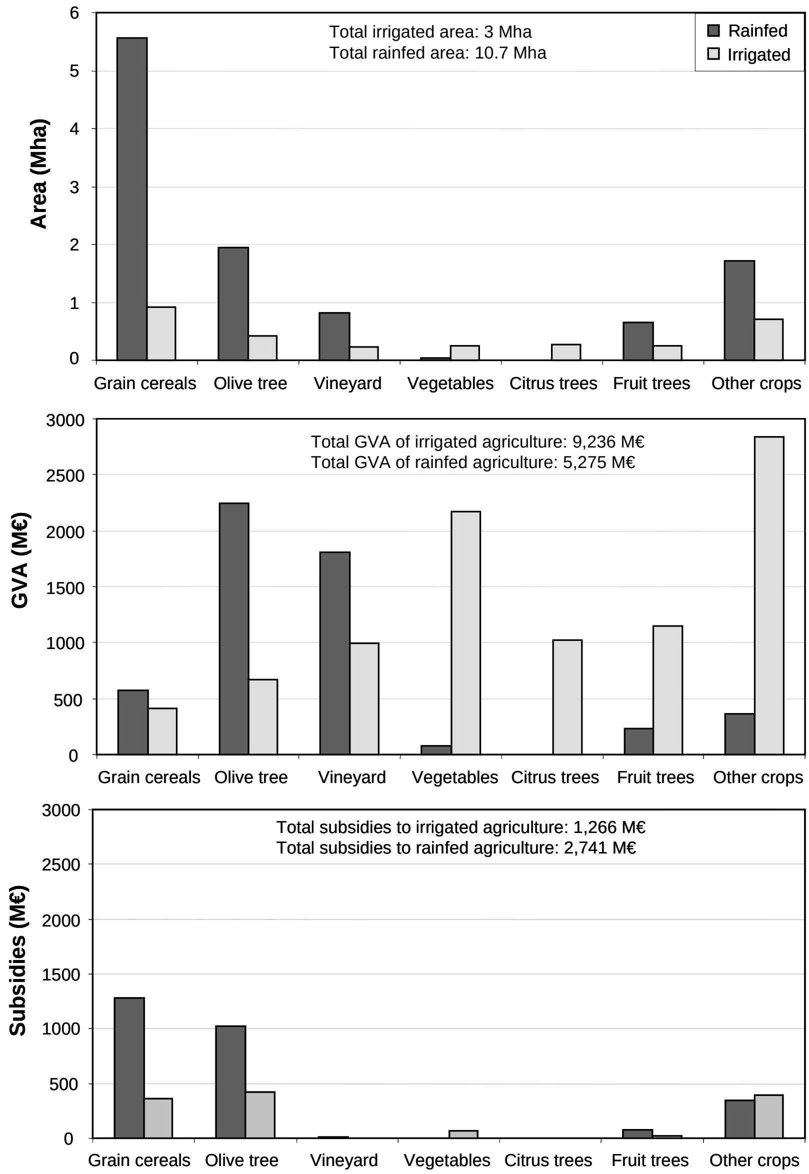


Figure 2. Total area (ha) per crop (Mha), total Gross Value Added (GVA) (M€) and total subsidies (M€) comparing rainfed and irrigated agriculture in Spain for the year 2001. *Source:* based on data from the Spanish Ministry for the Environment (MIMAM, 2007)

First of all, it has to be highlighted that rainfed grain cereals in Spain occupy more than 5 million hectares as shown in figure 2. In the year 2001, grain cereals were the main land and water users in Spain, utilizing the 47% of total arable land and 32% of blue water resources (figures 2 and 3) (MIMAM, 2007). In economic terms, however, they generated the lowest GVA value, which was about 6% GVA of irrigated agriculture according to MIMAM (2007) data. Nevertheless, we cannot just focus on economic aspects and forget the importance of agricultural multifunctionality (economic, social and environmental).

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. In addition, carbon-intensive agro-chemical doses used in irrigated agriculture are higher than those used in rainfed agriculture, with the corresponding ecologic impact (MIMAM, 2007). Blue water use in Spain, thus, has generally a higher opportunity cost and greater negative environmental externalities than green water use.

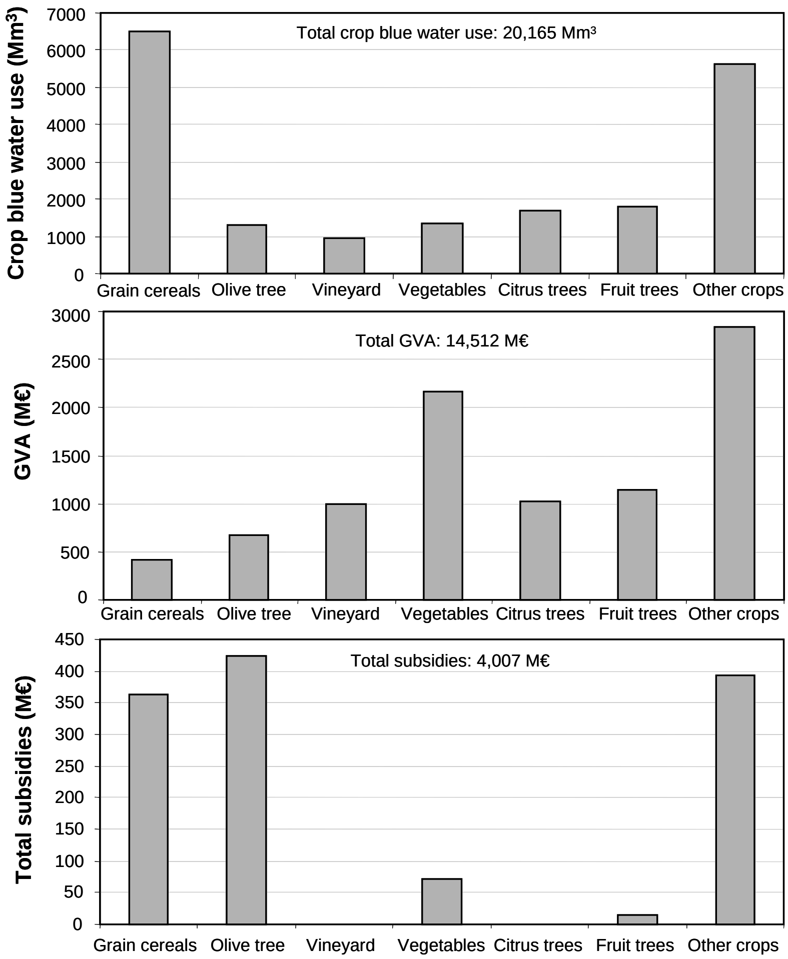


Figure 3. Crop blue water supply (Mm3), total Gross Value Added (GVA) (M€) and total subsidies (M€) to irrigated agriculture in Spain for the year 2001. When calculating the crop blue water use multiplying m^3/ha by the number of hectares given by MIMAM (2007), the total value (20,165 Mm^3) is an approximation to the numbers give by MIMAM (2007) (18,194 Mm^3). *Source:* based on data from the Spanish Ministry for the Environment (MIMAM, 2007)

The water apparent productivity analysis can be very useful in order to identify possible water uses not justified in economic efficiency terms and achieve an efficient allocation of water resources.

According to MIMAM (2007), average productivity of blue water used in irrigated agriculture is about 0.44 €/m^3. When looking at the productivity per crop type (figure 4), greenhouse crops (horticultural, flowers and ornamental plants) present the highest Gross Value Added per water unit (with a minimum 4.87 €/m^3 and a maximum 17.52 €/m^3). With lower values vegetables, vineyards and temperate climate trees show intermediate values. Finally, with remarkably lower values, grain cereals display an average productivity of just 0.06 €/m^3. So, apparent productivity of greenhouse crops is about one hundred times higher than that of cereals.

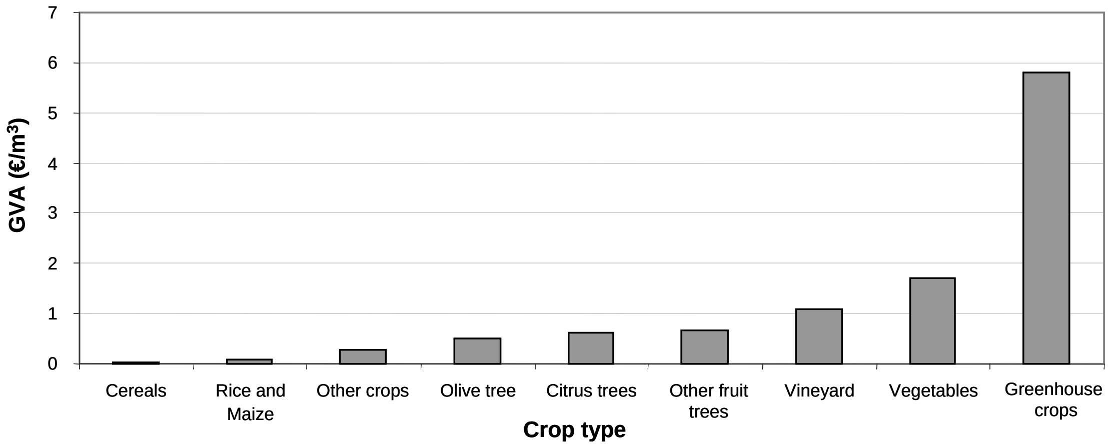


Figure 4. Water apparent productivity (Gross Value Added per cubic metre –GVA/m^3) per crop in irrigated agriculture in Spain for the year 2001-2002. Data for 78% of the irrigated area. *Source:* based on data from the Spanish Ministry for the Environment (MIMAM, 2007)

Figure 5 shows that a mere 4% of all blue water used in irrigated agriculture accounts for 66 % of total value added. Conversely, close to 60% of water uses produce a slight 5% of total value added in agriculture.

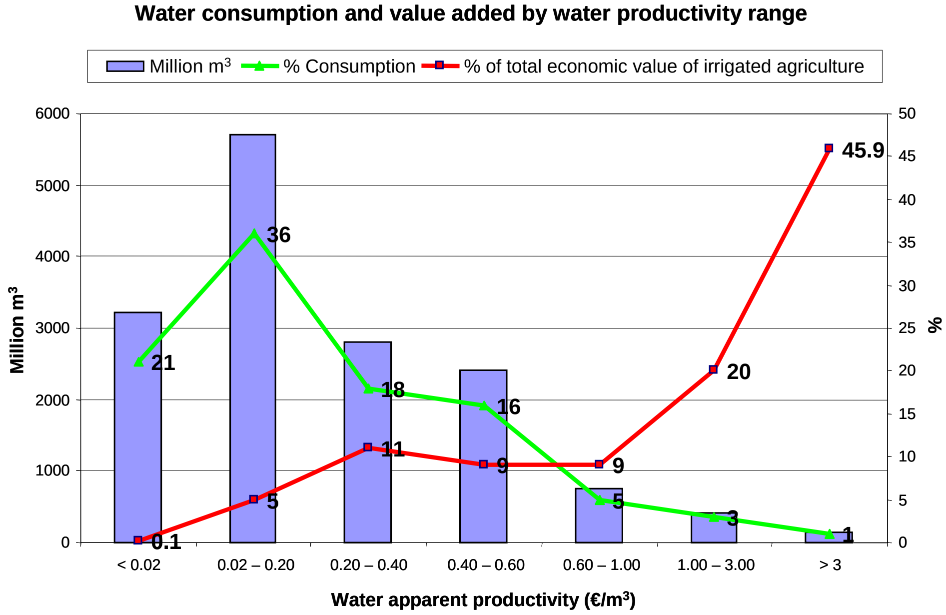


Figure 5. Total Water use in Agriculture by crop productivity range as percent of volume and value added (based on 78% of total irrigation in Spain) (2001-2002). *Source:* Varela-Ortega (2008), based on data of MIMAM (2007)

Even if not considered in the study of MIMAM (2007), most probably high value crops are watered with groundwater resources or combining ground and surface water (Llamas and Martínez-Santos, 2005). For instance, in table 5, Hernández-Mora et al. (2001) show that, in Andalusia, irrigated agriculture using groundwater is economically over five times more productive and generates almost three times the employment than agriculture using surface water, per unit volume of water used. This difference can be attributed to several causes: the greater control and supply guarantee that groundwater provides, which in turn allows farmers to introduce more efficient irrigation techniques and more profitable crops; the greater dynamism that has characterized the farmer that has sought out his own sources of water and bears the full costs of drilling, pumping and distribution; and the fact that the higher financial costs farmers bear motivates them to look for more profitable crops that will allow them to maximize their return on investments (Hernández-Mora et al., 2001). Surface and groundwater distinction, therefore, should be taken into account in order to achieve an efficient allocation of water resources.

Table 5. Irrigation economic indicators in Andalusia for ground and surface water.

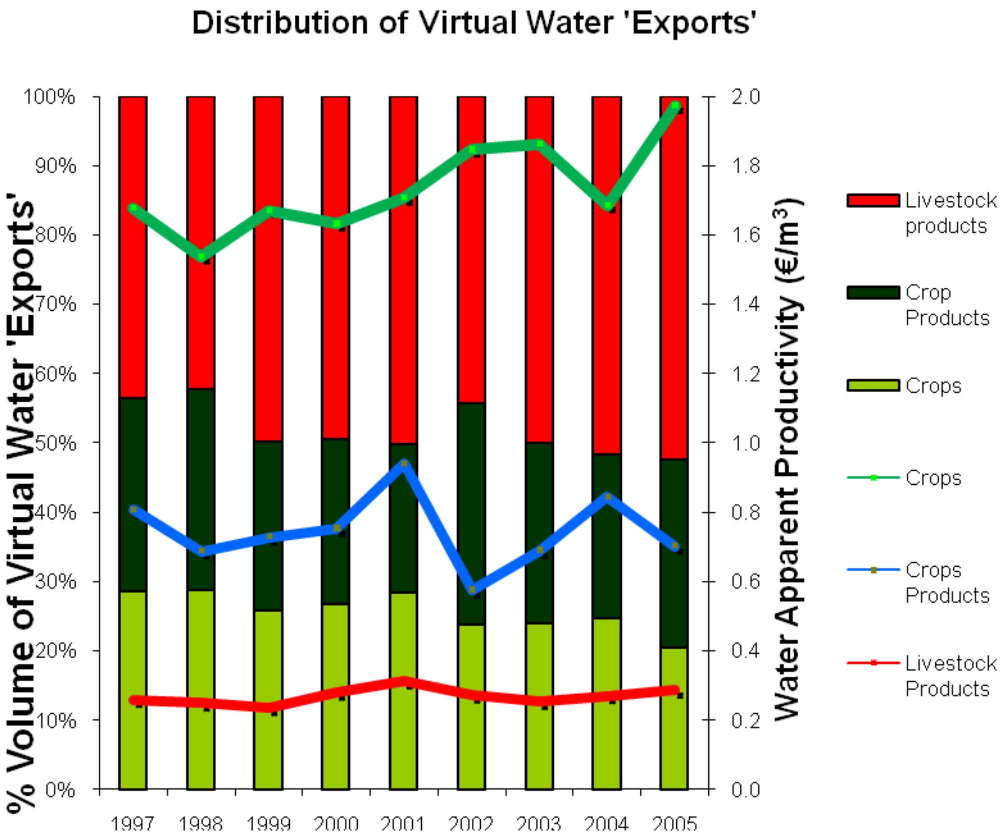
	Groundwater	Surface water	Total
Irrigated area (ha)	244,190 (27%)	648,009 (73%)	893,009 (100%)
Average water consumption (m^3/ha)	3,900	5,000	4,700
Total production (10^6 €)	2,222	2,268	4,480
Production (€/ha)	9,100	3,500	5,100
Employment generated (number jobs/100 ha)	23.2	12.6	15.4
EU aid to income (% of production value)	5.6	20.8	13.4
Gross water productivity (€/m^3)	2.35	0.70	1.08
Total average water price to farmer (€/m^3)	7.2	3.3	3.9

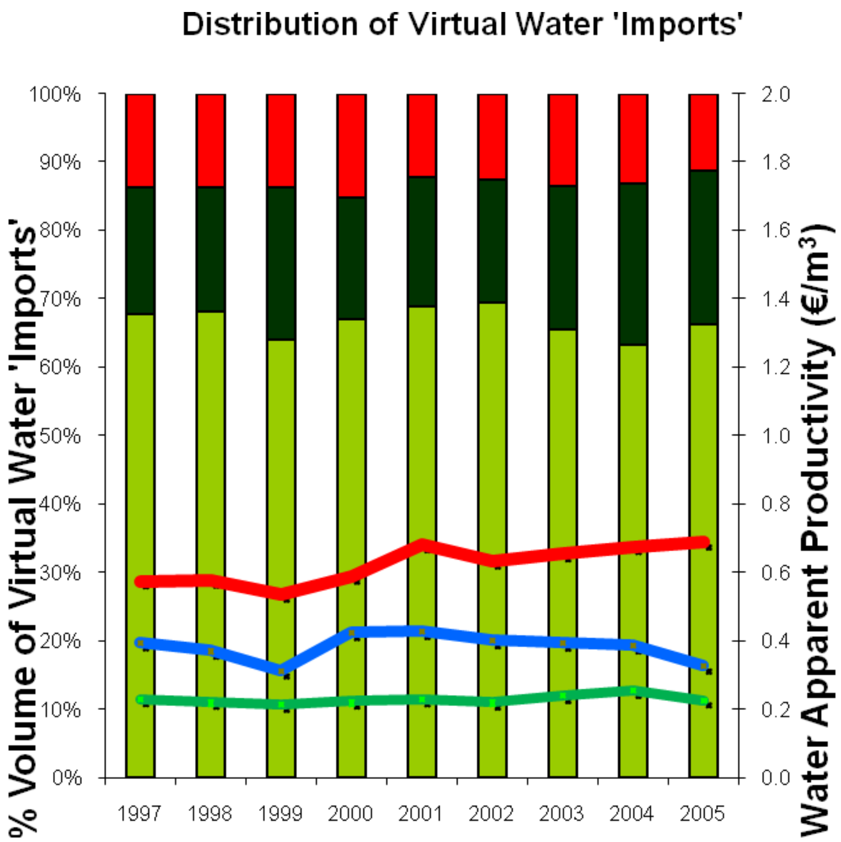
Source: Hernandez-Mora et al. (2001)

4. Virtual water ’trade‘ in Spain

Agricultural commodity trade in relation to water is an issue that has rarely been dealt with. It is important to take into account that Spain is a net virtual water ’importer‘ concerning agricultural commodities. According to Chapagain and Hoekstra (2004) Spain ’imports‘ about 27 km^3/year and ’exports‘ 17 km^3/year, resulting in a negative balance of 10 km^3/year. Spain exports high economic value and low virtual water content crops, such as citrus fruits, vegetables or olive oil, while it exports virtual water intensive and low-economic value crops, such as cereals (Novo, 2008; Rodríguez, 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 in terms of importance for food security to water scarce importing and developing countries (Yang at al., 2003). Spain’s cereals production is only 5% of total EU’s, so 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 (Yang and Zehnder, 2007). 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). 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 and Hung, 2005).

Figures 6a and 6b show that in Spain the composition of virtual water ‘imports’ and ‘exports’ are fairly stable in the time studied (1997-2005). Spain’s cereal imports make up about 70% of all water agricultural imports, whereas livestock exports represent 55%. 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. Lesser enforcement of environmental legislation, more empty territory and a great deal of economic integration explain rather it. 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.





Figures 6a and 6b. Volume of virtual water 'export' and 'imports' (%) and water apparent productivity (€/m^3) for the years 1997-2005.

5. Conclusion

1. From the results of the present study we can infer that the 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 footprint should be analysed in time and with sectorial and geographical standpoints. Furthermore, we cannot forget about the multifunctionality of agriculture.

2. 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 CAP 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.

3. The water footprint analysis, both hydrological and economic, at a river basin level facilitates the efficient allocation of water resources to the different economic and ecologic 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.

4. Finally, this analysis, in industrialized countries such as Spain can help to move from ’more crops and jobs per drop‘ towards ’more cash and nature per drop‘. Achieving, thus, the preservation of the environment without damaging the agricultural sector economy.

References

AgroNegocios (2008) El valor de la producción agraria se elevó a 40.202 M€. AgroNegocios 15-21 Febrero 2008.

Albiac, J., Tapia, J., Mema, M., Meyer, A., Hanemann, M., Mema, M., Calatrava, J., Uche, J. y Calvo, E. (2005) Los problemas económicos de la planificación hidrológica. *Revista de Economía Aplicada*, Madrid, 30 p.

Aldaya, M. M., Hoekstra, A. Y. y Allan, J. A. (2008) Strategic importance of green water in international crop trade. *Value of Water Research Report Series* No. 25, UNESCO- IHE Delft, The Netherlands.

Allan, J. A. (2006) Virtual Water, Part of an invisible synergy that ameliorates water scarcity. In *Water Crisis: Myth or Reality?* (Rogers, Llamas y Martinez, edts.) Balkema Publishers, pp. 131-150.

Andalusian Regional Government Irrigation Inventory (2003) Inventario y caracterización de los regadíos de Andalucía. Consejería de Agricultura y Pesca, Junta de Andalucía.

Berbel, J. (2007) *Análisis Económico del Uso del Agua en la Agricultura y la Ganadería.* Jornadas de debate sobre El Uso del Agua en la Economía Española. Situación y Perspectivas. Grupo de Análisis Económico del Ministerio de Medio Ambiente. Sevilla, marzo de 2.007.

Benoit, G and A. Comeau (eds); Plan Bleu (2005) A Sustainable Future for the Mediterranean: The Blue Plan's Environment and Development Outlook. UNEP-MAP-Blue Plan. Earthscan: London. 464 p.

Comprehensive Assessment of Water Management in Agriculture (2007) Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: International Water Management Institute.

Chapagain, A.K. and Hoekstra, A.Y. (2004) Water Footprints of Nations. Value of Water Research Report Series No. 16, UNESCO- IHE. Delft, The Netherlands.

European Commission (2008) CAP reform - a long-term perspective for sustainable agriculture. European Commission, Agriculture and Rural Development [online] Available from: http://ec.europa.eu/agriculture/capreform/index_en.htm [Accessed 15 March 2008]

Falkenmark, M. (2003) Freshwater as shared between society and ecosystems: from divided approaches to integrated challenges. *Philosophical Transactions of the Royal Society B: Biological Sciences* 358 (1440): 2037–2049.

Falkenmark, M. and Rockström, J. (2004) *Balancing water for humans and nature: The new approach in ecohydrology*. Earthscan, London, UK.

Food Ethics (2008) Food Ethics Magazine- Spring ´08: Water. Food Ethics Council (http://www.foodethicscouncil.org/node/343)

Garrido, A. and Llamas, M.R. (2008) Water Management in Spain: An example of changing paradigms. Presentation in the International Water Expo in Zaragoza, in the second session of 'Agua: Economía, Política y Agricultura', 13th May 2008.

Garrido, A. and Varela-Ortega, C. (2008) 'Economía del agua en la agricultura e integración de políticas sectoriales' Panel de Estudios. Universidad de Sevilla - Ministerio de Medio Ambiente.

Hernández-Mora, N. & Llamas, M.R. (eds.) (2001) *La economía del agua subterránea y su gestión colectiva*. Fundación Marcelino Botín y Mundi-Prensa. Madrid, 550 pp.

Hernandez-Mora, N., Llamas, M.R. and Martínez, L. (2001), Misconceptions in Aquifer Over-Exploitation. Implications for Water Policy in Southern Europe. In: *Agricultural Use of Groundwater. Towards Integration between Agricultural Policy and Water Resources Management.* Ed. C. Dosi. Kluwer Academic Publishers. Dordrecht, The Netherlands, pp. 107-125

Hernandez-Mora, N., Martinez-Cortina, L., Llamas, M. R. and Custodio, E. (2007) 'Groundwater Issues in Southern EU Member States. Spain Country Report'. [online] Available from: http://rac.es/2/2_ficha.asp?id=119&idN3=6&idN4=40 [Accessed 15 March 2008]

Hoekstra, A.Y. and Hung, P.Q. (2005) Globalisation of water resources: international virtual water flows in relation to crop trade. *Global Environmental Change* 15 (1): 45-56.

INE, Cuentas del agua (2002) 'Cuentas satélite del agua en España' Nacional Statistics Institute [online] Available from: http://www.ine.es/jaxi/menu.do?type=pcaxis&path=%2Ft26%2Fp067&file=inebase&L= [Accessed 20 May 2008].

INE (2008) 'National Statistics Institute' [online] Available from: http://www.ine.es/ [Accessed 20 May 2008].

Llamas, M. R. (2005) Los colores del agua, el agua virtual y los conflictos hídricos Discurso inaugural del año 2005-06. *Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales.* Madrid. Vol. 99, No 2, pp. 369-389

Llamas, M.R. and Martínez-Santos, P. (2005) Intensive Groundwater Use: Silent Revolution and Potential Source of Social Conflicts. *Journal of Water Resources Planning and Management, American Society of Civil Engineers*, September-October 2005, pp. 337-341

Lopez-Gunn, E. and Llamas, M. R. (2008) Re-thinking water scarcity: Can science and technology solve the global water crisis?. *Natural Resources Forum*. Vol. 32, Issue 3, pp. 228-238

MAPA (2008) 'Agro-alimentary Statistics Yearbook' Spanish Ministry of Agriculture, Fisheries and Food [online] Available from: http://www.mapa.es/es/estadistica/pags/anuario/introduccion.htm [Accessed 20 May 2008].

MIMAM (2000) 'Libro Blanco del Agua en España'. Spanish Ministry for the Environment.

MIMAM (2007) 'El agua en la economía española: Situación y perspectivas' Spanish Ministry for the Environment [online] Available from: http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/implementation_documents_1/wfd_reports/member_states/spain/article_5/completo_nivel1pdf/_EN_1.0_&a=d [Accessed 20 May 2008].

Naranjo, J. E. (2008) Agroindustria asociada al regadío. Presentación en la Jornada Técnica: Aguas regeneradas, regadío y desarrollo rural. Federación Nacional de Comunidades de Regantes de España.

National Irrigation Plan (2008) Plan Nacional de Regadios. Ministerio de Medio Ambiente y Medio Rural y Marino, [online] Available from: http://www.mapa.es/es/desarrollo/pags/pnr/principal.htm [Accessed 20 May 2008].

Novo, P. (2008) 'Análisis del 'comercio' de agua virtual en España: Aplicación al caso de los cereales' Master thesis. Universidad Politécnica de Madrid.

Rodríguez, R. (2008) 'Cálculo de la huella hidrológica de la agricultura española' Master thesis. Universidad Politécncia de Madrid.

Rogers, P., Llamas, M. R. and Martinez Cortina, L. (2006) Foreword. In: Water Crisis: Myth or Reality? Rogers et al. (eds.). Taylor and Francis Group. London, pp. IX y X

Rosegrant, M., X. Cai and S. Cline (2002) World Water and Food to 2025: Dealing with Scarcity, International Food Policy Research Institute (IFPRI), Washington, D.C.

Sancho, R. (2008) Importancia del regadío para fijar población en el territorio. Presentación en la Jornada Técnica: Aguas regeneradas, regadío y desarrollo rural. Federación Nacional de Comunidades de Regantes de España.

United Nations Development Programme (UNDP) (2006) Human Development Report 2006: Beyond scarcity: Power, poverty and the global water crisis [online] Available from: http://78.136.31.142/en/reports/global/hdr2006/ [Accessed 20 May 2008].

Varela-Ortega, C. (2008) The Water Policies in Spain: Balancing water for food and water for nature. Paper presented at the Rosenberg International Forum on Water Policy. Zaragoza, Spain

Vives, R. (2003) Economic and Social Possibility of Water Use for Irrigation in Andalucía (Spain). *Water International*, Vol. 28, No. 3, pp. 320-333

Yang, H., Reichert, P., Abbaspour, K.C., and Zehnder, A. J. B. (2003) A water resources threshold and its implications for food security. In *Virtual water trade: Proceedings of the International Expert Meeting on Virtual Water Trade*, Value of Water Research Report Series, No. 12, A.Y. Hoekstra (Ed.), UNESCO-IHE, Delft, The Netherlands.

Yang H. and Zehnder A. (2007) 'Virtual water': An unfolding concept in integrated water resources management. *Water Resources Research*, 43, W12301.