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Water Footprint Analysis (Hydrologic and Economic) of the Guadania River Basin

by Maite Martinez Aldaya, Twente Water Centre, University of Twente and Manuel Ramon Llamas, Department of Geodynamics, Complutense University of Madrid, Spain

United Nations Educational, Scientific and Cultural Organization

World Water Assessment Programme

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Water Footprint Analysis (Hydrologic and Economic) of the Guadiana River Basin

Maite Martinez Aldaya[1] and Manuel Ramon Llamas.[2]

Summary

In most arid and semi-arid countries, water resources management is an issue that is as important as it is controversial. Today most water resources experts admit that water conflicts are not caused by the physical water scarcity, but are mainly due to poor water management or governance. The virtual water concept, defined as the volume of water used in the production of a commodity, good or service, together with the water footprint (water volume used to produce the goods and services consumed by a person or community), link a large range of sectors and issues, providing an appropriate framework to find potential solutions and contribute to a better management of water resources, particularly in arid or semi-arid countries.

Water use and management in Spain, the most arid country in the European Union, is a hot political and social topic. The aim of this study is to analyze the virtual water and water footprint, both from a hydrological and economic perspective, in the semi-arid Guadiana basin. The transboundary Guadiana river basin, located in south-central Spain and Portugal, drains an area of 67,000 km^2, of which 17% lies in Portugal. The present analysis is carried out on the Spanish side of the basin, which has been divided into the Upper, Middle, and Lower Guadiana basin and TOP domain. The TOP domain is a group of three small river basins (Tinto, Odiel and Piedras) located near the Guadiana River mouth. In these regions, the main green water (rainwater stored in the soil as soil moisture) and blue water (surface water and ground water) consuming sector is agriculture, accounting for about 95% of total water consumption. Within this sector, high virtual-water crops with low economic values are widespread in the studied Upper and Middle Guadiana regions, particularly cereals with low blue water economic productivity. In particular, the Upper Guadiana basin is among the most significant in Spain in terms of conflicts between agriculture, with almost no food (virtual water) import, and the conservation of rivers and groundwater-dependent wetlands. On the other hand, in the Lower Guadiana basin and TOP domain, where vegetables and crops are grown under plastic, the blue water economic productivity values are much higher, using both surface water

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and groundwater resources. The quantity of crops and the amount of employment generated in the whole Guadiana basin are already producing 'more crops and jobs per drop'. The aim now is to move towards a policy of 'more cash and nature per drop', especially in the Upper and Middle Guadiana basin.

Adopting this approach however, requires a good understanding of the impacts of such policies on socio-cultural, economic and environmental conditions. Water is not the only factor involved in production and other factors, such as energy, may come to play an increasingly important role in determining water resources allocation and use.

1. Introduction

Most water resources experts admit that water conflicts are not caused just by water scarcity, but are mainly due to poor water management. Virtual water and water footprint analyses, link a large range of sectors and issues and provide a useful framework to find potential solutions and contribute to a better management of water resources, particularly in water-scarce countries.

The water footprint (WF) is a consumption-based indicator of water use defined as the total volume of water that is used to produce the goods and services consumed by an individual or community (Hoekstra and Chapagain, 2008). Closely linked to the concept of water footprint is the concept of 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; 1999; Hoekstra, 2003). Building on this concept, virtual water 'trade' represents the amount of water embedded in traded products (Hoekstra and Hung, 2002). A nation can preserve its domestic water resources by importing water-intensive products instead of producing them domestically. These 'water savings' can be used to produce alternative, higher-value agricultural crops, to support environmental services, or to serve growing domestic needs. Thus, virtual water 'import' is increasingly perceived as an alternative source of water for some water-stressed nations and is starting to change the current concepts of water and food security.

Furthermore, virtual water and water footprint analysis makes explicit how much water is needed to produce different goods and services. In semi-arid and arid areas, knowing the virtual water value of a good or service can be useful in determining how best to use the scarce water available. In this sense, it is important to establish whether the water used proceeds from rainwater evaporated during the production process (green water) or surface water and/or groundwater evaporated as a result of the production of the product (blue water) (Chapagain et al., 2006; Falkenmark, 2003). Traditionally, emphasis has been given to the concept of blue water through the 'miracle' of irrigation systems. However, an increasing number of authors highlight the importance of green water (Allan, 2006; Comprehensive Assessment of Water Management in Agriculture, 2007; Falkenmark and Rockström, 2004; Rockström, 2001). Virtual water and water footprint assessment could thus inform production and trade decisions, promoting the production of goods most suited to local environmental conditions and the development and adoption of water-efficient technology.

The present study deals with the economic and hydrological analysis of the virtual water and water footprint of the Guadiana river basin, and considers the ways in which both green water and blue (ground and surface) water are used by the different economic sectors. This could facilitate a more efficient allocation and use of water resources, providing simultaneously a transparent interdisciplinary framework for policy formulation. The Guadiana river basin is shared by Spain and Portugal, but this report focuses on the Spanish area of the river basin. The analysis of the Portuguese area (less than 20% of the total area of the basin) will be carried out by the Portuguese INAG (National Water Authority). It analyses the water footprint, virtual water and economic relevance of each economic sector in different rainfall years (evaluating an average year [2001], a dry year [2005], and a humid year [1997]). Special emphasis is given to the agricultural sector, which consumes about 95% of total green water and blue water resources. First of all, the whole Guadiana is evaluated. It has been divided into four sections: groundwater-based Upper Guadiana basin; mainly surface-water-based Middle basin; both groundwater- and surface-water-based Lower Guadiana basin, and the former Lower Guadiana or Guadiana II (henceforth TOP domain) comprising the Tinto, Odiel and Piedras river basins.

In the final section, virtual water 'trade' is evaluated. Finally, crop water consumption estimates are assessed against the results obtained by other national and international studies. A glossary with key terms is also included at the end of the study, a more extensive version of which can be found in Aldaya and Llamas (in press). It concludes that a better knowledge of the water footprint and virtual water 'trade' in the semi-arid Guadiana basin 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). As a whole, the Guadiana river basin 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'. An exception to this is the case of the Lower Guadiana basin and TOP domain in Andalusia, where virtual-water-extensive, high-economic-value crops adapted to the Mediterranean climate are grown, essentially vegetables, fruits and olive oil. At present, water footprint analysis throughout almost the entire world 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' (Aldaya et al., 2008). Finally, water footprint analysis is providing new data and perspectives that are offering a more optimistic outlook on the looming 'water scarcity crisis'. We expect that this new knowledge will change traditional water and food security concepts, concepts that have hitherto prevailed in the minds of most policy makers.

2. Study area

The Guadiana basin has an area of 66,800 km^2 (83% in Spain and 17% in Portugal). The climate is semi-arid, with an average precipitation of about 450 mm/year and average annual temperature of 14–16 °C (CHG, 2008*a*; INAG, 2007).

For practical purposes, the basin has been divided into four areas (Figure 1): these are a) the groundwater-based Upper Guadiana basin (entirely located in the Castilla-La Mancha Autonomous Region); b) the mainly surface-water-based Middle Guadiana basin (comprising part of Extremadura but not the small fraction of Cordoba); c) the Lower Guadiana basin (including the part of the basin in Huelva); and d) TOP domain (comprising the Tinto, Odiel and Piedras river basins). The TOP domain was the competence of the Guadiana River Basin Authority before 1 January 2006, but its competence was then transferred to the Government of Andalusia (CHG, 2008*a*).

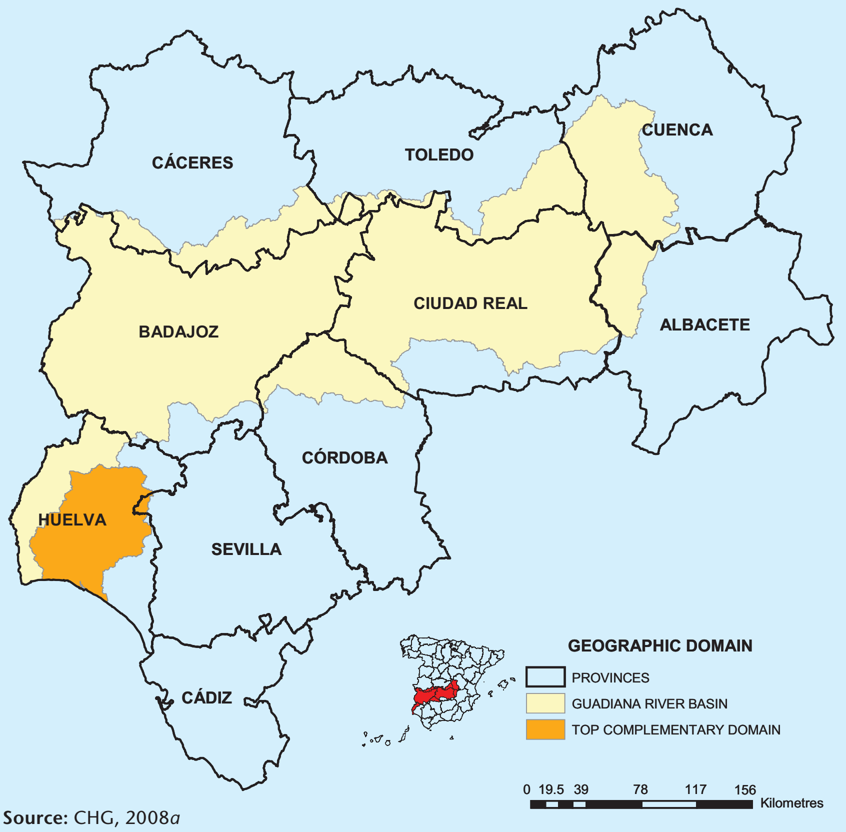
According to CHG (2008*b*), when referring to the Guadiana river basin on the whole ('Total Guadiana' in the present document), it comprises the Upper, Middle and Lower basins, including a small fraction of Cordoba.

The Upper Guadiana basin, located in Castilla-La Mancha, is one of the driest river basins in Spain (Hernández-Mora et al., 2003). In this part, UNESCO recognized the collective ecological importance of 25,000 ha of wetlands in 1980, when it designated the 'Mancha Húmeda' Biosphere Reserve. In a largely arid region, these wetlands provided crucial nesting and feeding grounds for European migrating bird populations and were home to rare animal and plant species. The Tablas de Daimiel National Park (2,000 ha), a Ramsar Site, stands out for its significance as a symbol for the Spanish conservation movement. Today however, this wetland, which used to receive the natural discharge from the Western Mancha aquifer (Figure 2), survives artificially, in a kind of 'ecological coma', thanks to the water transfers that have been coming from the Tagus-Segura Aqueduct since 1988 (Hernández-Mora et al., 2003) and to the artificial pumpage of groundwater that keeps about the 5% of the 2,000 hectares of wetlands in the undisturbed National Park flooded. More recently, some NGOs are claiming that UNESCO should no longer consider the 'La Mancha Humeda' as a World Biosphere Reserve. On the other hand, in order to recover these ecosystems, the Spanish Government, at the proposal of the Ministry of the Environment, approved a special plan for the Upper Guadiana (*Plan Especial del Alto Guadiana* – PEAG) on 11 January 2008 (CHG, 2008*c*). The formal approval of this Plan includes a budget of €5,500 million to be spent during the next 20 years.

3. Methodology

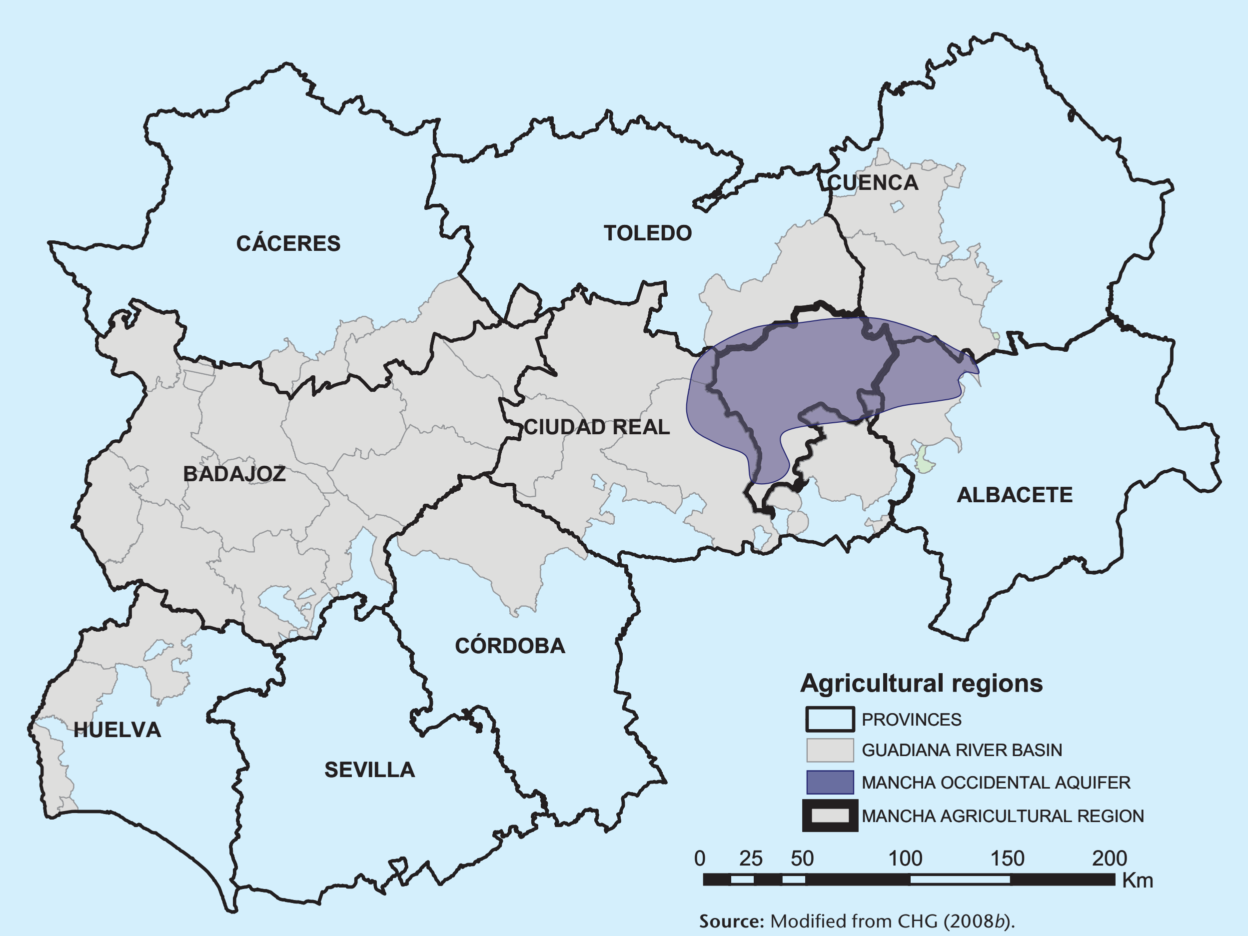
The present study estimates the virtual water and water footprint of the Guadiana river basin and considers the green water and blue water components for the most representative crops, as well as the blue water component for livestock, industrial products and domestic (urban) water use. Within the blue water component, the volumes of surface and groundwater consumption are differentiated. In parallel with these analyses, economic data are studied. This is done for each section of the river

Figure 1 Guadiana river basin geographic and administrative domain from 1 January 2006 onwards



Source: CHG, 2008*a*

Figure 2 **Western Mancha aquifer location within the Upper Guadiana Basin**



Source: Modified from CHG (2008*b*).

basin (Upper, Middle, Lower Guadiana and TOP domain) over three different time periods – during an average year (2001), a dry year (2005), and humid year (1997).

The virtual water and water footprint are calculated using the methodology developed by Hoekstra and Hung (2002; 2005) and Chapagain and Hoekstra (2003; 2004). For its emphasis on green water and blue water, the present research follows recent works of Chapagain et al. (2006), Hoekstra and Chapagain (2008) and Chapagain and Orr (2008).

The method followed in this work is described in more detail in a more extensive report of the Guadiana river basin, Aldaya and Llamas, (in press).

3.1 Virtual water content

The virtual water content of a product is the volume of freshwater used to produce it, which depends on the water used in the various steps of the production chain. The virtual water content of primary crops (m^3/tonne) (i.e. crops in the form in which they come directly from the land without having undergone any processing) has been calculated at a provincial level as the ratio of the volume of water used during the entire period of crop growth (crop water use, m^3/year) to the corresponding crop yield (tonne/ha) in the producing region. The crop water requirement of a certain crop under particular climatic circumstances was estimated with the CROPWAT model (Allen et al., 1998; FAO, 2003) using climate data at a provincial level. The volume of water used to grow crops in the field has two components: green water and blue water.

One particularity of the methodology used in this detailed study is that rainfed and irrigated agriculture were differentiated in the green and blue virtual water component calculations. That is, the green component in the virtual water content of a primary crop (V_g, m^3/tonne) is calculated as the green crop water use (m^3/ha) divided by the crop yield (Y, tonne/ha) for both rainfed (Y_r) and irrigated production (Y_{irr}). In parallel, the blue water component (V_b, m^3/tonne) is calculated as blue crop water use divided by crop yield in irrigated production (Y_{irr}).

3.2 Water footprint

In line with Chapagain and Hoekstra (2004), the water footprint of a country is equal to the total volume of water used, directly or indirectly, to produce the goods and services consumed by the inhabitants of that country. A national water footprint has two components, the internal and the external water footprint. First, the internal water footprint is defined as the volume of water used from domestic water resources to produce the goods and services consumed by the inhabitants of the region (Hoekstra and Chapagain, 2008). It is the sum of the total water volume used from the domestic water resources in the national economy minus the volume of virtual water export to other countries insofar as it's related to the export of domestically produced products. Second, the external water footprint is the volume of water used in other regions to produce goods and services imported and consumed by the inhabitants of that region. The present study calculates the water footprint per sub-basin related to production. Trade data at a provincial level are presented separately.

4. Data sources and limitations

In order to carry out this report, a number of simplifications have been assumed. First of all, the virtual water content values obtained with the CROPWAT model should be considered as a first approximation to reality. The main gaps in this approach are: a) the lack of data on the soils' characteristics and their storage capacity for the effective rain; b) the amount of irrigation water 'lost' from the surface reservoirs to the field; c) the amount of water necessary to abate the pollution; and d) the reduction in crop yield when the irrigation demand cannot be supplied. Second, the eight most representative crops in each area have been studied corresponding to about 80% of the total area (Appendix 1). Third, with the aim of analysing the impact of climate variability on the use of water resources, three different rainfall years were chosen: a humid year (1997), an average year (2001) and a dry year (2005). The average rainfall in 2001 was about 355 mm in Castilla-La Mancha, 547 in Extremadura and 510 mm in Andalucía. When available, data for these years were used. This was not possible, however, in every case– as indicated. Fourth, and following CHG (2008*b*) data, when estimating the urban water use, urban water supply and sanitation data have been taken into account. Fifth, concerning the industrial water use, because energy generation and the building industry are not considered within the industrial sector, hydroelectric energy was not included (CHG, 2008*b*). Sixth, with regard to the water consumption of livestock, their drinking water and the water used to clean livestock housing is considered, but the water used to grow and process their fodder is not. This is important when comparing these data with other analyses of the livestock water footprint. Finally, data have been compiled from different sources.

Geographic and social data: Data related to human population and employment were taken from the Guadiana River Basin Authority (CHG, 2008*b*).

Climatic data: Average monthly rainfall and evapotranspiration data at provincial level, as an input for the CROPWAT model, were obtained from the National Institute of Meteorology (INM, 2007).

Agricultural data: Data related to area (total area, crop area both rainfed and irrigated, and area irrigated by irrigation system) were taken from the Guadiana River Basin Authority (CHG, 2008*b*) and the Spanish Ministry of Agriculture, Fisheries and Food 1T sheets (MAPA, 1999; 2001*b*).

Data on average rainfed and irrigated crop yield (kg/ha) at the provincial level were taken from the Agro-alimentary Statistics Yearbook of the Spanish Ministry of Agriculture, Fisheries and Food (MAPA, 2007).

With regard to the crop parameters, as input data to CROPWAT, the crop coefficients in different crop development stages (initial, middle and late stage) were taken from FAO (Allen et al., 1998; FAO, 2003). The length of each crop in each development stage was obtained from FAO (Allen et al., 1998; FAO, 2003) when the climate region was specified; otherwise it was obtained from the work of Chapagain and Hoekstra (2004). The crop calendar was taken from the Spanish Ministry of Agriculture, Fisheries and Food (MAPA, 2001*a*). These data are also given at provincial level.

Economic data: Data related to gross value added (GVA) were taken from the Guadiana River Basin Authority (CHG, 2008*b*). The gross value added is obtained by deducting intermediate consumption from final agricultural production. That is, the gross value added is equal to net output or benefit to the farmer that can be used for the remuneration of productive factors. Nevertheless, in this study we will focus on the final economic agricultural production (total €) as well.

Crop economic value (€/tonne) for the different years was obtained from the Spanish Ministry of Agriculture, Fisheries and Food (MAPA, 2007). We are aware, however, that prices may change significantly from one year to the other. These data are an average for the whole Spain. In the present report CAP subsidies were not included (CHG, 2008*b*).

Hydrologic data: Data related to water origin (surface and groundwater) by agricultural region were taken from the Guadiana River Basin Authority (CHG, 2008*b*), which is based on the 1999 Agrarian Census of the National Statistics Institute (INE, 2007).

Green and blue crop consumptive water use (CWU, m^3/ha) data were estimated using the CROPWAT model (see Methodology section). Data on blue water withdrawals (surface and ground water) were taken from the Guadiana River Basin Authority (2007). It is noteworthy that these withdrawals are not the same as the estimated water consumption or evapotranspirative demand.

Average global irrigation efficiency at provincial level was taken from the CHG (2008*b*). It depends on the type of irrigation technique used by the farmer.

Localized or drip irrigation is the most efficient system with a 0.9 coefficient, followed by sprinkler irrigation with 0.7 and finally, surface flood irrigation with 0.5.

Trade data: Data related to international trade at a provincial level were taken from ICEX (2008).

5. Results

Since agriculture is the main water user in the Guadiana Basin (about 95%), the present study mainly focuses on water use by this sector. First of all, as seen in the methodology section, the Guadiana river basin has been divided and analysed in four areas (Upper, Middle, Lower Guadiana and TOP domain). Then, the obtained green and blue crop water consumption values are compared with national and international studies.

5.1. Guadiana water footprint

When comparing the Guadiana basin gross value added (GVA) with national figures for the different sectors, the agricultural sector represents 8.4 % of the national GVA total, with both agriculture and livestock having similar shares. In the TOP domain, agriculture represents 1.6 % of the national GVA, with livestock accounting for just a small amount (0.3 %). Concerning the industrial manufacturing sector GVA, in both the Guadiana basin and TOP domain, it is not relevant in comparison with the national total, representing 1.99 % and 0.45 % respectively of the national total. These figures show the relevance of agriculture in these areas in comparison with other Spanish regions where industry and tourism are more important.

A. Crop area

The Spanish Guadiana river basin crop area is 26,000 km^2, which is about 47% of the total area. As a whole, in the basin, 19% of the crop area is devoted to irrigated agriculture. This proportion is similar to the Spanish average which amounts to 22% (MIMAM, 2007).

As shown in figure 3 below, the area dedicated to each crop type varies in each Guadiana section in the year 2001 (average precipitation). When looking at rainfed agriculture, similar crops are grown in the different Guadiana sections, highlighting cereals, olive trees and vineyards. Concerning irrigated agriculture, in general cereals, vineyards and olive trees dominate in the Upper and Middle Guadiana basins, whereas citrus trees and vegetables are more prevalent in the Lower Guadiana and TOP domain. After the Common Agricultural Policy reform (2003), however, irrigated production of vineyard and olive tree has increased significantly in Spain (18% and 16% respectively) (MAPA, 2006). According to Garrido and Varela (2008) this is notable in the Castilla-La Mancha Autonomous Community. It is expected that significant changes in crop distribution will continue to occur in the near future due to a variety of causes, such as the increase in cereal prices.

B. Water use and consumption: total and by the agricultural sector

Total Water Use

As in most arid and semi-arid regions, in the Guadiana river basin the main sector consuming green water and blue water is agriculture, which accounts for about 95% of total water consumption in the basin as a whole (Table 1). The next-largest blue water user is the urban water supply, which uses less than 5% of the amount of water used in agriculture. If we consider that most urban water returns to the system, it can be said that water consumed in agriculture, accounts for more than 95% of all water use. However, the security of this supply is extremely relevant from a political and economic point of view. Concerning the Andalusian part (Lower Guadiana and the so-called TOP domain), agriculture consumes a smaller proportion of water (about 75–80%), which accounts for the increase in the proportion attributed to the urban water supply. The industrial sector, even if it is the smallest water user, represents the highest economic value (GVA). Agriculture is also a significant economic activity in the Guadiana river basin, being the most important share of the GVA after the industrial sector (Table 1). Thus, even if urban and industrial uses have an obvious economic and social relevance, agriculture, as the highest water consumer in the basin, is the key to water resources management in the area.

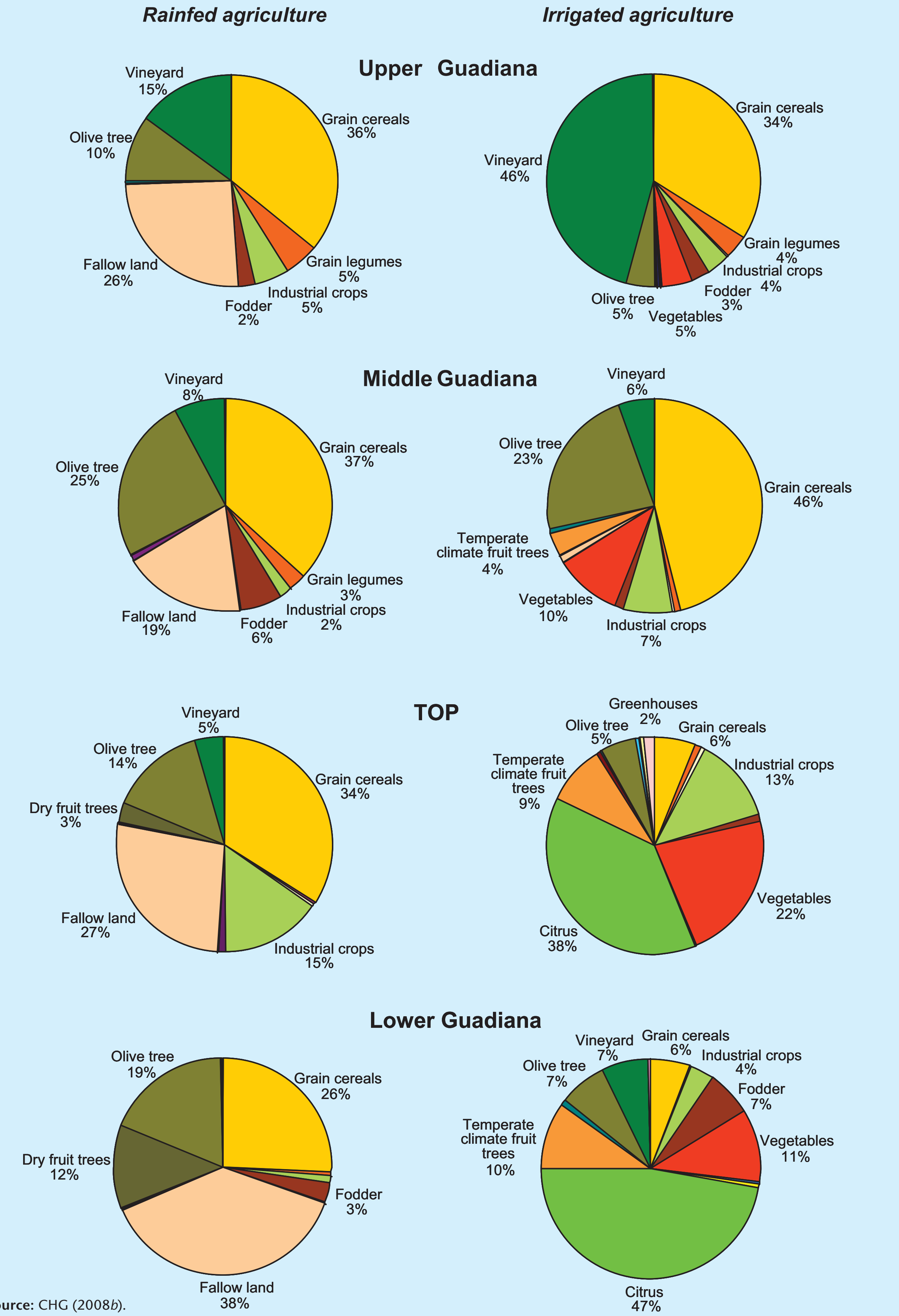
Concerning rainfed and irrigated farming in the whole basin excluding TOP domain, total rainfed area is more than five times the irrigated area (2,100x10^3 and 400x10^3 hectares respectively) (Appendix 2). Rainfed systems consume about 55% of the total water consumed by the agricultural sector (Table 1) and use green water that has a lower opportunity cost compared with the blue water use (Chapagain et al., 2005). Even if significantly smaller in extension, irrigated agriculture produces more tonnes and euros than rainfed agriculture (Appendix 2A and 2C).

Agricultural water consumption

As shown in figure 4, when taking into account rainfed and irrigated water consumption, crop water requirements are somewhat higher in the humid year. As might be expected, there are remarkable variations in the green water and blue water proportions in years with different rainfall patterns, with the blue water consumption higher in dry years and lower in humid years, while logically the green water consumption shows the opposite pattern.

The blue water consumption in the Upper Guadiana basin is mainly based on its groundwater resources, whereas the Middle Guadiana basin uses its surface water resources, mainly coming from large surface water reservoirs (Figure 5). The Lower Guadiana basin and TOP domain combine both ground and surface water strategies.

Figure 3 **Percentage of areas of irrigated and rainfed crops in the Upper, Middle, Lower Guadiana and TOP domain (average-year 2001). Showing crops occupying over 1% of land.**



Source: CHG (2008*b*).

Table 1 Internal water footprint of the Guadiana basin (2001)

TOTAL GUADIANA[1]

Population	Water footprint related to production[6]	Green	Blue	Total	Per capita	GVA[7]	Water economic productivity
		Mm^3/year			m^3/cap/year	million €	€/m^3
1,417,810	Agricultural	2,212	1,827	4,039	2,849	1,096	0.60
	Livestock		22	22	16	286	12.74
	Urban		130	130	91	128[8]	0.99[9]
	Industrial		20	20	14	1,557	77.90
	Total	2,212	1,999	4,211	2,970	3,068	1.53

UPPER GUADIANA[2]

Population	Water footprint related to production[6]	Green	Blue	Total	Per capita	GVA[7]	Water economic productivity
		Mm^3/year			m^3/cap/year	million €	€/m^3
636,721	Agricultural	1,286	928	2,214	3,478	599	0.65
	Livestock		5	5	8	131	25.05
	Urban		55	55	86	54[8]	0.99[9]
	Industrial		12	12	19	929	77.04
	Total	1,286	1,000	2,286	3,591	1,714	1.71

MIDDLE GUADIANA[3]

Population	Water footprint related to production[6]	Green	Blue	Total	Per capita	GVA[7]	Water economic productivity
		Mm^3/year			m^3/cap/year	million €	€/m^3
672,534	Agricultural	905	886	1,792	2,664	413	0.47
	Livestock		13	13	20	124	9.30
	Urban		65	65	96	64[8]	0.99[9]
	Industrial		6	6	9	485	78.82
	Total	905	970	1,876	2,789	1,086	1.12

TOP[4]

Population	Water footprint related to production[6]	Green	Blue	Total	Per capita	GVA[7]	Water economic productivity
		Mm^3/year			m^3/cap/year	million €	€/m^3
341,080	Agricultural	74	77	151	444	205	2.66
	Livestock		1	1	3	10	8.57
	Urban		38	38	112	38[8]	0.99[9]
	Industrial		8	8	24	554	68.62
	Total	74	125	199	583	807	6.47

LOWER GUADIANA[5]

Population	Water footprint related to production[6]	Green	Blue	Total	Per capita	GVA[7]	Water economic productivity
		Mm^3/year			m^3/cap/year	million €	€/m^3
62,213	Agricultural	21	13	33	535	45	3.54
	Livestock		1	1	20	9	7.42
	Urban		7	7	106	7[8]	0.99[9]
	Industrial		1	1	16	82	80.76
	Total	21	22	42	677	143	6.63

1 The Total Guadiana region includes the whole Guadiana river basin excluding the TOP domain. It is not the average of the Upper and Middle Guadiana.
2 The Upper Guadiana includes a fraction of Castilla-La Mancha Autonomous region.
3 The Middle Guadiana includes a fraction of Extremadura (Badajoz and Cáceres).
4 In line with CHG (2008*b*), TOP region is the Tinto, Odiel and Piedras river basin complementary region.
5 The Lower Guadiana region includes the fraction of the basin in Huelva.
6 Water footprint related to production by economic sectors.
7 Source: CHG (2008*b*)
8 Estimated with data from MIMAM (2007): 0.99 €/m3 for urban water supply and sanitation in the Guadiana river basin.
9 Source: MIMAM (2007)

Figure 4 Theoretical green and blue agricultural water consumption (Mm3/year) in the Upper, Middle, Lower Guadiana and TOP domain for a dry (2005), average (2001) and humid year (1997)

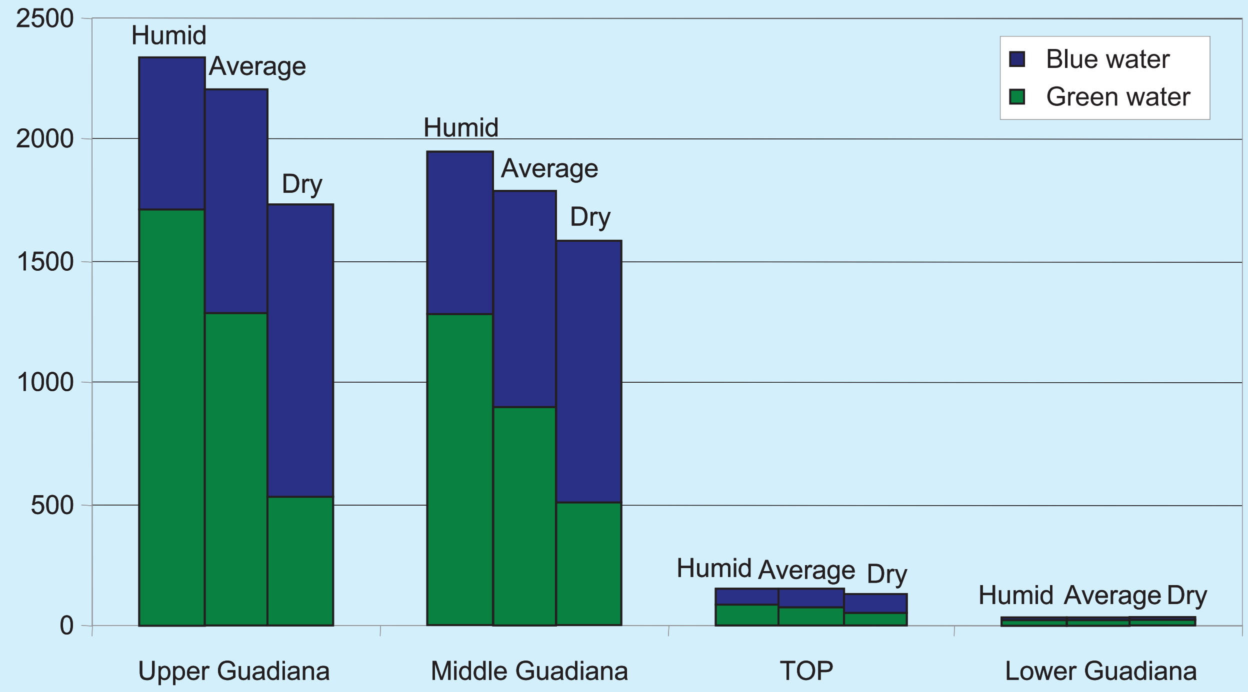
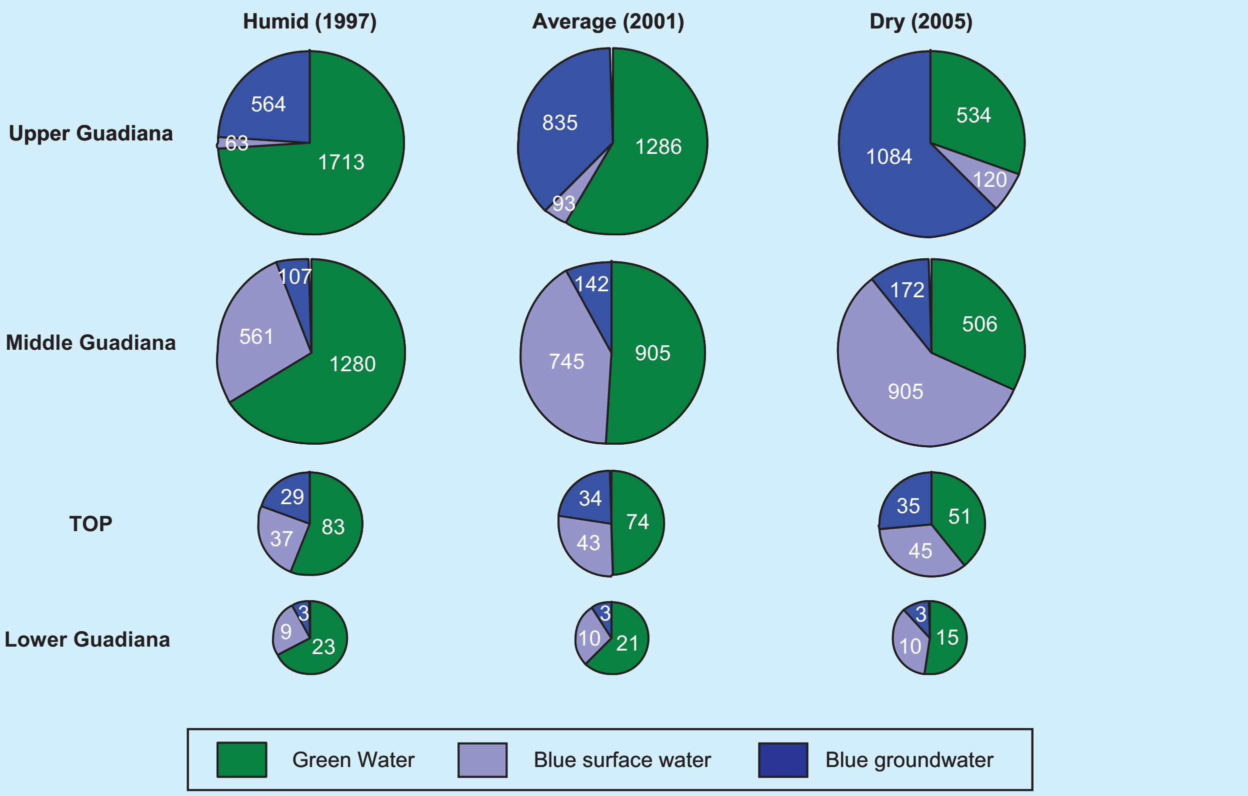


Figure 5 Theoretical green and blue (surface and ground) agricultural water consumption (Mm3/year) in the Upper, Middle, and Lower Guadiana and TOP domain in a dry (2005), an average (2001) and a humid year (1997). The size of the circle is proportional to the volume of water



C. Virtual water content in irrigated lands (m^3/tonne)

The virtual water analysis establishes the amount of water required by specific crops and it differs considerably among crop and climate types. For instance, Spain has a comparative advantage over most of the other European countries in the production of Mediterranean crops (such as certain vegetables, citrus fruits, vineyards and olive oil). It is also important to determine whether the water used proceeds from blue water or green water, and whether the blue water is surface or ground water.

Figure 6 provides an overview of the virtual water content of irrigated crops (m^3/ton) in the different sections of the Guadiana basin in the different rainfall years. As shown in this figure, it is noteworthy that, among the studied crops, industrial crops (such as sunflowers), grain legumes, grain cereals (1,000–1,300 m^3/tonne) and olive trees (about 1,000–1,500 m^3/tonne) show the highest virtual water contents in irrigated agriculture. In humid years, however, olive trees are mainly based on green water resources. As previously mentioned, olive trees (and vineyards) were, traditionally, rain-fed crops. However, in recent years the irrigated area seems to be significantly increasing for both crops.

It is widely believed that maize and vegetables are water-wasteful since in terms of m^3/ha, these crops consume large amounts of water. Nevertheless, when looking at the virtual water content in m^3/kg, these crops consume less water than is generally believed. In fact, among the studied crops, vegetables (100–200 m^3/tonne) show the smallest virtual water content figures, probably due to the high yields they have.

Finally, vineyards have intermediate virtual water contents, of about 300–600 m^3/tonne.

Despite the semi-arid nature of the Guadiana basin, in the Upper and Middle Guadiana basin, irrigated grain cereal production was widespread in the year 2001. Aside from cereals, vineyards and olive trees were the most widespread crop in the basin that year. Two reasons may explain this trend. First, vineyards are significantly water-efficient (in fact, vineyards are traditionally considered dryland crops) and second, irrigated vineyards provide quite high economic revenue per hectare.

In the Lower Guadiana basin and TOP domain, on the other hand, irrigated citrus trees and vegetables account for the largest part of the irrigated area and represent the highest total economic values in this region. What occurs in these two small areas of our study reflects the general situation in other coastal areas of Andalusia (Hernández-Mora et al. 2001; Vives, 2003).

The economic value of agricultural commodities is an important aspect since it can determine the type of crops that farmers grow along with the virtual water volumes. This can have an impact on the total amount of water used in a region. For example, many farmers have moved from low economic value (and water-intensive) crops to higher economic value (and water-extensive) crops. Alfalfa has been replaced by vines or olive trees (Llamas, 2005). According to Llamas (2005) the motto 'more crops and jobs per drop' should be replaced by 'more cash and nature per drop'. Nevertheless, there is still a long way to go to achieve this motto in the Upper and Middle Guadiana basins. In the Lower Guadiana and TOP domain, it has been partly achieved.

D. Agricultural economic productivity (€/ha)

As is widely known, the economic productivity of irrigated agriculture is higher than that of rainfed agriculture (Berbel, 2007; Hernández-Mora et al., 2001; MIMAM, 2007). In the case of the Guadiana basin this is true for any type of year (average, humid and dry) (Figure 7). From a socio-economic perspective, irrigated agriculture not only provides a higher income, but also a safer income. This is due both to the higher diversification it allows, and to the reduction of climate risks derived from rainfall variability (Comprehensive Assessment of Water Management in Agriculture, 2007).

Concerning the agricultural economic productivity per crop of irrigated agriculture, vegetables have the highest revenues per hectare (5,000–50,000 € ha), followed by vineyards (about 4,000–6,000 € ha), citrus in the Andalusian section (3,000–5,000 € ha), potatoes (2,000–6,000 €/ha), and olive trees (about 1,000–3,000 €/ha). Finally grain cereals, grain legumes and industrial crops have productivities of less than 1,000 €/ha.

E. Economic blue water productivity (€/m^3)

The agricultural total water economic productivity has been calculated in two different ways: using GVA (CHG, 2008*b*) (Table 1) and using crop economic value (MAPA, 2002) (Figure 8). In both cases the highest value per cubic meter is obtained in the Andalusian part (including the Lower Guadiana and TOP domain), due to the high economic value of the vegetables, which are widespread in the region.

According to Llamas and Martínez-Santos (2005), high value crops are most probably watered with groundwater resources or with a combination of groundwater and surface water. For instance, Hernández-Mora et al. (2001) show that, in Andalusia (in a study considering almost one million irrigated hectares), agriculture using groundwater is economically over five times more productive (and generates almost three times the employment) than agriculture that uses 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

Figure 6 **Irrigated agriculture green and blue virtual content per crop and year in the different Guadiana sections: UG: Upper Guadiana, MG: Middle Guadiana, LG: Lower Guadiana and TOP domain in different rainfall years (m3/tonne)**

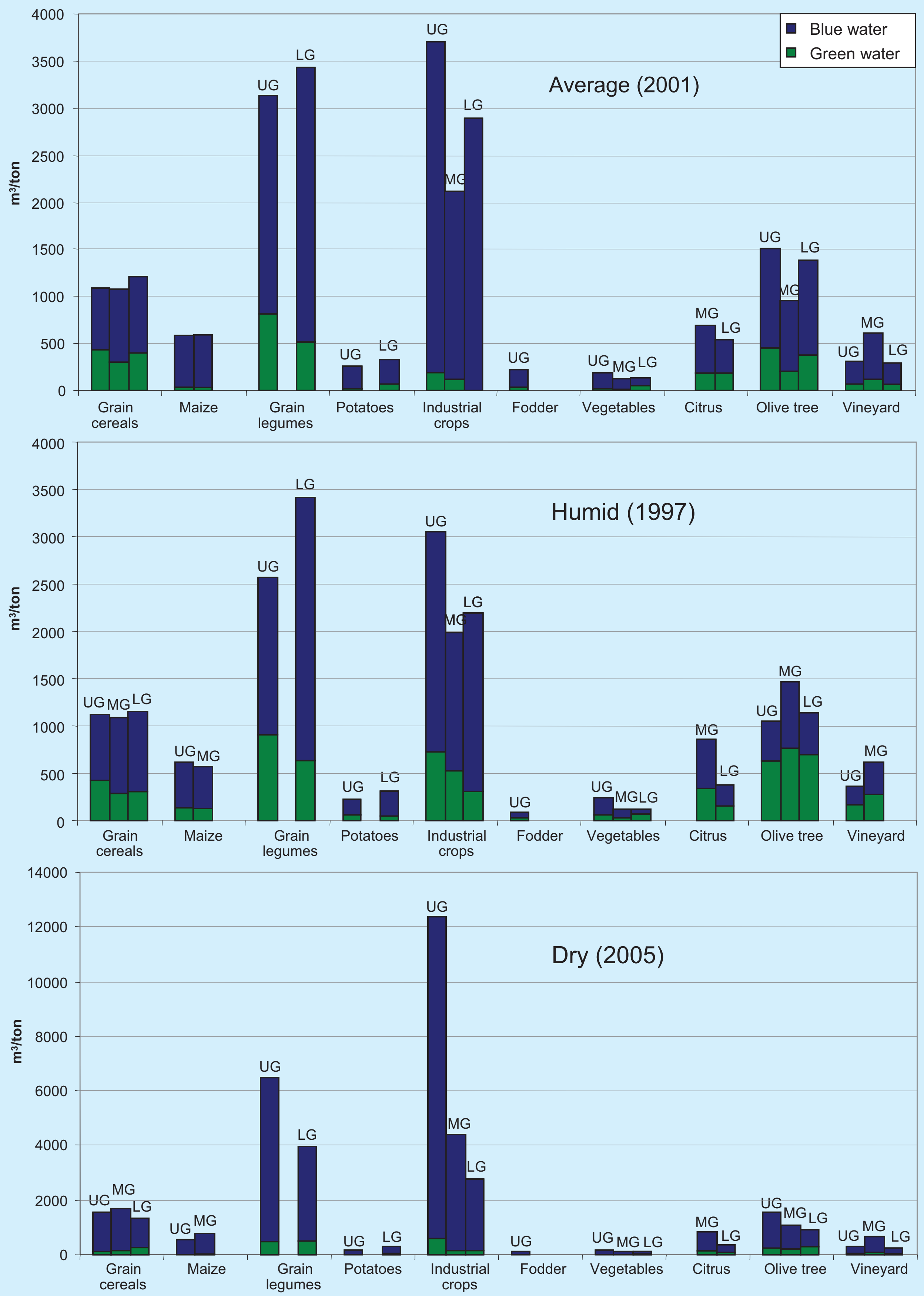


Figure 7 **Economic productivity of irrigated and rainfed agriculture per hectare by crop type in the different Guadiana sections in different rainfall years (€/ha)**

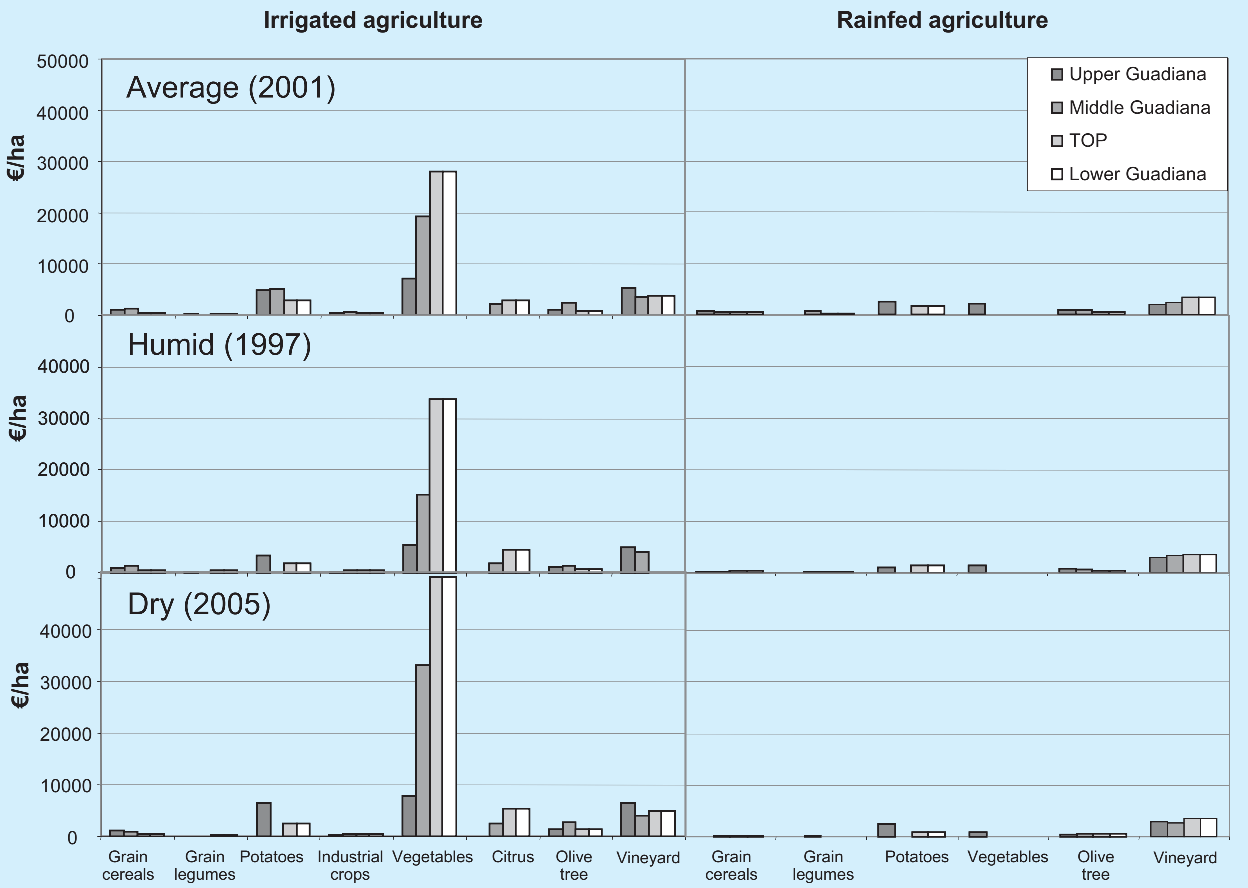


Figure 8 **Total blue water economic productivity (€/m3) concerning agricultural water consumption by year in the Upper, Middle and Lower Guadiana and TOP domain**

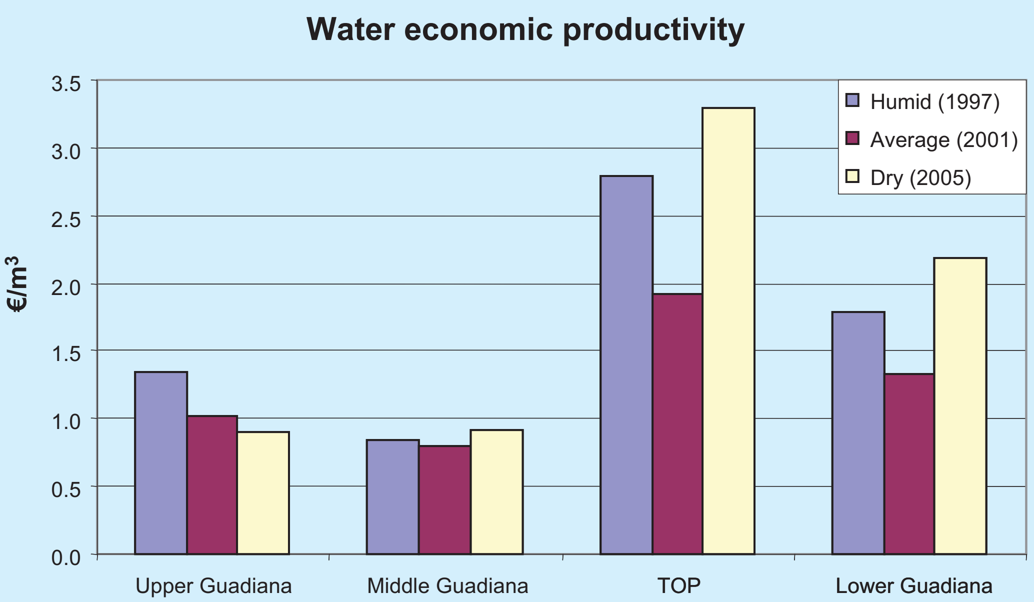
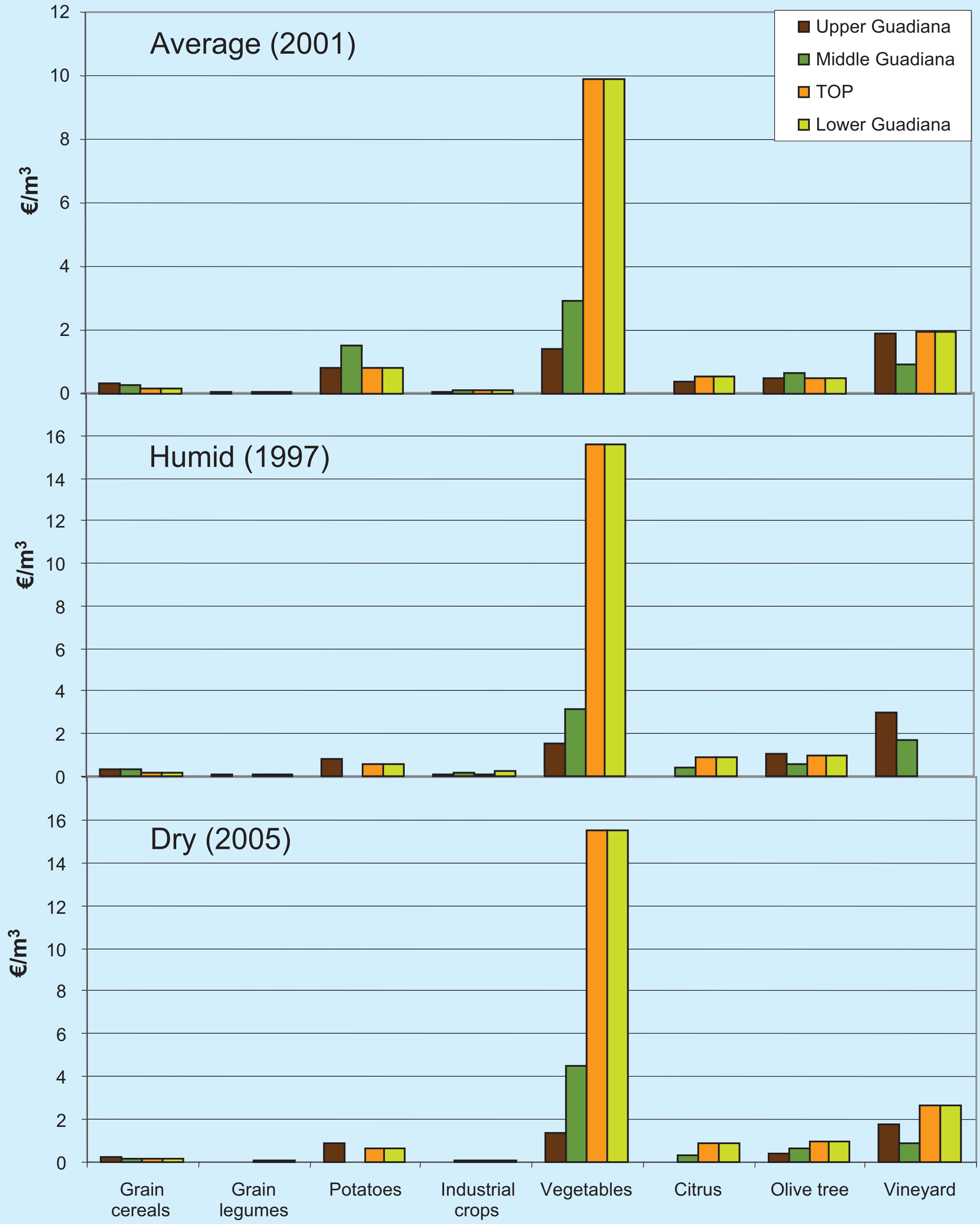


Figure 9 **Blue water economic productivity (€/m3) concerning agricultural water consumption by crop and year in the Upper, Middle and Lower Guadiana and TOP domain**



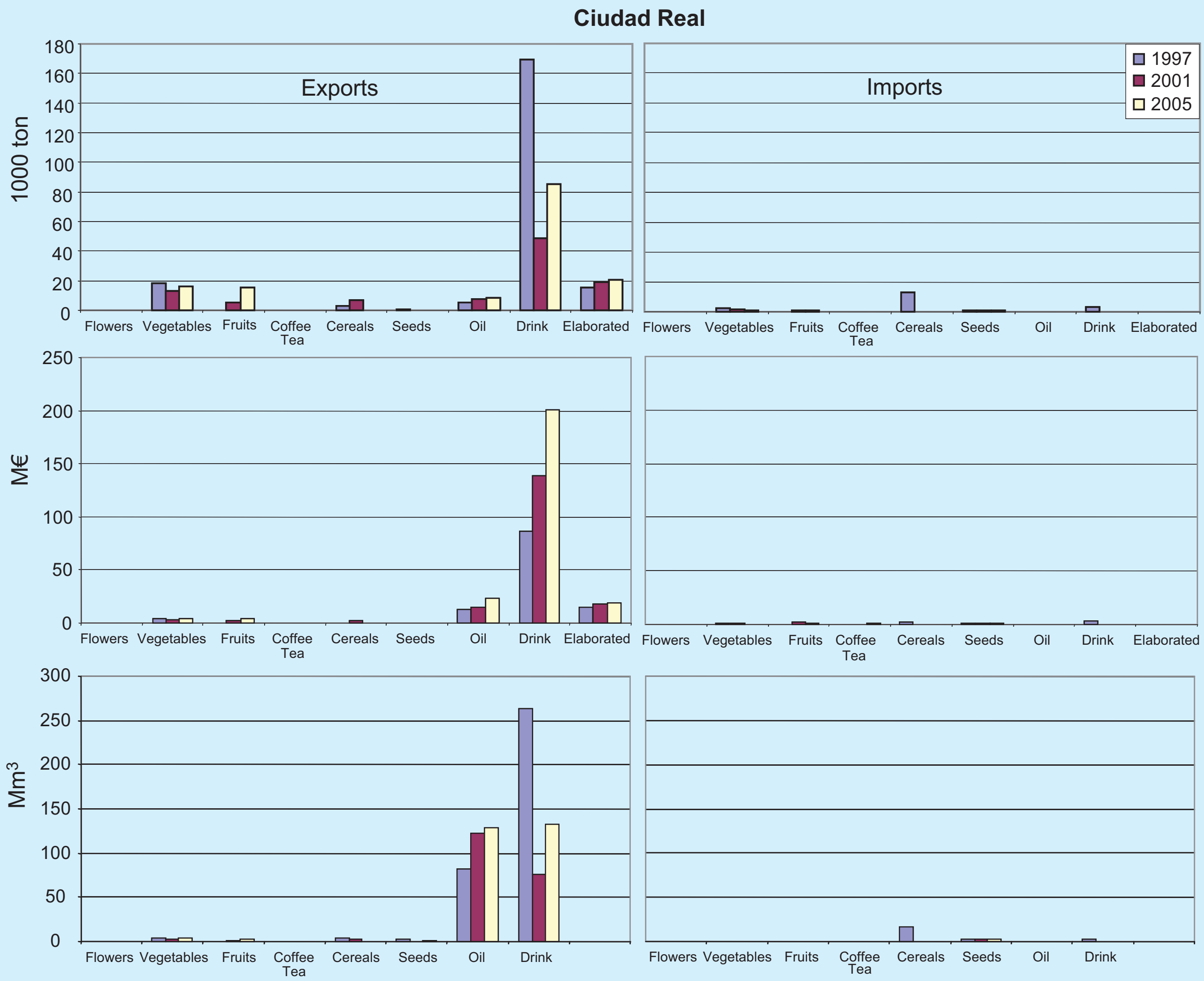
the full costs of drilling, pumping and distribution; and the fact that the higher financial costs farmers bear motivates them to look for more profitable crops that will allow them to maximize their return on investments (Hernández-Mora et al., 2001). Surface and groundwater distinction, therefore, should be taken into account in order to achieve an efficient allocation of water resources. Furthermore, in line with previous studies in arid and semi-arid regions (Garrido et al., 2006; Hernández Mora et al. 2001; Vives 2003), the social (jobs/m^3) and economic (€/m^3) value of groundwater irrigation generally exceeds that of surface water irrigation systems Agricultural water economic productivity was thus expected to be higher in groundwater-based areas.

Along these lines, the Lower Guadiana basin and TOP domain, with a joint surface and groundwater use, have the highest agricultural water economic productivities because they predominantly grow cash crops. The groundwater-based Upper Guadiana basin has intermediate values, whereas the surface-water-based Middle Guadiana shows the lowest water economic productivities. Nevertheless, Upper and Middle Guadiana present similar values in dry years. Probably, this small difference is due on the one hand, to the water irrigation security provided by the existing large surface water reservoirs in the Middle Guadiana; and, on the other, because the use of groundwater in the Upper Guadiana basin has serious legal and political restrictions, at least in theory.

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

According to MIMAM (2007), average productivity of blue water used in irrigated agriculture in Spain is about 0.44 €/m^3. When looking at the productivity per crop type in the Guadiana basin (Figure 9), vegetables (including horticultural and greenhouse crops) present the highest economic value per water unit (amounting to 15 €/m^3 in the Andalusian part:

Figure 10 **Agricultural commodity export and import in thousand tonnes, million euros and million cubic metres from Ciudad Real during the years 1997 (humid), 2001 (average) and 2005 (dry)**



Source: Based on data from ICEX (2008) and Chapagain and Hoekstra (2004).

Lower Guadiana and TOP domain). These numbers are similar to the figures estimated by Vives (2003) for greenhouse cultivation using groundwater in Almeria, which amount to 12 €/m^3. With lower values vineyards (1–3 €/m^3), potatoes (0.5–1.5 €/m^3), olive tree (0.5–1 €/m^3) and citrus trees (0.3–0.9 € m^3) show intermediate values. Finally, with remarkably lower values, grain cereals, grain legumes and industrial crops display an average productivity of less than 0.3 €/m^3. These data clearly show that the problem in the Guadiana basin is not water scarcity but the use of water for low value crops. Once again, the policy in the near future has to be to more cash per drop.

F. Agricultural trade

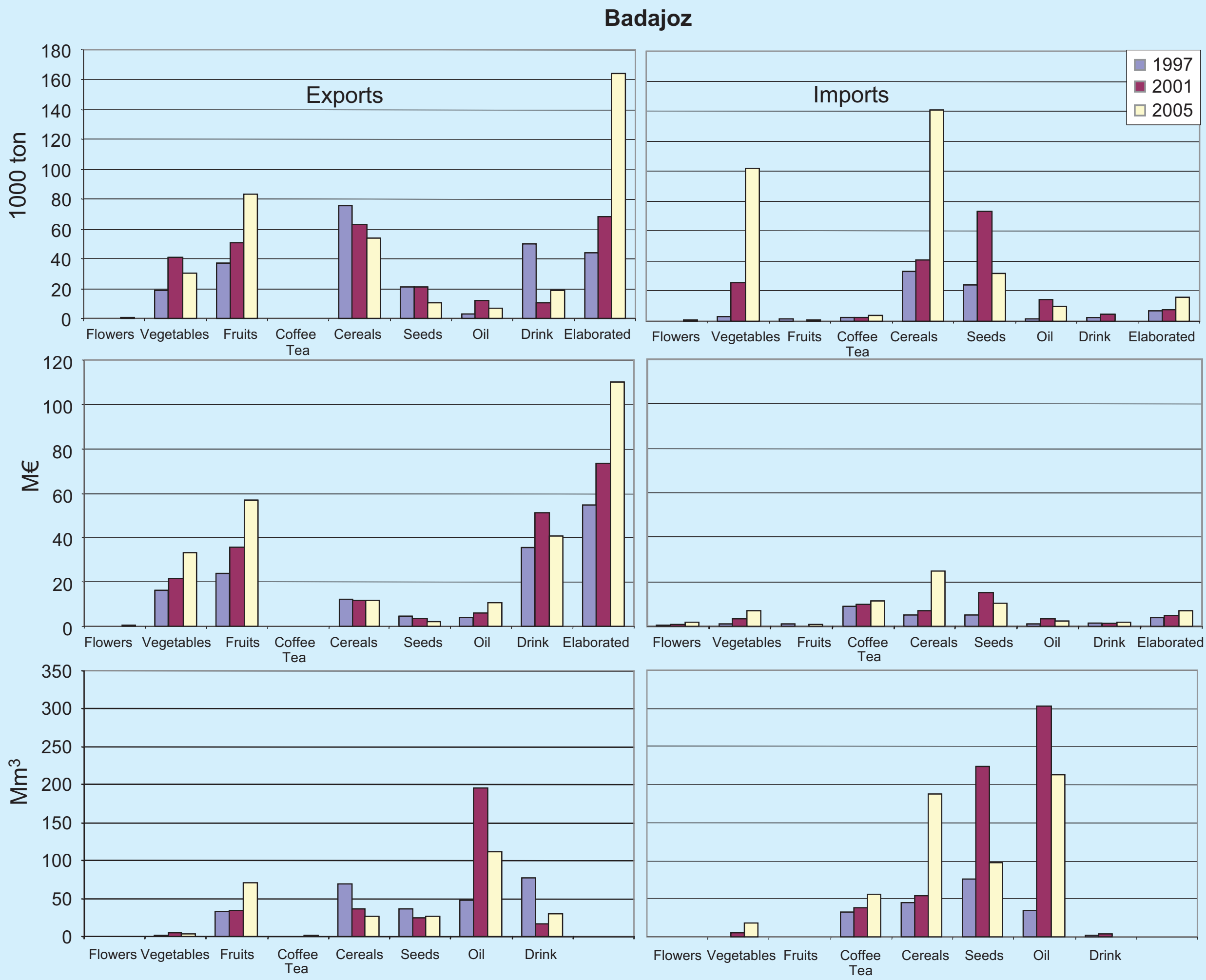
The international trade data provided in this section are given at a provincial level as more disaggregated data were not found (ICEX, 2008). The main provinces of each river basin section have been analysed: Ciudad Real for the Upper Guadiana, Badajoz for the Middle Guadiana and Huelva for the Lower Guadiana and TOP domain.

Concerning trade in tonnes, euros and virtual water, it is noteworthy that Ciudad Real is a net exporter, mainly of wine, and barely imports any commodity (Figure 10). During the period studied, this province has relied on its own food production without depending on global markets. This has probably been at the cost of using its scarce water resources.

The province of Badajoz is a net canned-tomato exporter, while importing other commodities such as cereals. The increase in cereal imports in drier years has to be highlighted (Figure 11).

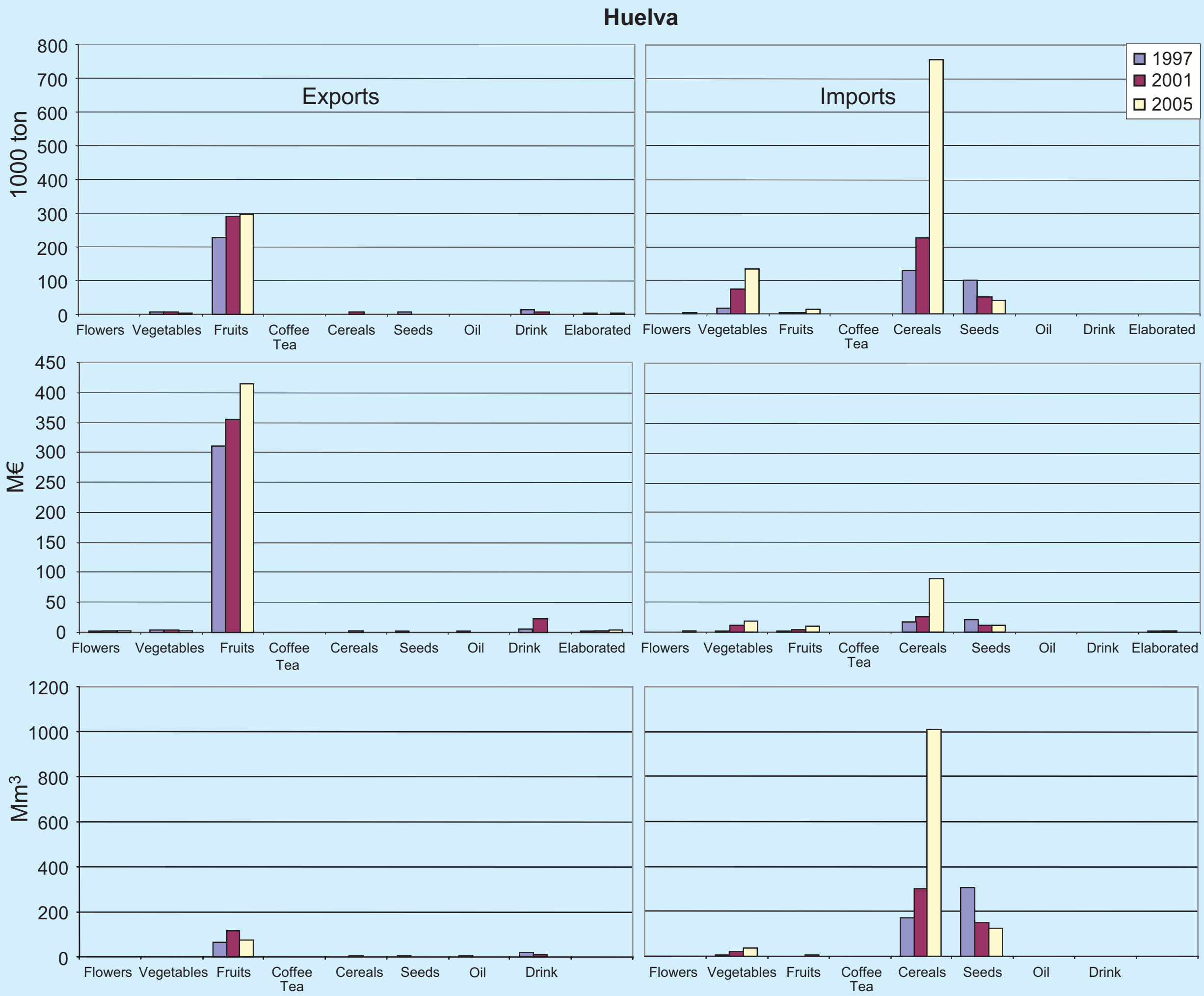
Huelva also imports virtual-water-intense commodities, such as cereals, whereas it exports low virtual water content fruits (Figure 12). The drier the year, the higher the cereal imports. In hydrologic terms, importing virtual water through cereals saves 1015 Mm^3 in Huelva, whereas growing vegetables for export uses just 100 Mm^3. Even if in terms of tonnes and water consumption, cereal imports remarkably surpass fruit exports, in economic

Figure 11 **Agricultural commodity export and import in thousand tonnes, million euros and million cubic metres from Badajoz during the years 1997 (humid), 2001 (average) and 2005 (dry)**



Source: Based on data from ICEX (2008) and Chapagain and Hoekstra (2004)

Figure 12 **Agricultural commodity export and import in thousand tonnes, million euros and million cubic metres from Huelva during the years 1997 (humid), 2001 (average) and 2005 (dry)**



Source: Based on data from ICEX (2008) and Chapagain and Hoekstra (2004)

terms fruit exports are much more important than cereal imports. These results are in line with those obtained by Chahed et al. (2007) when analysing the water footprint in Tunisia, even if they did not assess the economic aspects.

Virtual water imports, and in particular cereal imports, play a role in compensating for the water deficit and providing water and food security in the Middle Guadiana and Andalusian part (Lower Guadiana and TOP domain). For these regions, however, the underlying motivation of importing food (virtual water) is probably hardly a pursuit of comparative advantage, but to fill the domestic shortfall of food supply and to maintain social stability.

According to the World Water Council (2004), one can only speak of virtual water 'trade' if conscious choices are made in water and environmental management policies whether or not to make water available or to release pressure on the domestic water resources by importing goods that otherwise would have consumed much of the domestic water resources available. To make conscious choices, the elements of choice and the players involved in virtual water 'trade' have to be made visible. Allan (2001) states that virtual water 'trade' is so successful because it is invisible and is applied beyond the general political debate. However, invisibility may lead to the postponement of necessary reforms by politicians as imports can be regarded as 'secret reserves' that might be used to bail out in the short term (Warner, 2003).

Finally, the concept of virtual water 'trade' could be very relevant for this region. Local planning and regional collaboration incorporating the notion of virtual water 'trade' could result in the exchange of goods, diversification of crops, diet awareness creation or crop replacement actions.

Table 2 **Green water crop consumptive use values (m^3/ha) by different sources**

Upper Guadiana	Present study (Aldaya and Llamas, 2008)[1]			Rodríguez (2008)[2]	ITAP (2008)[3]	Chapagain and Orr (2008)[4]
Year	Humid 1997	Average 2001	Dry 2005	2001	2001 (2003)[5]	Historical time series
Location	Ciudad Real			Castilla-La Mancha	Albacete	Ciudad Real
Water consumption	CWU_g[6]			CWU_g[6]	CWU_g[6]	CWU_g[6]
Vineyard	(1452)[7]	(854)[7]	(556)[7]	352	237	
Olive tree	(1820)[7]	(1057)[7]	(664)[7]	665	231	
Oat	1237	1540	318	700		
Wheat	1245	1481	341	867	318	
Barley	1237	1540	318	799	319	
Maize	1254	392	319	594	267	
Tomato	(1156)[7]	(298)[7]	(319)[7]			880

1 Calculations based on FAO Penman-Monteith equation using CROPWAT model (FAO, 2003) and a time step of 5 days.
2 Calculations based on FAO Penman-Monteith equation and a time step of 30 days.
3 Calculations based on FAO Penman-Monteith equation, effective irrigation estimated as 70% of total rainfall.
4 Calculations based on FAO Penman-Monteith equation using CROPWAT model (FAO, 2003) and a time step of 5 days.
5 2001data for wheat, barley and maize, while 2003 data for vineyard and olive tree.
6 Green consumptive water use (m3/ha)
7 Estimated applying a location coefficient for localized irrigation (ET0 * Kc * Kl) following SIAR (2008).

5.2. Review of crop water consumption estimates by various experts

The present study should be taken as a very interesting but rough approximation of reality. Tables 2 and 3, show the green water and blue water requirements of the analysed crops according to various sources.

When comparing the green water consumption data with other sources, there is a remarkable disparity derived from the methodology in use (Table 2). The present green crop water use numbers, based on the FAO Penman-Monteith equation and CROPWAT model, are higher than figures given by the ITAP (2008), based on the FAO Penman-Monteith equation and an estimation of effective irrigation as 70% of total rainfall. Furthermore, small changes in planting and harvest dates entail big changes in crop water-use figures (m^3/ha). This could explain these differences.

With regard to the different rainfall years, as expected, there are notable differences depending on the type of year, being lower in dry years (Table 2).

When looking at the theoretical blue water consumption values, the present research results do not seem to differ significantly from other sources (Table 3). As shown in Table 2, wheat and other cereals as a whole consume great amounts of blue water whereas their economic value in the markets is very low. The blue water requirements of olive trees and vineyards vary depending on the source but they are generally somewhat lower than those of the cereals.

In our opinion, even if these data are a first approximation, they clearly show that the water policy in the Guadiana Basin can and should apply progressively the motto ‘more cash and nature per drop’.

6. Conclusions

1. The present virtual water and water footprint analysis of the Guadiana river basin, both hydrological and economic, provides very interesting results. This analysis however is a first approximation. The calculated theoretical crop water requirements differ somewhat from the calculations of other authors. There is an outstanding dispersion of data amounting to 100% in certain cases that may result from the different methodologies used. On the whole, calculations for our crop water requirements are based on the FAO Penman-Monteith equation and the CROPWAT model, whereas figures given by the CHG (2008*b*) and SIAR (2008) are based on the Thornthwaite model and the FAO Penman-Monteith equation respectively. In other cases, the uncertainties on some basic data are related to political issues. One example of this is the lack of acceptable accuracy on the inventory of water users and rights, and on the irrigated area by legal and illegal water wells.

2. As in most arid and semi-arid regions, in the Guadiana river basin the main green water and blue water consuming sector is agriculture, accounting for about 95% of total water consumption in the basin as a whole. Concerning the blue water economic productivity, however, urban water supply and industry values are higher than the corresponding value in agriculture. The multifunctional value of agriculture, however, has to be taken into account. Rainfed agriculture has a high relevance in the Guadiana basin in terms of total hectares. Agricultural economic productivity (tonne/ha) and total production (tonne/year) of rainfed agriculture, however, are notably lower than that of irrigated agriculture. Thus, even if it is less extensive, irrigated agriculture produces more tonnes and euros than

Table 3 Blue water crop consumptive use values (m3/ha) by different sources

Upper Guadiana	Present study (Aldaya and Llamas, 2008)[1]			Rodríguez (2008)[2]	CHG (2008*b*)[3]	CHG (2008*b*)[4]	CHG (2005)[5]	Tarjuelo (2000)[6]	PEAG (CHG, 2008c)[7]	ITAP (2008)[8]	SIAR (2008)[9]	Chapagain and Orr (2008)[10]	Hoekstra and Chapagain (2004)[11]
Year	Humid 1997	Average 2001	Dry 2005	2001	2001	2001	2001-2004	1974-1998	Not specified	2001 (2003)[12]	2001 (2007)[13]	Not specified	1997-2001
Location	Ciudad Real			Castilla-La Mancha	La Mancha	Ciudad Real	Western Mancha	Ciudad Real	Western Mancha	Albacete	La Mancha	Ciudad Real	Spain
Water consumption	CWUb[14]			CWUb[14]	CWUb[14]	CWUb[14]	CWUb[14]	CWUb[14]	CWUb[14]	CWUb[14]	CWUb[14]	CWUb[14]	CWU[15]
Vineyard	(1670)[16]	(2890)[16]	(3619)[16]	3977	2690	3678	1516	2000-2500	3678	2388	1693		6622
Olive tree	(1186)[16]	(2502)[16]	(3271)[16]	3991	1930		2153			2186			7350
Oat	2079	2200	3743	3801	(2350)[17]	2306			2306				2830
Wheat	2058	2277	3759	2533		2583	3342	2842	2583	3902	2403		3070
Barley	2079	2200	3743	3976		2999	2690	2759	2999	2630	1880		2831
Maize	4445	6534	7460	7347		7014	8117	5174	7014	7262	7604		6116
Tomato	(3845)[16]	(5779)[16]	(6510)[16]		(3510)[18]						5705	3730	3165

1 Calculations based on FAO Penman-Monteith equation using CROPWAT model (FAO, 2003) and a time step of 5 days.
2 Calculations based on FAO Penman-Monteith equation and a time step of 30 days.
3 Calculations based on Thornthwaite method.
4 Calculations based on FAO Penman-Monteith equation. Do not consider deficit irrigation strategies. These data may vary with respect to other CHG data calculated according to Thornwaite method.
5 Calculations following SIAR.
6 Calculations based on FAO Penman-Monteith equation, and 25 year climate series. For the vineyard deficit irrigation recommendations are followed (riego deficitario controlado, RDC).
7 Source: Tragsatec and MIMAM. Do not consider deficit irrigation strategies.
8 Calculations based on FAO Penman-Monteith equation, effective irrigation estimated as 70% of total rainfall.
9 Calculations based on FAO Penman-Monteith equation using deficit irritation for trees.
10 Calculations based on FAO Penman-Monteith equation using CROPWAT model (FAO, 2003) and a time step of 5 days.
11 Calculations based on FAO Penman-Monteith equation using CROPWAT model (FAO, 2003).
12 2001data for wheat, barley and maize, while 2003 data for vineyard and olive tree.
13 2001 data for every crop except for tomato (industry) in 2007.
14 Blue consumptive water use (m3/ha)
15 Total consumptive water use (including green and blue) (m3/ha)
16 Estimated applying a location coefficient for localized irrigation (ET0 * Kc * Kl) following SIAR (2008).
17 Value for grain cereals
18 Value for vegetables

rainfed agriculture. This economic and social fact explains the political relevance of groundwater irrigation in the Upper Guadiana basin.

3. As a whole, high-virtual-water low-economic-value crops are widespread in the analysed Upper and Middle Guadiana regions. For instance, cereals exhibit virtual water values of 1,000–1,300 m^3/tonne or even higher in dry years. On the other hand, maize and vegetables (mainly tomatoes and melons) present the smallest values with around 600 and 100–200 m^3/tonne respectively, due to their high yields.

4. One of the most important contributions of the present report is the analysis of the economic productivity of blue water use for the different crops. In the Upper and Middle Guadiana basin, it seems to range between 0.1–0.2 €/m^3 for low-cost cereals and 1.5–4.5 €/m^3 for vegetables. These values are relatively small in comparison with the ones obtained in the Andalusian region (Lower Guadiana and TOP domain). In this region, for vegetables (including horticultural and crops under plastic) using both surface water and groundwater resources, this value can amount to 15 €/m^3. Even with lower figures, vineyards (1–3 €/m^3) and olive trees (0.5–1 €/m^3) seem to be profitable crops. As a matter of fact, it is widely known that farmers are currently changing their production to vineyards and olive trees. It could be interesting to examine these trends in the near future.

5. Nevertheless, we should not over-simplify the issue by assuming that all the water that is not used for vegetables or trees is wasted water. Factors such as risk diversification, labour or other environmental, social, economic and agronomic reasons have to be taken into account in order to find a balance. The major environmental challenge of agriculture is the preservation of the environment without damaging the agricultural sector economy. The quantity of crops and the employment generated in the whole Guadiana basin is producing 'more crops and jobs per drop'. The aim now is to achieve the paradigm 'more cash and nature per drop'. The present results, indicating the low water consumption and high economic value of vegetables, followed by vineyards, is one of the factors that has to be taken into account in order to achieve an efficient allocation of water and economic resources.

6. Finally, the report provides a first estimation of trade in agricultural products by considering international imports and exports at a provincial level. The different sections of the Guadiana basin have different trade strategies. On the one hand, the Upper Guadiana basin is a net exporter, mainly of wine, barely importing any food commodity. On the other hand, the Lower Guadiana and TOP domain import low-value, high water-consuming cereals, while exporting high-value, low virtual-water content crops such as fruits. This reduces the demand on local (green and blue) water resources that can be used to provide ecological services and other more profitable uses.

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Symbols

Symbol	Unit	Description
$CWR_{[c]}$	m^3/year	Crop water requirement of crop c
$CWC_{[c]}$	m^3/ha/year	Crop water consumption to produce a particular crop c, also called evapotranspirative demand
ET_0	mm/day	Reference evapotranspiration
ETc	mm/day	Crop evapotranspiration of a crop c
GVA	million €	Gross Value Added
Kc		Crop coefficient
V	m^3/ton	Virtual Water Content
V_b	m^3/ton	Blue Virtual Water Content
V_g	m^3/ton	Green Virtual Water Content
WF	m^3/ton	Water Footprint
WF_b	m^3/ton	Blue Water Footprint
WF_g	m^3/ton	Green Water Footprint
WF_i	m^3/ton	Internal Water Footprint

Glossary

Blue water – surface and ground water (Hoekstra and Chapagain, 2008).

Blue virtual-water content (Vb) – of a product is the volume of surface water or groundwater that evaporated as a result of the production of the product. In the case of crop production, the blue water content of a crop is defined as the evaporation of irrigation water from the field. In the cases of industrial production and domestic water supply, the blue water content of the product or service is equal to the part of the water withdrawn from ground or surface water (m3/tonne) (Hoekstra and Chapagain, 2008).

Crop consumptive water use (CWU) – is defined as the accumulation of daily evapotranspiration over the complete growing period. It has two components: Green crop water and blue crop consumptive water use (m3/ha) (Hoekstra and Chapagain, 2008).

Crop water requirements (CWR) – is defined as the total water needed for evapotranspiration, from planting to harvest for a given crop in a specific climate regime, when adequate soil water is maintained by rainfall and/or irrigation so that it does not limit plant growth and crop yield (mm/time period) (Allen et al., 1998).

Crop water supply – is the quantity of irrigation water, in addition to rainfall, applied to meet a crop's evapotranspiration need and normal crop production. It includes soil evaporation and some unavoidable losses under the given conditions. It is expressed in cubic meters for a crop period (m3/year).

Effective rainfall (Peff) – in irrigation practice, that portion of the total precipitation that's retained by the soil so that it's available for crop production (mm/time period) (FAO, 2008).

External water footprint (WFe) – is defined as the annual volume of water resources used in other countries or regions to produce goods and services consumed by the inhabitants of the country or region concerned (km3/year, m3/capita/year) (Hoekstra and Chapagain, 2008).

Green virtual-water content (Vg) – of a product is the volume of rainwater that evaporated during the production process. This is mainly relevant for agricultural products, where it refers to the total rainwater evaporation from the field during the growing period of the crop (including both transpiration by the plants and other forms of evaporation) (m3/tonne) (Hoekstra and Chapagain, 2008).

Green water – rainwater stored in the soil as soil moisture, also called soil water (Hoekstra and Chapagain, 2008).

Gross value added (GVA) – is the value of goods and services produced in an economy at different stages of the productive process (million €). The gross value added is equal to net output or benefit that can be used for the remuneration of productive factors.

Internal water footprint (WFi) – is defined as the use of domestic water resources to produce goods and services consumed by inhabitants of a country or region (km3/year, m3/capita/year) (Hoekstra and Chapagain, 2008).

Total 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 €).

Virtual-water content (V) – the virtual-water content of a product (a commodity, good or service) is the volume of fresh water used to produce the product, measured at the place where the product was actually produced (production-site definition) (m3/tonne) (Hoekstra and Chapagain, 2008).

Water footprint (WF) – the water footprint 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. A water footprint can be calculated for any well-defined group of consumers, including a family, business, village, city, province, state or nation. A water footprint is generally expressed in terms of the volume of water use per year (km3/year, m3/capita/year) (Hoekstra and Chapagain, 2008).

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Appendices

Appendix I Crop Area, Production and Yield (2001)

A) UPPER GUADIANA[1]	Area (ha)[2]			Production (ton/year)[3]			Yield (kg/ha)[4]	
Crops	Rainfed	Irrigated	Total	Rainfed	Irrigated	Total	Rainfed	Irrigated
Grain cereals[5]:	478.572	97.634	576.206	1.959.752	740.309	2.700.061	4095	7583
Cereal – Wheat, barley, oat							1045	3460
Cereal – Maize							7145	11705
Grain legumes – Veza, yeros	68.974	10.567	79.541	17.864	11.835	29.699	259	1120
Potatoes	411	733	1.143	4.986	17.855	22.842	12140	24369
Industrial crops – Sunflower	73.038	10.450	83.488	24.541	16.752	41.293	336	1603
Fodder – Veza, alfalfa	30.312	7.701	38.013	182.784	173.269	356.052	6030	22500
Vegetables – melon	488	13.337	13.826	3.959	369.447	373.406	8110	27700
Flowers and ornamental plants	133	100	234					
Seeds and small plants	0	21	21					
Other grass crops	59	1.895	1.954					
Fallow land	343.142	0	343.142					
Vegetable gardens	0	39	39					
Citrus	0	10	10				-	-
Temperate climate fruit trees	84	210	295					
Subtropical climate fruit trees	0	0	0					
Dry fruit trees	5.503	293	5.796					
Olive tree – for olive oil	134.687	13.213	147.900	234.086	31.116	265.202	1738	2355
Vineyard – for wine production	199.277	131.866	331.143	799.100	1.588.985	2.388.085	4010	12050
Nursery	0	25	25					
Other permanent crops	185	6	191					
Greenhouse tree crops	0	2	2					
Mushrooms		15	15					
Greenhouses		86	86					
Total	1.334.865	288.205	1.623.070	3.227.072	2.949.568	6.176.640	4590	12410
	Surface[6]	26.390						
	groundwater[7]	237.857						

1 The Upper Guadiana includes a fraction of Castilla-La Mancha Autonomous region.
2 Source: CHG (2008*b*)
3 Calculated multiplying area (CHG, 2008*b*) and yield (MAPA, 2002)
4 Source: MAPA (2007)
5 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.
6 Irrigated area with surface water
7 Irrigated area with groundwater

B) MIDDLE GUADIANA[1]	Area (ha)[2]			Production (ton/year)[3]			Yield (kg/ha)[4]	
Crops	Rainfed	Irrigated	Total	Rainfed	Irrigated	Total	Rainfed	Irrigated
Grain cereals[5]:	281.182	96.161	377.343	750.101	742.533	1.492.634	2668	7722
Cereal – Wheat, barley, oat							2668	3734
Cereal – Maize							-	12000
Cereal – Rice							-	7431
Grain legumes – Chick peas	19.535	1.532	21.067	14.651		14.651	750	-
Potatoes	6	430	436	-	10.758	10.758	-	25000
Industrial crops – Sunflower	16.372	15.541	31.913	14.964	44.510	59.474	914	2864
Fodder – Clover, veza	46.957	2.558	49.514	469.565	0	469.565	10000	-
Vegetables – Tomato	504	21.597	22.101	0	1.232.619	1.232.619	-	57073
Flowers and ornamental plants	6	62	68					
Seeds and small plants	0	77	77					
Other grass crops	2	1.859	1.861					
Fallow land	143.481	0	143.481					
Vegetable gardens	0	88	88					
Citrus	0	41	41	0	489	489	-	12000
Temperate climate fruit trees	5.060	7.807	12.867					
Subtropical climate fruit trees	0	3	3					
Dry fruit trees	1.716	1.005	2.721					
Olive tree for olive oil and table	190.661	47.778	238.439	328.700	238.891	567.591	1724	5000
Vineyard for wine production	59.116	11.704	70.819	299.362	93.630	392.992	5064	8000
Nursery	0	69	69					
Other permanent crops	67	0	67					
Greenhouse tree crops	0	4	4					
Mushrooms		0	0					
Greenhouses		77	77					
Total	764.664	208.393	973.057	1.877.343	2.363.430	4.240.774	2950	14082
	Surface[6]	121.291						
	groundwater[7]	23.061						

1 The Middle Guadiana includes a fraction of Extremadura (Badajoz and Cáceres).
2 Source: CHG (2008*b*)
3 Calculated multiplying area (CHG, 2008*b*) and yield (MAPA, 2002)
4 Source: MAPA (2007)
5 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.
6 Irrigated area with surface water
7 Irrigated area with groundwater

C) TOP[1]	Area (ha)[2]			Production (ton/year)[3]			Yield (kg/ha)[4]	
Crops	Rainfed	Irrigated	Total	Rainfed	Irrigated	Total	Rainfed	Irrigated
Grain cereals[5] – Wheat	23,771	1,221	24,992	58,002	4,188	62,190	2440	3430
Grain legumes – Lupin, veza	477	206	683	324	299	623	679	1450
Potatoes	41	121	162	353	1,667	2,020	8554	13807
Industrial crops – Sunflower	10,659	2,579	13,237	11,192	5,286	16,478	1050	2050
Fodder – Veza	809	234	1,043	12,948		12,948	16000	-
Vegetables – Strawberry	131	4,374	4,505	0	147,600	147,600	0	33741
Flowers and ornamental plants	0	66	66					
Seeds and small plants	0	1	1					
Other grass crops	0	0	0					
Fallow land	18,900	0	18,900					
Vegetable gardens	0	27	27					
Citrus	0	7,665	7,665		118,337	118,337	-	15,438
Temperate climate fruit trees	292	1,789	2,081					
Subtropical climate fruit trees	0	101	101					
Dry fruit trees	1,787	81	1,868					
Olive tree for olive oil and table	10,171	1,059	11,229	8,747	1,673	10,420	860	1,580
Vineyard for wine and grape	3,178	129	3,307	23,549	1,056	24,605	7,410	8,200
Nursery	0	6	6					
Other permanent crops	2	0	2					
Greenhouse tree crops	0	64	64					
Mushrooms		0	0					
Greenhouses		352	352					
Total	70,220	20,073	90,293	115,115	280,106	395,221	5285	9962
	Surface[6]	11,076						
	groundwater[7]	8,695						

1 In line with CHG (2008*b*), TOP region is the Tinto, Odiel and Piedras river basin complementary region.
2 Source: CHG (2008*b*)
3 Calculated multiplying area (CHG, 2008*b*) and yield (MAPA, 2002)
4 Source: MAPA (2007)
5 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.
6 Irrigated area with surface water
7 Irrigated area with groundwater

D) LOWER GUADIANA[1]	Area (ha)[2]			Production (ton/year)[3]			Yield (kg/ha)[4]	
Crops	Rainfed	Irrigated	Total	Rainfed	Irrigated	Total	Rainfed	Irrigated
Grain cereals[5] – Wheat	7,363	203	7,566	17,965	696	18,661	2,440	3,430
Grain legumes – Lupin, veza	121	11	132	82	16	98	679	1,450
Potatoes	17	5	22	147	64	210	8,554	13,807
Industrial crops – Sunflower	340	127	468	358	261	618	1,050	2,050
Fodder – Veza	779	234	1,012	12,457		12,457	16,000	-
Vegetables – Strawberry	23	380	403	0	12,817	12,817	-	33,741
Flowers and ornamental plants	0	7	7					
Seeds and small plants	0	0	0					
Other grass crops	0	0	1					
Fallow land	10,839	0	10,839					
Vegetable gardens	0	20	20					
Citrus	0	1,672	1,672		25,817	25,817	-	15,438
Temperate climate fruit trees	104	360	464					
Subtropical climate fruit trees	0	1	1					
Dry fruit trees	3,433	24	3,456					
Olive tree for olive oil and table	5,324	246	5,570	4,579	388	4,967	860	1,580
Vineyard for wine and grape	63	251	314	465	2,061	2,526	7,410	8,200
Nursery	0	0	0					
Other permanent crops	0	0	0					
Greenhouse tree crops	0	0	0					
Mushrooms		0	0					
Greenhouses		7	7					
Total	28,406	3,548	31,954	36,053	42,119	78,171	5,285	9,962
	Surface[6]	2,435						
	groundwater[7]	780						

1 The Lower Guadiana basin comprises the Guadiana basin part in Huelva.
2 Source: CHG (2008*b*)
3 Calculated multiplying area (CHG, 2008*b*) and yield (MAPA, 2002)
4 Source: MAPA (2007)
5 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.
6 Irrigated area with surface water
7 Irrigated area with groundwater

Appendix II **Crop water consumption (m3/ha), total water resource consumption (106 m3/year) and virtual water content (m3/ton) (2001).**

	Crop Water Consumption (m^3/ha)					Total use of water resources ($10^6 m^3$/year)					Virtual Water Content (V) (m^3/ton)				
A) UPPER GUADIANA[1]	**Rainfed**	**Irrigated**				**Rainfed**	**Irrigated**				**Rainfed**	**Irrigated**			
Crop	V_g[2]	V_g[2]	V_b[3]	V_b[4]	**Total**	V_g[2]*A[5]	V_g[2]*A[5]	V_b[3]*A[5]	V_b[4]*A[5]	**Total*A[5]**	V_g[2]	V_g[2]	V_b[3]	V_b[4]	**Total**
Grain cereals[6]:	1238	1238	3303	2599	4541	593	121	322	254	443	302	163	436	343	599
Cereal - Wheat, barley, oat	1520	1520	2225		3746						1455	439	643		1083
Cereal - Maize	392	392	6534		6926						55	34	558		592
Grain legumes Veza, yeros	911	911	2598	2254	3510	63	10	27	24	37	3519	814	2320	2012	3133
Potatoes	370	370	6035	2864	6404			4	2	5	30	15	248	118	263
Industrial crops – Sunflower	311	311	5625	3168	5936	23	3	59	0	62	924	194	3509	0	3703
Fodder – Veza, alfalfa	816	816	4177	4079	4993	25	6	32	31	38	135	36	186	181	222
Vegetables – Melon	290	290	5136	3741	5426	0	4	69	50	72	36	10	185	135	196
Flowers, ornamental plants				4052					0						
Seeds and small plants				3400					0						
Other grass crops				3880					7						
Fallow land									0						
Vegetable gardens				3906					0						
Citrus				3900					0						
Temperate climate fruit trees				3980					1						
Subtropical climate fruit trees															
Dry fruit trees				4915					1						
Olive tree for olive oil	1057	1057	2502	1893	3560	142	14	33	25	47	608	449	1063	804	1512
Vineyard for wine production	854	854	2890	2692	3744	170	113	381	355	494	213	71	240	223	311
Nursery				3400											
Other permanent crops				4047											
Greenhouse tree crops				3400											
Mushrooms				18000											
Greenhouses6				4200											
Total	731	731	4033	2932	4764	1016	271	928	752	1199	728	223	939	477	1161

1 The Upper Guadiana includes a fraction of Castilla-La Mancha Autonomous region.
2 Vg: Green virtual water. Source: Own elaboration.
3 Vb: Blue virtual water. Source: Own elaboration.
4 Vb: Blue virtual water. Source: CHG (2008*b*)
5 A: Area in hectares
6 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.

B) MIDDLE GUADIANA[1]	Crop Water Consumption (m^3/ha)					Total use of water resources ($10^6 m^3$/year)					Virtual Water Content (V) (m^3/ton)				
	Rainfed	Irrigated				Rainfed	Irrigated				Rainfed	Irrigated			
Crop	$V_g{}^2$	$V_g{}^2$	$V_b{}^3$	$V_b{}^4$	Total	$V_g{}^2{*}A^5$	$V_g{}^2{*}A^5$	$V_b{}^3{*}A^5$	$V_b{}^4{*}A^5$	$Total{*}A^5$	$V_g{}^2$	$V_g{}^2$	$V_b{}^3$	$V_b{}^4$	Total
Grain cereals[6]:	1378	1052	4462	4.095	5514	387	101	429	394	530	516	136	578	530	714
Cereal – Wheat, barley, oat	1378	1378	2473		3851						516	369	662		1031
Cereal – Maize	-	366	6712		7078							30	559		590
Cereal – Rice	-	760	8178		8938							102	1100		1203
Grain legumes – Chick peas	325	-	-	3.050		6	0	0	5	0	433				
Potatoes	-	970	3437	2.821	4406	0	0	1	1	2					
Industrial crops – Sunflower	325	325	5741		6065	5	5	89	0	94	355	113	2004	0	2118
Fodder – Clover, veza	1665	1665	1745	5.346		78			14	0	167				
Vegetables – Tomato	317	317	6592	4.043	6909	0	7	142	87	149	-	6	115	71	121
Flowers, ornamental plants				4.050					0						
Seeds and small plants				3.400					0						
Other grass crops				4.430					8						
Fallow land															
Vegetable gardens				3.637					0						
Citrus	-	2244	6000	3.900	8244		0	0	0			187	500	325	687
Temperate climate fruit trees				3.718					29						
Subtropical climate fruit trees				4.000					0						
Dry fruit trees				5.500					6						
Olive tree	1048	1048	3733	1.975	4781	200	50	178	94	228	608	210	747	395	956
Vineyard	912	912	3901	2.683	4814	54	11	46	31	56	180	114	488	335	602
Nursery				3.400											
Other permanent crops															
Greenhouse tree crops				3.400											
Mushrooms															
Greenhouses				4.200											
Total	853	1067	4451	3758	5819	731	174	886	671	1061	397	141	750	276	891

1 The Middle Guadiana includes a fraction of Extremadura (Badajoz and Cáceres).
2 Vg: Green virtual water. Source: Own elaboration.
3 Vb: Blue virtual water. Source: Own elaboration.
4 Vb: Blue virtual water. Source: CHG (2008*b*)
5 A: Area in hectares
6 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.

	Crop Water Consumption (m^3/ha)					Total use of water resources ($10^6 m^3$/year)					Virtual Water Content (V) (m^3/ton)				
C) TOP[1]	**Rainfed**	**Irrigated**				**Rainfed**	**Irrigated**				**Rainfed**	**Irrigated**			
Crop	**V_g[2]**	**V_g[2]**	**V_b[3]**	**V_b[4]**	**Total**	**V_g[2]*A[5]**	**V_g[2]*A[5]**	**V_b[3]*A[5]**	**V_b[4]*A[5]**	**Total*A[5]**	**V_g[2]**	**V_g[2]**	**V_b[3]**	**V_b[4]**	**Total**
Grain cereals[6] – Wheat	1380	1380	2760	3677	4140	33	2	3	4	5	565	402	805	1072	1207
Grain legumes – Lupin, veza	752	752	4227	3050	4979	0	0	1	1	1	1108	519	2915	2103	3434
Potatoes	1015	1015	3560	1240	4575	0	0	0	0	1	119	74	258	90	331
Industrial crops – Sunflower	0	0	5936		5936	0	0	15	0	15	0	0	2896	0	2896
Fodder – Veza and others	1505	1505	3674	5023	5178	1			1		94				
Vegetables – Strawberry	1688	1688	2836	3840	4523	0	7	12	17	20	-	50	84	114	134
Flowers and ornamental plants				4050					0						
Seeds and small plants				3400					0						
Other grass crops				---											
Fallow land															
Vegetable gardens				3817					0						
Citrus	-	2828	5586	3952	8415		22	43	30	65		183	362	256	545
Temperate climate fruit trees				3765					7						
Subtropical climate fruit trees				4000					0						
Dry fruit trees				5900					0						
Olive tree for oil and table	589	589	1601	2282	2189	6	1	2	2	2	685	373	1013	1444	1386
Vineyard for wine and grape	564	564	1902	2888	2466	2	0	0	0	0	76	69	232	352	301
Nursery				3400					0						
Other permanent crops				---											
Greenhouse tree crops				3400					0						
Mushrooms				---											
Greenhouses[6]				4200					1						
Total	936	1147	3565	3635	4711	42	32	77	66	109	378	209	1071	679	1279

1 In line with CHG (2008*b*), TOP region is the Tinto, Odiel and Piedras river basin complementary region.
2 Vg: Green virtual water. Source: Own elaboration.
3 Vb: Blue virtual water. Source: Own elaboration.
4 Vb: Blue virtual water. Source: CHG (2008*b*)
5 A: Area in hectares
6 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.

	Crop Water Consumption (m^3/ha)					Total use of water resources ($10^6 m^3$/year)					Virtual Water Content (V) (m^3/ton)				
D) LOWER GUADIANA[1]	Rainfed	Irrigated				Rainfed	Irrigated				Rainfed	Irrigated			
Crop	V_g^2	V_g^2	V_b^3	V_b^4	Total	$V_g^2 * A^5$	$V_g^2 * A^5$	$V_b^3 * A^5$	$V_b^4 * A^5$	Total*A^5	V_g^2	V_g^2	V_b^3	V_b^4	Total
Grain cereals[6] – Wheat	1380	1380	2760	3677	4140	10	0	1	1	1	565	402	805	1072	1207
Grain legumes – Lupin, veza	752	752	4227	3050	4979	0	0	0	0	0	1108	519	2915	2103	3434
Potatoes	1015	1015	3560	1240	4575	0	0	0	0	0	119	74	258	90	331
Industrial crops – Sunflower	0	0	5936		5936	0	0	1	0	1	0	0	2896	0	2896
Fodder – Veza and others	1505	1505	3674	5023	5178	1			1		94				
Vegetables – Strawberry	1688	1688	2836	3840	4523	0			1	2	-	50	84	114	134
Flowers and ornamental plants				4050					0						
Seeds and small plants				3400					0						
Other grass crops				---											
Fallow land															
Vegetable gardens				3817					0						
Citrus	-	2828	5586	3952	8415	0	5	9	7	14		183	362	256	545
Temperate climate fruit trees				3765					1						
Subtropical climate fruit trees				4000					0						
Dry fruit trees				5900					0						
Olive tree for oil and table	589	589	1601	2282	2189	3	0	0	1	1	685	373	1013	1444	1386
Vineyard for wine and grape	564	564	1902	2888	2466	0	0	0	1	1	76	69	232	352	301
Nursery				3400					0						
Other permanent crops				---											
Greenhouse tree crops				3400					0						
Mushrooms				---											
Greenhouses[6]				4200					0						
Total	936	1147	3565	3635	4711	15	6	13	13	19	378	209	1071	679	1279

1 The Lower Guadiana basin comprises the Guadiana basin in Huelva.
2 Vg: Green virtual water. Source: Own elaboration.
3 Vb: Blue virtual water. Source: Own elaboration.
4 Vb: Blue virtual water. Source: CHG (2008*b*)
5 A: Area in hectares
6 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.

Appendix III **Economic value and economic water productivity (€/m³) (2001)**

	Economic value					Water economic productivity[5]	GVA[6]	Employment[7]
A) UPPER GUADIANA[1]	€/ha[2]	€/ha[2]	€/ton[3]	Total million €[4]		€/m³	million €	post number
Crop	**Rainfed**	**Irrigated**		**Rainfed**	**Irrigated**	**Irrigated**		
Grain cereals[8]:	549	1017	134	263	99	0,3		
Cereal - Wheat, barley, oat			133					
Cereal - Maize			136					
Grain legumes – Veza, yeros	46	197	176	3	2	0,1		
Potatoes	2508	5035	207	1	4	0,8		
Industrial crops – Sunflower		410	256		4	0,1		
Fodder – Veza, alfalfa			101					
Vegetables – Melon	2092	7144	258	1	95	1,4		
Flowers, ornamental plants								
Seeds and small plants								
Other grass crops								
Fallow land								
Vegetable gardens								
Citrus			192					
Temperate climate fruit trees								
Subtropical climate fruit trees								
Dry fruit trees								
Olive tree for olive oil	865	1172	498	116	15	0,5		
Vineyard for wine production	1823	5479	455	363	722	1,9		
Nursery								
Other permanent crops								
Greenhouse tree crops								
Mushrooms								
Greenhouses								
Total	560	3271		748	943	1,0	599	26818

1 The Upper Guadiana includes a fraction of Castilla-La Mancha Autonomous region.
2 Total economic value (total €) divided by area (ha)
3 Source: MAPA (2002)
4 Economic value (€/ton) multiplied by production (ton/year). Source: MAPA (2002)
5 Total economic value (total €) divided by the total use of water resources (m3/year)
6 Gross Value Added (GVA). Source: CHG (2008*b*)
7 Source: CHG (2008*b*)
8 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.

	Economic value					Water economic productivity[5]	GVA[6]	Employment[7]
B) MIDDLE GUADIANA1	€/ha[2]	€/ha[2]	€/ton[3]	Total million €[4]		€/m[3]	million €	post number
Crop	**Rainfed**	**Irrigated**		**Rainfed**	**Irrigated**	**Irrigated**		
Grain cereals[8]:	435	1259	163	122	121	0,3		
Cereal - Wheat, barley, oat			133					
Cereal - Maize			136					
Cereal - Rice			279					
Grain legumes – Chick peas	613		817	12				
Potatoes		5165	207		2	1,5		
Industrial crops – Sunflower		732	256		11	0,1		
Fodder – Clover, veza	0		101					
Vegetables – Tomato	0	19182	336	0	414	2,9		
Flowers, ornamental plants								
Seeds and small plants								
Other grass crops								
Fallow land								
Vegetable gardens								
Citrus		2302	192		0	0,4		
Temperate climate fruit trees								
Subtropical climate fruit trees								
Dry fruit trees								
Olive tree for oil and table	858	2488	498	164	119	0,7		
Vineyard for wine production	2303	3638	455	136	43	0,9		
Nursery								
Other permanent crops								
Greenhouse tree crops								
Mushrooms								
Greenhouses								
Total	568	3409		434	711	0,8	413	22991

1 The Middle Guadiana includes a fraction of Extremadura (Badajoz and Cáceres).
2 Total economic value (total €) divided by area (ha)
3 Source: MAPA (2002)
4 Economic value (€/ton) multiplied by production (ton/year). Source: MAPA (2002)
5 Total economic value (total €) divided by the total use of water resources (m3/year)
6 Gross Value Added (GVA). Source: CHG (2008*b*)
7 Source: CHG (2008*b*)
8 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.

	Economic value					Water economic productivity[5]	GVA[6]	Employment[7]
C) TOP[1]	€/ha[2]	€/ha[2]	€/ton[3]	Total million €[4]		€/m[3]	million €	post number
Crop	**Rainfed**	**Irrigated**		**Rainfed**	**Irrigated**	**Irrigated**		
Grain cereals[8] – Wheat	325	457	133	8	1	0,2		
Grain legumes – Lupin, veza	129	276	190	0	0	0,1		
Potatoes	1767	2852	207	0	0	0,8		
Industrial crops – Sunflower		524	256		1	0,1		
Fodder – Veza and others			101					
Vegetables - Strawberries	0	28039	831	0	123	9,9		
Flowers and ornamental plants								
Seeds and small plants								
Other grass crops								
Fallow land								
Vegetable gardens								
Citrus		2961	192		23	0,5		
Temperate climate fruit trees								
Subtropical climate fruit trees								
Dry fruit trees								
Olive tree	428	786	498	4	1	0,5		
Vineyard	3369	3728	455	11	0	2,0		
Nursery								
Other permanent crops								
Greenhouse tree crops								
Mushrooms								
Greenhouses[6]								
Total	327	7422		23	149	1,9	205	9435

1 In line with CHG (2008*b*), TOP region is the Tinto, Odiel and Piedras river basin complementary region.
2 Total economic value (total €) divided by area (ha)
3 Source: MAPA (2002)
4 Economic value (€/ton) multiplied by production (ton/year). Source: MAPA (2002)
5 Total economic value (total €) divided by the total use of water resources (m3/year)
6 Gross Value Added (GVA). Source: CHG (2008*b*)
7 Source: CHG (2008*b*)
8 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.

D) LOWER GUADIANA[1]	Economic value €/ha[2]	€/ha[2]	€/ton[3]	Total million €[4]		Water economic productivity[5] €/m³	GVA[6] million €	Employment[7] post number
Crop	Rainfed	Irrigated		Rainfed	Irrigated	Irrigated		
Grain cereals[8] – Wheat	325	457	133	2	0	0,2		
Grain legumes – Lupin, veza	129	276	190	0	0	0,1		
Potatoes	1767	2852	207	0	0	0,8		
Industrial crops – Sunflower		524	256		0	0,1		
Fodder – Veza and others			101					
Vegetables - Strawberries	0	28039	831	0	11	9,9		
Flowers and ornamental plants								
Seeds and small plants								
Other grass crops								
Fallow land								
Vegetable gardens								
Citrus		2961	192		5	0,5		
Temperate climate fruit trees								
Subtropical climate fruit trees								
Dry fruit trees								
Olive tree	428	786	498	2	0	0,5		
Vineyard	3369	3728	455	0	1	2,0		
Nursery								
Other permanent crops								
Greenhouse tree crops								
Mushrooms								
Greenhouses[6]								
Total	174	4765		5	17	1,3	45	2206

1 The Lower Guadiana basin comprises the Guadiana basin part in Huelva.
2 Total economic value (total €) divided by area (ha)
3 Source: MAPA (2002)
4 Economic value (€/ton) multiplied by production (ton/year). Source: MAPA (2002)
5 Total economic value (total €) divided by the total use of water resources (m3/year)
6 Gross Value Added (GVA). Source: CHG (2008*b*)
7 Source: CHG (2008*b*)
8 Grain cereals comprise main cereals in the area according to MAPA 1T sheets.

World Water Assessment Programme side publications, March 2009

During the consultation process for the third edition of the World Water Development Report, a general consensus emerged as to the need to make the forthcoming report more concise, while highlighting major future challenges associated with water availability in terms of quantity and quality.

This series of side publications has been developed to ensure that all issues and debates that might not benefit from sufficient coverage within the report would find space for publication.

The 17 side publications released on the occasion of the World Water Forum in Istanbul in March, 2009, in conjunction with *World Water Development Report 3: Water in a Changing World*, represent the first of what will become an ongoing series of scientific papers, insight reports and dialogue papers that will continue to provide more in-depth or focused information on water–related topics and issues.

Insights

IWRM Implementation in Basins, Sub-Basins and Aquifers: State of the Art Review
by Keith Kennedy, Slobodan Simonovic, Alberto Tejada-Guibert, Miguel de França Doria and José Luis Martin for UNESCO-IHP

Institutional Capacity Development in Transboundary Water Management
by Ruth Vollmer, Reza Ardakanian, Matt Hare, Jan Leentvaar, Charlotte van der Schaaf and Lars Wirkus for UNW-DPC

Global Trends in Water-Related Disasters: An Insight for Policymakers
by Yoganath Adikari and Junichi Yoshitani at the Public Works Research Institute, Tsukuba, Japan, for the International Center for Water Hazard and Risk Management (ICHARM), under the auspices of UNESCO.

Inland Waterborne Transport: Connecting Countries
by Sobhanlal Bonnerjee, Anne Cann,Harald Koethe, David Lammie, Geerinck Lieven, Jasna Muskatirovic, Benjamin Ndala, Gernot Pauli and Ian White for PIANC/ICIWaRM

Building a 2nd Generation of New World Water Scenarios
by Joseph Alcamo and Gilberto Gallopin

Seeing Traditional Technologies in a New Light: Using Traditional Approaches for Water Management in Drylands
by Harriet Bigas, Zafar Adeel and Brigitte Schuster (eds), for the United Nations University International Network on Water, Environment and Health (UNU-INWEH)

Dialogue Series

Water Adaptation in National Adaptation Programmes for Action Freshwater in Climate Adaptation Planning and Climate Adaptation in Freshwater Planning
by Gunilla Björklund, Håkan Tropp, Joakim Harlin, Alastair Morrison and Andrew Hudson for UNDP

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by Jan Hassing, Niels Ipsen, Torkil-Jønch Clausen, Henrik Larsen and Palle Lindgaard-Jørgensen for DHI Water Policy and the UNEP-DHI Centre for Water and Environment

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by Marie-Joëlle Fluet, International Secretariat for Water; Luc Vescovi, Ouranos, and Amadou Idrissa Bokoye, Environment Canada

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by Thomas Chiramba and Tim Kasten for UNEP

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by Jon Martin Trondalen for UNESCO PCCP

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Water and Climate Change in Quebec
by Luc Vescovi, Ouranos; Pierre Baril, Ministry of Transport, Québec; Claude Desjarlais ; André Musy; and René Roy, Hydro-Québec. All authors are members of the Ouranos Consortium

Investing in Information, Knowledge and Monitoring
by Jim Winpenny for the WWAP Secretariat

Water Footprint Analysis (Hydrologic and Economic) of the Guadania River Basin
by Maite Martinez Aldaya, Twente Water Centre, University of Twente and Manuel Ramon Llamas, Department of Geodynamics, Complutense University of Madrid, Spain

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