System of Water Accounting in Guadalquivir River Basin (SYWAG) FINAL REPORT

Autores: Berbel, J, Borrego-Marín, M., Gutierrez, C.

Proyecto: 0329/2013/671250/SUB/ENV.C (DG ENV: Comisión Europea)

Fecha: 8/1/2015

Objeto: Presentación al Consejo Asesor del Borrador de Informe Final para análisis y comentarios.

Consorcio:

UNIVERSIDAD
D
CÓRDOBA

EVREN
EVALUACIÓN DE RECURSOS NATURALES

Index

To quote/ Para citar:

Berbel, J, M.M. Borrego-Marín y C. Gutierrez, C.(2015) System of Water Accounting in Guadalquivir River Basin (SYWAG). Final Report. Helvia. Universidad de Córdoba.

Note: *Spreadsheet tables can be obtained from authors* *(berbel@uco.es)*

Las tablas en versión Hoja de Cálculo pueden solicitarse a los autores

1- Resumen ejecutivo

El proyecto SYWAG ha acometido la tarea de elaborar para la cuenca del Guadalquivir en el periodo 2004-2012 las tablas del Sistema de Cuentas Ambientales y Económicas del Agua (SCAE-Agua, SEEA-Water en inglés) y extraer indicadores de las mismas. El sistema SCAE-Agua ha sido preparado por la División de Economía y Asuntos Sociales de las Naciones Unidas en colaboración entre otros con EUROSTAT. SCAE-Agua proporciona el marco conceptual para la organización coherente y consistente de la información hídrica y económica y como marco básico el Sistema de Cuentas Nacionales 1993 (SCN 1993), que es el sistema estándar para la compilación de estadísticas económicas y de los indicadores económicos derivados, entre los que destaca el Producto Interno Bruto (PIB).

El SCAE-Agua cubre todas las interacciones importantes entre el medio ambiente y el sistema económico y el ejercicio que se ha planteado en SYWAG es demostrar su utilidad como herramienta de apoyo a la implementación de la DMA y la elaboración de los Planes Hidrológicos. El SCAE-Agua incluye, como parte de su presentación estandarizada, la siguiente información: (a) los stocks y los flujos de recursos hídricos en el medio ambiente (b) las presiones de la economía sobre el medio ambiente en términos de extracción de agua y de descargas de las aguas residuales (c) la oferta y utilización de agua como insumo en el proceso de producción y como consumo en los hogares; (d) la reutilización de agua en la economía; (e) el coste de los servicios de suministro, depuración, distribución y tratamiento de agua, así como los ingresos por las tasas de servicio pagadas por los usuarios; (f) el financiamiento de esos costes; (h) la capacidad hidráulica disponible, así como las inversiones en infraestructura hidráulica durante el período contable.

Los resultados del proyecto SYWAG constan del conjunto completo de tablas para la cuenca del Guadalquivir en el periodo 2004-2012 así como en la explotación de las tablas con algunos resultados derivados de la aplicación de indicadores a las mismas. Se pueden destacar los siguientes resultados:

1) Desarrollo del conjunto completo de 11 tablas SCAE-Agua a partir de información oficial y con la mínima intervención de los investigadores. Las tablas generadas son:

1.1 Suministro físico y uso de agua
1.2 Emisiones de agua
2.2 Matriz de flujos dentro de la economía
1.3 Tablas hibridas de suministro
1.4 Tablas hibridas de suministro y uso
1.5 Tablas hibridas de suministro y saneamiento
1.6 Tablas de servicios generales del Gobierno
1.7 Tabla de suministro y uso de agua (EUR)
1.8 Tablas de financiación (EUR)
1.9 Tablas de activos (hm^3)
2.5 Información suplementaria a las tablas de activos

2) Uso de las tablas SCAE-Agua para la caracterización de la cuenca de acuerdo con el Art 5º de la DMA (análisis económico de los usos del agua)

3) Análisis de series temporales combinando datos económicos e hidrológicos, incluyendo el estudio de sequías meteorológicas y la implementación a gran escala de la modernización (medidas de ahorro de agua en regadío). SYWAG ha llegado a la conclusión de que no se ha podido detectar el impacto de la sequía en el Guadalquivir basándose en las cuentas SCAE-Agua. No ha sido posible detectar el efecto directo en la agricultura ni el efecto indirecto en el resto de la economía de la cuenca a partir de datos agregados. Esto puede ser explicado por el importante papel del regadío (27% del área cultivada, 65% del valor de la PFA), el soporte de la PAC y la fluctuación de precios que compensa la reducción de rendimientos. Se necesita investigación adicional para poder deducir el impacto de la sequía en una economía desarrollada y donde los recursos hídricos se encuentran regulados a escala interanual.

4) SYWAG ha detectado alguna discrepancia en las definiciones del SCAE-Agua en relación con el papel del agua del suelo (agua 'verde' o lluvia útil) en el regadío así como algún problema de concepto como el ratio 'VAB/agua consumida' que puede ser un buen indicador de la productividad aparente del recurso pero que no debe confundirse con el 'valor del agua'.

5) La importancia de los servicios de regulación para gestionar la incertidumbre en los recursos hídricos disponibles ha sugerido llevar a cabo una ampliación de las tablas estándar de SCAE-Agua a) añadiendo una línea adicional que recoge el agua 'azul' y b) dividiendo en tres subsectores la columna ISIC 36 (suministro de agua). Esta adaptación tiene dos metas: 1) servir de conexión con los Planes Hidrológicos de Cuenca que se centran exclusivamente en el 'agua azul' que es objeto de planificación hidrológica y asignación de derechos y 2) permite estimar un indicador de recuperación de costes.

6) En el Guadalquivir el agua verde (agua del suelo según el SCAE) en tierras de riego supone el 62% del agua total consumida por los cultivos regados durante el año. Por tanto, nuestra propuesta es considerar que la definición que hace SCAE-Agua del agua consumida por los cultivos de riego considerando exclusivamente el agua 'azul' es inexacta cuando el riego deficitario es aplicado de manera general (como suele ocurrir en regiones áridas), por lo tanto es conveniente modificar dicha definición en el sentido de incluir tanto el agua de lluvia útil como al agua de riego para entender como agua consumida toda aquella evapotranspirada por los cultivos ya sea de lluvia o de riego.

7) Cuando se relacionan los datos económicos e hídricos pueden estimarse algunos valores de productividad del recurso como (VAB/agua consumida) por sector y año. El análisis de este ratio durante el periodo puede ayudar a entender el impacto de la evolución de condiciones meteorológicas e hidrológicas en la productividad del recurso y el rol que juegan tanto el agua distribuida (azul) como el agua del suelo (verde).

8) Se ha elaborado un método para estimar el ratio de recuperación de costes a partir de las tablas SCAE-Agua. La aplicación del mismo al caso del Guadalquivir permitió estimar para 2012 un ratio global (todos los sectores y servicios) del 78% que está en el rango de estimaciones previas en estudios de calidad. La propuesta metodológica para estimar el ratio de recuperación de coste tiene evidentes ventajas para la implementación de un sistema común en todos los EEMM de la UE. No se han incluido en las tablas los datos de servicios de navegación porque la DMA los excluye de la necesidad de la recuperación de costes, aunque es posible y deseable que se incluyan en la revisión de la DMA prevista para 2019.

Como conclusión, las Cuentas del Agua SCAE-Agua han confirmado ser una herramienta útil para estudiar el impacto agregado de la evolución de las condiciones de entorno natural (sequías, irregularidad en lluvias) y cambios en los agentes económicos (medidas de ahorro de agua, fiscalidad ambiental, aumento de costes). En nuestra opinión ha quedado demostrado que es una herramienta analítica muy relevante para el intercambio del conocimiento y puesta en común de técnicas, definiciones y métodos en la aplicación de la DMA en las distintas cuencas de la UE.

1- Summary

The System of Environmental-Economic Accounting for Water "SEEA-Water" provides a conceptual framework for organizing hydrological and economic information in a coherent and consistent manner. European Commission is working in a Guidance document on water balances with the aim to standardize economic information regarding water use in Europe, therefore facilitating WFD reporting. SEEA-Water provides a conceptual framework for organizing hydrological and economic information in a coherent and consistent manner.

This research has been financed by European Commission under grant "System of Water Accounting in the Guadalquivir River Basin" (SYWAG) that has elaborate the system for nine years (2004 to 2012).

Guadalquivir River is the longest river in southern Spain with a length of around 650 km. Its basin covers an area of 57,527 km^2 with a population of 4,1 million inhabitants. The basin has a Mediterranean climate with a heterogeneous precipitation distribution. In the period 2004-2012 there an average rain of 581 mm (basin average is 573 mm), minimum in the period is 285 mm (2004/05) and maximum is 1033 mm (2009/10) illustrating the extreme dispersion of rain and the necessity of a complex and interconnected system of 65 dams. Table A1.9 Asset account table gives the yearly evolution in stocks from Oct 1st 2004 to Sept 30th 2012, it can be seen that snow has a lesser importance and the relevant value of reservoirs that store as much as water as soil at the end of the hydrological year.

The importance regulation services to manage the uncertainty in water supply have suggested some adaptations of the standard SEEA-W tables. Firstly, table 1.1 'Standard physical supply and use' has been extended with an additional row to summarize the 'Blue water' flows (volume of water served that is subject to 'water rights' and controlled by the Hydrological Plan), this additional line serves as control en link to the Hydrological Plan values in order both to check quality of our data and to integrate both documents.

Additionally, column '36: W-Supply' has been divided into three agents: the utilities itself (ISIC 36) that has been complemented by Water Agency (CHG) that plays a key role as water supply guarantee and manages the system of reservoirs and environmental flow of the river and finally Water User Associations (WUA) that play a key role in the distribution of regulated water to farmers. This division is convenient for managing information such as '2.2 Matrix of flows of water within the economy' and for the exploitation of derived indicators, specially cost recovery index that need this detailed information.

The results of SYWAG project are the complete set of tables that will make a relevant material for future analysis regarding evolution and use of water resources and economic characterization of the basin and methodology for exploitation of data. Consequently, the main results are:

1) Development of the full set of SEEA-W tables from official data bases with minimum analyst intervention. The set comprises the following 11 tables:

    1.1 Standard physical supply and use table for water.
    1.2 Emission accounts tables
    2.2 Matrix of flows of water within the economy (millions of cubic meters per year)
    1.3 Hybrid supply and use tables
    1.4 Hybrid account table for supply and use of water (physical and monetary units)
    1.5 Hybrid account table for water supply and sewerage for own use (physical and monetary units)
    1.6 Government account table for water-related collective consumption services
    1.7 Account table for supply and use of water (monetary units)
    1.8 Financing account tables
    1.9 Asset account table (hm3)
    2.5 Supplementary information to the asset accounts

2) Use of SEEA tables for characterization of the basin according Art 5º WFD (economic analysis of water use)

3) Analysis of large temporal series of economic and hydrological data including meteorological and hydrological droughts and implementation of large scale water saving measures. Our research also found that it is difficult to determine the aggregate economic impact of meteorological and hydrological drought based upon basin SEEA Accounts. We have found difficulties for detecting direct effect of drought (on farming) and indirect effects (on the basin economy) based on aggregated basin data. This may be explained by the role of irrigation in the basin (approximately 27% cultivated area, 65% value), the support of Common Agricultural Policy and fluctuation of prices that compensate lower productions. Further research is required to assess the impact of drought through aggregate data.

4) Water Accounts according SEEA-W confirm to be a useful tool for the economic analysis of water use and the impact of climatic conditions but also this exercise has demonstrated the limitation of using aggregated economic data and the conceptual problems with some SEEA-W definitions such as the soil water in irrigated land and the water value that should not be confounded with the "GVA/water consumed" ratio, which can be a useful indicator of water productivity by sector.

5) The importance regulation services to manage the uncertainty in water supply has suggested some adaptations of the standard SEEA-W tables with additional lines and columns for two goals: a) to serves as control en link to the Hydrological Plan values in order both to check quality of our data and to integrate both documents and b) make possible computing cost recovery ratios of water services.

6) In Guadalquivir basin, 'green water' (soil water according SEEA) in irrigated land supposes around 62% of water consumed by irrigation in the period. Therefore, we argue that SEEA-W definition of water consumed by irrigation considering exclusively 'blue supplied water' is misleading when deficit irrigation is common in the basin (as it is frequent in water scarce areas) and should not be assumed and we proposed a modified version as 'soil water abstraction is the water evapotranspirated by crops both in rain fed and irrigated agriculture and by pastures and trees in forest areas'.

7) When economic and hydrologic data are linked, some average of water productivity values can be estimated as the ratio (GVA/water consumed) by sector and year. The analysis of this ratio during the period may help to understand the evolution of meteorological and hydrological conditions in productivity and the role of both irrigation blue (abstracted) and green (rain) in the irrigated land.

8) Analysis of cost recovery ratio directly from SEEA-W tables obtaining a global value of 78% for all sectors and services that is the range of previous relevant studies. The proposed methodology to estimate cost recovery rations has obvious advantages for the common implementation of WFD reporting procedures as it may supports EU Member States and Commission services with common definitions and algorithms to provide an indicator of cost recovery. We have not included in SEEA Water tables navigation services because they are not explicitly included in WFD cost recovery analysis, nevertheless we hope that this deficiency will be solved in the revision of WFD expected for 2019.

As a conclusion, Water Accounts according SEEA-W confirm to be a useful tool for the economic analysis of water use and the impact of climatic conditions. Additionally SYWAG has demonstrated the limitation of using aggregated economic data and the conceptual problems with some SEEA-W definitions and the need to extend the standard tables with additional information in cases where regulating services play a significant role in water management and water value.

2. Introduction

The present project will develop water balances in the Guadalquivir river basin following the methodology of the System of Economic and Environmental Accounts for Water (SEEA-Water). The period to be analyzed will be 2004-2012, this reference period has the following relevant features:

a) Before implementing water saving measures and before the last period of drought
b) Last severe drought (2005-2008)
c) After the water saving measures have been implemented

After 14 years of WFD approval, European Union is still lacking comparable systems for the reporting of administration and utility revenues to recover the costs European Commission is using a new standard reporting procedure for 2015 (second cycle of WFD implementation) in order to correct this shortcoming, but we believe that even if the presentation respond to a common standard for all 27 member states, the differences in methodology to compute this value will still require additional common methodology to be shared. In our opinion, it would be particularly useful to have a system, standardized across EU Member States and in our opinion SEEA-W presents an opportunity to fill this gap.

The case is relevant because applies the methodology to a Mediterranean large basin that contains 25% of Spanish irrigated area. The Guadalquivir River Basin has been managed through a centralized and hierarchical system since 1920's, which facilitated the evolution of a large and profitable agricultural sector that in turn has driven the basin towards closure, defined as those basins with a relatively small amount of uncommitted run-off. Although most of the drivers, pressures and processes are common among other closed basins around the world, three factors make the Guadalquivir distinct: the cultivation of high-value irrigated Mediterranean crops, a predominance of deficit irrigation and a large investment in water saving technologies.

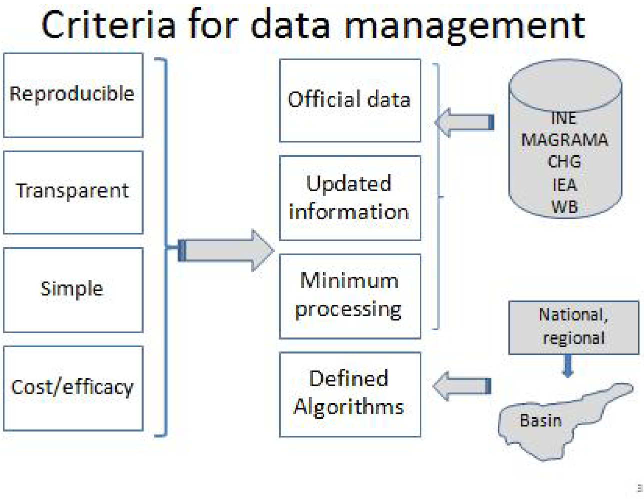
Regarding the modernization, the Spanish Government developed the National Irrigation Program with the aim to transform the old open channel distribution infrastructure into pressurized-pipe networks, and to achieve annual water savings of 3,000 Mm^3. The new pressurized-pipe systems operate on demand, which has allowed high frequency irrigation, optimal crop irrigation scheduling, and the diversification of the cropping pattern towards higher value crops. Modernization of irrigated systems and the projected water saving is a key measure in the implementation of the River Basin Management Plans in Spain.

The Guadalquivir basin is probably the area with more extensive application of water saving measures and techniques: modernization of irrigation systems and deficit irrigation techniques. Regarding deficit irrigation, this is a key issue that has not been treated properly by literature, and is crucial because water transpiration by plants is usually done by using full irrigation assumptions that do not hold in scarce water resource regions.

This project will provide an increase of the knowledge of the impact of water saving investment and management techniques in the physical and economic flows of the basin analyzed under the SEEA framework.

An important issue is the fact that abstraction from agriculture will be based on two extensive surveys (Inventario de Regadios 2004 and Actualizacion del Inventario de Regadios, 2008, CHG-Acuavir, 2010). A database has been integrated with the AQUATOOL hydrological model for close analysis of special demand and return flows. This information is available and will be a distinctive feature to use. The key point is the use of declared irrigation doses, usually deficit irrigation levels, as a generalized management technique to adapt to water scarcity.

The use of SEEA Water methodology implies the following criteria for data management that are summarized in figure 1.



As we can see, our design aims to obtain a system of accounts that are a) reproducible, it can be done again by any other exercise coming to same results, b) transparent management of information, c) simple and d) cost/efficacy, in order to improve existing methodology that adopt 'ad hoc' systems of presentation and data management.

The project will present a brief description of the basin contained in chapter 3, where main features will be described. This description is based on previous documents and will be complemented in chapter 7 with a detailed characterization of the basin based upon SEEA results.

The data sources is detailed described in chapter 4 where the data and algorithms for both economic data and hydrological data are detailed explained.

Chapter 5 describes the methodology used for developing the tables with hydrological and economic information.

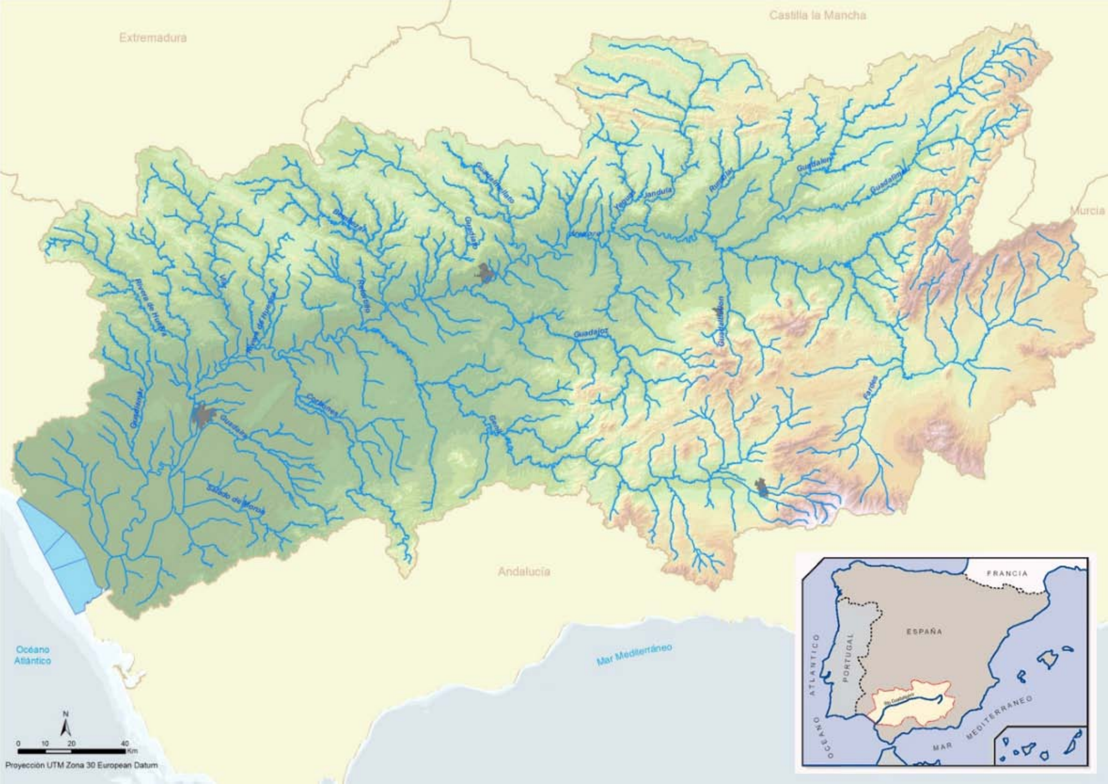
The results are detailed in chapter 6 where the evolution of the basin in the period 2004-2012 and a summary of selected variables is detailed explained.

Finally some exploitation of the results are done in order to demonstrate the usefulness of SEEA methodology for WFD implementation, we present the basin characterization, an analysis of the impact of the meteorological and hydrological droughts during the period and an assessment of Cost recovery ratio base on SEEA-Water.

3. Description of Guadalquivir River Basin

The Guadalquivir River is the longest river in southern Spain with a length of around 650 km. Its basin covers an area of 57,527 km^2 and has a population of 4,107,598 inhabitants (see Figure 1 for a map of the basin). The basin has a Mediterranean climate with a heterogeneous precipitation distribution. The annual average temperature is 16.8°C, and the annual precipitation averages at 573 mm, with a range between 260 mm and 983 mm (standard deviation of 161 mm). The average renewable resources in the basin amount to 7,043 (arithmetic mean) and 5,078 hm^3/year (median), ranging from a minimum of 372 hm^3/year to a maximum of 15,180 hm^3/year (Argüelles *et al.* 2012). In a normal year a potential volume of around 8,500 hm^3 can be stored through a complex and interconnected system of 65 dams. The main land uses in the basin are forestry (49.1%), agriculture (47.2%), urban areas (1.9%) and wetlands (1.8%) (CHG, 2010).

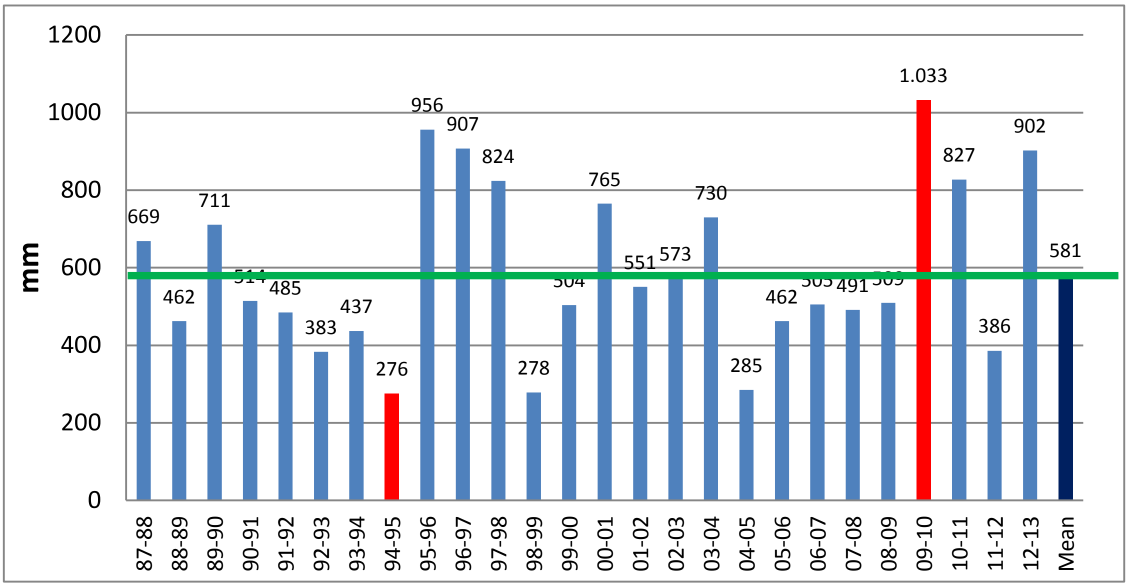
Figure 1. The Guadalquivir River basin



Source: Adapted from Confederación Hidrográfica del Guadalquivir, www.chguadalquivir.es

The water resources of the basin are highly regulated, with a total of 65 dams. There is also an inter-basin transfer (the “Negratin-Almanzora”) that exports water from the Guadalquivir to the intensive horticulture in Almeria, at the Southeast of Andalucía, on the basis of a water market trading and regulated administrative allocation.

Figure 2. Evolution of precipitation since 1987/88 and the average for the 25 years



(*) Source: Guadalquivir River Basin Authority
Red bars show years with maximum and minimum precipitation in the period.

According to the recent Hydrological Management Plan revision, the sum of all water abstractions in Guadalquivir River Basin suppose an estimated total volume of 3,801.13 hm^3/year, divided by the following uses:

Table 1. Water abstractions

Sector	hm^3
Urban	379.45
Irrigation	3,342.44
Industry	43.40
Energy	35.84
Total	3,801.13

Source: Confederación Hidrográfica del Guadalquivir (2014)

Table 1 shows that the main pressure in the basin is agricultural irrigation with almost 88% of total abstractions, followed by urban use that suppose a 10% and industrial and energetic uses with less than 2%. Regarding sources, approximately 74% are superficial abstractions, a total of 2829.10 million cubic meters (regulated and non regulated).

The variability in water resource availability, the increasing demand from different water users, and the recurrent droughts, lead to episodes of cyclical scarcity. Local and seasonal droughts cause aquifer salinization and environmental stress. Moreover, water quality is a significant problem throughout the river basin. The main sources of pollution include urban and industrial waste water discharge, erosion, and nutrient and pesticide runoff from agricultural land (CHG, 2014).

Agriculture is the main consumptive user in the basin and it has implemented an intense investment in water saving measures called ‘modernization’ (MARM - Ministerio de Medio Ambiente y Medio Rural y Marino 2006). The analysis of the Hydrological Basin Plan of the Guadalquivir River Basin (Spain) is done in Berbel *et al.* (2012). Berbel *et al.* (2014) make an analysis of evolution of the main indicators for a sample of irrigation water user association where water saving investment (modernization) has been done during the period of analysis 2004-2012 including the impact of the modernization on water use and cost.

There has been a growing pressure on water resources through high-value irrigated agriculture (citrus, olive and vegetables, among others) but there have been, at the same time, increases in efficiency of water use per hectare (reducing average consumption from 6,893 m^3/ha in 1992 to an estimation of 3,914 m^3/ha in 2015). However, due to increases in the total area of land irrigated, from 410,000 ha to 854,056 ha, the total consumption of water has increased by 1.5% per year since the 1990s, peaking in 2008. Water use by cities and industry accounts for just 10% of total water extraction, compared to 88% by agriculture.

Crops in the upper Guadalquivir valley such as olives rely on irrigation and rainfall. In the lower valley there is mixed cropping (rice, maize, citrus, cotton) which relies heavily on irrigation, whereas in mountainous areas of the basin only marginal irrigation is undertaken.

Berbel *et al.* (2011) stress the importance of deficit irrigation in the basin. This characteristic may illustrate the level of scarcity of water resources in the basin, as the average dose is 3,490m^3/ha, versus potential evapotranspiration (PET) needs of 4,919m^3/ha, resulting in an average relative irrigation supply (RIS) of 0.70 (i.e. the irrigation dose in Guadalquivir is 70% of PET on the average). Some crops may adapt to deficit irrigation, such as sunflower (RIS 0.31) or wheat (RIS 0.37), and other crops maybe “over-irrigated”, indicating that there is still room for water efficiency measures as the case of citrus illustrates (RIS 1.14). Consejería de Agricultura y Pesca. Junta de Andalucía (2010) gives a value for the average RIS in the basin of 0.60 in 2008/2009.

Considering the high profitability of olives as a crop, the irrigation of olive groves was a significant technological revolution in the 1980s, particularly in this basin. The marginal net profit of water, which is a more relevant indicator compared to the apparent productivity mentioned in previous paragraph, is found to be in the range €0.5/m^3 to €0.63/m^3 (Mesa-Jurado *et al.* 2010), explaining the intense pressure on water abstraction for this use.

Consequently, for the Guadalquivir river basin as a whole, olive groves have become the largest user of water despite their low dose (1,500m^3/ha, with an average RIS of 0.62).

Table 2 Irrigated area and demand according water origin in Guadalquivir (2015)

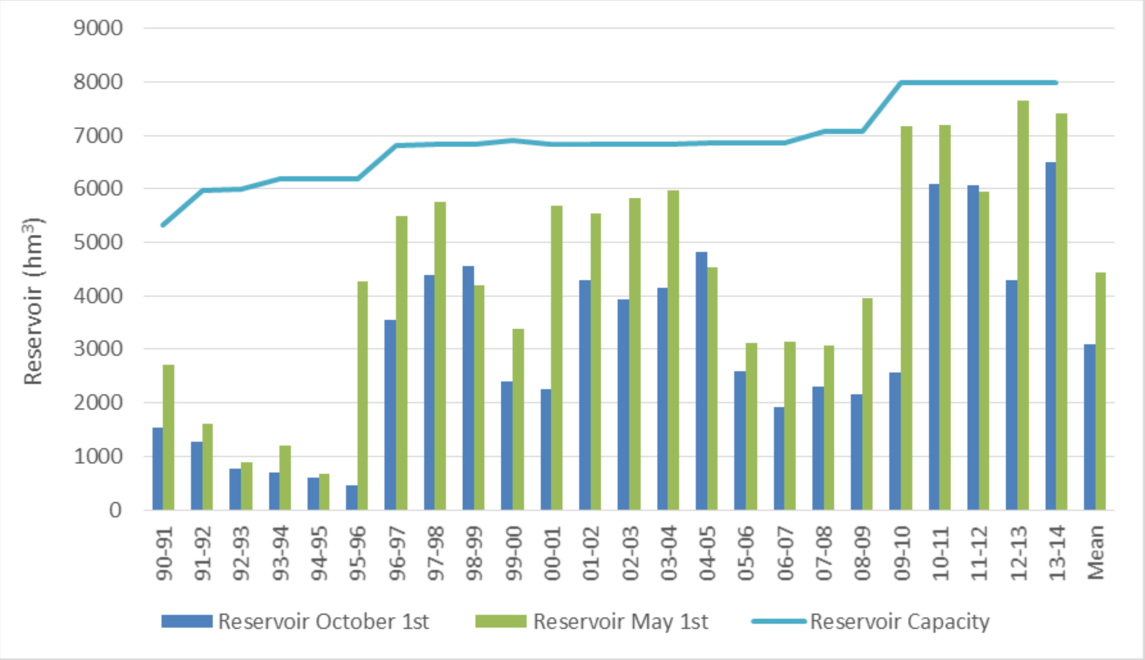
Water source	ha	hm^3	m^3/ha
Regulated surface	431,287	2,154.35	4,995
Non regulated surface	102,312	334.43	3,269
Groundwater	320,457	853.66	2,664
Total	854,056	3,342.44	3,914

Source: Confederación Hidrográfica del Guadalquivir (2014)

Currently groundwater constitutes 20% of the total water consumed in the basin. Groundwater abstraction has increased over the last few decades due to increasing demands for the irrigation of olive groves in the upper valley. As of 2008, irrigation systems consisted of drip (64%), sprinkler (14%) and surface (27%) irrigation (CHG, 2010).

The series of precipitation shows the occurrence of extreme events (drought and floods). Figure 3 shows the reservoir levels on October 1st and May 1st and the total reservoir capacity. In this figure two drought events are clearly shown, of which the second will be analysed in this report.

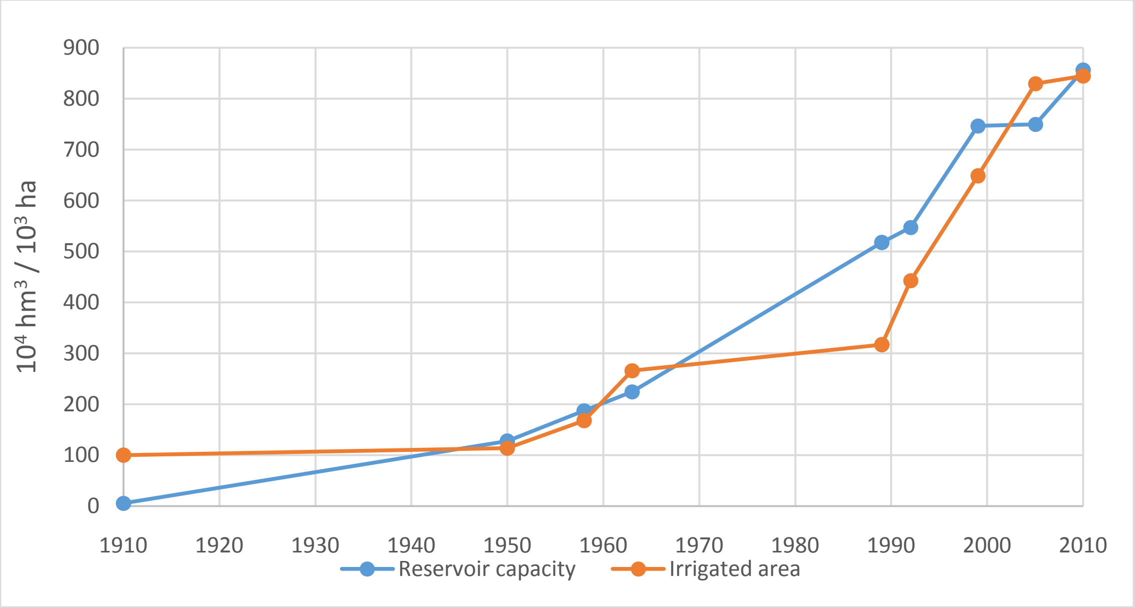
Figure 3. Evolution of water storage 1990-2014



Source: Confederación Hidrográfica del Guadalquivir

This natural disadvantage of extreme events has been addressed by means of increasing reservoir capacity: dams regulate around 8,000 hm^3. Additionally, there is an important natural regulation capacity, as groundwater can store 2,720 hm^3/year. This volume of reserve capacity implies an important volume compared to the average annual renewable resources (a ratio of 140% reserves/resources), but it is not sufficient when there are more than two consecutive years with insufficient precipitation.

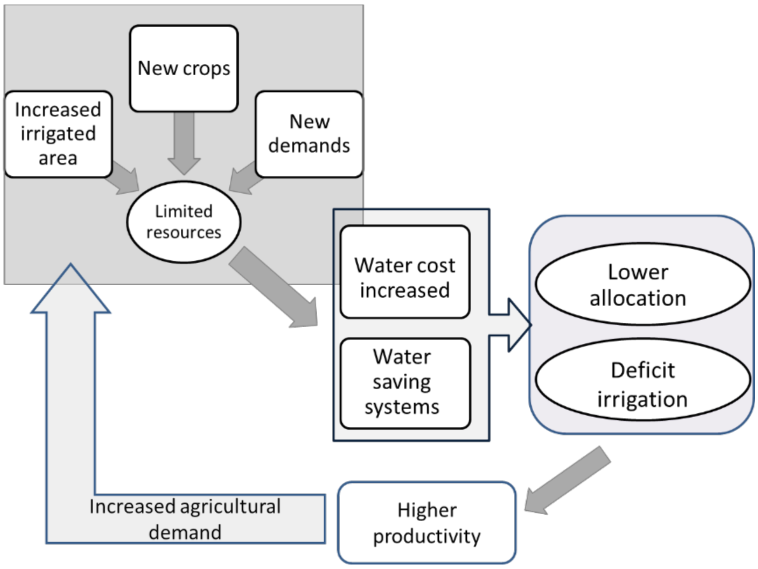
Figure 4. Water reservoir and irrigated area evolution 1910-2010



Source: Argüelles, Berbel et al. (2012)

The basin has reached its supply capacity, so no new sources of water are planned. This is known as basin closure. Figure 4 shows a diagram of the main drivers, pressures, impacts and responses related to the basin's closure. The main factors are as follows: a) Decreasing farm income; b) Increase in irrigated area and factor intensification; c) New irrigated crops; d) New demand from other sectors; e) Increase in environmental flow control; f) Reduction in water allocation; g) Increase in water costs; h) Increase in drip irrigation and other water saving technologies; i) Mainstream adoption of deficit irrigation; j) Administrative basin closure; k) Increase in water productivity and l) More inelastic irrigation demand (Berbel *et al.* 2013).

Figure 5. Model of the evolution of the Guadalquivir River Basin (1980–2015).



Source: Berbel, Pedraza et al. (2013)

In fact the draft HBP estimates a reduction in extraction rates of 8% through water efficiency measures from irrigation and urban sectors. Observations of water usage for irrigation during 2009 and 2010 indicate these projections are achievable.

Consequently, the HBP bans any new entrants from being authorized. This is in line with the results of the public debate and a political participatory process resulting in the legal document *Acuerdo por el Agua en la Cuenca del Guadalquivir* (CHG, 2005).

It was agreed that no new irrigated area could be introduced, with an exception for ongoing government projects that were under development but not fully operative that year. This agreement was a movement to stop political pressure from lobbying stakeholders and interest groups claiming additional water rights, especially for new users in the upper basin. Nevertheless, allocation of water for irrigation is still seen as a priority by the general public.

References

Argüelles, A., Berbel, J. and Gutiérrez-Martín, C. (2012). La evolución de la Cuenca del Guadalquivir (España). *Revista de Obras Públicas* 159 (3537):51-64.

Berbel, J., Gutiérrez-Martín, C., Rodríguez-Díaz, J.A., Camacho, E. and Montesinos, P. (2014). Literature Review on Rebound Effect of Water Saving Measures and Analysis of a Spanish Case Study. *Water Resources Management*:1-16.

Berbel, J., Kolberg, S. and Martin-Ortega, J. (2012). Assessment of the Draft Hydrological Basin Plan of the Guadalquivir River Basin (Spain). *International Journal of Water Resources Development* 28:43-55.

Berbel, J., Mesa-Jurado, M.A. and Piston, J.M. (2011). Value of Irrigation Water in Guadalquivir Basin (Spain) by Residual Value Method. *Water Resources Management* 25:1565-1579.

Berbel, J., Pedraza, V. and Giannoccaro, G. (2013). The Trajectory Towards Basin Closure of a European River: Guadalquivir. *International Journal of River Basin Management* 11(1):111-119.

Confederación Hidrográfica del Guadalquivir (2005). Acuerdo por el Agua en la Cuenca del Guadalquivir.

Confederación Hidrográfica del Guadalquivir (2010). Propuesta de Proyecto de Plan Hidrológico de la Demarcación Hidrográfica del Guadalquivir. 2010.

Confederación Hidrográfica del Guadalquivir (2014). Propuesta de Proyecto de Revisión del Plan Hidrológico de la demarcación del Guadalquivir (2º ciclo). 2014.

Consejería de Agricultura y Pesca. Junta de Andalucía (2010). Agenda del Regadío Andaluz. Horizonte 2015.

MARM - Ministerio de Medio Ambiente y Medio Rural y Marino (2006). Plan de choque de modernización de regadíos. Real Decreto 287/2006, de 10 de marzo.

Mesa-Jurado, M.A., Berbel, J. and Orgaz, F. (2010). Estimating marginal value of water for irrigated olive grove with the production function method. *Spanish Journal of Agricultural Research* 8:S197-S206.

4- Data sources

The philosophy of SEEA-W is the time and resource saving efficiency in data gathering, it is crucial that data is based in officially published information avoiding 'ad hoc' estimations. Following this strategy, our have used the following data base and official sources that are summarized in table 1 and 2.

1. Hydrological variables

Table 1. Data source for hydrological variables

Variable	Data source	Producer	Comment
Population (municipal)	INE	INE	
Industrial activity by ISIC/location	INE/MAGRAMA	INE/MAGRAMA	
Metropolitan area	MAGRAMA	MAGRAMA	
EDAR	MAGRAMA	MAGRAMA	
Agricultural production by branch	MAGRAMA (province)	MAGRAMA	
Evaporation rate from reservoirs	Evaporation stations	MAGRAMA/CEDEX	Evaporation stations available in the Guadalquivir RB.
Agricultural surface evolution	CHG	CHGuadalquivir	
Volume in reservoirs	CHG	CHGuadalquivir	
Rainfall	SIMPA monthly	CHGuadalquivir	
Rainfall	REDIAM	AEMET	Principal network of meteorological stations
Infiltration	SIMPA monthly	CHGuadalquivir	
Potential evaporation ETP	SIMPA monthly	CHGuadalquivir	
ETR	SIMPA monthly	CHGuadalquivir	
Groundwater runoff	SIMPA monthly	CHGuadalquivir	
Irrigation efficiency by units (1)	Inventario regadios	CHGuadalquivir	Efficiencies by Irrigation unit
Irrigation efficiency by units (2)	CHG	CHGuadalquivir	Own elaboration based on IPH
Irrigation use (water doses)	Inventario regadios	CHGuadalquivir	
Surface runoff	SIMPA monthly	CHGuadalquivir	
Temperature (1)	SIMPA monthly	CHGuadalquivir	

Gauging stations	SAIH/Gauge monitoring network	CHGuadalquivir/CEDEX	
Groundwater resources, aquifer characterization		CHGuadalquivir/IGME	Management plan for sustainability of GW resources.
Volume of dam/regulation capacity	CHG	CHGuadalquivir	Informes hidrológicos CHG (annual report)
Water demand	CHG	CHGuadalquivir	Own elaboration based on CHG reports, BHP,INE
River flow	SAIH	CHGuadalquivir	Water levels for river volume estimation
Returns	CHG	CHGuadalquivir	
Aquifer level (piezometric)	Piezometric monitoring network	MAGRAMA/IGME	Reference for the assessment of flows between groundwater and superficial resources
Agg ECRINS	CIRCA	EEA	
ANyECRINS	CIRCA	EEA	
FEC ECRINS	CIRCA	EEA	
GAZ ECRINS	CIRCA	EEA	
River ECRINS	CIRCA	EEA	
TR ECRINS	CIRCA	EEA	
CORINE	CIRCA	EEA	
Urban water water treatment	CIRCA	EEA	
Urban runoff DBO5 concentration	USEPA	USEPA	
Urban runoff volume	Own elaboration	US Dept. of Interior Boureau of Reclamation	
Census Discharges	CHG	CHGuadalquivir	
Red ICA/DMA (water quality)	CHG	CHGuadalquivir	

INE= Instituto Nacional de Estadistica; MAGRAMA=Ministerio de Agricultura, Alimentación y Medio Ambiente; CHG=Confederación Hidrográfica del Guadalquivir; CEDEX=Centro de Estudios Hidrográficos; SIMPA= Sistema Integrado para la Modelación del proceso Precipitación Aportación; REDIAM=Red de Información Ambiental de Andalucía; SAIH= Sistema Automático de Información Hidrológica; AEMET= Agencia Española de Meteorología; CIRCA=Siatema de Información Europeo; EEA=Agencia Europea de Medio Ambiente.

There have been consulted several sources to estimate the hydrological variables required. The evaporation rate in reservoirs has been taken from the evaporation stations that belongs to the CEDEX network stations in the Guadalquivir river basin. River flow rates in the Guadalquivir river basin are available through the gauge monitoring network SAIH. The aquifers characteristics were studied in the work carried out by the IGME (Instituto Geológico y Minero de España), to which CHG provided its access. Data from a piezometric monitoring network in control of IGME and MAGRAMA have been employed in order to evaluate the interaction between groundwater and superficial resources. The water volume accumulated in the reservoirs has been provided by the CHG. The ICA network was consulted to get water quality information.

The surveys conducted by the Confederación Hidrográfica del Guadalquivir (CHG) were used to assess the land surface devoted to irrigated agriculture. Another paramount parameter in this work is the irrigation efficiency. It appears in the irrigation database developed by CHG. It was also estimated based on the recommendations of the Instrucción de Planificación Hidrológica (IPH). The average water dose allocated to each irrigated cropland is included in the irrigation database.

The variables rainfall, temperature, infiltration, potential evaporation, actual evaporation, surface runoff and groundwater runoff have been assessed from the rasters generated using SIMPA model, which were facilitated by CHG.

The water demands have been calculated taking into account the information contained in the Hydrological Plan of the Guadalquivir basin (PHG), PHG reports and INE. The PHG includes values of returns that have been used. Irrigation returns have been estimated based on the IPH suggestions.

Geographical information was received by the European Environmental Agency (EEA), such as the land use shapefile CORINE. EEA also provided data related with urban water treatment.

Finally, some information concerning urban runoff was obtained from publications from USEPA an US Department of Interior. Additional meteorological information from the AEMET Principal network of meteorological stations was also used.

2. Economic and hydrological variables

Table 2. Data source for economic and hydrological variables

Variable	Units	Standard Table (1)	Data source	Institution	Scale (2)	Comments
Abstraction	hm^3/year	A.1.1	SIMPA, Own calculations	CHG, Environmental Ministry	Basin	
Use	hm^3/year	A.1.1	PHC, Survey water services, Own calculations	CHG, Environmental Ministry, INE	Basin	
Returns	hm^3/year	A.1.1	Own calculations based on IPH	CHG, Environmental Ministry	Basin	
Consumption	hm^3/year	A.1.1	Own calculations based on CHG	CHG, Environmental Ministry, INE	Basin	
Intermediate consumption	€/year	A.1.3	I/O Tables regional	IEA	Regional	
Gross Value Added	€/year	A.1.4	Regional Accounts	INE	Regional	
Gross fixed capital formation	€/year	A.1.4	Regional Accounts, WB investment series	INE, WB	Regional, National	Investment since 2009 estimated with WB annual investment series.

Clossing stocks of fixed assets	€/year	A.1.4	Water tariff, Administration budget (2004-2008)	Environmental Ministry	Basin	Investment since 2009 estimated with WB annual investment serie.
Water self-service production cost: Groundwater	€/m^3	A.1.5	Ministry Report	Environmental Ministry	Basin	Water cost published by Ministry.
Water self-service production cost: Surface	€/m^4	A.1.5	Water tariff	Environmental Ministry	Basin	Water tariff (yearly).
Water self-sanitation	€/m^5	A.1.5	Survey water services	INE	Regional	Yearly average all sectors.
Government account table	€/year	A.1.6	Administration budget (2004-2008), WB investment series	Environmental Ministry, WB	Regional, National	Expenditure since 2009 estimated with WB annual investment serie.
Specific transfers	€/year	A.1.7	Administration budget (2004-2008), WB investment series	Environmental Ministry, WB	Regional, National	

INE= Instituto Nacional de Estadistica; IECA= Instituto de Estadistica y Cartografia de Andalucia; WB = World Bank; (1) First apparence (2) Assembled to basin limits

In table 2, revenue to cover cost is included based upon the following instruments:

- Water tariff 'canon del agua' is applied by Water Agency at basin level to cover all cost of reservoirs, distribution, policy and management of basin surface resources.
- Utilities recover the cost of distribution, treatment, collection and sewage by the urban water price, utility recover 100% of their services.
- Water User Associations recover their distribution cost as the finance themselves in a cooperative way therefore they should self finance their common services.
- Water levy which is an environmental tax designed to protect water resources, with the objective of guaranteeing supply and quality. The charge is calculated as a function of the water used by domestic and industrial users and is designed as an increasing block tariff. This levy has been applied since 2011. The income from this tax finances mainly sewage and sanitation plants.
- Self-supply farmers and industry support the cost of abstraction (mainly groundwater), distribution, treatment and sanitation (the latest exclusively for industry).

Regarding the cost of water services, the capital and investment costs and operational and maintenance costs are also included in the SEEA-W. Regarding time series, we have always used the most recent information, with the following solutions:

- Annual data for hydrological variables, Gross Value Added, and so on.
- Intermediate consumption based on 20008 I/O tables.
- Public investment and expenditure; 2004-2008 yearly Administration budget (2004-2008) and 2009-2012 estimated based upon WB yearly investment series.

Spatial dimension has been addressed by assigning to basin scale data available at regional or national scale, according to population for industrial and urban data and area for agricultural and other land based activities.

5. Methodology

In this section the methodology for assessing some of the specific methodological development of SYWAG project is summarized. The complete explanation can be found in the pertinent document in the annex. The main innovations have been:

- Hydrological variables related to:
    - Estimation of irrigation water dose and agricultural returns
    - Extraction of soil water by agriculture and forestry
    - Water volume evaporated from reservoirs
    - Water volume evaporated from rivers
    - DBO5 emissions generated by sewerage industry
    - Water Assets Balance

5.a. Methodology for estimation of hydrological variables

In this section the methodology for assessing some of the required hydrological variables is outlined. The complete explanation can be found in the pertinent attached document.

5.a.1. Estimation of irrigation water dose and agricultural returns

A cluster analysis of the irrigated cropland units was conducted in order to predict the evolution of the whole surface and the surface of each cluster in the period of study. These values have helped us to correct the volume obtained applying the method to the year 2008.

The file of the gross water dose applied to the main croplands units (about 160,000 has) every year was used. The total volume of these areas was compared with the average value obtained from the irrigated cropland database. The ratio between these two values was extrapolated to the rest of the units so as to estimate the gross water volume devoted to irrigation. Since the irrigated cropland database is referred to the year 2008, this volume need to be corrected in the way described in the attached document.

The return volume was estimated based on the threshold proposed by the IPH. Next the return volume is split between distribution activity and agriculture, as it is detailed in the attached file.

5.a.2. Extraction of soil water by agriculture and forestry

One of the outcomes of SIMPA model is the monthly rasters of actual ET, which is equivalent to the water extracted by crops and forests. The values included in each zone (rainfed crops, irrigated crops and forested areas) have been added with the shapefiles of the year 2008. These results have been corrected as said before.

5.a.3. Water volume evaporated from reservoirs

The evaporimetric network offers the values of daily evaporated water from reservoirs. Knowing the geometry of the reservoirs it is possible to estimate the water surface and the evaporated volume. After that the ratio of evaporated volume divided by the store water in the reservoirs of the network is assessed. This ratio is applied to the volume stored in the basin which results in the water volume lost by evaporation.

The years in which there is no data a regression curve was fit in order to estimate the variable.

5.a.4. Water volume evaporated from rivers

The evaporation rate measured in the network has been applied to the river water surface. It has been only considered the water surface that takes place on summer as most water loss takes place on this season. To assess the water width a sample of sections has been taken on a summer image of Google Earth. The stationary rivers have been removed from the study as they get dry during summer, therefore the water surface have been estimated only for permanent rivers.

5.a.5. DBO5 emissions generated by sewerage industry

The pollutants contained in urban runoff are collected by the sewerage system; as a consequence this emission is assigned to the sewerage industry. It has been assumed a unitary system for the whole basin that gets the sewerage water and the urban runoff. In order to assess the amount of pollutants (DBO5) that reach the water resources is necessary to estimate the volume of urban runoff that undergoes treatment and that which not.

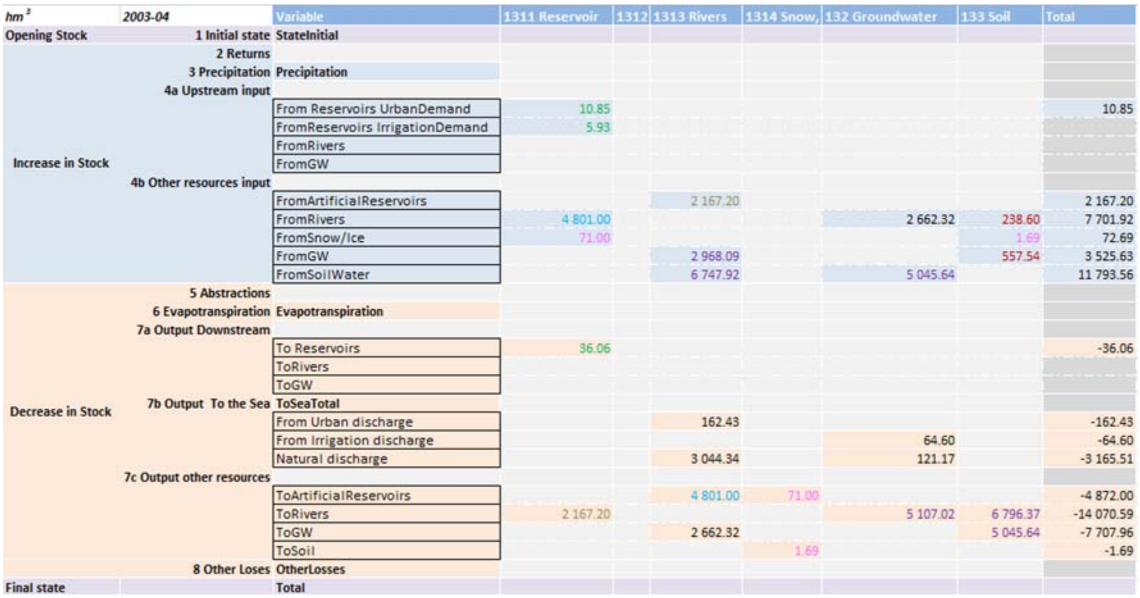
These runoff volumes have been calculated using the urban unitary synthetic hydrograph proposed in Cudworth (1989). The hydrograph has been defined for the city of Cordoba and the calculations were carried out in the same city. The results were extrapolated to the rest of urban surface included in the watershed.

An average value of concentration of DBO5 in urban runoff was taken from several surveys conducted in urban areas in the United States. The concentration after treatment was set based on information issued by the INE.

5.b. Methodology report for Water Assets Balance

The sixth chapter of the SEEAW manual for water accounts determines the definition of accounts and the context and format of the information to be included, while the method proposed below explains the process followed to compile information, process the data, complete the sheets, adjust water balances and asses the results. The complete description of the methodology used is included in the Annex V.

A relevant aspect of the whole process is the origin/destination identification of fluxes between resources. This approach, reflected on the extended structure of the Water assets tables (see figure below), facilitates the correct recognition of resources in accordance with the definitions provided in the Manual.



hm^3	2003-04	Variable	1311 Reservoir	1312	1313 Rivers	1314 Snow,	132 Groundwater	133 Soil	Total
Opening Stock	1 Initial state	StateInitial							
Increase in Stock	2 Returns								
	3 Precipitation	Precipitation							
	4a Upstream input								
		From Reservoirs UrbanDemand	10.85						10.85
		FromReservoirs IrrigationDemand	5.93						
		FromRivers							
		FromGW							
	4b Other resources input								
		FromArtificialReservoirs			2 167.20				2 167.20
		FromRivers	4 801.00				2 662.32	238.60	7 701.92
		FromSnow/Ice	71.00					1.69	72.69
		FromGW			2 968.09			557.54	3 525.63
		FromSoilWater			6 747.92		5 045.64		11 793.56
Decrease in Stock	5 Abstractions								
	6 Evapotranspiration	Evapotranspiration							
	7a Output Downstream								
		To Reservoirs	36.06						-36.06
		ToRivers							
		ToGW							
	7b Output To the Sea	ToSeaTotal							
		From Urban discharge			162.43				-162.43
		From Irrigation discharge					64.60		-64.60
		Natural discharge			3 044.34		121.17		-3 165.51
	7c Output other resources								
		ToArtificialReservoirs			4 801.00	71.00			-4 872.00
		ToRivers	2 167.20				5 107.02	6 796.37	-14 070.59
		ToGW			2 662.32			5 045.64	-7 707.96
		ToSoil				1.69			-1.69
	8 Other Loses	OtherLosses							
Final state		Total							

Figure 1.– Identification of input/ output fluxes depending on their origin/destination.

Taking into account the aforementioned comments, and in order to summarize the methodology proposed for each of these steps, the following paragraphs describe each part. In spite of that, the staple part lies on the data process and adjustment of water balances that are explained in detail.

5.b.1. Specific data gathering

The first step consists of searching for any data required for the variables involve in the balance. Most of the data finally included comes from Official sources such as Guadalquivir River Basin Agent (CHG) with the purpose of keeping results on a reliable basis. Similarly, the permanent reference for the production of balances is the published balances included in the Guadalquivir River Basin Management Plan (PHG), on its annex 6: ‘Water Management Systems and Balances’ of the current.

Several of these sources are not continuous or available, as in the case of ERHIN monitoring records, and needed more or less complex treatment to be suitable for the table’s completion.

A complete reference of the major sources of official data is attached in the last section of the Annex ‘Methodology for Water Balance’.

5.b.2. Data processing

The construction of water balances depends on the correct treatment of hydrological and use & supply data. In this section, only some relevant comments for the balance process are included following the list of required data, as shown below:

1 SIMPA Model:

SIMPA data include all the variables involve in the terrestrial water cycle: rainfall, evapotranspiration, surface runoff, groundwater discharge, total runoff, infiltration and soil water content (SWC). As datasets are provided in a monthly basis, all of them were annually aggregated. In the case of SWC, it represents the initial annual storage of humidity in the soils of the basin. With the exception of the rainfall, evapotranspiration and soil water content, the rest are fluxes between resources that must be included reciprocally, depending on their input /output nature when dealing with each resource balance.

2 Reservoir and Gauge monitoring networks:

Reservoir’s storage records have been measured on a regular basis and represent the most reliable figures of all kind of resources storages. These data could be considered the foundations of the water assets balance.

3 Interaction fluxes:

Gauge stations series were used as assistant reference for both contribution and diversion volumes, due to the lack of disaggregation of the intakes. The estimation of their components is essential because interaction fluxes as the one from reservoir to rivers affects the balance of two resource’s balances. Other variables such as river water levels are used in the calculation of initial state for river resources.

4 Groundwater resources:

There is consistent information about hydrogeological units located in the Guadalquivir basin, on which detailed estimations of each aquifer, their potential resource and their possible interactions are included. Despite this fact, the quantification of their resources faces the lack of continuity of the measurements, and only allows taking average values that could only partly represent the variability of a highly contrasted climate. For this reason, the final balance of aquifers is exposed only in relative terms according to the piezometers’ records.

5 Snow resources:

The balance of water resources from snow is very straightforward because there are neither glaciers nor other important accumulative forms in upper catchments of Guadalquivir river basin (Sierra Nevada). In any case, the destination of the melted water is considered to reach reservoirs without significant losses to soils.

6 Output to the sea:

Guadalquivir’s outlet to the Atlantic forms a complex tidal wetland that overcomes the river far up from Seville. Consequently, the last gauge suitable to identify the solely fluvial discharge of Guadalquivir is that of the Alcalá del Río reservoir. Hence, the river interacts with the alluvial floodplain, marshes and rice fields with so complex patterns that the hypothesis of adding the volume of returns from cultivation and the discharge from the Almonte-Doñana aquifer must be taken with caution. Interannual cycle of flooding and draining of Doñana would answer most of the uncertainty found when dealing with annual water balances.

5.b.3. Balance procedure

The balance procedure involves closing balances for each component of water resources cycle regarding the classification expressed in SEEAW water assets tables: Reservoir ‘1311’, Rivers ‘1313’, Snow & ice ‘1314’, Groundwater ‘132’ and Soil water ‘133’. Lakes subtype is not considered due to the small dimension of this water form in the basin.

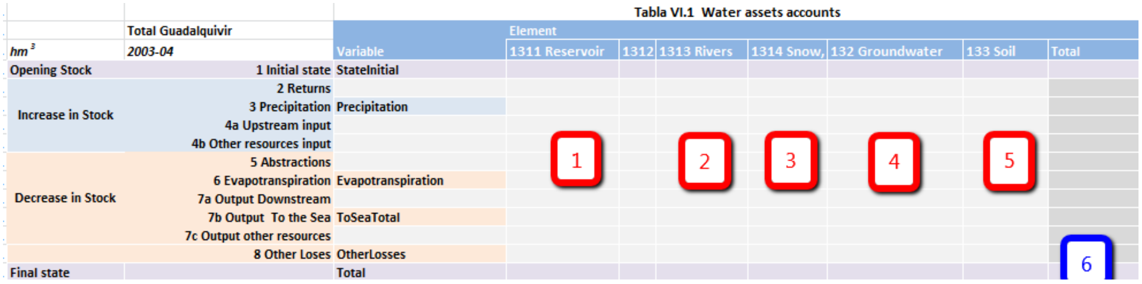


Tabla VI.1 Water assets accounts

	Total Guadalquivir		Element						
hm³	*2003-04*	Variable	1311 Reservoir	1312	1313 Rivers	1314 Snow,	132 Groundwater	133 Soil	Total
Opening Stock	1 Initial state	StateInitial							
Increase in Stock	2 Returns								
	3 Precipitation	Precipitation							
	4a Upstream input								
	4b Other resources input								
Decrease in Stock	5 Abstractions								
	6 Evapotranspiration	Evapotranspiration							
	7a Output Downstream								
	7b Output To the Sea	ToSeaTotal							
	7c Output other resources								
	8 Other Loses	OtherLosses							
Final state		Total							

Figure 2.– Order of balance processes through the different water resources

The premise of keeping temporal continuity must be highlighted, as well as the coherence between resources when affected by interaction fluxes.

The first issue requires completing every input/output with the aim to reach the next year’s initial state figure. Unless the final state have just equal that amount, it will be necessary some adjustment of each individual balance (i.e. reservoir’s column) by assessing the figures of the uncertain fluxes. If there is no possibility to ensure that the interaction’s uncertainty is the responsible of the leftovers, losses assume the remnants. It has been noticed that extreme climatic years tend to provoke larger losses, which might be caused to the lack of understanding about the processes in the basin.

Secondly, continuity must be held within interaction fluxes. Input / output definition clarifies the way of including their volumes in the tables. SIMPA model variables are examples of this mutual accounting: the amount of infiltration that leaves the soil entries the aquifer from soil. Nonetheless, other interactions may vary due to other considerations, like river-aquifer interaction. This only flux, which is apparently well represented from SIMPA model, does not seem to perform so well in those rainy years when the river surpasses the levees.

Floodplains during floods result in large areas where complex interactions between river, soils and aquifer, differ from the predicted by the simplified models. This issue along with the vast Guadalquivir’s lowlands territory explains the significant error range incurred in rivers and groundwater accounts, especially those years when floods occurred.

Soil water also displays some conflicts during the balance closing procedure. In this case due to the lack of monitoring networks or field campaigns. Therefore, uncertainty dominates this resource balance. Despite the fact that some soil water content observations begin to be released from remote sensing publishers (i.e. ESA-SMOS), and in any case, they are not available for the period of study or required very specialized application.

Evapotranspiration account has helped to match the final state of soil water. It is because this variable, calculated through a calibrated method of Thornthwaite performs better than the simple Thornthwaite but still poorer than FAO Penman-Monteith , underestimating the total amount of AE.

Having closed each resource's column, and the final state matches the value of next year initial state, the balance is complete, and only the sums are to be checked.

5.b.4. Conclusions

Once the balances completed, some relevant conclusions should be highlighted from the process.

The method for the balances lies on the reliability of the information available. Balances are built up from the reliable and official values of surface resources, reservoirs and gauge stations, to the uncertain field of groundwater and soil accounts.

Then, the complexity of groundwater behavior complicates the adoption of representative values for its storage and fluxes. This fact, illustrates the need for more integrated monitoring of surface resources with groundwater resources.

To achieve that aim much more effort should be addressed to the study and understanding of interactions between water resources, not only concerning rivers and groundwater but also those related with soil. Remote sensing is thought to solve some of these gaps when their ultimate advances will be available.

The effect of the climatic variability has a significant impact on the reliability of the balances, at least under very wet or very dry conditions when error range increases considerably. The generous contribution of wet years to water storage all through their components (reservoirs, aquifers and soil water) deserves better evaluation, because of its importance in ensuring supply for human activity, as well as their resilience guarantees the survival of ecosystems during long-lasting droughts.

5.c Methodology hybrid accounts

The methodology of the hybrid accounts is presented in Annex IV.

SEEA-Water accounts study the economy of water, that is, describe in monetary terms the supply and use of water-related products and identify:

a) costs associated with the production of these products;
b) income generated by their production;
c) investment in water-related infrastructure and the costs to maintain that infrastructure;
d) fees paid by users for water-related services, as well as the subsidies received.

The economic instruments for managing water, namely, taxes on the use of the resource and permits to access it, are also included in these accounts.

The starting point for studying the economy of water involves presenting the conventional national accounts together with physical information on water abstraction, namely, its supply and use within the economy, and the discharge of wastewater and pollutants into the environment. These accounts are referred to as “hybrid accounts”, where the term “hybrid” refers to the combination of different types of units of measurement in the same accounts. (Tables A1.3 and A1.4).

The presentation of physical and monetary information in the same accounts enables the derivation of consistent indicators for evaluating the impact on water resources of changes in the economy, such as changes in economic structure and in interest rates.

Economic accounts expand the hybrid accounts for:

a) water-related activities carried out for own use, that is, when industries and households abstract water for their own use, or treat the wastewater they generate; (Tables A1.5).
b) government expenditures for water-related services, such as the formulation and administration of government policy and the setting and enforcing of public standards. Even though the value of these activities is likely to be small compared with other activities, the full extent of national expenditures on water can be understood only when all these expenditures are accounted for. (Tables A1.6).

Tables A1.7 and A1.8 present national expenditure and financing accounts for water-related activities classified by purpose. The national expenditure accounts give an indication of the expenditure by resident units on specific activities related to water, such as wastewater and water management. The financing accounts are particularly important because users of water and water-related products do not always pay for the entire costs associated with their use. They benefit from transfers from other economic units (generally governmental) which bear part of the costs. Similarly, investments in infrastructure are also often partly financed by units other than the one that benefits from its use. Analysis of the financing of the use of water and water related products, as well as investments in water-related infrastructure, produces information on how the expenditures are financed: by which agent and by means of what instrument, such as the sale of services or environmental taxes. Such information is relevant, for example, for assessing the implementation of the polluter/user-pays principle, as the accounts for financing show the portion of the total cost paid by the polluter or user.

6. Results and tables exploitation

This chapter will make an overview of the project. Complete set of tables are available for policy makers, authorities and general public so that additional work is always possible from the standard SEEA Water tables. Our objective in this chapter is to provide a summary of main results that are available in Annex I.

This chapter will present three specific results where the hybrid nature of SEEA Water tables allows the exploitation of data for specific needs of water management. The three results are:

a. Exploitation of SEEA Tables for basin characterization
b. Impact of drought through SEEA Tables
c. Assessment of Cost Recovery ratio based on SEEA

The results are a positive outcome of the goals of SYWAG project as our main objective was the use of SEEA Water as a standardized method to develop some of the economic task of the WFD of the Directive (Article 5 Characterization and Article 9 Recovery of costs for water services). Additionally the important issue of economic and environmental drought impact is addressed at basin level based upon the SEEA tables.

6.a Characterization of Water Uses based on SEEA-Water

1. Introduction

Water Framework Directive Art. 5.1 (European Commission 2000) stablish the compulsory analysis of economic water use in every basin. This analysis was carried out in Spain with year 2005 information.

The System of Environmental-Economic Accounting for Water (SEEA-Water) provides a conceptual framework for organizing hydrological and economic information in a coherent and consistent manner. SEEA-Water Tables can be used for characterization of the basin according WFD Art.5. SYWAG Project has developed SEEA-Water tables for years 2004-2012 which are going to be used to the characterization of water uses.

Firstly, it is necessary to define water users. Economics units considered in SEEA-Water are (ISIC rev.4 is shown in brackets):

- Agriculture (1-3).
- Industry (5-33/41-43)
- Energy (35)
- Water Supply:
    - Collection, treatment and supply for urban uses (36)
    - CHG: Confederación Hidrográfica del Guadalquivir (River Basin Authority)
    - WUA: Water Users Associations
- Water Sanitation (37)
- Services (38,39/45-99)
- Households
- Rest of the world

Water Supply (originally ISIC division 36 in SEEA-Water) has been divided in three different economic units. Thus, 36 is water collection, treatment and supply, and correspond to the water for urban, industry and services uses; CHG means water abstracted for 'upper distribution' to several uses, among which are WUA, that involve the last step in the agricultural water supply chain and ISIC division 36. These economic units will be analysed in more detail in Water supply section.

GVA from official sources has been treated to calculate GVA by economic unit considered in SEEA-Water in table 1.

Table 1. GVA[1] according SEEA-W sectors 2004-2012 (mill €)

SECTOR	ISIC	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agriculture	1-3	3,786	3,373	3,219	3,532	3,287	3,127	3,466	3,359	2,961
Industry	5-33/41-43	13,110	15,088	16,574	17,740	16,600	14,799	13,020	12,922	11,581
Energy	35	865	968	1,014	1,061	854	750	810	857	787
Water-Supply	36	319	357	374	391	315	276	298	316	290
	CHG	0	0	0	0	0	0	0	0	0
	WUA	0	0	0	0	0	0	0	0	0
W-Sanitation	37	334	374	391	409	330	290	313	331	304
Services	38,39/45-99	35,222	37,092	40,251	43,793	46,775	47,389	46,729	47,690	48,581
	Total	53,636	57,251	61,823	66,926	68,160	66,632	64,636	65,473	64,503
Rest of the world		4,802	4,885	5,222	5,703	6,160	6,335	6,406	6,535	6,686
	TOTAL	58,437	62,136	67,045	72,629	74,320	72,967	71,042	72,008	71,189

Source: SYWAG Project Table A1.4

---

[1] GVA showed does not take into account any correction due to subsidies in order to not modify official data. However, GVA before 2006 include direct subsidies that are not take into account after that year because decoupled agricultural subsidies does not take part in GVA.

SEEA-Water table *A1.1 Standard physical supply and use table for water (A)* provide us all data about use of water, water abstractions, supply of water and water consumption among other variables. It is necessary to clarify the difference between use and consumption. Use is the amount of water utilised in a sector, not necessarily lost, while consumption is the amount of water that does not return to either water resources or sea. Therefore, consumption will be the result of subtracting returns of water into the environment from use. In the sections that follows, it will be asses all these variables.

2. Use of water

The total use of water in GRB in 2012 was 47,961 hm^3, which is the sum of the individual uses of water by each sector. A particular quantity of water may be used more than once. For example, the River Basin Authority abstracts water that is accounted as use. After that, this water is distributed to other economic units as Water Users Associations (WUA) of energy sector, that use the water supplied. So the total use of water does not represent water abstractions or consumption, but only the sum of uses of water along the cycle. Table 2 came from SEEA-Water table A1.1 and shows the use of water by each sector for the considered years.

Table 2. Use of water by economic units 2004-2012 (hm^3)

SECTOR	ISIC	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agriculture	1-3	31,549	18,811	28,277	29,592	28,095	28,661	31,710	31,344	21,730
Industry	5-33/41-43	94	99	95	86	83	70	69	68	68
Energy	35	10,139	10,139	10,139	10,139	10,139	10,139	10,139	10,139	10,139
W-Supply	36	600	625	559	540	529	532	493	488	488
	CHG	12,558	13,097	11,879	11,808	11,863	12,372	12,455	12,359	12,729
	WUA	1,758	2,220	1,149	1,095	1,153	1,637	1,734	1,652	2,012
W-Sanitation	37	810	579	687	680	650	585	817	707	455
Services	38,39/45-99	98	109	96	83	79	70	63	63	63
Households		325	342	315	281	282	285	264	261	261
Rest of the world		17	17	17	17	17	17	17	17	17
TOTAL		57.946	57,946	46,036	53,212	54,322	52,891	54,368	57,760	57,097

Source: SYWAG Project Table A1.1

3. Water abstraction

SEEA-Water table A1.1 also include information about water abstraction as part of use of water. In this sense, it has to be taking into account soil water. Soil water is not provided by supply chain, but is abstracted directly from environment. This is the reason of the high water quantity abstracted by agriculture. Total abstraction without soil water (blue water only) is shown at the bottom of table 3.

Table 3. Water abstraction by economics units 2004-2012 (hm^3)

SECTOR	**ISIC**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Agriculture	1-3	29,778	16,574	27,111	28,481	26,925	27,008	29,960	29,675	19,702
Industry	5-33/41-43	36	36	36	36	36	36	36	36	36
W-Supply	36	77	80	72	69	68	68	63	63	63
	CHG	12,541	13,080	11,862	11,791	11,847	12,355	12,438	12,342	12,712
Sanitation	37	425	168	312	349	324	274	529	422	171
Total		42.857	42,857	29,939	39,392	40,727	39,199	39,741	43,026	42,538
Total (blue water only)		13.876	13,876	14,551	12,839	12,787	12,823	13,540	13,868	13,714

Source: SYWAG Project Table A1.1

Table 4 considers the abstracted water for each end use, without regard to soil water and considering only the uses agriculture, industry, energy, services and households, plus rest of the world.

Table 4. Water abstraction by final user 2004-2012 (hm^3)

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Agriculture	2,567	3,406	1,707	1,636	1,702	2,443	2,536	2,503	3,129
Industry	94	99	95	86	83	70	69	68	68
Energy	10,139	10,139	10,139	10,139	10,139	10,139	10,139	10,139	10,139
Services	98	109	96	83	79	70	63	63	63
Household	325	342	315	281	282	285	264	261	261
Rest of the world	36	46	38	45	43	47	54	60	60
TOTAL	13,259	14,140	12,389	12,270	12,328	13,055	13,125	13,094	13,719

Source: SYWAG Project Table A1.1

4. Supply of Water

SEEA-Water table A1.1 present a second table (B) showing physical supply in a wide sense, not only to other economic units but also to environment (in form of returns). Table 5 shows water volume mostly supplied to other economic unit (in white) or mostly returned to environment (in green). SEEA-Water tables also provide information about flows of water within economic units. In this sense it can be noted that CHG is the main supplier to Energy and Water Users Associations, associations that at the same time supply to agriculture.

Table 5. Supply of water 2004-2012 (hm^3)

SECTOR	ISIC	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agriculture	1-3	113	189	63	57	67	100	115	113	150
Industry	5-33/41-43	62	66	63	55	53	43	42	41	41
Energy	35	10,108	10,108	10,108	10,108	10,108	10,108	10,108	10,108	10,108
W-Supply	36	600	625	559	540	529	532	493	488	488
	CHG	12,558	13,097	11,879	11,808	11,863	12,372	12,455	12,359	12,729
	WUA	1,758	2,220	1,149	1,095	1,153	1,637	1,734	1,652	2,012
Sanitation	37	810	579	687	680	650	585	817	707	455
Services	38,39/45-99	78	87	77	67	63	56	51	50	50
Households		26,086	26,970	24,584	24,410	24,488	25,433	25,814	25,518	26,033
Rest of the world		36	46	38	45	43	47	54	60	60
TOTAL		26,382	27,289	24,873	24,680	24,756	25,708	26,080	25,787	26,302

Source: SYWAG Project Table A1.1

5. Water consumption

As explained earlier, the concept of water consumption gives an indication of the amount of water that is lost by the economy during use, in the sense that the water has entered the economy but has not returned to either water resources or the sea. This happens during use because part of the water is incorporated into products, evaporated, transpired by plants or simply consumed by households or livestock. The difference between the water use (row ‘Total’ in table 2) and the water supply (row ‘Total’ in the table 5) is referred to as water consumption. Again, we have to take into account soil water. In this sense, water consumption without soil water (total blue water use – water supplied) is shown at the bottom row in table 6.

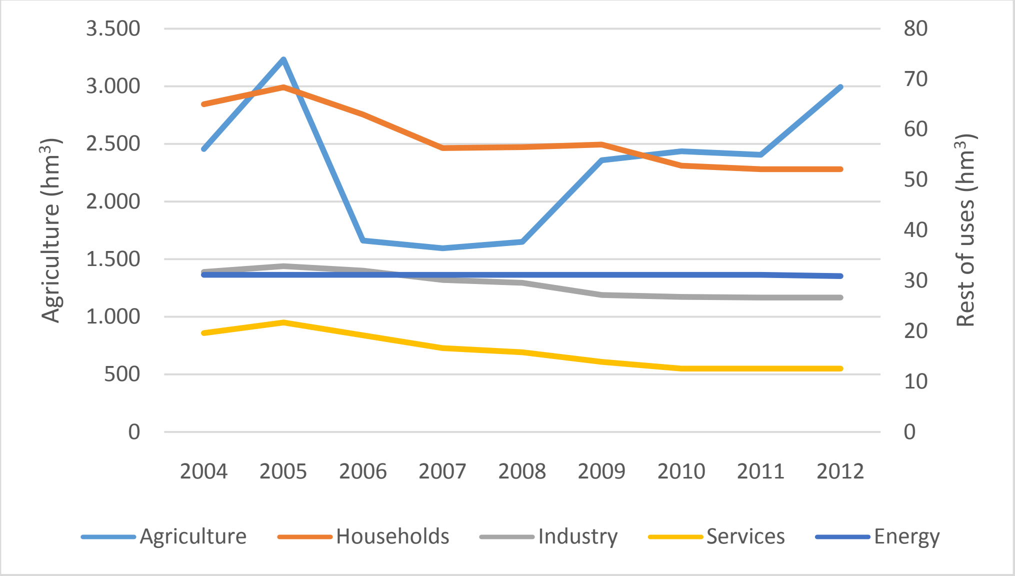
Table 6. Water consumption 2004-2012 (hm^3)

SECTOR	ISIC	2004	2005	2006	2007	2008	2009	2010	2011	2012
Agriculture	1-3	31,436	18,621	28,214	29,535	28,027	28,561	31,595	31,230	21,580
Industry	5-33/41-43	32	33	32	30	30	27	27	27	27
Energy	35	31	31	31	31	31	31	31	31	31
Services	38,39/45-99	20	22	19	17	16	14	13	13	13
Households		65	68	63	56	56	57	53	52	52
TOTAL		31,564	18,747	28,339	29,641	28,134	28,660	31,681	31,310	21,659
TOTAL (blue water only)		2,602	3,387	1,806	1,730	1,784	2,489	2,561	2,529	3,117

Source: SYWAG Project Table A1.1

Total consumption quantity only considering blue water in agriculture sounds more familiar to whom has analysed the basin. As far as consumption is concerned, water for agricultural purposes was 96% of total consumption in 2012. Figure 1 shows graphically the water consumption evolution throughout the series without taking into account soil water. Figure 1 reveals that there has been a decrease in households, industry and services uses (2.5%, 1.9% and 4.9% yearly respectively), while agriculture water consumption varies depending on precipitations.

Figure 1. Water consumption (blue water only) 2004-2012 (hm^3)



Source: SYWAG Project Table A1.1

6. Emissions

SEEA-W table A1.2 provides information about emissions into water, i.e., flows of pollutants added to wastewater that discharge into water resources. Net emission in 2012 was 10,961 hm^3 and 107,180 t DBO_5.

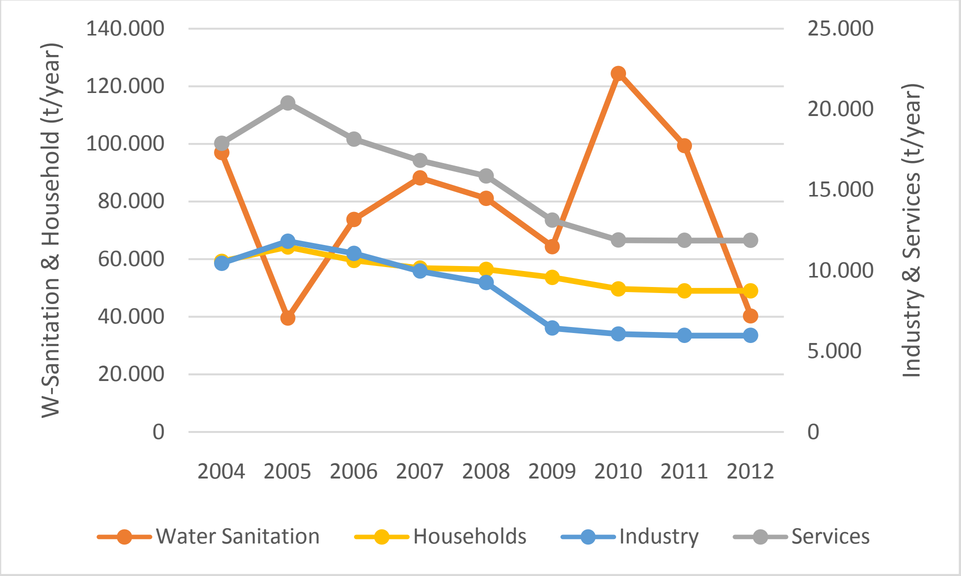
Table 7. Net emissions of DBO_5 2004-2012 (t/year)

SECTOR	ISIC	2004	2005	2006	2007	2008	2009	2010	2011	2012
Industry	5-33/41-43	10,450	11,824	11,065	9,973	9,259	6,440	6,081	5,985	5,985
Sanitation	37	97,015	39,537	73,781	88,219	81,095	64,359	124,480	99,409	40,274
Services	38,39/45-99	17,887	20,390	18,148	16,824	15,870	13,129	11,903	11,875	11,875
Households		59,277	64,212	59,598	56,899	56,503	53,669	49,725	49,046	49,046
TOTAL		184,628	135,963	162,592	171,915	162,727	137,597	192,189	166,315	107,180

Source: SYWAG Project Table A1.2

Evolution of DBO_5 clearly show a gradual decline in the quantity of pollutants discharged to water flows. This fact may be the consequence of the Programme of Measures of the last River Management Plan. Nevertheless, water sanitation markedly vary depending on precipitation. It can be seen how 2005 and 2012, that were very dry years and 2004, 2010 and 2011 that were very wet years, are clearly correlated with water sanitation discharges.

Figure 2. Evolution of net emissions of DBO_5 2004-2012 (t/year)



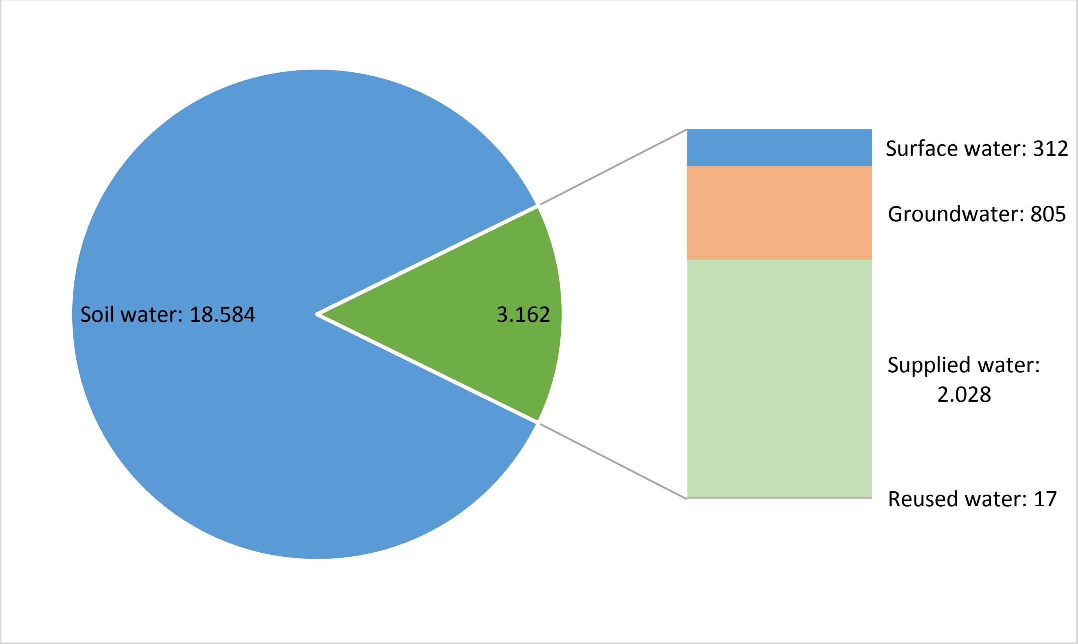
Source: SYWAG Project

7. Analysis by use

7.1. Agriculture

SEEA-Water incorporated a concept not usually included in the water use analysis. That is soil water. Soil water could be defined as the water evapotranspirated by crops both in rain-fed and irrigated agriculture (and by pastures and trees in forest areas) that comes from precipitation. This fact makes water use very high. In figure 3 it can be analysed water use source with and without soil water.

Figure 3. Agricultural use of water sources (2012)

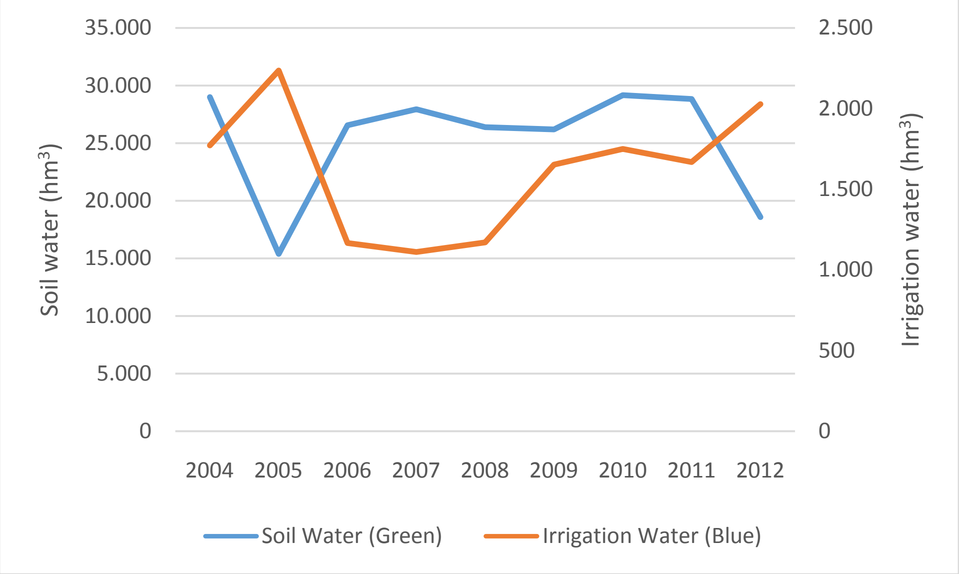


Source: SYWAG Project Table A1.1

Taking into account soil water, agriculture represent 45% of total use of water in 2012 (see table 2), but it can vary from 41% to 55% depending on soil water used (Table 2). Without soil water, agriculture vary from 6% to 11% of total use of water. It should be note that water has many uses along the water cycle and agriculture is only one of the last steps. Assigning abstractions to its end users, agriculture supposed around 20% of total abstractions (only blue water, see Table 4). However, regarding consumption agriculture represented 96% of total blue water (without soil water) consumption in 2012, and varied slightly from 92% since 2004 (Table 6).

Rain-fed agriculture, with approximately 2,100,000 ha produces 23.3% of GVA, while irrigation agriculture, with only 854,056 is responsible for 63.8% of final agriculture and livestock GVA. Soil water not only concern rain-fed agriculture, but also use of water in irrigated land from precipitation. Soil water is the main source for agricultural use. It has to be notice that despite the fact that supplied water is a small part of the total water use in agriculture (Figure 4), it plays an essential role in final output along with surface water and groundwater. Regarding irrigated lands, soil water suppose approximately 62% of water, while 38% is blue water (water abstracted for own use or supplied by Water Users Associations). Although blue water is less than green water, it is supplied at critical moments, significantly raising the final value of agricultural production.

Figure 4. Relation between Soil Water and water supplied by WUA



Source: SYWAG Project

It can be seen a clear relation between Soil water and irrigation water: when soil water is scarce, water from WUA is high. Year classification can be determined from figure 4 because soil water is determined by precipitation and WUA by the water supplied from storage. In this way, it can be drawn the following classification:

- 2005 and 2012: very dry year with full irrigation
- 2006, 2007 and 2008: restricted irrigation but with enough soil water
- 2004, 2009, 2010 and 2011: Normal years with full irrigation

As discussed above, blue water is essential for final production, and in order to point out this relevance, we are going to construct a monetary-consumption ratio. SEEA-Water is by definition a hybrid accounting system so that yields economic and hydrologic data. When economic and hydrological data is confronted some indicators measured as ratio "GVA/consumption" can be estimated, a summary is shown in table 8. This ratio can be defined as apparent water productivity (value added per consumed water). This ratio serves to underscore the importance of blue water, despite its importance in quantity is less than the green water. This analysis will be expanded in chapter 7b.

Table 8. Apparent productivity of water Guadalquivir 2004/2008 (GVA/consumption)

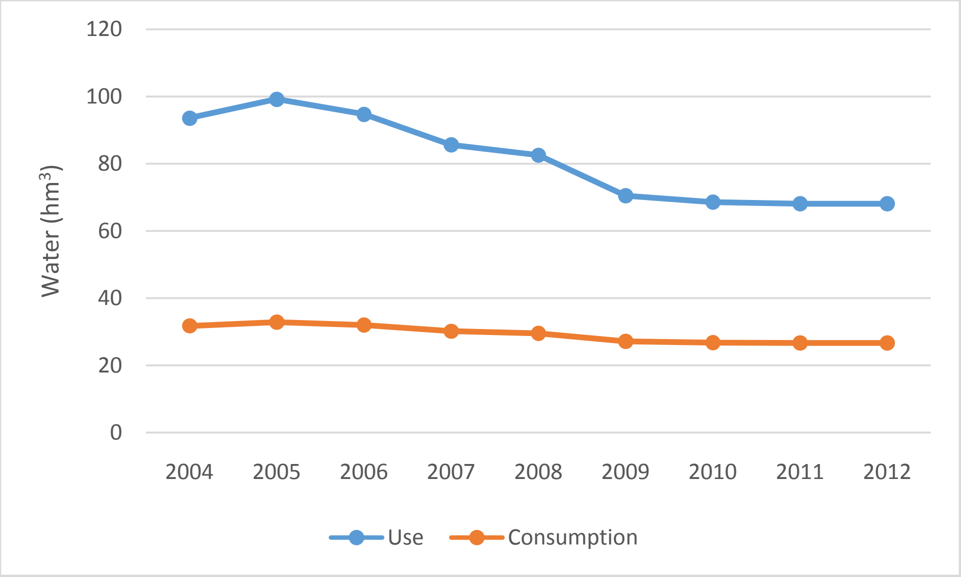
GVA/consumption (EUR/m^3)	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Mean**
Total Agriculture/ (Green + Blue Water)	0.15	0.22	0.13	0.13	0.13	0.12	0.12	0.11	0.14	0.14
Forest + Livestock (Green Water)	0.06	0.09	0.05	0.05	0.05	0.05	0.04	0.04	0.05	0.05
Rain-fed (Green Water)	0.07	0.13	0.07	0.07	0.07	0.06	0.06	0.06	0.08	0.07
Irrigation Blue Water only	1.21	0.79	1.42	1.58	1.37	0.91	0.96	0.91	0.63	1.09
Total Irrigation Water (Green + Blue)	0.47	0.48	0.42	0.44	0.40	0.34	0.33	0.31	0.34	0.39

Source: SYWAG Project

7.2. Industry

Industry is less than 1% of total use of water in the Guadalquivir and approximately 1% of total consumption. Consumption averages 36% of the total use in the period, ranging from 33% (in 2005) to 39% (2009-2012). Years with more consumption percentage match with year with less total use. Both total use and consumption have decreased in the period analysed, but use has dropped more sharply than consumption, that only has decreased slightly. The decrease in water consumption may be due to economic crisis. The different slope of these two curves make evident the improvement in water efficiency by industry sector.

Figure 5. Industry use and consumption of water 2004-2012 (hm^3)



Source: SYWAG Project

In 2012, almost 50% of water used by industry was abstracted directly by industry for its own use (36 hm^3). This amount has remain stable throughout the period analysed, so industry has reduce water supplied by supply sector.

Regarding emissions, 16 hm^3 are discharged directly to water masses by industry after on-site treatment, amount that has remain constant in the period. Obviously, if use of water has decrease faster than consumption, discharges have decreased throughout the period.

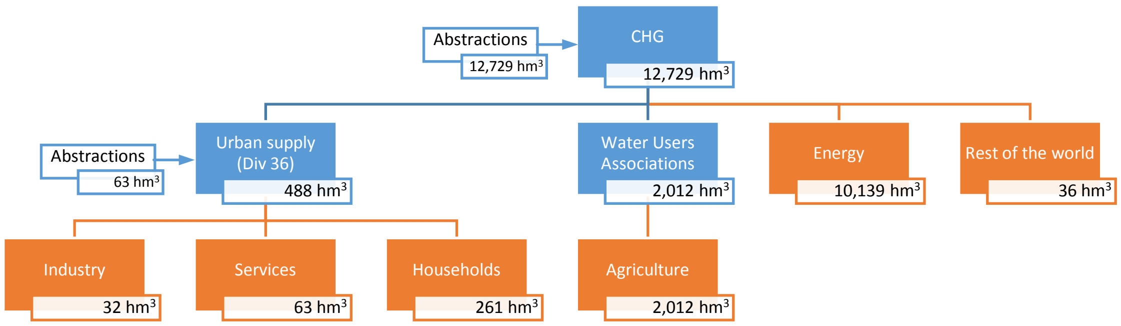
7.3. Energy

Energy sector use large amounts of water but only consume a small proportion. 10,139 hm^3 are supplied by river basin authority to energy sector every year, but only 31 hm^3 are consumed. Use of water by energy sector represented 21% of total use of water in 2012, but 17-19% in meteorologically normal years. It also represent 38 to 41% of supplied water but as pointed out above, only represent less than 0.2% of total consumption in the basin. This water is used in hydroelectricity power generation and in cooling water for thermal power generation. Water for hydroelectricity power generation is returned immediately to environment after used without alteration, but cooling water may induce thermal pollution.

7.4. Water Supply

As was mentioned in previous sections, water supply has been divided in three different economic units. River basin authority (CHG) is responsible for water storage and supply water to other agents. Collection, treatment and supply ISIC division 36 correspond to the economic unit that receives water from CHG and after treatment supplies to industry and service sector and households. Finally, Water Users Associations, which is supplied by CHG, supply water to farmers. So, at the top of the diagram is CHG that supply to ISIC division 36 for urban uses and to WUA for agricultural uses. CHG abstraction is known as ‘upper distribution’, while distribution of water by urban division 36 and by WUA are known as ‘lower distribution’. Figure 6 shows the diagram of water suppliers (blue boxes) and water end users (oranges boxes). Signalled amounts represent water supplied (blue boxes) or received (oranges boxes).

Figure 6. Scheme of water abstraction and distribution 2012



Water supply economic units does not consume water. They only abstract or receives water in order to supply to other economic units. Nevertheless, they has some returns to environment.

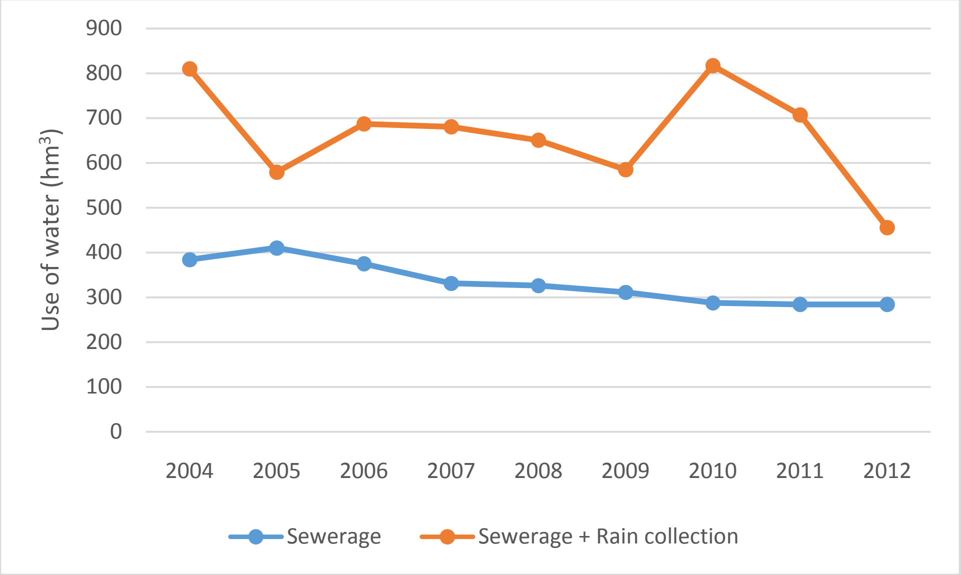
7.5. Sanitation

Water sanitation (ISIC division 37) uses water after another water user has discharged to sewerage. Water sanitation is also responsible for collecting rainwater in urban areas.

Water from sewerage is supplied to a treatment facility and after that discharged into the environment. Sewerage include wastewater from industry, urban services and households. Figure 7 shows use of water both from sewerage and rain collection. It can be seen a decrease in the amount of water from sewerage along the period, and an irregular abstraction of water from rainwater. As analysed above, the decrease in use of water by industry contribute to a decrease in wastewater in sewerage. 2012 was the year with less use of water throughout the period with 455 hm^3, of which 284 hm^3 came from sewerage and only 171 hm^3 from rainwater collection because of drought.

Water use by sanitation sector has two final destinations. On the one hand, every year 17 hm^3 from treatment facilities are used by agriculture as reused water; on the other hand, the remaining water is discharged to environment.

Figure 7. Use of water sanitation and sources 2004-2012 (hm^3)

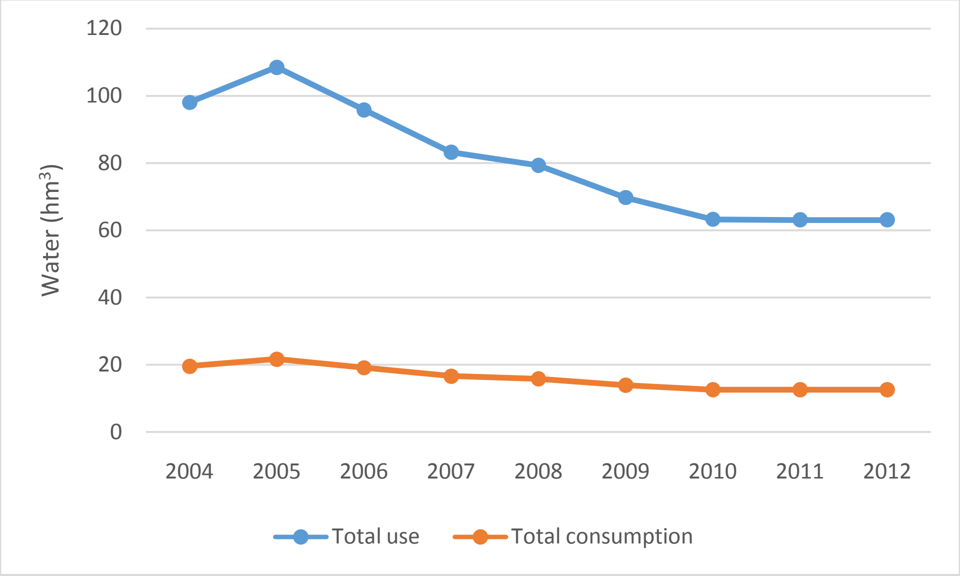


Source: SYWAG Project

7.6. Services

Service industries are supplied by division 36: water collection, treatment and supply, consume a small proportion of supplied water and discharge wastewater to sewerage. From 2005 a decreased both in water use and water consumption can be observed in service industries (see figure 8). Economic crisis may be link to a decrease in consumption after 2008 but decrease in use of water is stronger than consumption, suggesting an improvement in water use efficiency.

Figure 8. Service industries use of water and consumption 2004-2012 (hm^3)

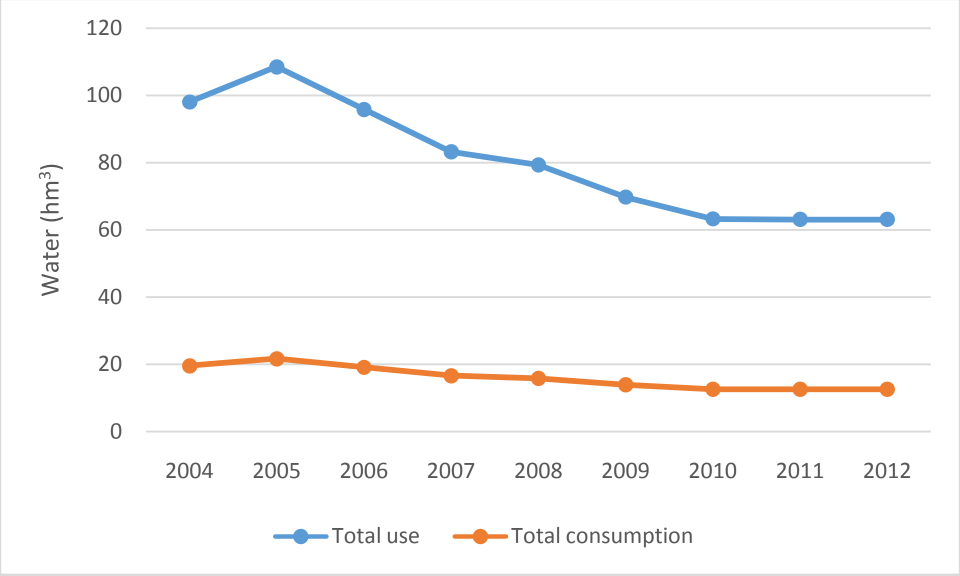


Source: SYWAG Project

7.7. Households

In 2012, the 4,107,598 inhabitants in Guadalquivir River Basin used 261 hm^3 supplied by ISIC division 36, collection, treatment and supply of water. It should be noted that the physical supply of water by households generally represents a flow of wastewater to ISIC division 37, sewerage. Households consumption is 20% of water supplied, which represented between 1.7% and 3.5% of total water consumption in the basin. Nevertheless, it should be noted that households is a priority user, and in case of drought, households have full guaranteed water supply (99.8% probability). Figure 9, in line with previous analysis, shows how use of water by households has decreases steadily since 2005.

Figure 9. Evolution of households use and consumption of water 2004-2012 (hm^3)

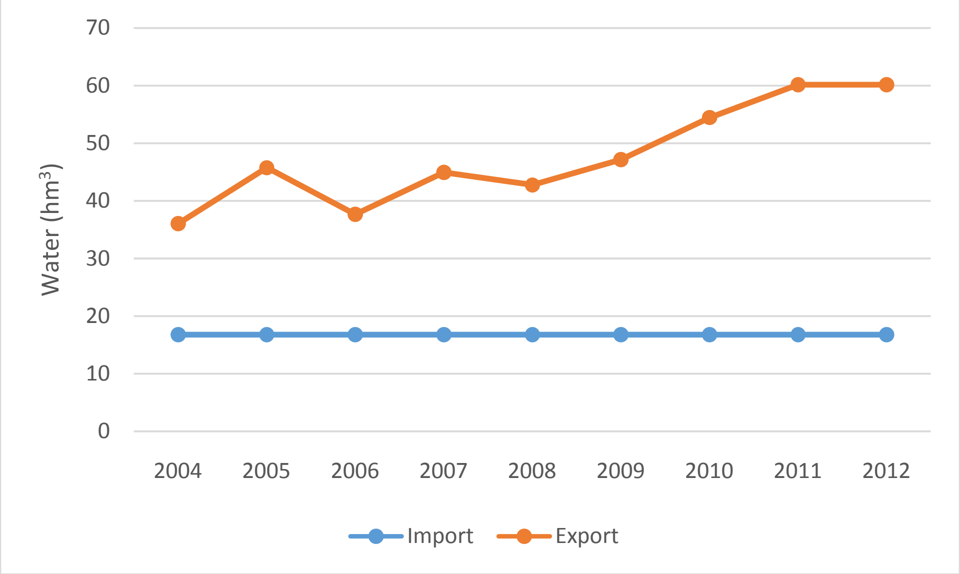


Source: SYWAG Project

7.8. Rest of the world

There are two flows of water between Guadalquivir River Basin and rest of the world. Every year 17 hm^3 are supplied by CHG which origin is outside the basin. In the other hand, there is a water export through Negratín-Almanzora transfer to another basin. Figure 10 shows this water transfer to Andalusian Mediterranean Basins. Despite the fact that 2006 to 2008 were dry years, water transfers were possible thanks to inter-basins water market.

Figure 10. Water import and export 2004-2012 (hm^3)



Source: SYWAG Project

8. Concluding remarks

As we can see the use of tables for characterization has many advantages for the standardization of reporting procedures in the WFD implementation of Art 5 characterization.

- A common requirement of information
- A common presentation (standard tables)
- Common definitions (SEEA handbook)
- Hybrid tables: economic and physical tables
- Use of officials published sources
- Easy revision in following cycles

In general, all urban water final uses, including industry, services and household have decrease both use of water and consumption, and the later more than proportional to the former. These decreases may be linked to the Programme of Measures proposed in the previous Basin Management Plan.

9. References

Argüelles, A., Berbel, J. and Gutiérrez-Martín, C. (2012). La evolución de la Cuenca del Guadalquivir (España), *Revista de Obras Públicas* 159 (3537), 51-64.

Berbel, J., Gutiérrez-Martín, C., Rodríguez-Díaz, J.A., Camacho, E. and Montesinos, P. (2014). Literature Review on Rebound Effect of Water Saving Measures and Analysis of a Spanish Case Study, *Water Resources Management*1-16.

Berbel, J., Kolberg, S. and Martin-Ortega, J. (2012). Assessment of the Draft Hydrological Basin Plan of the Guadalquivir River Basin (Spain), *International Journal of Water Resources Development* 28, 43-55.

Berbel, J., Mesa-Jurado, M.A. and Piston, J.M. (2011). Value of Irrigation Water in Guadalquivir Basin (Spain) by Residual Value Method, *Water Resources Management* 25, 1565-1579.

Berbel, J., Pedraza, V. and Giannoccaro, G. (2013). The Trajectory Towards Basin Closure of a European River: Guadalquivir, *International Journal of River Basin Management* 11(1), 111-119.

Confederación Hidrográfica del Guadalquivir (2005). Acuerdo por el Agua en la Cuenca del Guadalquivir.

Confederación Hidrográfica del Guadalquivir (2010). Propuesta de Proyecto de Plan Hidrológico de la Demarcación Hidrográfica del Guadalquivir.

Confederación Hidrográfica del Guadalquivir (2014). Propuesta de Proyecto de Revisión del Plan Hidrológico de la demarcación del Guadalquivir (2º ciclo).

Consejería de Agricultura y Pesca. Junta de Andalucía (2010). Agenda del Regadío Andaluz. Horizonte 2015., Sevilla.

European Commission (2000). Water Framework Directive.

MARM - Ministerio de Medio Ambiente y Medio Rural y Marino (2006). Plan de choque de modernización de regadíos. Real Decreto 287/2006, de 10 de marzo.

Mesa-Jurado, M.A., Berbel, J. and Orgaz, F. (2010). Estimating marginal value of water for irrigated olive grove with the production function method, *Spanish Journal of Agricultural Research* 8, S197-S206.

6b Analysis of Guadalquivir droughts 2004-2012 based on SEEA-W tables[2]

1. Introduction

Droughts create periods of water scarcity that affect all urban, industrial, and agricultural water supply systems, and they disturb the flow of environmental services. This research is focused on the economic analysis of droughts. The Water Framework Directive (WFD) establishes a legislative framework for Community action in the field of water policy, aiming at improving and protecting the status of water bodies along Europe. The WFD also provides general criteria to consider drought impacts in the state of water bodies.

The Drought Management Plans (DMPs) are regulatory instruments that establish priorities among the different water uses during droughts, being usually agriculture the lowest priority behind environmental flows, urban and industry uses. DMP have recently become widespread across EU Southern basins (EC, 2008). Estrela & Vargas (2012) present a general overview of drought management in the European Union, review scientific and technical advances, as well as the status of implementation of policy tools and focus on drought management plans.

In a recent review on the evaluation of costs of natural hazards, Meyer et al (2013) present the state of the art of cost analysis. The studies documenting the economic losses due to droughts are scarce, and the analysis differs in their scope and the used methodology. To estimate direct tangible costs, different proposals can be found in the literature: a) Single and Multi-parameters models; b) Market price method; c) Biophysical-Agroeconomic Models; d) Hydrological-Economic Models and e) Computable General Equilibrium Models. Regarding direct damages in agricultural production there has been a growing interest in the literature over the last decade in Insurance Based on Meteorological Indices (IBMIs) as cost-efficient solution to farmers.

Indirect tangible costs are the result of the direct impact over affected sectors (agriculture, industry, etc.), spread downstream (services, supplies, etc.) and upstream (industry, etc.). There are intangible costs which are non-market costs, either of environmental assets or by social losses measured as reduction in welfare of affected agents. A complete assessment of drought losses is done by Martin-Ortega and Markandya (2009).

---

[2] Una versión previa de este capítulo ha sido publicada en "Borrego-Marín et al (2015) Analysis of Guadalquivir droughts 2004-2012 based on SEEA-W tables. Conference on Drought. Valencia March 2015"

Our approach is innovative as it will try to assess the impact of drought in agricultural production and, if possible, indirect impact through the analysis of SEEA-W tables.

2. SEEA-W tables and methodology

The System of Environmental-Economic Accounting for Water "SEEA-Water", United Nations - DESA (2012) provides a conceptual framework for organizing hydrological and economic information in a coherent and consistent manner. It has been developed by Department of Economic and Social Affairs of the United Nations Secretariat with the support of other institutions. This is a key issue, as the origin is economics and the nature of the accounts is hybrid. In our opinion Water Accounts give the analyst the opportunity for facilitate analysis for both dimensions, economic and physical.

European Commission is working in a Guidance document on water balances Draft-v1.0 (European Commission, 2014) with the aim to standardize economic information regarding water use in Europe, therefore facilitating WFD reporting. Despite of the interest of SEEA methodology, applications to European basin and regions are scarce.

SEEA-Water comprises the five categories of accounts:

Category 1: Physical supply and use tables and emission accounts.

This category of accounts brings together hydrological data on the volume of water used and discharged back into the environment by the economy, as well as the quantity of pollutants added to the water. It provides information on the volumes of water exchanged between the environment and the economy (abstractions and returns) and within the economy (supply and use within the economy).

Category 2: Hybrid and economic accounts.

These accounts are referred to as “hybrid” flow accounts in order to reflect the combination of different types of measurement units in the same accounts. In these accounts, physical quantities can be compared with matching economic flows, for example, linking the volumes of water used with monetary information on the production process, such as value added, and deriving indicators of water efficiency.

Category 3: Asset accounts.

This category of accounts comprises accounts for water resource assets measured mostly in physical terms. Asset accounts measure stocks at the beginning and the end of the accounting period and record the changes in the stocks that occur during the period. They describe all increases and decreases of the stock due to natural causes, such as precipitation, evapotranspiration, inflows and outflows, and human activities, such as abstraction and returns. These accounts are particularly useful because they link water abstraction and return to the availability of water in the environment, thus enabling the measurement of the pressure on physical water induced by the economy.

Category 4: Quality accounts.

This category of accounts describes the stock of water in terms of its quality. It should be noted that the quality accounts are still experimental. Quality accounts describe the stocks of water resources in terms of quality: they show the stocks of certain qualities at the beginning and the end of an accounting period. Because it is generally difficult to link changes in quality to the causes that affect it, quality accounts describe only the total change in an accounting period, without further specifying the causes.

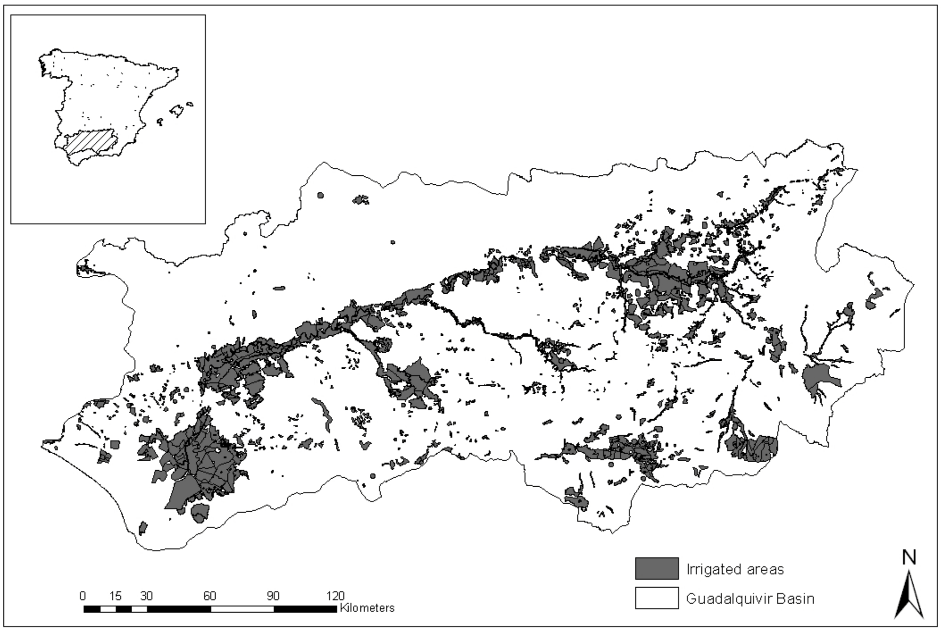
Category 5: Valuation of water resources.

The final category of the SEEA-Water accounts comprises the valuation of water and water resources. With regard to the quality accounts, this category of accounts is still experimental; there is still no agreement on a standard method for compiling them.

3. Case study: Guadalquivir basin 2004-2012

The Guadalquivir River is the longest river in southern Spain with a length of around 650 km. Its basin covers an area of 57,527 km^2 and has a population of 4,107,598 inhabitants (see Figure 1 for a map of the basin). The basin has a Mediterranean climate with a heterogeneous precipitation distribution. The annual average temperature is 16.8°C, and the annual precipitation averages at 573 mm, with a range between 260 mm and 983 mm (standard deviation of 161 mm). The average renewable resources in the basin amount to 7,043 (arithmetic mean) and 5,078 GL/year (median), ranging from a minimum of 372 GL/year to a maximum of 15,180 GL/year (Arguelles *et al.*, 2012). In a normal year a potential volume of around 8,500 GL can be stored through a complex and interconnected system of 65 dams. The main land uses in the basin are forestry (49.1%), agriculture (47.2%), urban areas (1.9%) and wetlands (1.8%).

Figure 1: Guadalquivir basin



Regarding our project, it is interesting to note that agriculture is the main user in the basin and it has implemented an intense investment in water saving measures called 'modernization' (MARM, 2006). The analysis of the Hydrological Basin Plan of the Guadalquivir River Basin (Spain) is done in Berbel et al (2012). Berbel et al (2014) make an analysis of evolution of the main indicators for a sample of irrigation water user association where water saving investment (modernization) has been done during the period of analysis 2004-2012 including the impact of the modernization on water use and cost.

Generally, farmers' adaptation to water supply limitations in water scarce regions is to cultivate crops with supplementary or deficit irrigation, (i.e. annual water application is smaller than annual irrigation water requirements for maximum yield). This ratio (water application/water requirements) is known as Relative Irrigation Supply (RIS). The level of scarcity of water resources in the basin as the average dose is 3,490 m3/ha, versus Potential Evapotranspiration (PETmax) needs of 4,919 m3/ha, resulting in an average RIS of 0.70, (i.e. the irrigation doses in Guadalquivir is 70% of PETmax on the average), Berbel et al (2011) analyse RIS values and consequences for economic of irrigation.

Water rights need to be allocated by Administration in a dynamic world, i.e. considering not only 'average values' but rather it should consider the uncertainty in yearly water resources. In Spanish normative, both groundwater and surface water are allocated with a 'probabilistic nature', i.e. urban users have a water right volume allocated with a 99.8% probability of obtaining this volume, while irrigators are allocated a water right that can be guaranteed in 90% of the years. This implies that years with low resources (drought) the priority uses are environmental flow and urban which get the full quota / environmental flow whereas irrigation is legally a second priority and in drought years it may see the quota partially or totally reduced. Guadalquivir River Basin Authority (2007) has implemented a drought management plan (DMP) that has been applied in the last recent period of drought 2005-2008 and we will see the effects in the reduction of irrrigation quota in the SEEA accounts. The period to be analysed will be 2004-2012, this reference period has the following relevant features:

d) The period starts before implementing water saving measures and before the last period of drought (2004)
e) Includes last severe drought (2005-2008)
f) Ends after some water saving measures have been implemented and impact can be observed (2009-2012)

Next section details meteorological and hydrological data in the basin during the period under study.

4. Meteorological and hydrological drought in Guadalquivir basin 2004-2012

Implementation of SEEA-W tables requires good quality for hydrological and economic data. Our research has selected 9 years including dry and wet years. Description of characteristics are given in Table 1.

Table 1: Hydrologic characteristics of Guadalquivir 2004-2012

Year	Rain (mm)	Irrigation (mm)	Rain %	Irrigat. %	Comments
2003/4	730	343	126%	123%	Wet year, full irrigation

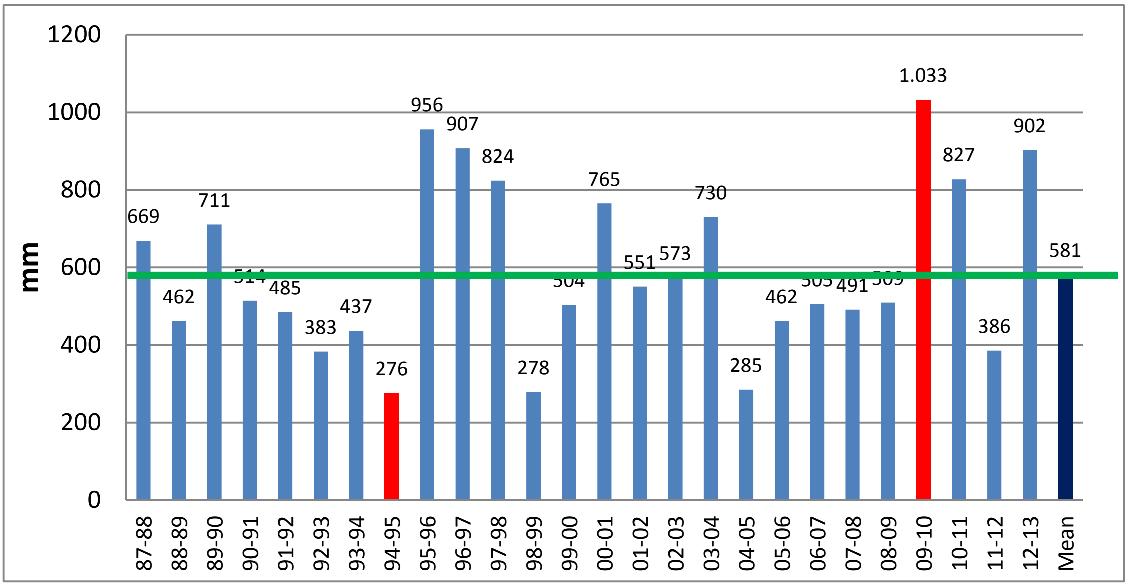
2004/5	285	389	49%	140%	Very dry year, full irrigation
2005/6	462	198	80%	71%	Dry year, restricted irrigation
2006/7	505	190	87%	68%	Normal year, restricted irrigation
2007/8	491	194	85%	70%	Normal year, restricted irrigation
2008/9	509	276	88%	100%	Normal year, full irrigation
2009/10	1,033	284	178%	102%	Wet year, full irrigation
2010/11	827	279	142%	100%	Wet year, full irrigation
2011/12	386	345	66%	124%	Very dry year, full irrigation
Mean*	**581**	**278**	**100%**	**100%**	

(*) Source: Guadalquivir River Basin Authority
"Normal year" defined when precipitation is 15% around average;
2004/12 average rain coincides with last 25 years average (1987-2013)

Analysis of table 1 shows that hydrologicaly the years can be grouped according to meteorological/hydrological conditions in three classes:

- Two very dry years 2004/5 and 2011/12 with rain at 51% and 33% below average (annual precipitation averages at 581 mm – see Figure 2). These years can be defined as 'meteorological drought' but water supply to irrigation was normal.
- Four years with normal to low precipitation, (80-88% of average), these years rain fed crops suffer a minor productivity reduction and we cannot consider them properly drought period from meteorological point of view but water storage was below critical point and reduction of irrigation doses was applied according to DMP. We consider these years 'hydrological drought'.
- Three wet years 26% to 78% above average precipitation

Figure 2: Evolution of precipitation since 1987/88 and the average for the 25 years

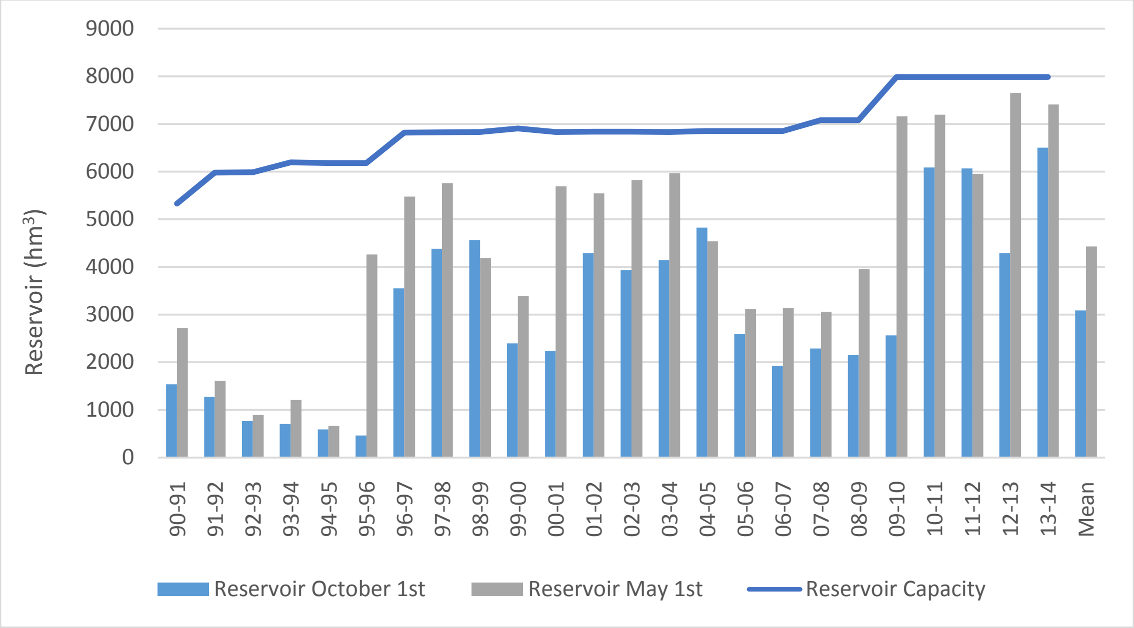


(*) Source: Guadalquivir River Basin Authority
Red bars show years with maximum and minimum precipitation in the period.

Regarding water storage, figure 3 shows evolution of reservoirs storage at October 1st (when irrigation campaigns ends) and May 1st (when irrigation campaign begins). Argüelles et al (2012) analyse the evolution of supply water in Guadalquivir describing evolution of reservoir volume and Berbel et al (2013) the trajectory towards of the basin closure when growing demand cannot be attended by enlarging supply.

It can be seen that water volume stored at May 1st 2006, 2007 and 2008 is low compared to the rest of the series, and according to DMP the irrigation quota are reduced to 50% of water rights whereas urban and industry demand is not affected.

Figure 3: Evolution of water storage 1987-2013 and 25 year average



(*) Source: Guadalquivir River Basin Authority

The impact of the meteorological conditions and the stored water management affects the evolution of water variables in the basin. According to SEEA-W methodology the key variables for agriculture are: soil water, supply of irrigation and reused water and return flows. The evolution of these variables is shown in table 2. Soil water is estimated by SIMPA (Alvarez, 2005) that uses 1km^2 simulation cells, and it has been estimated for irrigated area, rain fed area and forest according vegetation cover. Estimation of soil water consider the estimated rain in the location and type of vegetation, considering three groups within agrarian soil: permanent, herbaceous and hetereogeneous systems. SIMPA may overestimate soilwater used by crops, but SIMPA is the standard method in Spain for determining water resources in the basin and we consider that it is preferible to adopt this standatrd for the water tables generation.

Table 2: SEEA-W hydrological variables related to agriculture

Water (hm^3)	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Average**
Soil Water Irrigated land	3,833	2,091	3,923	4,152	3,990	4,052	4,593	4,626	2,631	3,765
Irrigation supply	2,448	3,227	1,655	1,589	1,645	2,354	2,431	2,400	2,989	2,304
Total Irrigation	6,281	5,318	5,577	5,742	5,635	6,406	7,024	7,026	5,621	6,070
Rain-fed Soil water	14,589	7,396	12,835	13,378	12,627	12,607	13,824	13,735	8,800	12,199
Forest Soil water	10,560	5,901	9,796	10,410	9,759	9,542	10,741	10,464	7,153	9,369
Total	31,430	18,615	28,208	29,529	28,021	28,555	31,589	31,224	21,574	27,638
Water (mm)										
Soil Water Irrigated land	537	252	470	496	471	476	537	537	304	453
Irrigation supply	343	389	198	190	194	276	284	279	345	278
Total Irrigation	879	641	669	685	666	752	821	816	650	731

Rain-fed Soil	511	270	469	490	464	464	509	507	325	446
Forest Soil	495	277	460	488	458	448	504	491	336	440

Source: Own elaboration; Methodology and complete data can be seen in Perales et al. (2014)

Regarding irrigation soil water, SEEA-W (2012) handbook defines (section 3.29/page 46). "***Abstraction from soil water includes water use in rain-fed agriculture, which is computed as the amount of precipitation that falls onto agricultural fields***". This definition is not operative when some Mediterranean basins have around 25% of area irrigated (and also forgets forestry and rangelands). It does not take into account soil water use in irrigated agriculture. Therefore we have adapted this definition to Guadalquivir conditions as *'soil water abstraction is the water evapotranspirated by crops both in rain fed and irrigated agriculture and by pastures and trees in forest areas'*. We should mention that green water (soil water abstracted by irrigated agriculture) in Guadalquivir is an average of 55% with the remaining 45% coming from the irrigation water (blue water), this can be estimated by observing evolution of values for "Soil Water Irrigated" and "Irrigation supply" in the period. Supply of reused water is very small (16 GL, i.e. less than 1% of irrigation supply).

Therefore, we must modify the definition that SEEA-W(2012) gives of 'soil water' to account for all soil water in the territory and not limited to rain fed agriculture that may give a partial and misleading information.

5. Economic analysis

The methodology of SEEA-W tables links physical water balances to socio-economic information on the main water abstractors such as gross income, value added or employment. This can be used to compare the economic importance of water quantity for the given water catchment or river basin (see European Commission, 2014).

Regarding economic data the critical issue is 'reproducibility' and transparency, and data obtained directly from official sources should be maximized in order to 'mechanize' and make economically viable the assessment of Water Account tables as frequently as possible. Economic data has been obtained from official sources, and main information is summarized in table 3. The complete detailed report can be found in Borrego et al (2014).

Table 3: Main economic data for Guadalquivir basin 2004-2012 (Million EUR 2012)

GVA	**2004**	**2005[1]**	**2006[2]**	**2007[2]**	**2008[2]**	**2009**	**2010**	**2011**	**2012[1]**	**Average**
Irrigation	2,967	2,557	2,358	2,516	2,250	2,147	2,338	2,195	1,889	2,357
Rain-fed (crops)	1,083	934	861	919	822	784	854	802	690	861
Livestock+Forestry	600	517	477	509	455	434	473	444	382	477
Industry	9,324	10,089	10,211	10,392	8,039	7,085	7,511	7,699	6,901	8,583
Construction	8,644	9,859	10,859	11,498	11,379	10,260	7,756	7,079	6,060	9,266
Services	43,266	44,078	46,208	48,905	50,184	51,002	49,402	48,856	48,581	47,831
Total GVA	65,885	68,034	70,973	74,738	73,128	71,711	68,333	67,075	64,503	69,376

Source: Own elaboration from INE;

(1) Meteorological drought; (2) hydrological drought

Table 3 shows a continuous decrease in economic value of agriculture (in real terms), as added value in agriculture (sectors 01-03 according classified according to ISIC Rev. 4) is reduced an average 4.5% yearly from initial 2004 levels. GVA is in 2012, 31% lower in real terms that in 2004 and we cannot detect the influence of drought in the economic series. Reasons for the difficulty to detect drought impacts at aggregate economic level maybe due to:

- Irrigation compensate dry years, as the two more dry years in the series could irrigate with no restrictions due to good state of water reserves.
- Influence of Common Agricultural Policy (approximately 30% of agricultural income), not subject to climate influence.
- Prices of some agricultural crops (olive oil, oranges, and others) increase as production decreases due to drought conditions.

6. Results, exploitation of hybrid tables

SEEA-Water is by definition a hybrid accounting system so that yields economic and hydrologic data. When economic and hydrological data is confronted some indicators measured as ratio "GVA/consumption" can be estimated, a summary is shown in table 4. This ratio can be defined as Apparent water productivity (value added per consumed water), in this document when we use the abbreviate term 'water productivity' we refer to this ration and therefore it is the apparent productivity because other factors (land, labour, capital, management) also are included (see Young, 2005).

The analysis of meteorological and hydrological drought is a difficult task as the data show a difficult pattern to interpret. Nevertheless, a first analysis can be done by comparing precipitation (mm) with apparent productivity (GVA/consumption in EUR/m^3).

Table 4. Apparent productivity of water Guadalquivir 2004/2008 (GVA/consumption)

GVA/consumption (EUR/m^3)	**2004**	**2005[1]**	**2006[2]**	**2007[2]**	**2008[2]**	**2009**	**2010**	**2011**	**2012[1]**	**Mean**
Total sector/ (Green+Blue Water)	0.15	0.22	0.13	0.13	0.13	0.12	0.12	0.11	0.14	0.14
Forest + Livestock (Green Water)	0.06	0.09	0.05	0.05	0.05	0.05	0.04	0.04	0.05	0.05
Rainfed (Green Water)	0.07	0.13	0.07	0.07	0.07	0.06	0.06	0.06	0.08	0.07
Irrigation Blue Water only	1.21	0.79	1.42	1.58	1.37	0.91	0.96	0.91	0.63	1.09
Total Irrigation Water (Green+Blue)	0.47	0.48	0.42	0.44	0.40	0.34	0.33	0.31	0.34	0.39

Source: Own elaboration.

Green water = Soil water; Blue water = Supply of irrigation water.

Figure 4 and figure 5 shows the analysis of this ratio. It can be seen a pattern where the meteorological drought with full irrigation (2004, 2012) shows a high water value. On the contrary, wet and normal years without irrigation constraints (2004, 2009, 2010 and 2011) show a lower value of water. In an intermediate position we have normal years with irrigation constraints (2006, 2007 and 2008). Both figures (4 and 5) include all subsectors of classes 01-03 (irrigation, rain fed, livestock and forest) which are included in the ratio according SEEA guidelines.

Figure 4: Water productivity GVA vs. rain (mm) (EUR/m^3 base 2012)

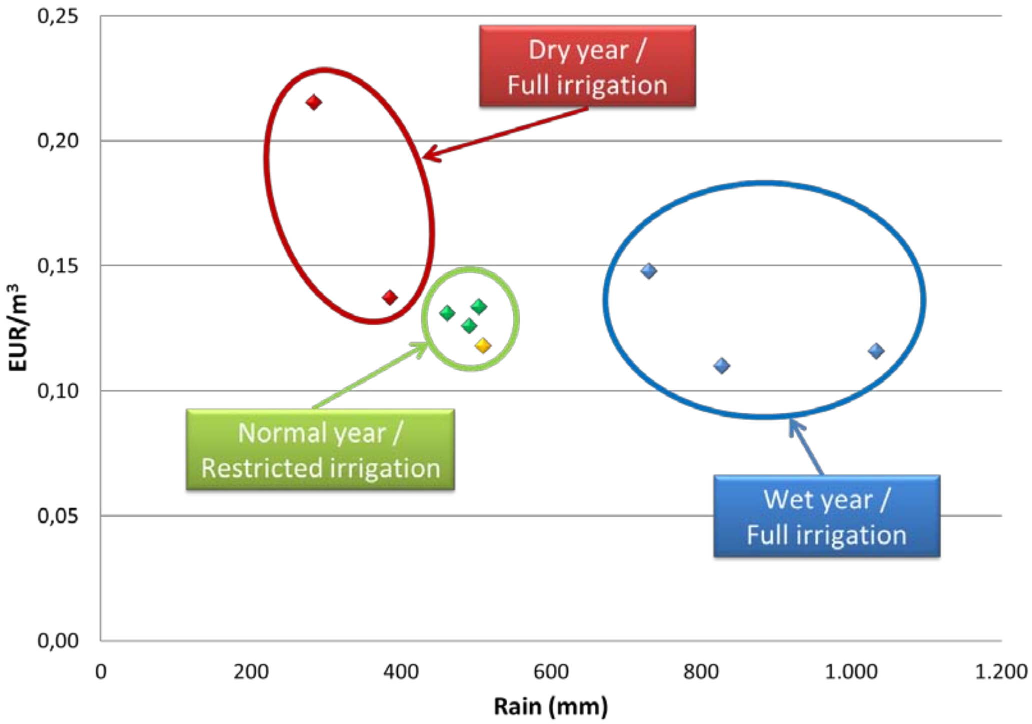
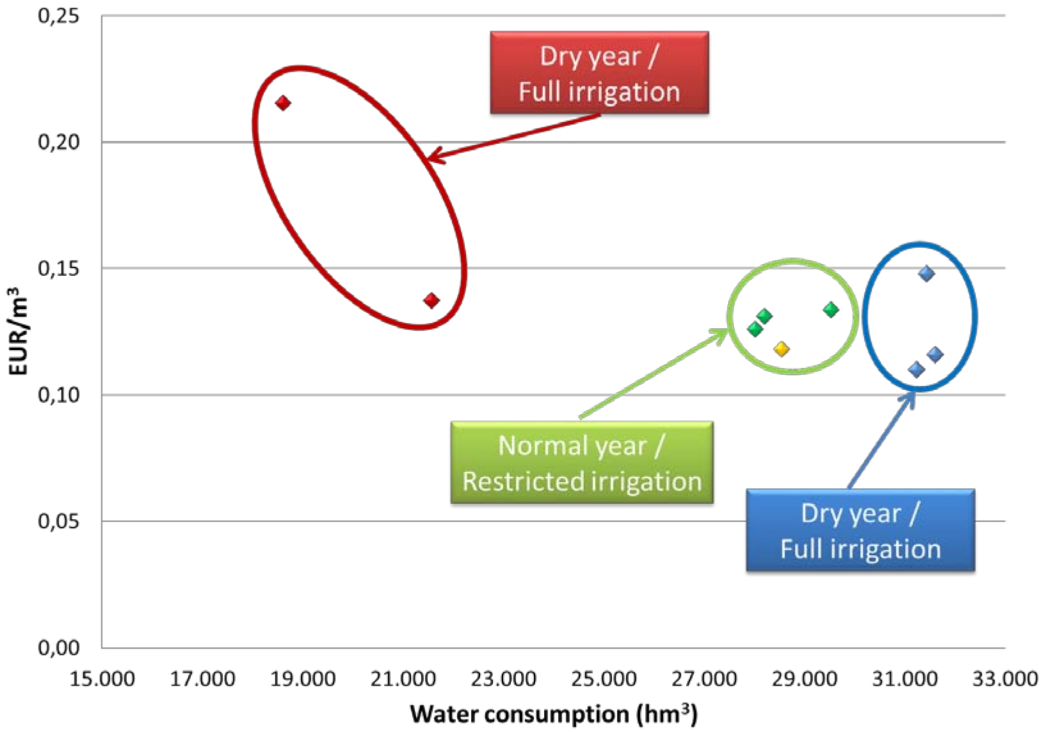


Figure 5: Water productivity GVA vs. water consumed (hm^3) (EUR/m^3 base 2012)



Row 1 in table 4 shows the total average productivity of water in sector 01-03 (agriculture, livestock, forestry) as GVA divided by water consumed that is equal to soil water plus irrigation water according to SEEA-W. Row 2 makes this computation considering only livestock and forestry (grossly around 15% of GVA of agriculture in the basin. Row 3 makes this ratio by dividing the estimated GVA of rain fed crops by estimated soil water consumption. Mean values (2004-2012) of this subsectors are below the sector ratio (0.07 and 0.11 compared to 0.13 EUR/m^3), the explanation falls in irrigated area that is around 27% of cultivated area and 14% of primary sector, with higher productivity.

Finally, rows 4 to 5 decompose water productivity of irrigated agriculture by making two ratios:

- row 4) GVA irrigation/irrigated water (only blue water), gives an average of 1.09 EUR/m^3
- row 5) GVA irrigation/total consumed water (green + blue), with average 0.39EUR/m^3

Considering that the irrigation is the main consumer of 'blue water', a detailed analysis conducted in table 4 and figure 6 and 7 illustrates the evolution focusing in water consumed by irrigated agriculture comparing the productivity with of GAV/water consumed (Blue + green) and GAV/water supplied (blue)

Figure 6: Irrigated GAV vs. "B+G water consumed" (EUR/m^3 base 2012)

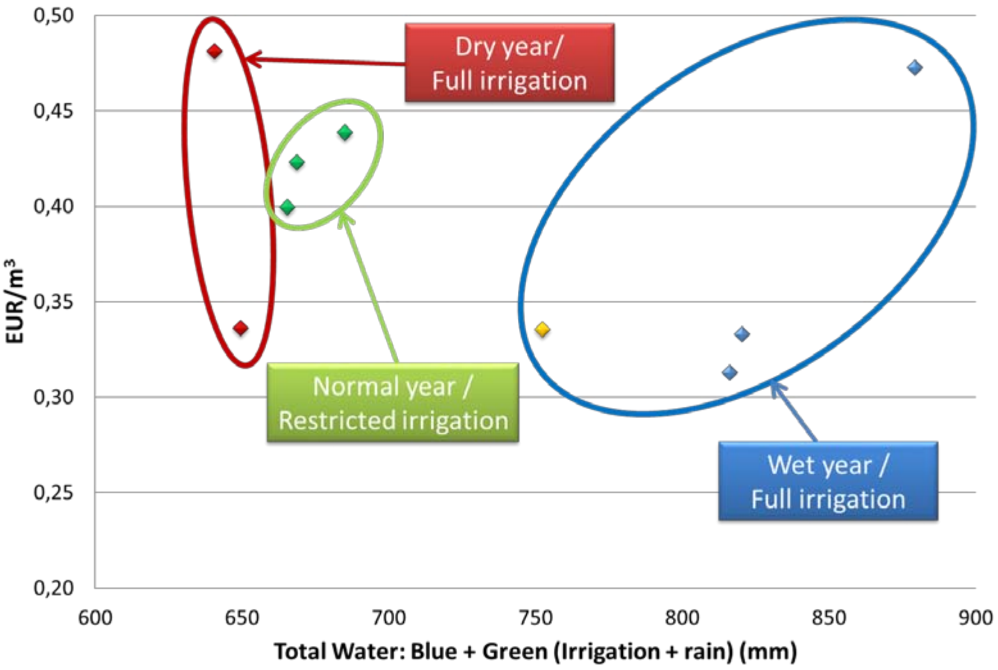
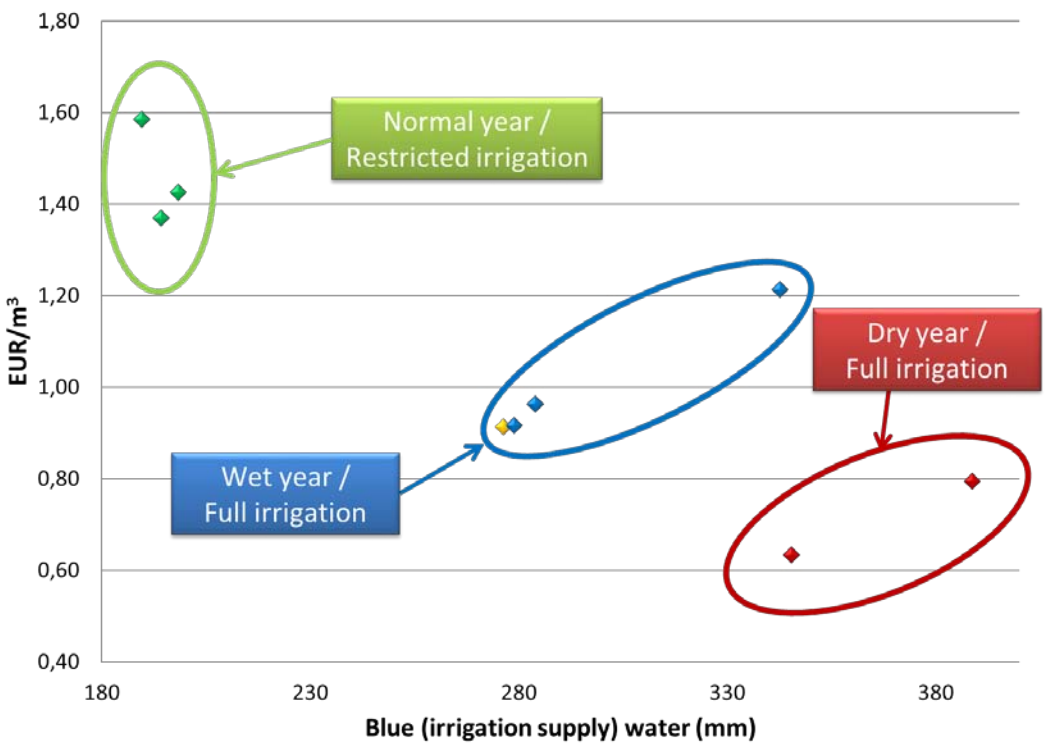


Figure 7: Irrigated GAV vs. "Blue (supply) water" (EUR/m^3 base 2012)



7. Discussion

The Department of Economic and Social Affairs of the United Nations Secretariat with the support of other institutions has made an ambitious effort to build Water Accounts and define a standard methodology that may facilitate international inter-basin comparisons and knowledge on the status and quantitative management of water resources.

This project has made a contribution by applying the SEEA-W to a basin (Guadalquivir) and a period (2004-2012) where different hydrological and meteorological conditions are present. We have found three types of years: (a) meteorological drought with rain below 33% of average but no constraints in irrigation water; (b) normal years (rain 20% around average but with irrigation supply reduction and (c) normal and wet years with no constraints in irrigation.

Some results maybe mentioned:

- Impact of meteorological drought is not observed in economic aggregated data.
- Explanation for previous statement can be found in the role of irrigation (blue) water and CAP support, further research is required.
- Impact of hydrological drought results in higher value of the ratio "GAV/blue water" but again, no conclusion can be drawn at aggregated sector/basin level.

- Heterogeneity in the productivity of water estimated as the ratio GAV/water consumed and some differences may be found in the three climatic/hydrologic scenarios.

Guadalquivir agriculture is around 5% of total GVA in the basin and a well developed agribusiness is present in the region with food industry as the main industrial sector, but in spite of previous statement, the analysis of aggregated economic data for the basin when all sectors are considered shows neither the direct impact (as commented above) nor the indirect impact of drought.

The ratio of "GVA/water consumed" cannot be considered strictly 'water value' according to the arguments given by Young (2005, pg 98-99) for determining the economic value of water. From a theoretical point of view, the term 'value of water' should consider preferably the marginal value of water whereas the value of GVA includes also some items such as salary, interest etc. that should not be included in the water value. Following Young (2005) we believe that "GVA/water" ratio is an indicator of the productivity of water that can be useful for economic analysis and water management.

8. Concluding remarks

This research has implemented Water Accounts according to SEEA-W methodology to a Mediterranean basin affected by meteorological and hydrological drought.

When economic and hydrologic data are linked, some average of water productivity values can be estimated as the ratio (GVA/water consumed) by sector and year. The analysis of this ratio during the period may help to understand the evolution of meteorological and hydrological conditions in productivity and the role of both irrigation blue (abstracted) and green (rain) in the irrigated land.

Results show that hybrid tables can be used to estimate basin water productivity values (GVA/water consumed). The evolution of this ratio in the period 2004-2012 shows that some useful knowledge of water productivity evolution and the role of supplied irrigation water (blue) and soil water (green) can be obtained with the added value of a common methodology according SEEA guidelines allowing knowledge sharing.

On the other hand, our research also found that it is difficult to determine the aggregate economic impact of meteorological and hydrological drought based upon basin SEEA Accounts. We have found difficulties for detecting direct effect of drought (on farming) and indirect effects (on the basin economy) based on aggregated basin data. This may be explained by the role of irrigation in the basin (approximately 27% cultivated area, 65% value), the support of Common Agricultural Policy and fluctuation of prices that compensate lower productions. Further research is required to assess the impact of drought through aggregate data.

Finally, the research discovers that green water in irrigated land supposes around 55% of water consumed by irrigation in the period. Therefore, we argue that SEEA-W definition of water consumed by irrigation considering exclusively 'blue supplied water' is misleading and should not be assumed and we proposed a modified version as *'soil* *water abstraction is the water evapotranspirated by crops both in rain fed and irrigated agriculture and by pastures and trees in forest areas'.*

As a conclusion, Water Accounts according SEEA-W confirm to be a useful tool for the economic analysis of water use and the impact of climatic conditions but also this exercise has demonstrated the limitation of using aggregated economic data and the conceptual problems with some SEEA-W definitions such as the soil water in irrigated land and the water value that should not be confounded with the "GVA/water consumed" ratio, which can be a useful indicator of water productivity by sector.

Acknowledgements

This research has been financed by European Commission under grant "System of Water Accounting in the Guadalquivir River Basin" (SYWAG). Authors want to thank Guadalquivir River Basin Authority for the support with data acquisition.

9. References

Álvarez, J., Sánchez, A., & Quintas, L. (2005). SIMPA, a GRASS based tool for Hydrological Studies. International journal of geoinformatics, 1(1), 13-20.

Argüelles, A., Berbel, J., Gutiérrez-Martín, C., (2012). La evolución de la Cuenca del Guadalquivir (España). *Revista Obras Públicas*. Nov-2012 (3537), 51-64.

Berbel, J., Mesa-Jurado, M. A., & Pistón, J. M. (2011). Value of irrigation water in Guadalquivir Basin (Spain) by residual value method. *Water resources management*, 25(6), 1565-1579.

Berbel, J., S. Kolberg, and J. Martin-Ortega, J. (2012). Assessment of the Draft Hydrological Basin Plan of the Guadalquivir River Basin (Spain). *International Journal of Water Resources Development*, 28 (1), 43-56, doi: 10.1080/07900627.2012.640875.

Berbel J, V. Pedraza and G. Giannoccaro (2013). The trajectory towards basin closure of a European river: Guadalquivir, *International Journal of River Basin*.

Berbel, J., Gutiérrez-Martín, C., Rodríguez-Díaz, J.A., Camacho, E. and Montesinos, P. (2014), Literature review on rebound effect of water saving measures and analysis of a Spanish case study. *Water Resources Management.* DOI10.1007/s11269-014-0839-0.

Borrego, M.M., Perales, J.M. & Berbel, J. (2014). "Metodología para elaboración de cuentas híbridas SEEA-W. Proyecto SYWAG (System of Water Accounting in Guadalquivir River Basin)". Working Paper Departamento de Economía Agraria. Universidad de Córdoba. http://hdl.handle.net/10396/12360

Guadalquivir River Basin Authority (2007). Plan Especial de Actuación en Situaciones de Alerta y Eventual Sequía de la Cuenca Hidrográfica del Guadalquivir. Available on: http://www.chguadalquivir.es/opencms/portalchg/servicios/politicaGestionSequias/planEspecialSequias/

United Nations - DESA (2012). System of Environmental-Economic Accounting for Water (SEEA-Water). Department of Economic and Social Affairs Statistics Division ST/ESA/STAT/SER.F/100.United Nations publication.

European Commission (2014). Guidance document on water balances. Draft – Version 1.0 – 19/09/2014. Brussels.

MARM-Ministerio de Medio Ambiente, Medio Rural y Marino (2006). Plan de Choque de Modernización de Regadíos. Real Decreto 287/2006, de 10 de marzo.

Martin-Ortega, J. and Markandya, A. (2009). The costs of drought: the exceptional 2007-2008 case of Barcelona. *BC3. Basque Centre for Climate Change: Working Paper Series.*

Meyer, V., Becker, N., Markantonis, V., Schwarze, R., van den Bergh, J. C. J. M., Bouwer, L. M and Viavattene, C. (2013). Review article: Assessing the costs of natural hazards–state of the art and knowledge gaps. *Natural Hazards and Earth System Science*, *13*(5), 1351-1373.

Perales, J.M., Borrego, M.M. and Berbel, J. (2014). "Metodología para el cálculo de variables hidrológicas. Proyecto SYWAG (System of Water Accounting in Guadalquivir River Basin)". Working Paper. Departamento de Economía Agraria. Universidad de Córdoba. http://hdl.handle.net/10396/12362

Young, R.A. (2005). *Determining the Economic Value of Water: Concepts and methods*. Johns Hopkins University Press.

6.c Guadalquivir water services cost recovery based on SEEA-W

1. Introduction

The Water Framework Directive (WFD) establishes a legislative framework for Community action in the field of water policy, aiming at improving and protecting the status of water bodies along Europe. The WFD also provides general criteria to consider drought impacts in the state of water bodies and includes the goal of full cost recovery of water services.

The WFD does not request compulsory full cost recovery as it states that Member States may in doing so have regard to the social, environmental and economic effects of the recovery as well as the geographic and climatic conditions of affected basin/region. In case that full cost recovery is not applied, WFD request that these exceptions shall be justified in the river basin management plans subject to the guarantee that environmental objectives of the Directive are reached.

In more detail, WFD Article 9 establishes that: water prices must allow for the (adequate) cost recovery of water services, including environmental and resource costs; the main water uses (disaggregated for households, industry and agriculture) must adequately contribute to the recovery of costs of water services, proportionally to their contributions to the pressures imposed on aquatic ecosystems in line with the 'polluter pays principle' and water pricing policies must 'provide adequate incentives for users to use water resources efficiently and thereby contribute to the environmental objectives' of the WFD.

The System of Environmental-Economic Accounting for Water "SEEA-Water", United Nations - DESA (2012) provides a conceptual framework for organizing hydrological and economic information in a coherent and consistent manner. It has been developed by Department of Economic and Social Affairs of the United Nations Secretariat with the support of other institutions. This is a key issue, as the origin is economics and the nature of the accounts is hybrid. In our opinion Water Accounts give the analyst the opportunity for facilitate analysis for both dimensions, economic and physical.

European Commission is working in a Guidance document on water balances Draft-v1.0 (European Commission, 2014) with the aim to standardize economic information regarding water use in Europe, therefore facilitating WFD reporting. SEEA-Water accounts also comprise valuation of water and water resources, although this category of accounts is still experimental and we will present some result regarding this issue. This research has been financed by European Commission under grant "System of Water Accounting in the Guadalquivir River Basin" (SYWAG).

European Environment Agency (2013) in a large review of water pricing and cost recovery in European Union concludes that, there is a lack of harmonised and operational concepts of cost recovery, Strosser and de Paoli (2013) conclude that recognising the diversity of MS contexts and priorities, priority should be given to good accountability and transparency in order to enhance the relevance of the economic assessments for MS policy making and for EU-wide policy making and additionally the need for additional guidance on the topic of cost recovery.

The European Commission (2014) affirm the convenience of linking SEEA-Water accounts to economic aspects of the WFD, and this research aims to fill the gap in knowledge on these issues:

- Application of SEEA-W tables to European Mediterranean basins.
- Proposal of a method to estimate cost recovery ratios based on the standard SEEA (W) tables.

Although some examples can be found of partial developments of SEEA-Water tables, no precedent of neither economic nor hybrid tables is found in European basins and to our knowledge there is a lack of common cost recovery definition and estimation in European Union and no precedent can be found of application of the tables for the estimation of cost recovery ratios. Next section will review the relevant literature describing the state of the art of the scientific and political knowledge on this topic.

2. Literature review on cost recovery in water services

The European Water Framework Directive (WFD) was adopted in 2000 with a holistic view of water management and established the objective to achieve good status by 2015. WFD make an emphasis in the use of economic tolls and instruments to reach this goal. European Commission has published a strategic paper with the analysis of the achievements of this norm after 10 years of implementation (European Commission, 2012). The analysis concludes that the reasons for the currently insufficient levels of implementation and integration are complex consisting of a series of water management problems related to the insufficient use of economic instruments, lack of support for specific measures, poor governance and knowledge gaps.

Article 9 of the WFD requires implementation of pricing policies that provide an incentive to use water efficiently. Pricing is a powerful awareness-raising tool for consumers and combines environmental with economic benefits, while stimulating innovation. Metering is a pre-condition for any incentive pricing policy. Article 9 also requires cost-recovery (including environmental and resource costs) for water services, taking into account the polluter pays principle.

There is an extensive treatment of water pricing and water demand in the literature, both for irrigation and urban use, a review of European water pricing policies can be seen at Berbel et al (2007) and an integrated evaluation of impact of water pricing in irrigation demand can be seen Berbel et al (2009) and House-Peters et al (2011) for Urban water demand.

EEA (2013) presents a detailed assessment of current water pricing for selected EU Member States, the main conclusion being that there is a lack of harmonised and operational concepts of cost recovery, and environmental and resource costs including incentives to saving. Full cost recovery refers to 'water services' as the resource has no price itself although the definition of water services varies clearly among countries, the wider definition includes all man-made changes in the hydrological system that serve to a policy objective and benefits the society as a whole or some specific economic uses. Spain is a country where definition of water services is wider due the characteristic of climate and territory.

Prices constitute the economic information system but water itself has not a price in European Union as markets are almost absent (see Giannoccaro et al 2013). Water pricing generally in literature refers to the processes of assigning a price to water services, using instruments such as utility taxes, charges, tariffs. The revenue from water pricing instruments according WFD Article 9 should reach cost-recovery in order to support environmental and economic goals.

The concept of cost recovery as defined in the WFD and its call for the internalisation of all cost of service provision although the exact value of the costs of water service provision recovered is difficult to estimate due to the variability of climatic and economic uses of water among EU Member States. There are economic instruments like the water levy (canon del agua) in Spain which are said to tackle both environmental and resource costs under a single mechanism.

Compared with the abundant literature in water pricing, the published research and policy guidelines for cost recovery assessment is scarce, among the scarce published research on this theme, besides the mentioned EEA (2013) review, we may mention Krinner (2014) who presents a financial analysis of the Spanish water sector based upon financial and budget information of administrations, agencies, companies and users' associations involved in water resources management and water service provision using financial records to estimate the overall amounts of expenditure, cost and revenues, this reports follows the line of Environmental Ministry (2007) although with some methodological changes. Calatrava and Garrido (2010) focus their research in the analysis of irrigation subsidies based upon the information that Spain reported to the European Union.

According Strosser and de Paoli (2013) EU Member State have applied a diversity of methods to estimate cost recovery rates although the methods applied are rarely well-specified making difficult any use (as source of inspiration by other MS or for EU-wide assessment) of the results reported.

After 14 years of WFD approval, European Union is still lacking comparable systems for the reporting of administration and utility revenues to recover the costs European Commission is using a new standard reporting procedure for 2015 (second cycle of WFD implementation) in order to correct this shortcoming, but we believe that even if the presentation respond to a common standard for all 27 member states, the differences in methodology to compute this value will still require additional common methodology to be shared. In our opinion, it would be particularly useful to have a system, standardized across EU Member States and in our opinion SEEA-W presents an opportunity to fill this gap.

3. SEEA- Water economic tables

SEEA-Experimental Ecosystem Accounting offers a synthesis of the current knowledge of ecosystem accounting. Countries and institutions making complementary guidance and work are the EU (European Commission, 2014), Canada’s MEGS and Wetland Asset Accounts and Experimental Ecosystem Accounts in Australia Cosier and McDonald (2010) are example of country experimental developments.

The advantage of water accounts over other types of water statistics is the ability to integrate water accounts with economic information, which facilitates economic analysis. Lange et al (2007) give water accounting following SEEA-Water for the Orange River Basin from an economic perspective on managing a transboundary resource building National water accounts for Botswana, Namibia and South Africa level. The accounts include supply and use tables, which are used to compare the contribution to water supply from each riparian state to the amount used. The water accounts are then linked to economic data for each country to calculate water use and productivity by industry and country.

The System of Environmental–Economic Accounting for Water is applied in many countries, such as Australia where Vardon et al., (2012) make an adaptation of the national level water account practices by the Australia Bureau of Statistics (ABS) to the SEEA-W framework eased by the similarity between both accounting frameworks. In China, the objectives of National Water Accounting Framework (CWAF) are consistent with those of SEEA (Gan et al., 2012), South Africa (Lange et al., 2007). Most of the applications use the hybrid nature of the table to produce ratios of apparent water productivity by sector/region. Unfortunately the published research on SEEA-Water implementation is scarce, specially with a full exploitation of economic tables.

Our research aims to explore this gap, specially the cost recovery estimation that can be obtained by using SEEA-Water tables as the basis for the computation.

4. Case study: Guadalquivir basin 2004-2012

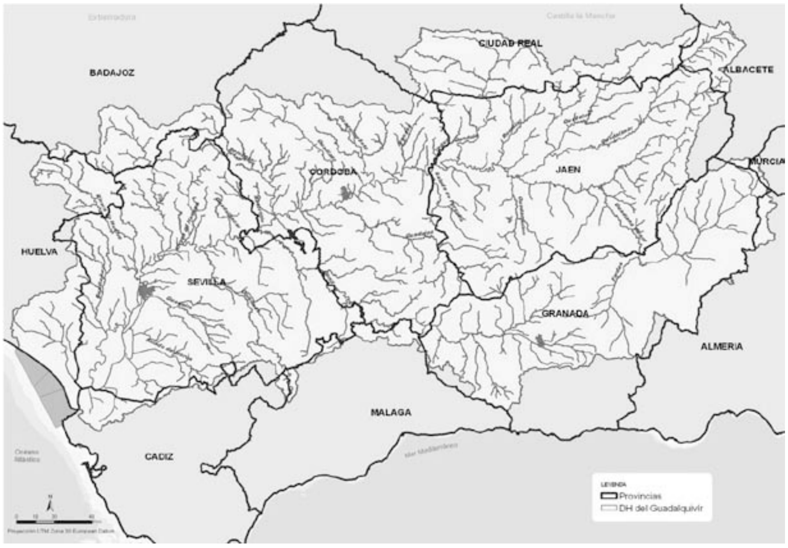
The Guadalquivir River is the longest river in southern Spain with a length of around 650 km. Its basin covers an area of 57,527 km2 and has a population of 4,107,598 inhabitants (see Figure 1 for a map of the basin). The basin has a Mediterranean climate with a heterogeneous precipitation distribution. The annual average temperature is 16.8°C, and the annual precipitation averages at 573 mm, with a range between 260 mm and 983 mm (standard deviation of 161 mm). The average renewable resources in the basin amount to 7,043 (arithmetic mean) and 5,078 GL/year (median), ranging from a minimum of 372 GL/year to a maximum of 15,180 GL/year (Arguelles et al., 2012). In a normal year a potential volume of around 8,500 GL can be stored through a complex and interconnected system of 65 dams. The main land uses in the basin are forestry (49.1%), agriculture (47.2%), urban areas (1.9%) and wetlands (1.8%). For a complete description of basin evolution see Berbel et al (2013).

Agriculture is the main user in the basin and it has implemented an intense investment in water saving measures (called 'modernization' (MARM, 2006). An interesting feature in this basin is the widespread of deficit irrigation technique, Berbel et al (2011) analyse the influence of this system in the basin and the consequences for economic of irrigation.

The period to be analysed is 2004-2012 where we can find the following features:

- Drought period 2005-2008.
- Increase of water saving investment (modernization).
- Increase of energy cost.
- Approval of Program of Measures and Hydrological Basin Plan (2009-2015).

Figure 1: Guadalquivir River basin



Source: Adapted from Confederación Hidrográfica del Guadalquivir. www.chguadalquivir.es.

5. Material: the SEEA-W tables for Guadalquivir 2004-2012

The philosophy of SEEA-W is the time and resource saving efficiency in data gathering, it is crucial that data is based in officially published information avoiding 'ad hoc' estimations. Following this strategy, our have used the following data base and official sources that are summarized in table 1.

Table 1. Economic and hydrological variables related to cost recovery analysis

Variable	Units	Standard Table (1)	Data source	Institution	Scale (2)	Comments
Abstraction	hm^3/year	A.1.1	SIMPA, Own calculations	CHG, Environmental Ministry	Basin	
Use	hm^3/year	A.1.1	PHC, Survey water services, Own calculations	CHG, Environmental Ministry, INE	Basin	
Returns	hm^3/year	A.1.1	Own calculations based on IPH	CHG, Environmental Ministry	Basin	
Consumption	hm^3/year	A.1.1	Own calculations based on CHG	CHG, Environmental Ministry, INE	Basin	
Intermediate consumption	€/year	A.1.3	I/O Tables regional	IEA	Regional	
Gross Value Added	€/year	A.1.4	Regional Accounts	INE	Regional	
Gross fixed capital formation	€/year	A.1.4	Regional Accounts, WB investment series	INE, WB	Regional, National	Investment since 2009 estimated with WB annual investment serie.
Clossing stocks of fixed assets	€/year	A.1.4	Water tariff, Administration budget (2004-2008)	Environmental Ministry	Basin	Investment since 2009 estimated with WB annual investment serie.
Water self-service production cost: Groundwater	€/m^3	A.1.5	Ministry Report	Environmental Ministry	Basin	Water cost published by Ministry.
Water self-service production cost: Surface	€/m^4	A.1.5	Water tariff	Environmental Ministry	Basin	Water tariff (yearly).
Water self-sanitation	€/m^5	A.1.5	Survey water services	INE	Regional	Yearly average all sectors.
Government account table	€/year	A.1.6	Administration budget (2004-2008), WB	Environmental Ministry, WB	Regional, National	Expenditure since 2009 estimated with

			investment series			WB annual investment serie.
Specific transfers	€/year	A.1.7	Administration budget (2004-2008), WB investment series	Environmental Ministry, WB	Regional, National	

INE= Instituto Nacional de Estadistica; IECA= Instituto de Estadistica y Cartografia de Andalucia; WB = World Bank; (1) First apparence (2) Assembled to basin limits

In table 1, revenue to cover cost is included based upon the following instruments:

- Water tariff 'canon del agua' is applied by Water Agency at basin level to cover all cost of reservoirs, distribution, policy and management of basin surface resources.
- Utilities recover the cost of distribution, treatment, collection and sewage by the urban water price, utility recover 100% of their services.
- Water User Associations recover their distribution cost as the finance themselves in a cooperative way therefore they should self finance their common services.
- Water levy which is an environmental tax designed to protect water resources, with the objective of guaranteeing supply and quality. The charge is calculated as a function of the water used by domestic and industrial users and is designed as an increasing block tariff. This levy has been applied since 2011. The income from this tax finances mainly sewage and sanitation plants.
- Self-supply farmers and industry support the cost of abstraction (mainly groundwater), distribution, treatment and sanitation (the latest exclusively for industry).

Regarding the cost of water services, the capital and investment costs and operational and maintenance costs are also included in the SEEA-W. Regarding time series, we have always used the most recent information, with the following solutions:

- Annual data for hydrological variables, Gross Value Added, and so on.
- Intermediate consumption based on 20008 I/O tables.
- Public investment and expenditure; 2004-2008 yearly Administration budget (2004-2008) and 2009-2012 estimated based upon WB yearly investment series.

Spatial dimension has been addressed by assigning to basin scale data available at regional or national scale, according to population for industrial and urban data and area for agricultural and other land based activities.

We want to focus in cost recovery analysis which is in another task inside WFD implementation that need also a common standard methodology assumed by all Member States, and this will be done in the next section.

6. Method

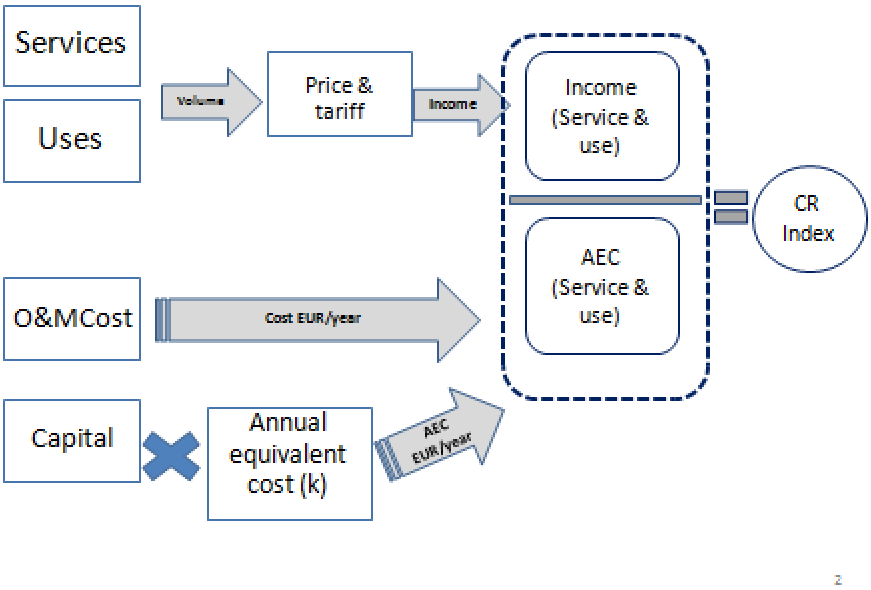
This exercise will address only financial cost recovery because only financial costs are captured by SEEA-Water in the 2012 version. Therefore, environmental and resource cost are not addressed. Some environmental services are summarized in table "A1.6 Government account table for water-related collective consumption services". These services are classified according to the Classification of the Functions of Government (COFOG). It should be noted that the COFOG categories refer to collective services of the Government. The categories COFOG 05.2 (wastewater management) and 06.3 (water supply) should not be confused with activities of "sewerage" and "water collection, treatment and supply", classified under ISIC divisions 37 and 36, respectively, which are considered individual services in SEEA-Water. Expenditures incurred by Governments at the national level in connection with individual services, such as water supply and sanitation, are to be treated as collective when they are concerned with the formulation and administration of government policy, the setting and enforcement of public standards, the regulation, licensing or supervision of producers, etc., as in the case of education and health.

Also only expended urban sanitation cost are captured by the Spanish Statistical Office (INE) in a yearly basis but the 'avoided cost' for deficient sanitation (lack of equipment or under-operation of facilities) that can be considered 'environmental cost' are present in official data base that are the basis for the SEEA-Water. When pollution removal is solved by adequate treatment they are internalized. This discussion is not present in SEEA-Water guidelines (UN-DE, 2012) therefore this research does not address this important and difficult question that should be treated at European level with practical and operative definitions.

Besides this improvement to standard tables, the distinction between Blue water and Green water is crucial to understand recovery cost. SEEA-W (2012) handbook defines (section 6.29/page 94). "Abstraction also includes the use of precipitation for rain-fed agriculture as this is considered removal of water from the soil as a result of a human activity, such as agriculture. Water used in rain-fed agriculture is thus recorded as abstraction from soil water".

This definition is not operative when some Mediterranean basins have over 25% of area irrigated (and also forgets forestry and rangelands). Therefore we have adapted this definition to Guadalquivir conditions as 'soil water abstraction is the water evapotranspirated by crops both in rain fed and irrigated agriculture and by pastures and trees in forest areas'. We should mention that green water (soil water abstracted by irrigated agriculture) in Guadalquivir is an average of 55% with the remaining 45% coming from the irrigation water (blue water) properly. Therefore, we must modify the definition that SEEA-Water-2012 gives of 'soil water' to account for all soil water in the territory and not limited to rain fed agriculture that may gives a partial and misleading figure 2.

Figure 2: Methodology for estimation of Cost Recovery Index



In order to give a relevant and meaningful cost recovery ratio, it is important to understand that only blue water services (urban and irrigation) should pay the cost of the water storage, distribution and supply. Similarly, cost of water sanitation should be paid by users of industrial and urban water. Diffuse pollution (agricultural or other origin) is not addressed by the existing cost recovery instruments.

Spanish water management is based in the Basin Water Agencies that have been in charge since decade of 1920' of all Spanish basins. Confederación Hidrográfica del Guadalquivir (CHG) is the Water Agency responsible for water reservoirs and water supply to economic activities and environmental management. In Spain this is called 'upper services' and the Water Law (BOE, 2001) determines the tariff to compensate this services. Another important institution is the 'Water Users Associations' (WUA) that manages collective services to farmers. Therefore we have subdivided the “Water Suplly” division into three agents: urban water utilities (generally accepted 36 industry) plus another two divisions that are CHG and WUA. Those three agents are in charge of water supply either at 'high level' or at 'bottom distribution level'. This method allows the cost recovery estimation with more detail and transparency according en SEEA-W handbook ((UN-DE 2012, pg. 71). “Note that activities are classified into the relevant ISIC (International Standard Industrial Classification of All Economic Activities) category regardless of the kind of ownership, type of legal organization or mode of operation. Therefore, even when activities for water collection, treatment and supply (ISIC division 36) and sewerage (ISIC division 37) are carried out by the Government (as may be the case in some countries), they should be classified to the extent possible in the specific divisions (ISIC 36 and 37) and not in ISIC division 84, public administration".

The hypothesis behind the estimation of cost recovery for Guadalquivir basin is:

H1) Public and private costs are mainly dedicated to 'blue water' and soil water used agriculture is not relevant for this analysis. 'Blue water' expenses are mainly:
  a) 'blue water' (irrigation + industry and urban supply);
  b) sanitation and sewage treatment.
H2) Operation and management cost are covered 100% by expenses paid either:
  a) self supply operations (groundwater farmers, WUA, industry);
  b) utilities for urban sanitation and sewage treatment (both network industry and domestic users).
H3) Capital cost are not partially recovered when there is an economic instrument (tariff or tax):
  a) capital investment in surface management by Water Authority, recovered by 'canon del agua';
  b) capital investment by Regional Government (recovered in 98% of basin by 'infrastructure canon' self supply operations (groundwater farmers, WUA, industry).
H4) Capital cost are not recovered when there is a subsidy to private agent and there is not instrument to recover the subsidy (as it is the case generally).
H5) Capital cost paid by private users and utility are fully recovered.

We have developed a method based on the official data detailed in table 1, a relevant source is the I/O table (IECA) that gives the intermediate consumption. Combining intermediate consumption and Gross Value Added by sector obtained by Regional Accounts by INE, we compute the total income (earnings) by all sectors in the basin. Regarding water services we divide the total value of payments in the basin for water services according each sector contribution. As an illustration, from GVA and intermediate consumption we can know the expenses for water supply for agriculture and the global figure obtained from this source can be split up between 'upper services' (supplied by the water agency -CHG) and 'bottom services' supplied by WUAs, similarly for rest of sectors. Additionally, for those self-supply users (groundwater use farmers and industry) the total cost of self-supply and the volume served can be obtained directly from "Table A1.5 Hybrid account table for water supply and sewerage for own use".

From table A.1.6 "Government account table for water-related collective consumption services", it can be obtained a value for 'collective' water services financed by the Government trough general taxation and the table A1.8 "Financing account tables", gives information about the financing of water services, including operation and capital expenses.

7. Results

Table 2 presents the standard reporting format for the 2015 Basin Plan revision according to CIS WFD roles. Theoretically all member state should use this table to report the cost recovery exercise. The table gives a detailed description of cost estimation and income collected by all agents that play any role in the water supply and treatment either public (Water Agency, National Government, Regional Government, Cities) collective (WUA) or private (domestic, industry, farmers). The table also presents an estimation of water volume served and consumed.

Table 2. Cost recovery index Guadalquivir Basin (2012).

Water service		**Water use**		**Volume served (hm^3)**		**Financial cost (EUR·10^6)**			**Collected (EUR·106)**	**Cost recovery index (%)**
				Water served	**Water consumed**	**O & M expenses**	**Capital AEC**	**Financial AEC Total**	**Tariff, price and self supply cost**	
				A	**B**	**C**	**D**	**E = C + D**	**I**	**K = I/E*100**
Abstraction, storage, distribution of water	Upper services abstraction, supply & distribution	1	Urban	447,5		56,88	38,13	95,01	70,04	**74%**
		2	Agriculture/livestock	2088,2		24,03	22,11	46,15	29,59	**64%**
		3	Industry/energy	30,9	30,9	3,93	2,45	6,38	4,84	**76%**
	Upper services groundwater abstraction	1	Urban	62,7		12,33	2,71	15,04	15,04	**100%**
		2	Agriculture/livestock	-	-	-	-	-	-	-
		3	Industry/energy	-	-	-	-	-	-	-
	Low service irrigarion distribution	2	Agriculture	2011,6	1861,4	97,1	69,2	166,3	121,36	**73%**
	Urban distribution	1	Domesticc	323,6	64,7	282,51	39,62	322,13	313,9	**97%**
		2	Agriculture/livestock	-	-	-	-	-	-	-
		1	Industry (connected)	31,8	6,4	27,75	4	31,75	30,84	**97%**
	Self supply	1	Domestic	-	-	-	-	-	-	-
		2	Agriculture/livestock	1117,1	1117,1	138,98	92,66	231,64	231,64	**100%**
		3	Industry/energy	36,3	36,3	3,06	0,77	3,83	3,83	**100%**
	Reuse	1	Urban reuse	-	-	-	-	-	-	-
		2	Agriculture/livestock	16,7	16,7	3,8	0,2	4	4	**100%**
		3	Industry/energy	-	-	-	-	-	-	-
	Desalation	1	Urban supply	-	-	-	-	-	-	-
		2	Agriculture/livestock	-	-	-	-	-	-	-
		3	Industry/energy	-	-	-	-	-	-	-
Collection and treatment	Collection outside public	1	Domestic	-	-	-	-	-	-	-
		2	Agriculture/livestock	-	-	-	-	-	-	-

of used water	networks	3	Industry/energy	16		6,3	0,7	7,02	7,02	**100%**
	Public networks	1	Domestic	258,9		102,52	19,62	122,14	113,91	**93%**
		1	Industry (connected)	25,4		10,07	2,03	12,1	11,19	**92%**

We apply the method described in previous section, and the initial information starts from table A.1"Standard physical supply and use table for water" where the standard table proposed in the SEEA Handbook by (UN-DE, 2012), is expanded with an additional line that extracts 'Blue water' values from this table and the complementary "Table A2.2 Matrix of flows of water within the economy". With this tables we obtain the volume of water either self supplied or received from other unite, most of them come from sector 36 (Water Agency, utilities and WUA).

From I/O tables and regional accounts we obtain the 'expenses by sector/service that is the 'numerator' of the cost recovery indicator. Our method not use directly the water volumes for neither cost nor income estimation but we report this information to be in line with the reporting standards as some of the alternative methodologies use unit cost/price (EUR/m^3) as the methodology to assess the global collective recovery ratio. The volume is relevant as complementary information about the expenses and it serves as a double check to control the results of using the results of SEEA tables itself.

Table 3 presents a Summary of cost recovery index Guadalquivir for 2012 where all information comes directly from SEEA standard tables that have been extended with the detailed analysis of 'blue water' services and the division of sector 36 into three supply agents.

Table 3: Summary of cost recovery index Guadalquivir, 2012.

		Financial cost recovery index			
Service		Urban	Agrarian	Industry	Total
		1	2	3	
Water supply: abstraction, storage and distribution, surface and groundwater	Upper level surface services	74%	64%	76%	66%
	Collective groundwater abstraction	100%			100%
	Water irrigation distribution		73%(*)		73%
	Urban cycle (distribution of drinking water)	97%			97%
	Self service (surface & GW)		100%	100%	100%
	Reuse		100%		100%
	Desalation	--	--	--	n/a
Collection and treatment of sewage water	Non connected collection	--	--	100%	100%
	Public network collection	93%			93%
		87%	**75%**	**91%**	**78%**

Source: Own elaboration from SEEA tables. (*) Non recovered cost for water irrigation distribution are justified by the reduction in farmers' water rights (25% on average).

Table 3 illustrates the interest of a detailed breakdown of income and cost by service and users. The result shows that upper level surface services apparently have a cost recovery around 66% for all sectors. This value should be explained:

Upper level surface services

- According to Environmental Ministry (Libro Blanco del Agua), the capital cost is recovered around 56% according Water Law normative, there is some initiative to change the fiscal regulation that implies this partial recovery. This value is in line with our results.
- Water Agency makes a multipurpose service when regulating water supply, and water utilities pay the 'general water levy' in a ration of 3:1 , that explain the higher recovery ration for industry and urban, but those sectors have also a priority when drought conditions are present (around 20% of the years in the series). The higher tax paid gives the privilege to full guaranteed water supply (99.8% of guarantee against 80% for irrigation users), therefore the higher price gives industry and urban users a higher value of water services (higher reliability). This service has not been included expressly in this analysis.

Water irrigation distribution

- Farmers usually through their WUA receive a subsidy for 'modernization of water networks' and the 'water savings' are kept by the State for environmental use, this implies that farmers to renounce to a volume around 25% of the water rights. Therefore the subsidy justifies the part of cost not recovered.

Rest of use/service are simpler to interpret ate. We should mention that WFD states (Art 5) that only the services of urban, industry and irrigation should be subject to cost recovery analysis and the discussion in the WFD definition levees out of this requirement the navigation and energy sectors that are responsible in Europe of the main impact on water masses (hydromorfological alterations) and the highest percentage of water use (energy accounts for 44% of withdrawals), European Commission (2012).

8. Discussion and concluding comments

As mentioned above previous published cost recovery rates give different figures. Guadalquivir figures give a cost recovery estimation of 99.83% for the supply and sanitation of urban water (MIMAM, 2007, page 201) and 97.70% for irrigation services (MIMAM, 2007, page 189). Krinner (2014) based on an alternative methodology gives 72% the overall global figure for the total national and all the sectors and levels of supply. Finally the EEA (2013) give a misleading figure for Guadalquivir 49.78% quoting CHG sources, but no report from CHG has never give this value.

From a global view, the EEA (2013) report gives values for cost recovery ranging from 20% (lowest in southern Italy) to 80% (highest in northern Italy), with an average of about 50% close to France average (55%) but below the amazing Dutch value of 99%. The problem with EEA report is that each country uses their own methodology, some include groundwater self supply cost, other exclude self supply services, the rate of depreciation of assets is not defined, neither the boundary of the analysis.

The range of estimations is too wide from a low 50% according EEA (2013) for most of the Southern Europe members, to a high index of 97% (Environmental Ministry, 2007). Probably real cost recovery is between both extreme values, in our opinion most robust estimation for Spanish case are:

- Guadalquivir Hydrological Plan estimates a global ratio of 86% for 2015 (CHG, 2013).
- Krinner (2014), based on financial and budget information gives a value of 72% as the average for 2005–2011.

Nevertheless, comparison between different results is not very informative when boundaries for the analysis: a) including self supply; b) including agriculture drainage services; c) rate of assets depreciation; d) rate of interest; e) definition of environmental services; f) definition of public services and other relevant definitions are not shared between members.

Our proposal to use SEEA-W to standardize computation is a step forward that may gives comparable figures that can be called 'cost recovery rates' itself or simply 'cost recovery indicators', but in any case will be an improvement against present chaotic situation in this field.

Some issues need to be defined yet, specially the government expenses in public services (protection of environment, good and human lives). Northern countries usually focus public protection in flood control meanwhile Southern countries need both to protect people and environment against excessive water (flood) and cyclical drought periods, the question maybe: "What is the boundary between water service and public service?, it is not a clear cut question as some issues maybe in the fuzzy border. Another relevant point to discuss is the introduction of environmental and resource cost into the analysis that cannot be done in the present form of SEEA-W but that maybe undertaken as soon as there is a general consensus on the measurement of environmental and resource cost.

To conclude, we believe that our proposal to use SEEA-W as the basis for cost recovery estimation should be explored by other Member States in European Union and other policy makers to evaluate the level of recovery of public investment and expenses in water services provision. The advantage of this methodology is: a) it is based in an international standard methodology, b) definitions have been articulated by consensus, c) it uses official information that is public and updated periodically, d) transparent, e) cost-efficient. All this features allow territorial (inter countries/basins) and temporal evolution analysis.

Besides cost recovery treated in this paper and Water Accounts also gives relevant information for the knowledge of economic and hybrid variables that allow a good characterization of water use. An example is the evaluation of water productivity information that has been addressed by Borrego et al (2015).

Finally, according WFD implementation normative, economic characterization of water use is a critical task in the development of Program of Measures according WFD implementation. The application of SEEA-W for a common methodology applied by all Member States in order to improve and standarize 'reporting procedures' for WFD allowing a better knowledge transfer and results comparability is a possibility that presents SEEA-W. Nevertheless this issue is out of the scope of this paper and should be addressed as an urgent topic by the economic and water management community.

9. References

Berbel, J., Calatrava, J., & Garrido, A. (2007). 1 3 Water Pricing and Irrigation: A Review of the European Experience. Irrigation Water Pricing: The Gap Between Theory and Practice, 4, 295.

Berbel, J., Viaggi, D., & Manos, B. (2009). Estimating demand for irrigation water in European Mediterranean countries through MCDM models. Water policy, 11(3), 348-361.

BOE (2001) Real Decreto Legislativo 1/2001, de 20 de julio, por el que se aprueba el texto refundido de la Ley de Aguas. BOE núm. 176 de 24 de Julio de

Borrego, M.M., Perales, J.M. & Berbel, J. (2014). "Metodología para elaboración de cuentas híbridas SEEA-W. Proyecto SYWAG (System of Water Accounting in Guadalquivir River Basin)". Working Paper Departamento de Economía Agraria. Universidad de Córdoba. http://hdl.handle.net/10396/12360

Borrego-Marín, M.M., Perales, J.M., Gutiérrez-Martín, C. y J. Berbel (2015) Analysis of Guadalquivir droughts 2004-2012 based on SEEA-W tables. International Conference on DROUGHT: Research and Science-Policy Interfacing. Valencia

Calatrava, J., & Garrido, A. (2010). Measuring Irrigation Subsidies in Spain: An application of the GSI Method for quantifying subsidies. International Institute for Sustainable Development (IISD, Geneva, Switzerland. ISBN 978-1-894784-42-9. Available at: http://www. globalsubsidies. org/files/assets/irrig_Spain. pdf.

Confederacion Hidrografica del Guadalquivir (2013) Plan Hidrológico de la demarcación hidrográfica del Guadalquivir, Real Decreto 355/2013. https://www.chguadalquivir.es/ consult Dec. 2014

Cosier, P., & McDonald, J. (2010). A common currency for building environmental (ecosystem) accounts. Santiago, 25, 28.)

European Commission (2000) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Official Journal L 327 , 22/12/2000 P. 0001 - 0073 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32000L0060

European Commission (2012) COM (2012) 673 final A Blueprint to Safeguard Europe's Water Resources, Brussels.

European Commission (2014). Guidance document on water balances. Draft – Version 1.0 – 19/09/2014. Brussels.

European Environment Agency (2013) Assessment of cost recovery through water pricing. Luxembourg: Publications Office of the European Union, Technical report No 16/2013. doi:10.2800/93669

Gan, H., Wang, Y., Lu, Q., Vardon, M., Chanchai, A., 2012. Development and Application of the System of Environmental–Economic Accounting for Water in China. In: Godfrey, J., Chalmers, K. (Eds.), International Water Accounting: Effective Management of a Scarce Resource. Edward Elgar Publishing Inc., New York, pp. 139–161.

Giannoccaro, G., Pedraza, V., & Berbel, J. (2013). Analysis of Stakeholders' Attitudes towards Water Markets in Southern Spain. Water, 5(4), 1517-1532.

House-Peters, L. A., & Chang, H. (2011). Urban water demand modeling: Review of concepts, methods, and organizing principles. Water Resources Research, 47(5).

Krinner, W. (2014). Financial Analysis of the Spanish Water Sector. Water Resources Management, 1-20.

Lange, G. M., Mungatana, E., & Hassan, R. (2007). Water accounting for the Orange River Basin: An economic perspective on managing a transboundary resource. Ecologicaleconomics, 61(4), 660-670.

Ministerio de Medio Ambiente (2007) Precios y costes de los Servicios del Agua en España. Madrid.

Momblanch, A., Andreu, J., Paredes-Arquiola, J., Solera, A., & Pedro-Monzonís, M. (2014). Adapting water accounting for integrated water resource management. The Jucar water resource system (Spain). Journal of Hydrology.

Perales, J.M., Borrego, M.M. and Berbel, J. (2014). "Metodología para el cálculo de variables hidrológicas. Proyecto SYWAG (System of Water Accounting in Guadalquivir River Basin)". Working Paper. Departamento de Economía Agraria. Universidad de Córdoba.http://hdl.handle.net/10396/12362

Strosser, P. G. de Paoli (2013) Background document for the Workshop "Supporting a better economic analysis for the 2nd RBMP and beyond", 1-2 October 2013, Brussels

United Nations - DESA (2012). System of Environmental-Economic Accounting for Water (SEEA-Water). Department of Economic and Social Affairs Statistics Division ST/ESA/STAT/SER.F/100.United Nations publication.

Vardon, M., Martinez-Lagunas, R., Gan, H., Nagy, M., 2012. The system of environmental–economic accounting for water: development,implementation and use. In: Godfrey, J., Chalmers, K. (Eds.), International Water Accounting: Effective Management of a Scarce Resource. Edward Elgar Publishing Inc., New York, pp. 32–57.

7- Conclusions

The project "System of Water Accounting in the Guadalquivir River Basin" (SYWAG) has applied SEEA-Water methodology for Guadalquivir basin for the period 2004 to 2012. The results of SYWAG project can be seen in the complete set of tables that will make a relevant material for future analysis regarding evolution and use of water resources and economic characterization of the basin. Main results of SYWAG project can be summarized as the following achievements:

1) Development of the full set of SEEA-W tables from official data bases.

2) Regarding hydrological variables, SYWAG has found that green water in irrigated land supposes around 62% of water consumed by irrigation in the period. Therefore, we argue that SEEA-W definition of water consumed by irrigation considering exclusively 'blue supplied water' is misleading and should not be assumed and we proposed a modified version as 'soil water abstraction is the water evapotranspirated by crops both in rain fed and irrigated agriculture and by pastures and trees in forest areas'.

3) Regarding use of economic information, various relevant results, firstly a proposal for the use of SEEA tables for characterization of the basin according Art 5º WFD (economic analysis of water use).

4) Methodology for the analysis of cost recovery ratio directly from SEEA-W tables. The application to Guadalquivir (2012) gives a global value of 78% for all sectors and services that is the range of previous relevant studies.

5) Finally, some derived hybrid indicators has been produced, such as 'apparent value of water', that has been very helpful to study the impact of economic impact of meteorological and hydrological droughts.

As a conclusion, Water Accounts according SEEA-W confirm to be a useful tool for the economic analysis of water use and the impact of climatic conditions but also this exercise has demonstrated the limitation of using aggregated economic data and the conceptual problems with some SEEA-W definitions. We hope that SYWAG makes a contribution for the setting of a common methodology for economic analysis water resources.