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Estimation of Cost Recovery Ratio for Water Services Based on the System of Environmental-Economic Accounting for Water

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Abstract This paper proposes a methodology to compute a cost recovery ratio directly from the System of Environmental-Economic Accounting for Water (SEEA-Water) standard tables. The methodology is applied to the Guadalquivir River Basin in southern Spain. Results illustrate that it allows cost recovery analysis in line with Water Framework Directive Article 9. Wider adoption of the methodology would enhance comparability and knowledge sharing between regions, countries and sectors both in the European Union and worldwide.

Keywords Water framework directive · Cost recovery · System of environmental-economic accounting · Water policy

1 Introduction

Water is closely linked with socio-economic development, and the management of water resources therefore has to take an integrated overall approach. Integrating information on the economy, hydrology, other natural resources and social aspects can help to design policies in an informed and integrated manner. The European Water Framework Directive (WFD) (European Commission 2000) adopts such an integrated approach to water management and gives a critical role to economic instruments. The use of 'Water Pricing' and 'full cost recovery' (Art. 9) are probably the most widely known provisions of the WFD.

Environmental accounting is an emerging field which deals with the integration of complex biophysical data, tracking changes in ecosystems and linking those changes to economic and other human activities. The System of Environmental and Economic Accounting (SEEA) of the United Nations Statistics Division (UNSD) was created in 1993 and modified in 2003 and

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2012. Its main aim has been to integrate environmental and economic information in a common, comprehensive and coherent way to measure the contribution of the environment to the economy and the impact that economic activities have on the environment. The Central Framework (SEEA-CF) serves as an international statistical standard and guideline for environmental economic accounting (UNSD 2014). SEEA-CF adopts a compartmental approach where natural resources (forest, water, etc.) are addressed individually. Accounting for ecosystems in physical (i.e., non-monetary) terms is a key feature of SEEA-CF.

This study tries to integrate the WFD economic instruments with the developments in environmental accounting as developed in SEEA-CF, and specifically in SEEA-Water (UNSD 2012). This creates a standard tool that, if adopted widely, would allow international comparison of the state and quantitative management of water resources. For European policy, it would facilitate Member States' WFD reporting to the European Commission on the quantitative status of groundwater resources and on the abstraction pressures on surface and groundwater bodies.

Consequently, the objective of this paper is to produce a method capable of estimating a cost recovery ratio for water services based exclusively on the standard accounting information contained in SEEA-Water. This method will be applied to the Guadalquivir River Basin in southern Spain. There is no precedent of an application of the SEAA-Water tables to estimate cost recovery ratios and this paper may be considered a novelty and useful for a standard and replicable estimation of this ratio. The future adoption of the methodology in the European Union could suppose a significant tool for a better application of "cost recovery principle" established in the WFD.

The next section reviews the concept of cost recovery in the WFD, followed by a short introduction to SEEA-Water and an overview of other examples where it has been applied to river basins. This is followed by a presentation of the case study and our proposed methodology, before discussing our data sources and presenting our results.

2 Cost Recovery in the Water Framework Directive

The Water Framework Directive (WFD) has established a legislative framework for Community action in the field of water policy which is aimed at improving and protecting the status of water bodies in the European Union. The WFD promotes the use of economic instruments to reach these goals, one of which is the cost recovery of water services (Article 9).

In more detail, Article 9 establishes that: i) water prices must allow for the adequate cost recovery of water services, including environmental and resource costs; ii) 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 (i.e., be in line with the 'polluter pays principle'); and iii) water pricing policies must 'provide adequate incentives for users to use water resources efficiently and thereby contribute to the environmental objectives' of the WFD (European Environmental Agency, EEA 2013).

Economic information systems are based on prices, but water itself has no price in the European Union, as markets are almost absent (see Giannoccaro et al. 2013). In the literature, water pricing generally refers to the process of assigning a price to water services, using instruments such as utility taxes, charges and tariffs. The definition of water services varies strongly among countries. The widest definitions include all man-made changes to the hydrological system, both those that benefit society as a whole and those that serve specific economic uses. Spain uses a wide definition of water services due to the characteristics of its climate and territory.

Full cost recovery is not compulsory in the European Union, and Member States can deviate from full recovery if found necessary considering its social, environmental or economic effects. Geographic and climatic conditions of the affected basin/region are also allowed to be taken into account when deciding about cost recovery. However, if full cost recovery is not pursued or achieved, the WFD requires the exceptions to be justified in the River Basin Management Plans, and accomplishment of the environmental objectives of the Directive has to be guaranteed (Court of Justice of the European Union 2014).

The WFD does not define the methodology to calculate the costs of water service provision and this method has not yet been defined by any institution. In a large review of the concept in the European Union, the European Environment Agency (2013) concludes that there is a lack of harmonised and operational concepts relating to cost recovery. Similarly, in an examination of how to improve WFD-related economic analysis, Strosser and de Paoli (2013) highlight the need for additional guidance on the topic of cost recovery, arguing that EU Member States have applied a diversity of methods to estimate cost recovery rates, but these methods are rarely well-specified, which limits their usefulness as a source of inspiration for other Member States or for EU-wide assessments.

Fourteen years after approving the WFD, the European Union still lacks a uniform system to report administration and utility revenues and cost recovery rates. The European Commission is using a new standard reporting procedure for 2015 (second cycle of WFD implementation) in order to correct this shortcoming. However, we believe that, even if all 27 Member States present their data in a common standard, the differences in the methodologies used to compute these values would still not allow a useful comparison.

Further standardization across EU Member States would therefore be desirable and the European Commission (2015) has published a guidance document on water accounting with this aim and to facilitate the above-mentioned WFD reporting. This document specifically mentions the convenience of integrating economic information from within SEEA-Water.

We should mention that the WFD states (Article 5) that only services to urban users, industry and irrigation are subject to a cost recovery analysis. There is no such requirement in the WFD neither for the navigation nor for the energy sectors (European Commission 2012). We expect that the revision of WFD due for 2019 will eliminate these exemptions.

The WFD prescribes that ‘Member States shall take account of the principle of recovery of the costs of water services including environmental and resource cost’ but SEEA-Water tables only capture market prices or payable expenses and do not include environmental and resource costs. Our methodology therefore only provides an estimate of financial cost recovery, this and other shortcomings will be considered in the Discussion Section.

3 SEEA-Water Accounting Framework

The use of an accounting framework enables the stock of ecosystems (*ecosystem assets*) and flows from ecosystems (*ecosystem services*) to be defined in relation to each other, and also in relation to a range of other environmental, economic and social information. SEEA-CF focuses on the flows of materials and energy that either enter the economy as natural inputs or return to the environment from the economy as residuals. It is based on individual environmental assets, such as timber, water and soil resources. SEEA-Water is the specific adaptation of the Central Framework and has been developed by the Department of Economic and Social Affairs of the United Nations Secretariat with the support of other institutions (EUROSTAT among them). It provides a conceptual framework for organizing hydrological and economic information in a coherent and consistent manner. The system has its origin in economics, but also includes physical information. The hybrid nature of the accounts gives the analyst the opportunity to study both dimensions.

The standard approach to measuring the economy is based on human activities that are reflected in markets prices and transactions. SEEA supplements the monetary description of economic activities with the accounting of natural resources in physical terms, such as water stocks measured as cubic meters or water flow measured as cubic meters per second. The idea behind the framework is to capture the dependency of the economy on flows from the environment and vice versa. SEEA-Water has been applied in several countries.

- Lange et al. (2007) use the SEEA-Water tables for the transboundary Orange River Basin, building on national water accounts from Botswana, Namibia and South Africa, and compare each country's contribution to the water supply to the amount it used.
- Vardon et al. (2012) adapt the national water accounts from the Australia Bureau of Statistics to the SEEA-Water framework, which is eased by the similarity between both frameworks.
- Gan et al. (2012) analyse the Chinese National Water Accounting Framework (CWAF) in relation to those of SEEA.
- Statistics Canada (2013) presents an accounting framework based on SEEA designed to support the valuation of ecosystem goods and services and creates pilot ecosystem accounts, which it then applies to wetlands valuation.
- Edens and Graveland (2014) present an experimental evaluation of Dutch water resources according to SEEA discussing approaches for the valuation of the water resources provisioning services to the Dutch economy.

Most of the above-mentioned applications use the hybrid nature of the tables to produce ratios of apparent water productivity by sector/region. Unfortunately, apart from these examples, implementation of SEEA-Water remains scarce, and full exploitation of the economic tables of the framework is negligible.

The SEEA-Water tables organize information by water source and by economic activity according to the United Nations International Standard Industrial Classification of All Economic Activities (ISIC) groups. The industries are grouped into: ISIC divisions 1–3, which include agriculture, forestry and fishing; ISIC divisions 5–33 and 41–43, which include mining and quarrying, manufacturing, and construction; ISIC division 35: electricity, gas, steam and air-conditioning supply; ISIC division 36: water collection, treatment and supply; ISIC division 37: sewerage; ISIC divisions 38, 39 and 45–99, which correspond to the service industries.

We should note that ISIC divisions 36 and 37 may include private firms but also government agencies (river basin authorities and municipalities), water user associations (WUAs) and utilities that can be municipally owned, private companies or mixed. The SEEA-WATER handbook states: "*Note that activities are classified into the relevant ISIC 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 (...), they should be classified to the extent possible in the specific divisions (ISIC 36 and 37) and not in ISIC division 84, public administration" (UNSD 2012, pg. 71).

Services provided by government agencies (such as RBA) are also classified according to the Classification of the Functions of Government (COFOG). COFOG is a classification of Government expenditures according to the function that the transaction serves. It should be noted that COFOG categories refer to Government collective services although 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.

4 Case Study: Guadalquivir River Basin 2004–2012

Guadalquivir River (Fig. 1) 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 population of 4,107,598 inhabitants. The basin has a Mediterranean climate with a heterogeneous precipitation distribution, 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 7043 (arithmetic mean) or 5078 hm^3/year (median), ranging from a minimum of 372 hm^3/year to a maximum of 15,180 hm^3/year. In a normal year a potential volume of around 8500 hm^3 can be stored in 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 %). Berbel et al. (2012) describe the River Basin Management Plan, and Berbel et al. (2013) discuss the evolution of the basin's water supply and extraction. Table 1 summarizes the main water uses following SEEA-Water definitions.

SEEA-Water defines water abstraction as the amount of water that is removed from any source, either permanently or temporarily. This definition includes soil water which according to SEEA is the "*water suspended in the uppermost belt of soil that can be discharged into the atmosphere by evapotranspiration*". This is equivalent to the concept of 'green water' as used in the hydrological literature, where 'blue water' refers to surface and groundwater that is abstracted, stored, transported and applied.

An analysis of Table 1 shows that soil water makes up 57 % of total abstraction followed by hydropower generation (31 %). It should be noted that almost all water abstracted for hydropower is returned to the ecosystem, while abstracted soil water is evapotranspired and lost for the basin ('consumed' in hydrological terms). There is therefore a crucial difference between abstracted (used) water and consumed water. In Guadalquivir, soil water constitutes 86 % of the water consumed by the primary sector, with the remaining 14 % supplied by irrigation.

Agriculture is the basin's main water consumer of 'blue water' and it has invested considerably in water saving measures in a process known as 'modernization', which has led to the widespread use of deficit irrigation and drip systems. Berbel et al. (2011a) analyse

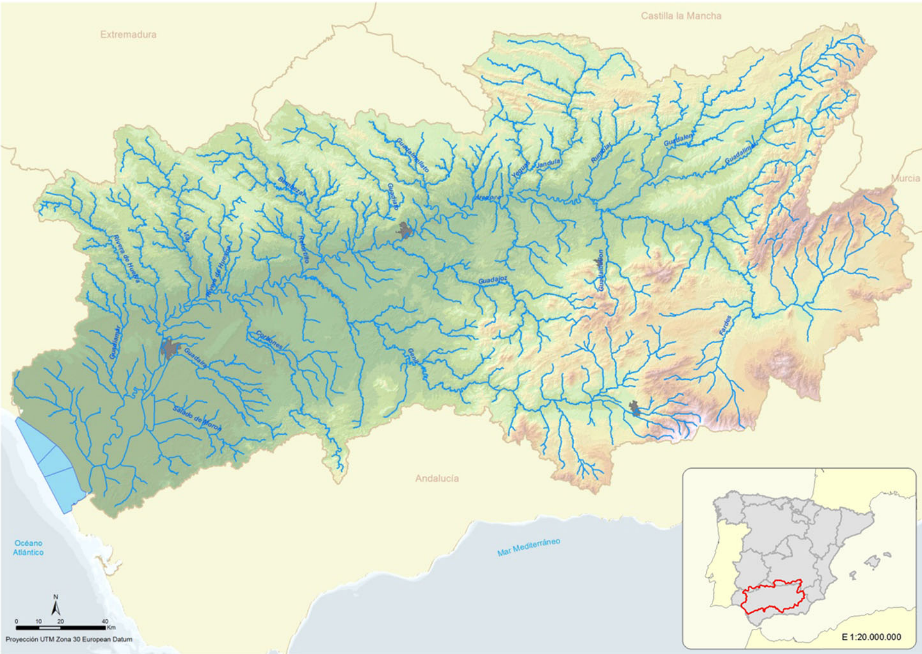

Fig. 1 Guadalquivir basin. Source: Adapted from Confederación Hidrográfica del Guadalquivir, www.chguadalquivir.es

the 'ex-ante' impact of water saving systems in the basin and Berbel et al. (2015) made an 'ex-post' analysis of these measures.

For the application of our methodology to the Guadalquivir Basin, we use the SEEA-Water framework as developed by Borrego-Marín et al. (2015) for period 2004–2012 which was characterized by the following occurrences: a) drought 2005–2008; b) water saving investments (modernization); c) increase in energy consumption and water cost for irrigators, and d) the approval of the Program of Measures and the Hydrological Basin Plan (2009–2015).

Table 1 A breakdown of water abstraction in the Guadalquivir River Basin, 2012

Water resource/ use (hm^3)	Total ISIC 1–3[a]	Total industry	Water utilities	Remaining sectors	Total	Abstraction %
Surface water	2324	24	493	17	2858	9 %
Groundwater	805	12	63	0	879	3 %
Energy (hydro)	0	10,270	0	0	10,270	31 %
Abstracted 'blue water'	3129	10,306	556	17	14,008	43 %
Soil (green) water	18,601				18,601	57 %
Total water abstracted from the environment	21,730	10,306	556	17	32,609	100 %
Returns (net)	134	10,149	455	0	10,738	33 %
Total consumption	21,596	157	100	17	21,870	67 %

[a] ISIC 1–3 includes Agriculture, Livestock and Forestry (ISIC 01, 02, 03)

Source: Own elaboration

5 Data Sources

The philosophy behind SEEA-Water is to save time and resources by gathering data in an efficient way and where possible link up to regularly published official sources avoiding 'ad hoc' estimations. Accordingly, we have mainly used existing data bases and official sources to complete the SEEA-Water tables. These sources are summarized in Table 2.

5.1 Hydrological Data

As apparent from Table 2, the hydrological data are measured in physical terms (hm^3/year). The data have been based on the official Ministry for Environment framework SIMPA (Integrated System Modeling Process Precipitation Contribution), which gives rain precipitation and evapotranspiration for the basin at 1 km^2 cells, complemented with further estimates based on the Guadalquivir River Basin Authority (RBA) surveys for irrigated area and measurements of water served to large irrigation schemes and municipal users. The RBA publishes accurate measures of water consumption and river flow in strategic locations that gives us a good estimate of annual water resources use that have been integrated in the analysis of water volumes in the SEEA Tables.

5.2 General Economic Data

The SEEA-Water tables require information on the following economic variables, for both public and private sectors of the economy:

- Output by economic sector (measured at basic prices),
- Intermediate consumption (cost of inputs),
- Personnel costs (salaries and pensions),
- Depreciation of fixed capital,
- Other relevant costs,
- Investment by year and accumulated stock of capital.

For all private sectors, this information, including the value of gross capital formation, was available from the Regional Input/Output Tables, but the tables do not include the public sector. For all the private agents, we can derive the production value and the costs of water services by sector, these are either the costs of self-provision (e.g., groundwater for farmers) or payments to third party water service providers (utilities, basin authorities or WUAs), with the latter split into payments to parties acting as water utilities (ISIC 36) and those providing water sanitation (ISIC 37). Dietzenbacher and Velázquez (2007) used an input–output framework to analyse the consumption of water in the Andalusian production process and an input–output decomposition analysis is also used to find the main drivers of water usage by Di Cosmo et al. (2014).

As mentioned above, annual public expenditure for water services and annual public investments in water related infrastructure is not included in the Regional I/O Tables. For the 2004–2008 period, we used a report from the Ministry of Environment (2009). Data for the remaining years (2009 to 2012) were estimated based on the World Bank series of 'Public Investment Expenditures' (see Table 2 for details).

Table 2 Economic and hydrological variables used in the cost recovery analysis

Variable	Unit	SEEA Standard Table[a]	Data source	Institution	Scale[b]	Comments
Abstraction	hm^3/year	A.1.1	SIMPA, Own calculations	CHG, Ministry for Environment	Basin	
Use	hm^3/year	A.1.1	PHC, Survey water services, Own calculations	CHG, Ministry for Environment, INE	Basin	
Returns	hm^3/year	A.1.1	Own calculations based on IPH	CHG, Ministry for Environment	Basin	
Consumption	hm^3/year	A.1.1	Own calculations based on CHG	CHG, Ministry for Environment, INE	Basin	
Intermediate consumption	€/year	A.1.3	Regional I/O Tables	IECA	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
Closing stocks of fixed assets	€/year	A.1.4	Water tariff, Government budget (2004–2008)	Ministry for Environment	Basin	Investment since 2009 estimated with WB annual investment series
Self-supply costs: Groundwater	€/m^3	A.1.5	Ministry for Environment report	Ministry for Environment	Basin	Water cost published by the Ministry for Environment
Self-supply costs: Surface water	€/m^3	A.1.5	Water tariff	Ministry for Environment	Basin	Water tariff (yearly)
Self-sanitation costs	€/m^3	A.1.5	Survey water services	INE	Regional	Yearly average all sectors
Government account table	€/year	A.1.6	Government budget (2004–2008), WB investment series	Ministry for Environment, WB	Regional, National	Expenditure since 2009 estimated with WB annual investment series
Specific transfers	€/year	A.1.7	Government budget (2004–2008), WB investment series	Ministry for Environment, WB	Regional, National	

SIMPA Integrated System Modeling Process Precipitation Contribution, *CHG* Guadalquivir River Basin Authority, *PHC* Guadalquivir Hydrological Plan, *IPH* Water Planning Instruction, *INE* National Statistics Institute, *IECA* Andalusian Statistics Institute, *WB* World Bank

[a] If appearing in several tables, we quote the first appearance

[b] Adjusted to basin limits

Whenever a variable was available at basin scale from an official source, this was used. For data unavailable at basin scale, we adjusted to basin scale he available regional or national level through an algorithm weighting by population or area.

5.3 Collective Services Exempt from the WFD Cost Recovery Provision

Some public services, such as flood control, are defined as collective and not subject to water pricing and cost recovery, because the benefits accrue to society as a whole, rather than to individual agents. This information should be included in 'Table A1.6 Government account table for water-related collective consumption services'. These data were obtained by analysing the Government budget when available and using World Bank series for the missing data estimation.

5.4 Data Related to Cost Recovery Instruments

Tables A1.7 and A1.8 in SEEA-Water present national expenditure and financing accounts for water-related activities classified by purpose, and both tables are synthetized in Table 3 below. 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.

As mentioned in the previous paragraph, expenditure on collective water services that benefits society as a whole is not subject to cost recovery, and can be financed through general taxation. Only water services related to the satisfaction of specific agent needs (irrigation, water as an economic input, water supply and sanitation) are subject to cost recovery. Spanish legislation provides several fiscal and market instruments to recover the cost of water service provision.

Financial cost recovery instruments can be managed by public or private agents at different stages in the provision and management of water services. To calculate cost recovery rates, we need to estimate what public and private agents receive for the water services they provide. We can assume that private agents recover 100 % of their costs (e.g., private groundwater abstraction should pay all cost), while public agents may recover their costs in full or partially as the public agent may support a deficit in a service financed by public sources. We shall first discuss the instruments related to water provision, classified as ISIC 36, for which there are three responsible agents: the RBA, utilities and WUAs.

- Surface water storage and distribution at basin level is financed through a water tariff administered by the RBA. It is intended to cover the cost of reservoirs, distribution, policy

Table 3 EU standard cost recovery table completed for the Guadalquivir River Basin, 2012

Water service		SEEA-water table	Water use		Volume served (hm^3)		Financial costs ($EUR \cdot 10^6$)			Collected income ($EUR \cdot 10^6$)	Cost recovery index (%)
					Water served	Water consumed	O & M expenses	Capital AEC	Financial AEC total	Tariffs, prices and self supply costs	
					A1.1	A1.1	A1.4	A1.4 / A1.6		A1.7/A1.8	
					A	B	C	D	E = C + D	I	K = I/E*100
Abstraction, storage, distribution of water	Upper services: surface water abstraction, supply & distribution	A1.4 / A1.6	1	Urban	447.5		56.8	38.1	95.0	70.0	74 %
			2	Agriculture/ livestock	2088.2		24.0	22.1	46.1	29.5	64 %
			3	Industry/ energy	30.9	30.9	3.9	2.4	6.3	4.8	76 %
	Upper services: groundwater abstraction	A1.4 / A1.6	1	Urban	62.7		12.3	2.7	15.0	15.0	100 %
			2	Agriculture/ livestock	–	–	–	–	–	–	–
			3	Industry/ energy	–	–	–	–	–	–	–
	Lower services: irrigation distribution	A1.4/ A1.6	2	Agriculture	2011.6	,861.4	97.1	69.2	166.3	121.3	73 %
	Urban distribution	A1.4	1	Domestic	323.6	64.7	282.5	39.6	322.1	313.9	97 %
			2	Agriculture/ livestock	–	–	–	–	–	–	–
			1	Industry (connected)	31.8	6.4	27.7	4.0	31.75	30.8	97 %
	Self supply	A1.5	1	Domestic[a]	–	–	–	–	–	–	–
			2	Agriculture/ livestock	1117.1	1117.1	138.9	92.6	231.6	231.6	100 %
			3	Industry/ energy	36.3	36.3	3.0	0.7	3.8	3.8	100 %

Table 3 (continued)

Water service		SEEA-water table		Water use	Volume served (hm^3)		Financial costs ($EUR \cdot 10^6$)			Collected income ($EUR \cdot 10^6$)	Cost recovery index (%)
					Water served	Water consumed	O & M expenses	Capital AEC	Financial AEC total	Tariffs, prices and self supply costs	
					A1.1	A1.1	A1.4	A1.4 / A1.6		A1.7/A1.8	
					A	B	C	D	E = C + D	I	K = I/E*100
	Reuse	A1.4	1	Urban reuse	–	–	–	–	–	–	–
			2	Agriculture/ livestock	16.7	16.7	3.8	0.2	4.0	4.0	100 %
			3	Industry/ energy	–	–	–	–	–	–	–
	Desalination		1	Urban supply	–	–	–	–	–	–	–
			2	Agriculture/ livestock	–	–	–	–	–	–	–
			3	Industry/ energy	–	–	–	–	–	–	–
Collection and treatment of used water	Collection outside public networks	A1.5	1	Domestic	–	–	–	–	–	–	–
			2	Agriculture/ livestock	–	–	–	–	–	–	–
			3	Industry/ energy	16		6.3	0.7	7.0	7.0	100 %
	Public networks	A1.4 / A1.6	1	Domestic	258.9		102.5	19.6	122.1	113.9	93 %
			1	Industry (connected)	25.4		10.0	2.0	12.1	11.1	93 %

[a] Domestic self-supply is neligible (only some gardens and isolated houses). it has not been considered by the Basin Water Authority to be relevant

and management of basin surface resources. The tariff is charged to irrigators, municipalities, industries and energy users in the basin.

- Utilities become responsible once the water enters municipal networks. They recover the cost of treatment and, distribution (ISIC 36) or collection and sewerage (ISIC 37) through the 'urban water charge'.
- WUAs can manage water supplied by the RBA (regulated surface water) or they may abstract and distribute groundwater, in both cases, they should fully recover the internal cost of distribution. WUAs are self-financed by irrigators in a cooperative way and consequently cannot generate deficits in the service of distribution. The instrument to recover the cost of this service is called '*derrama*'.
- Additionally, the cost of self-provision by either farmers or industries is recovered in full.

Regarding water sanitation, besides certain large industries that 'self-provide' sanitation, most frequently, these services are provided by ISIC 37 industries and government, which use the following instruments for cost recovery:

- Regional Government's 'water infrastructure levy', in use since 2011, is an environmental tax designed to protect water resources, with the objective to guarantee 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. The income from the tax mainly finances sewerage and sanitation plants.
- Industry ISIC 37 (Water sanitation) companies use the 'waste water levy' to cover operation and maintenance costs of waste water treatment plants and – in full or in part – the depreciation of infrastructure as we will see in the Results Section. Private agents and industries are charged according quantity and quality of discharges.
- Internalised in the waste water levy is the 'waste water control levy', which the RBA uses to cover the costs made for pollution monitoring in water bodies.

6 Method of Cost Recovery Estimation

Based on the standard SEEA-Water tables, cost recovery ratios are computed by dividing the income generated from water services (as taxes, prices or any other financial instruments) by the cost of their provision. Figure 2 tries to illustrate the method where each critical value is obtained directly from the different SEEA Tables. Our objective is the reliability, repeatability and reproducibility of cost recovery estimations and we believe that this has been achieved, this section describe the process.

The cost of water service provision is defined as the Annual Equivalent Cost (AEC), consisting of two elements: a) the annual operation and maintenance expenses and b) the annual depreciation and interest related to the infrastructure capital stocks. The definition of AEC can be found in (Berbel et al. 2011a); we use a 4 % interest rate to discount capital stocks.

For the public sector the accumulated water service capital infrastructure is equal to the sum of annual (public) investment. We have defined a time frame of 50 years for civil works (dams and auxiliary infrastructure) and 25 years for waste water treatment facilities.

We have adapted the results of the SEEA cost recovery estimation to the new standard EU reporting procedures mentioned in Section 2. This procedure includes a standard table, which we completed for the Guadalquivir Basin (Table 3). All Member States are obliged to use this

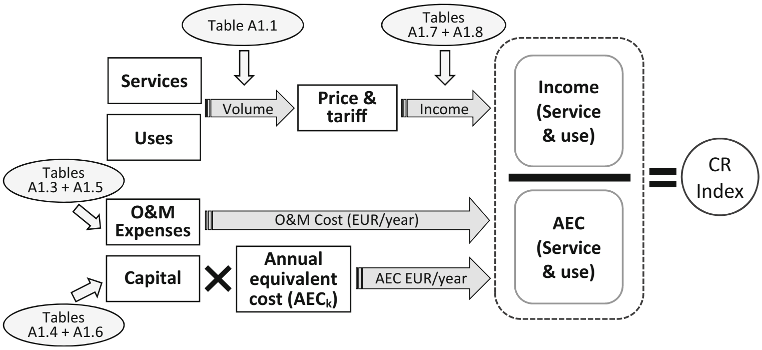

Fig. 2 Methodology for estimation of Cost Recovery Index. Source: Own elaboration

table to report cost recovery results. It requires a detailed estimate of the costs and income for all agents that play a role in water supply and treatment, whether they are public, collective or private. As can be seen, cost recovery estimation is divided between 'Abstraction, storage, and distribution of water' and 'Collection and treatment of used water', and each of these is further subdivided into the sectors Urban, Agriculture/livestock and Industry/energy. We define 'upper' as the services given by the RBA and 'lower' the services given by rest of agents.

Table 3 includes an estimate of the total water volume provided and consumed, (SEEA-Table A1.1) that is consistent with standard WFD reporting. However, unlike other cost recovery estimation applications,[1] we do not use these volumes for the estimation of costs or income.

Income generated by the water services is collected in the column 'Tariffs, prices and self supply costs', which we completed using information from 'Table A1.8 Financing account tables' in the SEEA-Water framework.

7 Results: Cost Recovery Ratios in the Guadalquivir River Basin

The ratios from Table 3 have been brought together in Table 4, to which we added combined ratios for the different sectors and services and a ratio for overall water services. It can be seen that some services reach full (100 %) financial cost recovery: urban groundwater abstraction; self-supply by agriculture and industry; reuse of treated waste water in agriculture/livestock; and the self-managed waste water treatment by industries not connected to public networks. The remaining services or sectors do not reach full cost recovery, which we explain below.

- Overall, upper level surface water services have a cost recovery of around 66 % (2012 data), that implies an implicit subsidy from the RBA for the abstraction, regulation and distribution. This subsidy exists because not all capital (infrastructure) costs are recovered in the water tariff that all RBA, including Guadalquivir apply as only 56 % of the AEC (annual depreciation and financing of the infrastructure) is recovered (Ministry of Environment 2000). Although draft legislation has been drawn up to change this regulation, which dates back 60 years, it has proved difficult to reach political consensus.

[1] Most of the estimation of cost recovery the receipts are computed based on unit prices (EUR/m^3) multiplied by total volumes.

Table 4 Cost recovery ratios for the Guadalquivir River Basin. 2012

		Financial cost recovery index			
Service		Urban	Agriculture	Industry	Total[a]
Water supply: abstraction. storage and distribution. surface and groundwater	Upper level surface water services	74 %	64%[a]	76 %	66 %
	Upper level groundwater abstraction	100 %			100 %
	Irrigation water distribution		73 %[b]		73 %
	Urban cycle (distribution of drinking water)	97 %		97 %	97 %
	Self supply (surface & groundwater)		100 %	100 %	100 %
	Reuse		100 %		100 %
	Desalination	–	–	–	n/a
Collection and treatment of sewage water	Non connected collection	–	–	100 %	100 %
	Public network collection	93 %		93 %	93 %
		87 %	75 %	91 %	78 %

Source: Own elaboration from SEEA tables

Overall ratio based on the total economic income

[a] Non agricultural sectors receive a premium service of having a higher provision guarantee during droughts

[b] Non recovered costs for water irrigation distribution are justified by the reduction in farmers' water rights (25 % on average)

- The RBA provides a multipurpose service in regulating the water supply, and the cost of this service (with the implicit subsidy explained above) is distributed between the three economic sectors: urban users, agriculture and industry. Agriculture has the lowest recovery ratio, and apparently pays less for this service. However, the SEEA Water tables does not reflect the quality of the service when we consider the guarantee and of the water supply. Water rights entitlement that user are acknowledged are probabilistic, the RBA does not guarantee an assured provision of water and gives a probability of failure (0.2 % for non agricultural users and 20 % for agricultural users). Because drought conditions are quite common in the basin, this is a real premium. The premium results in an apparently higher water recovery ratio for non-agricultural users. To correct for this, the value of the guarantee would have to be estimated, but this is beyond the scope of this paper (see Mesa-Jurado et al. 2012) for an analysis of the economic value of water supply guarantees for irrigation under scarcity conditions).
- Cost recovery ratio of 73 % for the distribution of irrigation water is due to subsidies for 'modernization of water networks' (water saving investments). Farmers receive subsidy of 50 % of the total investment (see Berbel et al. 2015) although they pay totally the operation and maintenance costs. In return, the RBA retains 25 % of the water rights held prior to the modernization for 'environmental goals'. In practice this means that farmers renounce to a quarter of their previous water rights, and the subsidies can be interpreted as 'water rights buyouts'. Because the mechanism to retain the water rights is complex, it is not captured by our estimation of the cost recovery ratio, which therefore appears lower than it in fact is.

- Cost recovery rates for urban water distribution (97 %) and waste water collection and treatment (93 %) show that the subsidies to infrastructure are not transmitted to final users. We assume that operation and maintenance cost are fully recovered and the deficit appears because part of the investment is subsidized to the utility manager.

8 Discussion and Concluding Comments

Previously published cost recovery rates for water services in Spain show a heterogeneous picture:

- The Ministry of Environment (2007, page 201 and page 189) provides estimates of 99.83 % for the urban sector and 97.70 % for irrigation services.
- The Guadalquivir Hydrological Plan (CHG 2013) reports a global ratio of 86 % for the basin.
- Krinner (2014) finds an overall rate for Spain of 72 %.
- The European Environment Agency (2013) reports a misleading figure for the Guadalquivir Basin of 49.78 %, but the RBA has never published this figure and it is not clear where the EEA obtained it.

Values for other Mediterranean countries in the mentioned EEA report vary from a low of 20 % in southern Italy to 80 % in northern Italy, with an average of 50 %. The wide range of the estimations is caused in part by the differences in the applied methodologies. For example water self-supply and agricultural drainage services are not included in the different country estimations, and asset life and the interest rate are treated differently in different countries, as well. Our proposal to use the SEEA-Water tables to standardize the estimation is a step towards obtaining comparable figures and would be an improvement on the present disordered situation.

Our methodology does not resolve all existing issues, such as the treatment of government expenses for public collective services (e.g., the protection of the environment, goods and human lives). Another example is how to include environmental and resource costs. Diffuse pollution coming from agricultural or other industries is not addressed by the existing cost recovery instruments and is out of the scope of our analysis. These issues cannot be included in the SEEA-Water tables in their present form. Also, a general consensus on how to measure environmental and resource costs does not yet exist, but would be necessary for them to be included in a uniform way. Some methods to include environmental and resources cost of water in order to achieve the full cost recovery have been developed for the case study area. Berbel et al. (2011b) estimate the value of irrigation water while Martin-Ortega et al. (2011) use the choice experiment method to determine environmental and resource cost of water. Others methods have been used to calculate total cost as in Martínez et al. (2011) or Sechi et al. (2013) among others.

To conclude, we believe that our proposal to use SEEA-Water as the basis for cost recovery estimates should be explored by policy makers within and outside the EU. The advantages of the methodology are that: a) it is based on an international standard methodology, b) it uses definitions that have been agreed by consensus, c) it uses official information that is public and updated periodically, d) it is transparent, and e) cost-efficient. Finally, we believe that our proposal allows territorial comparisons and temporal series analysis with the properties of reliability, repeatability and reproducibility.

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