Special section - Water, Sanitation and SDGs in Brazil: challenges, contradictions and governance
Vol. 62, p. 979-995, jul./dez. 2023. DOI: 10.5380/dma.v62i0.88876 e-ISSN 2176-9109

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Environmental-economic accounting for water and its contribution to water resources management, planning, and SDG 6

Contas econômicas ambientais da água e sua contribuição para a gestão, o planejamento dos recursos hídricos e o ODS 6

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Article received on December 1, 2022, final version accepted on May 18, 2023, published on November 10, 2023.

ABSTRACT: Despite the importance of water resources to society, there are several gaps in the availability of data to support the public policy decision-making process domain. In this context, the System of Environmental-Economic Accounting for Water (SEEA-Water) is a tool used for water resources management and planning. Its main goal is to harmonize and standardize of hydrological and economic data using the same conceptual framework. This framework is based on tables and indicators, following the System of National Accounts (SNA), as regularly published by the Brazilian Institute of Geography and Statistics (IBGE). The SEEA-Water has been adopted to provide strategic information systematically and reliably to support the decision-making process considering the water resource management challenges at the national and subnational scale. This paper discusses the main contribution of SEEA-Water to water resources planning and management. Moreover, SEEA-Water's contribution to the Sustainable Development Goals (SDG) monitoring is presented considering the information that is obtained directly from the SEEA framework and/or adapted for the SEEA and the SDG 6 integration, or even as a support for the monitoring of the goals and objectives linked with SDG 6. Finally, the broader characteristics of frameworks such as SEEA-Water are discussed in the context of the Brazilian environmental policy and the advances toward integrating natural capital for the composition of the country's Gross Domestic Product.

Keywords: environmental economics; water accounting; water statistics; sustainable development goals.

RESUMO: Apesar da importância dos recursos hídricos para o ser humano, observam-se diversas lacunas na disponibilidade de dados para o suporte às tomadas de decisão na esfera das políticas públicas. Neste contexto, o System of Environmental-Economic Accounting for Water (SEEA-Water) é uma ferramenta auxiliar da gestão e planejamento de recursos hídricos cujo objetivo é a sistematização e padronização de dados hidrológicos e econômicos em um mesmo quadro conceitual. Esse quadro é constituído por tabelas e indicadores que seguem a organização dos Sistemas de Contas Nacionais (SNA), conforme regularmente publicado pelo Instituto Brasileiro de Geografia e Estatística (IBGE). O modelo tem sido adotado com o objetivo de fornecer informações estratégicas, de maneira sistematizada e confiável, para apoiar a tomada de decisão frente aos desafios da gestão de recursos hídricos em escala nacional e subnacional. Este artigo apresenta uma discussão sobre a contribuição do SEEA-Water para o planejamento e gestão de recursos hídricos. Além disso, a contribuição do SEEA-Water ao monitoramento dos Objetivos do Desenvolvimento Sustentável (ODS) é apresentada considerando as informações que podem ser obtidas diretamente do SEEA e/ou adaptadas para o ODS 6, ou ainda suporte ao monitoramento das metas e objetivos vinculados. Por fim, apresenta-se uma discussão sobre o caráter amplo de modelos como o SEEA-Water no contexto da política ambiental brasileira e os avanços rumo a integração do capital natural na composição do Produto Interno Bruto do país.

Palavras-chave: economia ambiental; contas da água; estatísticas da água; objetivos do desenvolvimento sustentável.

1. Introduction

Insufficient water availability in qualitative and quantitative terms has been indicated as one of the major contemporary socio-environmental issues (Salminen, 2018). In addition, the cross-cutting role of water in guaranteeing the sustainability of the water–energy–food nexus (Bhaduri *et al.*, 2015) in the face of global climate change requires an appropriate approach to ensure water, energy and food security on a global scale (UN-Water, 2022).

Thus, it seeks to support coordinated strategies for the use of water resources for economic production and social development without compromising environmental sustainability (Momblanch *et al.*, 2018). With the aim of promoting integrated water resource management which maximizes positive results and minimizes harmful impacts on the environment, the most diverse sources of available data must be integrated. In this way, it enables the production of effective information on water availability and water use from an economic perspective, with an emphasis on water accounting methods (Momblanch *et al.*, 2014).

The United Nations Statistics Division (UNSD) has developed a conceptual model for measuring the Environmental-Economic Accounting for Water (EEA-W), integrated into the central framework of the System of Environmental-Economic Accounting. In 2018, the 8th World Water Forum in Brazil published the "Environmental-Economic Accounting for Water in Brazil: First Results (2013-2017)" (ANA *et al.*, 2018), a pioneering study in Latin America that integrates data on water use and economic data using the System of Environmental-Economic Accounting for Water – SEEA-Water (UNSD, 2012).

The process of building the EEA-W in Brazil showed its importance for the 1st National Water Resources Plan (PNRH) - 2006 - 2020 and subsequent revisions, especially in the context of the implementation of Program I - Strategic Studies on Water Resources (Góes & Mendonça, 2019). In addition, several actions listed in the PNRH had a direct or indirect contribution from the EEA-W, as presented in GIZ (2019). These contributions can still be considered in the context of integrated and long-term water resources planning, currently guided by the PNRH - 2022-2040, under the aegis of federal law No. 9.433/97 (BRASIL, 1997), which establishes the National Water Resources Policy in Brazil.

Current water management practices are governed by technocratic and scenario-based approaches that are effective in the short term (Sivapalan *et al.*, 2014; Di Baldassarre *et al.*, 2019). However, they bring long-term uncertainties due to limited consideration of the interaction among natural, technical and social dimensions in the context of the water crisis and climate change (Hussein *et al.*, 2018). Moreover, current challenges and growing demands for water use increase the complexity of the water resource management environment in Brazil (Marques *et al.*, 2022).

In this context, among the main challenges for water resource management in the country, Paiva *et al.* (2020) discuss the need to advance economic instruments and the emergence of new perspectives and approaches based on the water – energy – food nexus and the 2030 Agenda for Sustainable Development. The 2030 Agenda for Sustainable Development is a United Nations directive designed to support countries in their national sustainability policies in a global context, using its 17 SDGs, which bring together issues such as hunger, social inequality, climate change, water and others (UN, 2015; Fukuda-Parr, 2016).

By incorporating water stocks from the economic perspective, measuring water flows from nature to the economy, water flows from the economy to nature and among the economic units, SEEA-Water becomes an important tool for integrated water resources management (UNSD, 2012). It also aims to monitor the efficiency of water use by the economic sector, assessing the water intensity and productivity associated with the use of water in the economy, thereby becoming an important tool for managing water resources.

In this sense of being able to integrate data of a diverse nature, management challenges and related instruments, the EEA-W is integrated with the SDGs. Specifically for SDG 6 "Ensure availability and sustainable management of water and sanitation for all", the EEA-W can be used to monitor the SDGs and present a set of information that serves to monitor their goals and objectives according to shared purposes and definitions expressed through indicators and/or contextual information obtained directly from the EEA-W (Bann, 2016; Pirmana *et al.*, 2019; Setioningtyas *et al.*, 2022).

In this context, this paper explores how the construction of EEA-Ws offers a set of fundamental statistics that can assist water resources management and planning, public policy formulation and, in a broader context, the monitoring of SDG 6. We will therefore begin by evaluating the main definitions and structures of physical and economic databases for compiling the EEA-W. The Brazilian example is also presented, highlighting how the EEA-W can be used to support the management and planning of water resources in the long term, through the National Water Resources Plan. Based on this debate, the aim is also to relate the structuring of the EEA-W to support the monitoring and follow-up of the goals and objectives of SDG 6.

2. The System of Environmental-Economic Accounting for Water, planning support system and the SDGs

The importance of water as a productive resource for economic activity and for ecosystem services in the context of integrated management has recently been emphasized (UNSD, 2012; Grizzetti *et al.*, 2016; Garrick *et al.*, 2017). In recent years, various international development organizations (e.g. United Nations (UN) and its agencies, such as the Food and Agriculture Organization (FAO), United Nations Department of Economic and Social Affairs (UN DESA) and others), non-governmental organizations – e.g. World Wide Fund for Nature (WWF)– and research institutes (e.g. International Water Management Institute (IWMI) has emphasized the need to integrate economic and environmental information in order to support the natural capital accounting. This is done based on various environmental aspects such as Water, Ecosystems, Material Flows, Energy, among others.

For the purposes of standardization and searching for a dialogue with consolidated systems, this logic of integrating economic and environmental data tends to follow the systematization of information on a country's economic activities carried out by the System of National Accounts (SNA). This system provides for the presentation of data on stocks and economic flows in a standard format for the purposes of planning and formulating public policies. Within this panorama, the United Nations Statistics Division presented the central framework of the System of Environmental-Economic Accounting (SEEA) (UNSD, 2014), which emerges as a standardized set of conceptual definitions and methodologies applied to the accounting of natural resources (i.e. water, forests and ecosystems).

Specifically for water resources, various methodologies have recently been applied at different scales. One objective for carrying out multidimensional diagnoses is the pressure exerted by the demands of water use on the environment in a particular territory. Countries with a wide range of water availability in their territory, such as Brazil and Mexico, or countries suffering from water scarcity, such as Australia, have adopted models such as SEEA-Water (UNSD, 2012) and the Australian Water Accounting Standards (AGBM, 2012).

In general terms, these models can provide strategic information in a systematized and reliable way to support decision-making in the face of water resource management challenges on a national and sub-national scale (Bagstad *et al.*, 2020), and have been developed by different countries and institutions with different presentation formats and results obtained (Van Dijk *et al.*, 2014; Vicente *et al.*, 2016).

Other similar models have been widely applied in different contexts. It is worth mentioning the Water Footprint method (Hoekstra *et al.*, 2011) and the systems developed by IWMI, such as the Water Accounting Framework (WA) and its later version, developed in partnership with UNESCO - IHE Delft and FAO, entitled Water Accounting Plus (WA+) (Karimi *et al.*, 2013), as highlighted in Goodfrey & Chalmers (2012).

By definition, the Water Footprint concept presents a multidimensional indicator of water use that is carried out directly and indirectly by a specific consumer/producer considering all stages of the supply chain (Hoekstra *et al.*, 2011). In turn, WA deals with the systematization of information on water supply and use in relation to economic activities, while WA+ is a system for monitoring water use and production that allows estimates of flows, stocks, consumption and services related to water productivity based on the influence of land use and management on evapotranspiration in river basins (Karimi *et al.*, 2013). To do this, WA+ uses a public domain database from remote sensing products.

From a broader perspective, the UN encourages the use of SEEA-Water (UNSD, 2012) as an auxiliary tool in the integrated management of water resources, by presenting a theoretical, conceptual and multi-scalar model whose main objective is the systematization and standardization of hydrological and socio-economic information. In general terms, SEEA-Water aims to describe the interactions between the economic and environmental spheres, covering a broad spectrum of environmental issues and, more specifically, concerning water availability and demand in a given territory. The systematization of data and statistics promoted by SEEA-Water starts with the preparation of a set of standardized tables that present information on water use and supply, volumes consumed by economic activities and households, as well as volumes returned into the environment and the economic output of each activity.

In addition, SEEA-Water presents the interrelationships between the sectors of the economy on a specific time scale (Gutierrez-Martín *et al.*, 2017), structured by means of the Physical (PSUTs) and the Hybrid (HSUTs) Supply and Uses Tables (made up of the composition of the physical and monetary supply and use tables). It is worth noting that the classification of economic activities adopted in SEEA-Water follows the same standard as the SNAs, that is, the International Standard Industrial Classification of All Economic Activities (ISIC).

SEEA-Water also provides water balance information for the main asset categories (e.g. rivers, lakes, artificial reservoirs, soil water and groundwater) of a territory (e.g. Asset / Stock tables). Vicente *et al.* (2016) identify the system as a key political instrument for assessing the quantity of water and its availability in a territory. From this set of tables, various indicators can be easily obtained, such as the ones measuring:

i) the availability of and pressure on water resources,

ii) the use of water by and for human activities and

iii) water intensity and productivity associated with water (UNSD, 2012).

2.1. Brazil's Environmental-Economic Accounting for Water

Brazil is currently in stage III of the process of implementing the Economic-Environmental Accounting (UNSD, 2022), which means that the compilation of the accounting is part of the process of regularly producing and disseminating statistics in the country through sectoral studies coordinated by the IBGE together with other data-producing agencies on a national scale. Thus, in addition to the two editions of the EEA-W, since 2018 Brazil has presented its Economic-Environmental Accounting for Energy: biomass products (IBGE, 2021), for Land: physical accounting (IBGE, 2022), among others of an experimental nature, especially the valuation of ecosystem services for the provision of Blue Water (IBGE, 2021a) and the condition of water bodies in Brazil (IBGE, 2021b).

In a wider sense, the development of the Environmental-Economic-Accounting is part of an inter-institutional effort to calculate the country's Green Domestic Product (GDP). The GDP is an economic indicator designed to integrate a country's income, well-being and socio-economic value generated exclusively by green and sustainable growth (Aguilar-Rivera, 2021) and which reflect the trade-off between the ecosystem and economic system. In turn, this growth is the result of structural transformation, infrastructure development, technological change, among other actions focused on sustainability and can be measured considering the standards and procedures of the SNA and SEEA.

The estimation of the GDP in Brazil is supported by Federal Law No. 13.493/2017 (BRASIL, 2017), which states that its calculation should enable convergence with the SEEA adopted in other countries, allowing for comparability. Additionally, it is planned to include the valuation of natural capital in its composition. In this sense, this objective is aligned with a global movement towards a green and sustainable economy, contributing to an egalitarian society and better governance practices under the auspices of initiatives such as the SDGs in a broader perspective of the sustainability of the water – energy – food nexus.

In March 2018, on the World Water Forum the publication "Environmental-Economic Accounting for Water in Brazil" (EEA-W) was released. The publication, institutionally signed by the Ministry of the Environment (MMA), the National Water and Sanitation Agency (ANA) and the Brazilian Institute of Geography and Statistics (IBGE), was the result of intense institutional coordination and collaboration among these institutions, which for five years (2013 to 2017) allocated material and human resources to the preparation of Brazil's EEA-W, in accordance with the methodological framework of the UNSD-UN SEEA-Water.

As a matter of fact, Brazil is a leading country in the production of Environmental-Economic Accounts following the SEEA criteria, publishing studies in the areas of Water, Energy and Ecosystems in recent years. This is coordinated by the IBGE in partnership with other national institutions. With regard to water specifically, since the adoption of SEEA-Water, the country has presented a set of studies that are among the most comprehensive and detailed to date (Moura *et al.*, 2022). In a joint effort coordinated by ANA, IBGE and other institutions, two recently published reports present the application of SEEA-Water in the country (ANA, IBGE, SRHQ, 2018; IBGE, 2020).

This first publication of SEEA-Water in Brazil introduced the construction of the historical series of asset tables, physical and hybrid supply and use tables and various indicators for the country for the period 2013-2015. As an advance on this first publication, the IBGE (2020) presented a revision and expansion of the national results by disaggregating these results for the five major Brazilian regions (North, Northeast, Central-West, Southeast and South), as well as new estimates and definitions based on gaps identified in ANA, IBGE, SRHQ (2018).

The EEA-W for the period 2013-2017 presented the following data tables[1]:

[1] The tables and the main results of the EEA in Brazil are available on the IBGE website.

(i) **Assets Tables** for the period 2013 to 2017: showing the increases and decreases to the country's stocks of water resources;

(ii) **Physical Supply and Use Tables** for the period 2013 to 2017: which provide information on water abstraction and flows from the environment to the economy, from the economy to the environment and within the economic activities;

(iii) **Hybrid Supply and Use Tables** for the period 2013 to 2017: which correlates the monetary values of water production and consumption with the respective physical volumes, as well as explaining flows that do not correspond directly to monetary values, such as water abstraction for own use;

(iv) **Indicators Tables**: which summarize the data shown in the previous tables into assets, physical and hybrid indicators, such as: i) Total Renewable Water Resources per capita; ii) total water use; iii) domestic water use per capita; iv) cost of water supply per volume of treated water supplied, among others.

The publication of these EEA-W tables (2018 and 2020) has enabled the development of several studies that contribute to water management and governance in Brazil. In this context, we mention the works of:

i) Naspolini *et al.* (2020) carried out an Input-Output and structural decomposition analysis to describe water consumption in the Brazilian economy and the main drivers during the period of water scarcity and economic recession in the country between 2013-2015,

ii) Montoya & Finamore (2021) with a focus on agribusiness, disaggregated the EEA-W tables with the Input-Output (IO) Matrix in 2015 to evaluate water use and consumption, water efficiency and intensity in relation to income and employment.

iii) Montoya (2020), who, also based on the EEA-W and the country's IO Matrix, proposes an ecological input-output model and evaluates the national Water Footprint and the Virtual Water trade balance[2] in Brazil.

2.2. The role of Environmental-Economic Accounting for Water in long-term management and planning: a support for the National Water Resources Policy

The relevance of the EEA-W to the National Water Resources Policy (is defined both by its application as a management tool, guiding short- and medium-term decision-making, and in long-term planning.

The first PNRH was implemented between 2006-2010. After the consultation process with the National Water Resources Management System (SINGREH), the document "National Water Resources Plan: Priorities 2012 - 2015" was drawn up, followed by the National Water Resources Plan for 2016-2020. On March 22, 2022, World Water Day, the National Water Resources Council (CNRH) approved the new National Water Resources Plan for the period 2022 to 2040 (MDR, 2022).

The programs and actions of the PNRH 2022-2040 are aligned with the commitments made by the Brazilian government to the 2030 Agenda and

[2] The concept of virtual water was proposed as an adaptation of a previously used term, embedded water, translated as the volumes of water incorporated into products (Allan, 2003). It can therefore be defined as the total volume of water required to produce a good, either through direct incorporation or through the production of inputs (Hoekstra, 2003).

SDG 6. In this sense, different databases on water use in the country can support its actions, such as the indirect estimates of consumptive uses presented in the National Database of Water Uses (ANA, 2022), water users database (e.g. National Register of Water Resources Users - CNARH), among others.

However, the construction of the EEA-W is based on the integration of these and other data sources to link data on supply and demand of water uses with economic data. Although EEA-W does not explicitly appear in the PNRH 2022-2040, there are guidelines and actions within the PNRH's programs and actions that can encompass studies of this nature.

For example, the document "PNRH Action Plan 2022-2040" shows that in studies of this type, the EEA-W could be based on Subprogram 1.5 - Innovation, Science and Technology for Water Resources Management, whose macro guidelines are to develop studies and research aimed at expanding the current knowledge base in the field of groundwater and surface water resources, from the perspective of quality and quantity. The corresponding action is: to develop strategic studies to improve the National Water Resources Policy and strengthen SINGREH. In addition to this, other subprograms could benefit from the results and analyses coming from the EEA-W, for example, Subprogram 2.3 - Charging for the Use of Water Resources, linked to Program 2 - Implementation of Water Resources Management Instruments and Subprogram 3.5 Supply and Efficient Use of Water, linked to Program 3 - Management of the Quality and Quantity of Water Resources.

With regard to long-term applications in the context of the PNRH, the successive editions of the EEA-W will make this possible:

(i) the development of analytical tools aimed at establishing quantitative water resource scenarios linked to the country's economic development,

(ii) the analysis of the impact of relevant changes imposed by public policies,

(iii) the development of models that will enable the assessment of the macroeconomic consistency of the quantifications to be carried out and (iv) the impacts on natural resources associated with the country's national/regional development.

3. Indicators of availability and pressure on water resources from the EEA-W

Table 1 shows the indicators used to assess the availability of water resources in a territory from an environmental perspective. Overall, these indicators allow the assessment of some natural characteristics of a geographical region from the perspective of available water volumes. UNSD (2012) emphasizes the importance of considering these indicators from the perspective of the pressure caused by human activities, in order to correlate information on water demands with the availability of water in the environment.

With the goal of monitoring the efficiency of water use by the economic sector, SEEA-Water also enables a set of indicators to be obtained relating to water intensity and productivity associated with the use of water in the economy (Table 2). These indicators are defined as the integration of the results systematized in the model over time for a specific sector of the economy in relation to the volume of water abstracted and/or consumed, allowing the evaluation of trends in efficiency and intensity of water use and consumption in a territory.

TABLE 1 - Selected indicators for assessing availability and pressure on water resources derived from SEEA-Water (UNSD, 2012).

Indicator	Definitions	Equation
Internal Renewable Water Resources (*IRWR*)	Average annual river flows and aquifer recharge generated by endogenous precipitation in the territory.	IRWR = Precipitation (hm³/year) - Evapotranspiration (hm³/year)
External Renewable Water Resources (*ERWR*)	The portion of a territory's renewable water resources that is shared with neighboring territories. Total external resources are the flow from neighboring territories (transboundary groundwater and surface water flows) and part of shared lakes and/or rivers.	ERWR = ∑ of inflows of water resources from other territories (hm³/year), equivalent to line 4.b of the SEEA-Water Assets Table.
Total Natural Renewable Water Resources (*TRWR*)	The sum of the territory's internal and external renewable water resources. Corresponds to the maximum amount of water available for a territory in a reference year.	TRWR = IRWR (hm³/year) + ERWR (hm³/year)
Dependency ratio (*DR*)	Ratio between ERWR and TRWR, indicating the proportion of water resources that are generated in neighboring territories in relation to the reference territory.	DR = ERWR (hm³/year) / TRWR (hm³/year)
Per capita renewable resources	Ratio between TRWR and the population of the reference territory in a specific year.	TRWR per capita = TRWR (hm³/year) / population (inhabitants)
Volume abstracted as a proportion of TRWR - *Exploitation index* (*EI*)	Total volume abstracted by economic activities as a percentage of TRWR per year.	EI = ∑ (Withdrawals, Agriculture, Industry, Water Collection, Treatment and Distribution and Other Activities) (hm³/year) / TRWR (hm³/year)
Consumption Index (*CI*)	Ratio between total water consumption by economic activities and TWRW.	CI = ∑ (Total consumption by sector of the economy) (hm³/year) / TRWR (hm³/year)

SOURCE: prepared by the authors based on UNSD (2012).

TABLE 2 - Selected indicators for assessing water intensity and productivity based on SEEA-Water (UNSD, 2012).

Indicator	Definitions	Equation
Volume of artificial reservoir capacity per capita (***Vr***)	Ratio between the total storage volume of reservoirs for electricity generation in a territory and the population in a given year.	Vr = Storage capacity of artificial reservoirs in the territory (hm³) / population (inhabitants)
Total volume abstracted per capita (***Vt***)	Ratio between the total volume abstracted by economic activities and the population in a certain year.	Vt = ∑ (Withdrawals, Agriculture, Industry, Water Collection, Treatment and Distribution and Other Activities) (hm³/year) / population (inhabitants)
Volume abstracted for supply per capita (***Vab***)	Ratio between the total volume abstracted by the economic activity of water collection, treatment and distribution and the population on a certain day.	Vab = Volume abstracted by the ISIC 36 sector (excluding agriculture, drinking water) (l) / population (inhabitants) / 365
Proportion of water losses in distribution (***Vp***)	Ratio between the volume of water lost in water distribution and the volume abstracted by the Water Collection, Treatment and Distribution sector.	Vp = Losses in water distribution (hm³/year) / Volume captured by the sector (hm³/year)

Volume of water received by "Households" per capita (***Vf***)	Ratio between the volume of water received by "Households" connected to the public water supply network and the population on a certain day.	Vf = Volume of water received by "Households" connected to the public supply network (l/year) / population (inhabitants) / 365
Total water use by Households per capita per day (***Vfu***)	Ratio between the total water use of "Households" and the population on a certain day.	Vfu = Total water use by "Households (l/year) / population (inhabitants) / 365
Efficiency of sectoral water consumption (***Ec***)	Ratio between the gross value added by disaggregated economic activities (Agriculture, Livestock and Extractive Industry and Manufacturing Industry) and the sector's water consumption in a particular year, expressed in R$/m³.	$Ec_{set} = \frac{VAB}{Va - Ra}$ Where: GVA (gross value added for the economic activity - R$/year; Va (abstracted flows by the sector - m³/year); Ra (return flows by the sector - m³/year).
Sectoral water consumption intensity (***Ic***)	Ratio between the sector's water consumption in a certain year and the gross value added by disaggregated activities (Agriculture, Livestock and Extractive Industry and Manufacturing Industry), expressed in liters/R$	$Ic_{set} = \frac{Va - Ra}{VAB}$ Where: GVA (gross added value for the economic activity - R$/year; Va (abstracted flows by the sector - liters/year); Ra (return flows by the sector - liters/year).

SOURCE: prepared by the authors based on UNSD (2012).

4. The Environmental-Economic Accounting for Water and the SDGs

The 17 SDGs of the 2030 Agenda for Sustainable Development represent an ambitious global plan that aims to help countries shape their national policies and priorities in the field of sustainability. The SDGs emerge at a time when environmental economics is gaining attention among institutions (Setioningtyas *et al.*, 2022) and present a set of 169 goals and 232 interconnected indicators to assess the challenges towards sustainability (Sachs, 2012; Mio *et al.*, 2020). Within this context, the possibility of the SEEA contributing to the monitoring of the SDGs is presented in two technical documents formulated by the UN Committee of Experts on Economic and Environmental Accounting (UNCEEA) (UNSD, 2015a; UNSD, 2015b).

In a complementary analysis of this potential, through a literature review and consultation with experts, Pirmana *et al.*(2019) list 46 indicators and point out that:

i) can be obtained directly from the SEEA,

ii) can be adapted for SEEA and SDG integration,

iii) the SEEA presents a set of contextual information for monitoring SDG targets,

iv) in which there is a conceptual overlap between the SEEA and the SDGs.

More broadly, SEEA, as an international statistical standard, can contribute to the formulation of policies and the monitoring of SDG indicators. This capacity emerges due to the comprehensive vision of this system's methodology for compiling physical and monetary information for a wide range of resources, including water resources, and relating them to the economic dynamics of a territory in a manner compatible with the SNAs. Therefore, the success of the integration between the SDGs and the SEEA will require an institutional arrangement for compiling information to the SEEA standards, and is also related to factors such as the availability and quality of data on a local and global scale.

To assess whether the SDG targets related to water are specific, measurable, achievable, realistic and timely, BWS (2013) indicates that a wide and in-depth knowledge of water availability and use at global and local scales is crucial. Therefore, being a statistical system that is widely integrated with the SNA, SEEA and of a multi-scalar nature, SEEA-Water represents a possibility to support the monitoring of the progress of SDG 6, especially in the context of the nexus between the economy and the environment.

Due to the integrative nature of water, which is a fundamental part of human development and the maintenance of ecosystem needs (Harlin & Kjellén, 2015), the SEEA's greatest potential in relation to monitoring the SDGs lies in compiling information on water resources, by structuring the SEEA-Water (Pirmana *et al.*, 2019), especially on topics related to water availability, sustainable water management, and sanitation services.

SDG 6 is composed of eight individual targets that deal with the issue of water resources and sanitation from an integrated and integrating perspective, placing water as a central element also in themes addressed by other SDGs (e.g. environment, energy, food security, and public health). The targets of each SDG are monitored by global indicators standardized by UN institutions, based on data of various kinds (census, demographic, water use, diagnostics, etc.) at different spatial scales (e.g. countries, regions, river basins, etc.).

Thus, the data compiled and structured following SEEA-Water and the indicators proposed in SDG 6 are fully compatible (Table 3), based on shared objectives and philosophies (Bann, 2016). In this sense, the compilation of the EEA-W initially requires an assessment of the availability of data and the process of generating existing statistics.

In situations of data scarcity, the structuring of databases through SEEA-Water allows data to be used in different ways, as well as identifying the main gaps in data production and, in a second phase, supporting the creation of strategies to develop reliable statistics from gaps or uncertainties in the databases.

The implementation of the monitoring of the SDGs and their targets has brought with it a demand for robust and reliable databases (Guppy *et al.*, 2019) and at different scales (Bhaduri *et al.*, 2016). In this regard, obtaining SDG indicators implies on continuous monitoring and periodic evaluation of aspects related to data production and its integration with other conceptual frameworks.

In this context, the biggest challenges for monitoring the SDG 6 indicators are their conceptual complexity and limitations in terms of the consistency and availability of the data necessary to calculate them. According to Pirmana *et al.* (2019), the SDGs originate from a political framework and SEEA-Water serves as the foundation for structuring the necessary databases towards sustainable development.

TABLE 3 - Relation between the set of SDG 6 indicators and the EEA-W compiled from SEEA-Water.

Target	Indicator	SEEA-Water information	Tier
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all.	6.1.1 Proportion of Population Using Safely Managed Drinking Water Services	PSUT + HSUT	II
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, with special attention to the needs of women and girls and people in vulnerable situations.	6.2.1 Proportion of Population using a) safely managed sanitation services, b) including facilities for washing hands with soap and water.	PSUT + HSUT	II
6.3 By 2030, improve water quality in water bodies by reducing pollution, eliminating discharges and minimizing the discharge of hazardous materials and substances, reducing by half the proportion of untreated effluent discharged and substantially increasing safe recycling and reuse locally.	6.3.1 Proportion of Wastewater Treated Safely	PSUT	II
6.4 By 2030, substantially increase the efficiency of water use in all sectors, ensuring sustainable withdrawals and the supply of fresh water to substantially reduce the number of people suffering from scarcity	6.4.1 Changes in Water Use Efficiency	PSUT + Productivity indicators	II
	6.4.2 Water Stress Level: Ratio of freshwater withdrawals to the country's total available freshwater resources.	PSUT + Assets	I
6.5 By 2030, implement integrated water resources management at all levels of government, including through transboundary cooperation	6.5.1 Degree of implementation of integrated water resources management	PSUT + Assets	I
6.a By 2030, expand international cooperation and capacity-building support for developing countries in activities and programs related to water and sanitation, including, among others, water resources management, water harvesting, desalination, water use efficiency, wastewater treatment, recycling and reuse technologies.	6.a.1 Amount of official development aid in the area of water and sanitation, included in a government spending plan.	HSUT	I

SOURCE: adapted by the authors from Bann (2016) and Pirmana *et al.*

Indicators of SDG 6 targets, such as 6.1.1, 6.2.1, 6.3.1 and 6.5.1, represent the ones where the SDG indicator is not obtained directly from the SEEA-Water compilation. However, an integrated analysis of the EEA-W tables and indicators allows the opportunity to contextualize and support the monitoring of SDG 6 and its targets. For example, in the EEA-W, information on volumes of water collected, treated and distributed by the Water Supply sector and wastewater collected and treated by the Sewerage and Related Activities sector, including final disposal, is separated by sector of the economy. With a focus on Households and the respective economic sectors, this compilation of information serves to support the evaluation of the sector's progress in relation to serving the population in a territory, supporting the monitoring and contextualization of targets 6.1, 6.2 and 6.3, along with indicators 6.1.1, 6.2.1, 6.3.1.

Figure 1 shows information from the EEA-W for Brazil on the volume of wastewater generated by households and its destination in conjunction with SDG indicator 6.3.1, obtained from ANA (2022).

In this context, the time series of EEA-W in Brazil presents the separation of wastewater volumes by economic activities and Households, as defined by SEEA-Water. In the specific case of Households, the volume of wastewater going into sewerage and the volume of wastewater going directly into the environment, without collection and treatment, were estimated. In an integrated analysis, while there has been an increase in the proportion of safely treated wastewater and in the volumes of wastewater sent to the sewage system, the volumes of wastewater generated by Households, without collection and with a direct return to the environment (i.e. surface water or soil), have shown a downward trend in the period.

There is also a similarity of definitions between the SEEA-Water water productivity and efficiency indicators (Table 2) and SDG indicator 6.4.1, which means that the information compiled in the Physical and Hybrid Supply and Use tables allows for the compilation of the SDG indicator separated by sector.

With regard to indicator 6.4.2, information required for its calculation, such as water demands (i.e. water abstractions directly from the environment by sectors of the economy) and total freshwater stocks, including surface and groundwater, as well as upstream water inflows from other countries, is compiled in the Physical Supply and Use and Asset Tables, respectively.

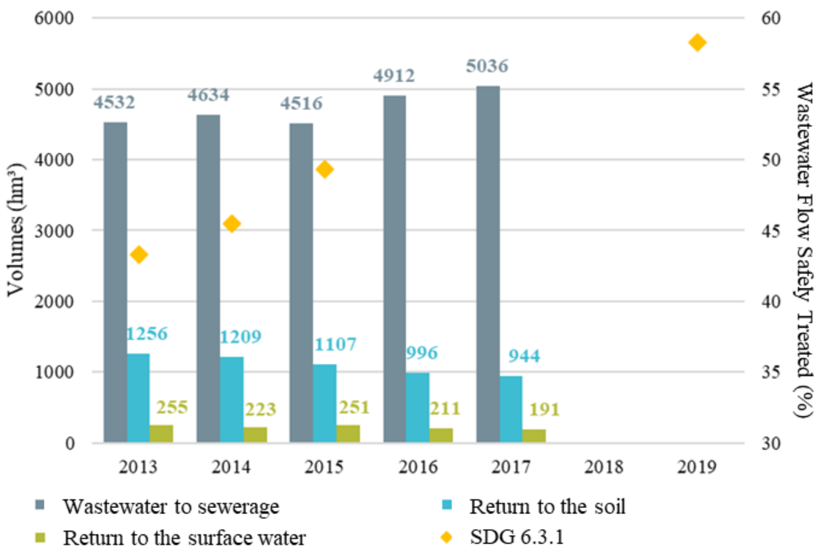

FIGURE 1 - Volumes of wastewater produced by households and their destination (i.e.sewage systems, untreated - surface water and untreated – soil), originating from EEA-W Brazil and indicator SDG 6.3.1- Proportion of wastewater flow safely treated.

NOTE: The EEA-W historical series covers 2013-2017 and the SDG indicator covers 2009-2019, with the exception of 2010 and 2016-2018.

SOURCE: ANA (2022).

5. Final considerations

The main goal of this paper is to discuss the main possibilities for the EEA-W to contribute to the process of systematizing auxiliary information for decision-making in the planning and management of water resources at various scales. The possibility of integrating the EEA-W with the targets and indicators of SDG 6 also provides for the possibility of incorporating concepts and systematized information bases for their compilation and monitoring.

Hence, it should be emphasized that studies of an integrative nature, such as those resulting from the application of SEEA-Water and other water accounting systems, are fundamental for consolidating a technical-scientific knowledge base aimed at supporting the monitoring of public policies at a range of scales.

In a broader context, the consolidation path of SEEA-Water, given its convergence with the monitoring of the SDG targets and indicators, serves to support the process of assessing the availability of water resources, demands and uses of water for human activities, access to water supply services and sewage collection and treatment, as well as the monitoring of sectoral water efficiency and intensity in a country from a relatively simplified conceptual framework.

Brazil has gained prominence on the international stage as one of the pioneering countries in consolidating its Environmental-Economic Accounting and, in particular, the EEA-W. The text showed that this tool enables new studies and qualified monitoring of water demand, and is in line with the National Water Resources Policy. Currently, publications of studies of this nature are already part of the routine of statistical and water resource management bodies and can be strengthened for medium- to long-term planning in Brazil.

In addition, this planning provides databases for forecasting water use demands, analyzing the economic impacts associated with water scarcity, the feasibility of public policies toward water security and others. Considering this panorama, the results of the EEA-W, which relate aspects of the economy and the multiple uses of water, are expected to be incorporated into the context of the sustainability and balance in the use of water resources in the country.

References

ANA — Agência Nacional de Águas e Saneamento Básico; IBGE — Instituto Brasileiro de Geografia e Estatística; SRHQ — Secretaria de Recursos Hídricos e Qualidade Ambiental. Ministério do Meio Ambiente. *Contas econômicas ambientais da água*: Brasil: 2013-2015, Brasília, 2018. Disponível em: <https://arquivos.ana.gov.br/portal/contas_economicas.pdf>. Acesso em: set. 2022.

ANA — Agência Nacional de Águas e Saneamento Básico. *ODS 6 no Brasil*: visão da ANA sobre os indicadores, 2022. Disponível em: <https://metadados.snirh.gov.br/geonetwork/srv/api/records/c93c5670-f4a7-4de6-85cf-c295c3a15204/attachments/ODS6_Brasil_ANA_2ed_digital_simples.pdf> . Acesso em: mar. 2023.

ANA — Agência Nacional de Águas e Saneamento Básico. *Base Nacional de Usos da Água e as Resoluções ANA nº 92 e nº 93/2021*. 2022. Disponível em: <https://metadados.snirh.gov.br/files/ac9b36cd-88fc-4211-911a-741b5f290c00/ANA_Boletim-SNIRH_1a-Ed_Web.pdf>. Acesso em: mar.2023.

Aguilar-Rivera, N. Green Gross Domestic Product (Green GDP) and sustainable development. *In*: *Encyclopedia of the UN Sustainable Development Goals*, Reduced Inequalities, 1-15, 2021.

AGBM — Australian Government - Bureau of Meteorology. *Australian Water Accounting Standard 1 Preparation and Presentation of General Purpose Water Accounting Reports*, 2012. Disponível em: <http://www.bom.gov.au/water/standards/documents/awas1_v1.0.pdf>. Acesso em: set. 2022.

Allan, J. A. Virtual water-the water, food, and trade nexus. Useful concept or misleading metaphor? *Water International*, 28(1), 106-113, 2003.

Bagstad, K. J.; Ancona, Z. H.; Hass, J.; Glynn, P. D.; Wentland, S.; Vardon, M.; Fay, J. Integrating physical and economic data into experimental water accounts for the United States: lessons and opportunities. *Ecosystem Services*, 45, 1-21, 2020. doi: 10.1016/j.ecoser.2020.101182

Bann, C. Natural capital accounting and the sustainable development goals. 2016. Disponível em: <https://documents1.worldbank.org/curated/en/323151568692500022/pdf/Natural-Capital-Accounting-and-the-Sustainable-Development-Goals.pdf>. Acesso: set. 2022.

Bhaduri, A.; Ringler, C.; Dombrowski, I.; Mohtar, R.; Scheumann, W. Sustainability in the water–energy–food nexus, *Water International*, 40, 5-6, 723-732, 2015. doi: 10.1080/02508060.2015.1096110

Brasil. *Lei n.° 9.433 de 8 de janeiro de 1997*. Institui a Política Nacional de Recursos Hídricos. Brasília: DOU de 08/01/1997.

BWS — Budapest Water Summit. *Budapest Water Summit Statement*: a sustainable world is a water-secure world. 2013. Disponível em <http://www.Budapestwatersummit.hu/data/images/Budapest_Water_Summit_Statement___Final___11_October_2013.pdf>. Acesso em: out. 2022.

Di Baldassarre, G.; Sivapalan, M.; Rusca, M.; Cudennec, C.; Garcia, M.; Kreibich, H.; Blöschl, G. Sociohydrology: scientific challenges in addressing the sustainable development goals. *Water Resources Research*, 55(8), 6327-6355, 2019. doi: 10.1029/2018WR023901

Fukuda-Parr, S. From the millennium development goals to the sustainable development goals: shifts in purpose, concept, and politics of global goal setting for development. *Gender and Development*, 24(1), 43-52, 2016. doi: 10.1080/13552074.2016.1145895

Garrick, D. E.; Hall, J. W.; Dobson, A.; Damania, R.; Grafton, R. Q.; Hope, R.; Money, A. Valuing water for sustainable development. *Science*, 358(6366), 1003-1005, 2017.

Giz. A contribuição das contas econômicas ambientais nas políticas públicas no Brasil: água. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Brasília/DF: 2019.

Goodfrey, J.; Chalmers, K. *Water Accounting - International Approaches to Policy and Decision-making*. Edward Elgar Pub, 2012.

Góes, G. S.; Mendonça, M. J. C. As contas econômicas ambientais da água como instrumento para a gestão da política nacional de recursos hídricos. *Boletim Regional, Urbano e Ambiental - BRUA*. 20, 2019.

Grizzetti, B.; Lanzanova, D.; Liquete, C.; Reynaud, A.; Cardoso, A. C. Assessing water ecosystem services for water resources management. *Environmental Science & Policy*, 61, 194-203, 2016. doi: 10.1016/j.envsci.2016.04.008

Guppy, L.; Mehta, P.; Qadir, M. Sustainable development goal 6: two gaps in the race for indicators. *Sustainability Science*, 14(2), 501-513, 2019. doi: 10.1007/s11625-018-0649-z

Gutiérrez-Martín, C.; Borrego-Marín, M. M.; Berbel, J. The economic analysis of water use in the water framework directive based on the system of environmental-economic accounting for water: A case study of the Guadalquivir river basin. *Water*, 9(3), 180, 2017. doi: 10.3390/w9030180

Harlin, J.; Kjellén, M. Water and development: from MDGs towards SDGs. Content, 8, 2015. Disponível em: <http://programme.worldwaterweek.org/sites/default/files/2015_www_report_web.pdf#page=8>. Acesso em: set. 2022.

Hoekstra, A. Y. Virtual water: an introduction. *Virtual water trade*, 13, 2003.

Hoekstra, A.Y.; Chapagain, A.K.; Mekonnen, M. M.; Aldaya, M. M. *The water footprint assessment manual*: setting the global standard. Routledge, 2011.

Hussein, H.; Menga, F.; Greco, F. Monitoring transboundary water cooperation in SDG 6.5. 2: how a critical hydropolitics approach can spot inequitable outcomes. *Sustainability*, 10(10), 36-40, 2018. doi: 10.3390/su10103640

IBGE — Instituto Brasileiro de Geografia e Estatística. *Contas de ecossistemas: condição dos corpos hídricos: 2010/2017*. IBGE, Coordenação de Contas Nacionais, Coordenação de Recursos Naturais e Estudos Ambientais, Rio de Janeiro, 2021b. Disponível em <http://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101797>. Acesso em: set. 2022.

IBGE — Instituto Brasileiro de Geografia e Estatística. *Contas de ecossistemas: valoração do serviço do ecossistema de provisão de água azul: 2013-2017*. IBGE, Coordenação de Contas Nacionais, Coordenação de Recursos Naturais e Estudos Ambientais, Rio de Janeiro, 2021a. Disponível em <http://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101799>. Acesso em: set. 2022.

IBGE — Instituto Brasileiro de Geografia e Estatística. *Contas Econômicas Ambientais da Terra: contabilidade física 2000 - 2020*. IBGE, Coordenação de Contas Nacionais, Coordenação de Recursos Naturais e Estudos Ambientais Rio de Janeiro, 2022. Disponível em <https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101965>. Acesso em: set. 2022.

IBGE — Instituto Brasileiro de Geografia e Estatística. *Contas Econômicas Ambientais de Energia: produtos de biomassa*. IBGE, Coordenação de Contas Nacionais, Coordenação de Recursos Naturais e Estudos Ambientais, Rio de Janeiro, 2021. Disponível em <http://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101894>. Acesso em: set. 2022.

Karimi, P.; Bastiaanssen, Wgm, Molden, D. Water Accounting Plus (WA+) - a water accounting procedure for complex river basins based on satellite measurements. *Hydrology and Earth System Sciences*, 17(7), 2459-2472, 2013. doi: 10.5194/hessd-9-12879-2012

Marques, G. F.; Formiga-Johnsson, R. M.; de Oliveira, P. P. D. F.; Molejon, C.; Braga, C. F. C. Os serviços de gestão de recursos hídricos. *Revista de Gestão de Água da América Latina*, 19, 2022. doi: 10.21168/rega.v19e1

MDR — Ministério do Desenvolvimento Regional. *Plano Nacional de Recursos Hídricos*: Plano de Ação, 2022. Disponível em: <https://www.gov.br/mdr/pt-br/assuntos/seguranca-hidrica/plano-nacional-de-recursos-hidricos-1/pnrh_2022_para_baixar_e_imprimir.pdf>. Acesso em: set. 2022.

Mio, C.; Panfilo, S.; Blundo, B. Sustainable development goals and the strategic role of business: a systematic literature review. *Business Strategy and the Environment*, 29(8), 3220-3245, 2020. doi: 10.1002/bse.2568

Momblanch, A.; Andreu, J.; Paredes-Arquiola, J.; Solera, A.; Pedro-Monzonís, M. Adapting water accounting for integrated water resource management. The Júcar Water Resource System (Spain). *Journal of Hydrology*, 519, 3369-3385, 2014. doi: 10.1016/j.jhydrol.2014.10.002

Momblanch, A.; Pedro-Monzonís, M.; Solera, A.; Andreu, J. Water accounting for integrated water resources management: experiences and recommendations. *In*: *Advances in Chemical Pollution, Environmental Management and Protection*. Elsevier, 2018, p. 63-96.

Montoya, M. A. A pegada hídrica da economia brasileira e a balança comercial de água virtual: uma análise insumo--produto. *Economia Aplicada*, 24(2), 215-248, 2020. doi: 10.11606/1980-5330/ea167721

Montoya, M. A.; Finamore, E. B. Os recursos hídricos no agronegócio brasileiro: uma análise insumo-produto do uso, consumo, eficiência e intensidade. *Revista Brasileira de Economia*, 74, 441-464, 2021. doi: 10.5935/0034-7140.20200021

Moura, A.; Lutter, S.; Siefert, C. A. C.; Netto, N. D.; Nascimento, J. A. S.; Castro, F. Estimating water input in the mining industry in Brazil: a methodological proposal in a data-scarce context. *The Extractive Industries and Society*, 9, 1-15, 2022. doi: 10.1016/j.exis.2021.101015

Naspolini, G. F.; Ciasca, B. S.; La Rovere, E. L.; Pereira Jr, A. O. Brazilian environmental-economic accounting for water: a structural decomposition analysis. *Journal of Environmental Management*, 265, 1-9, 2020. doi: 10.1016/j.jenvman.2020.110508

Paiva, R. C. D. D.; Chaffe, P. L. B.; Anache, J. A. A.; Fontes, A. S.; Araujo, L. M. N. D.; Araujo, A. N. D.; Zanandrea, F. Advances and challenges in the water sciences in Brazil: a community synthesis of the XXIII Brazilian Water Resources Symposium. RBRH, 25, 2020. doi: 10.1590/2318-0331.252020200136

Pirmana, V.; Alisjahbana, A. S.; Hoekstra, R.; Tukker, A. Implementation barriers for a system of environmental-economic accounting in developing countries and its implications for monitoring sustainable development goals. *Sustainability*, 11(22), 1-35, 2019. doi: 10.3390/su11226417

Sachs, J. D. From millennium development goals to sustainable development goals. *The Lancet*, 379(9832), 2206-2211, 2012. doi: 10.1016/S0140-6736(12)60685-0

Salminen, J. M.; Veiste, P. J.; Koskiaho, J. T.; Tikkanen, S. Improving data quality, applicability and transparency of national water accounts - A case study for Finland. *Water Resources and Economic*s, 24, 25-39, 2018. doi: 10.1016/j.wre.2018.05.001

Setioningtyas, W. P.; Illés, C. B.; Dunay, A.; Hadi, A.; Wibowo, T. S. Environmental economics and the SDGs: a review of their relationships and barriers. *Sustainability*, 14(12), 75-13, 2022. doi: 10.3390/su14127513

Sivapalan, M.; Konar, M.; Srinivasan, V.; Chhatre, A.; Wutich, A.; Scott, C. A. Sociohydrology: use-inspired water sustainability science for the Anthropocene. *Earth's Future*, 2, 225-230, 2014. doi: 10.1002/2013EF000164

United Nations (UN). *Transforming our world: the 2030 Agenda for Sustainable Development*, 2015.

United Nations Statistics Division (UNSD). *System of Environmental-Economic Accounting for Water*, 2012.

United Nations Statistics Division (UNSD). *System of Environmental-Economic Accounting - Central Framework*, 2014.

United Nations Statistics Division (UNSD). *SEEA and transforming global and national statistical systems for monitoring SDG indicators*. In: Proceedings of the Tenth Meeting of the UN Committee of Experts on Environmental Economic Accounting, New York, NY, USA, 24-26, 2015a.

United Nations Statistics Division (UNSD). *The SEEA as the statistical framework in meeting data quality criteria for SDG indicators*; UNSD: New York, NY, USA, 2015b.

United Nations Statistics Division (UNSD). 2021 *Global Assessment of Environmental-Economic Accounting and Supporting Statistics*, 2022.

Van Dijk, A.; Mount, R.; Gibbons, P.; Vardon, M.; Canadell, P. Environmental reporting and accounting in Australia: progress, prospects and research priorities. *Science of the Total Environment*, 473, 338-349, 2014. doi: 10.1016/j.scitotenv.2013.12.053

Vicente, D. J.; Rodríguez-Sinobas, L.; Garrote, L.; Sánchez, R. Application of the system of environmental economic accounting for water SEEAW to the Spanish part of the Duero basin: lessons learned. *Science of the Total Environment*, 563, 611-622, 2016. doi: 10.1016/j.scitotenv.2016.04.078