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Application of the system of environmental economic accounting for water SEEAW to the Spanish part of the Duero basin: Lessons learned

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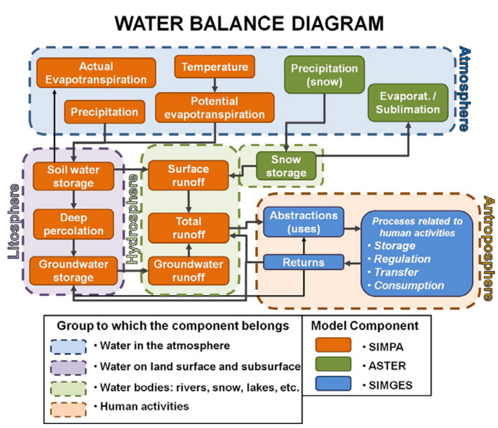
HIGHLIGHTS

- Elaboration of SEEA water asset accounts and application on the Spanish Duero basin.
- Methodology based on three hydrological/hydraulic models (SIMPA, ASTER, and SIMGES).
- Yearly and monthly balances to study inter-annual and seasonal variability.
- Lessons learned about spatial disaggregation and suggestions on how to proceed.
- Analysis of water uses, particularly non-consumptive and rainfed agriculture uses.

GRAPHICAL ABSTRACT



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ABSTRACT

The System of Environmental-Economic Accounting for Water (SEEA-W) consists of an agreed international framework for organizing hydrological and economic information in a coherent and consistent manner. The methodology yields to the SEEA-W physical tables focusing on the quantitative assessment of the stocks and their changes in a river basin during the accounting period. For that purpose, the information on the abstraction and water discharge is linked with the environment water stocks, which assesses how current levels of abstraction and discharge affect such water stocks. This study presents the methodology and results to fill out the SEEAW tables for asset accounts on the Spanish Duero basin. Duero is a transboundary river between Spain and Portugal where 80% of its basin area (78,860 km^2) runs into the Spanish territory. The Spanish part is divided in five zones and 13 management systems. The methodology applied the three models used by the Spanish Water Authorities for the planning and allocation of water resources in Spain: 'SIMPA' model (rainfall-runoff model), 'ASTER' model (hydro-meteorological model related to snow processes) and 'SIMGES' model (water management simulation model). The required information was collected with the support from the Duero River basin Authority and the Spanish Ministry of Agriculture. Special care was paid to issues such as: inter-annual variability, the selection of spatial and temporal scale, seasonality, disaggregation of human abstractions into use's type, and transboundary agreements. The results highlighted some drawbacks in the SEEAW methodology for the Duero basin. However, the developed balances are a valuable tool to support the decisions of the Spanish Duero basin

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Authority on the management and allocation of water in the basin and in the transboundary area with Portugal. Finally, the paper outlines some recommendations for future work.

1. Introduction

Water supply management is becoming a severe problem in many parts of the world, due to the ever-increasing rates of water demand together with the changes in climate during the past decades. Climate change is projected to alter water availability varying its impact from region to region (ICCP, 2014). Europe is concerned by this situation especially affecting Mediterranean area (Ludwig and Roson, 2016; Iglesias et al., 2007). Water availability and scarcity has progressively emerged as a key aspect in European Union water policy making and implementation, as noted in the strategic objectives of latest European Directives and Communications (Quevauviller, 2014) – e.g. 'A Blueprint to Safeguard Europe's Water Resources' (EC, 2012), 'EU Water Framework Directive' (WFD) (EP, 2000), 'White Paper – Adapting to climate change: Towards a European framework for action' (EC, 2009), among others. The extent of its importance is also reflected in the large number of EU-funded and national research projects directly or indirectly supporting water policies, in particular, the scientific challenges posed by the WFD (Quevauviller et al., 2012).

For this purpose, water balances or asset accounts has been identified as a key policy instrument for assessing the amount of water and its availability in a territory. In overall terms, water accounting is a tool that defines water availability and helps stakeholders and users to understand water use and benefits and costs derived from its use. Another definition was introduced by Momblanch et al. (2014) as the development of water balances in a territory that includes elements related with water use (country, river basin, etc.) reported in a certain format.

There are several water accounting methodologies developed by different countries and specialized organizations with different presentation formats of the information included (van Dijk et al., 2014). Moreover, the context in which they were conceived also differs from one another and thus the information included itself. One of the most widely accepted methods is the Water Accounting Framework (WA) proposed in 1997 by the International Water Management Institute (IWMI) (Molden and Sakthivadivel, 1999) and its improved version (WA+) (Karimi et al., 2013). While the former provides information on supply and use of water and relates water use to economy, the latter adds explicit spatial information on water depletion and net withdrawal processes in complex river basins.

Australia is one of the main drivers in the elaboration of water accounting methodologies. Some of the proposals launched are the Australian Bureau of Statistics (ABS) Water Accounts (ABS, 2004) and more recently, the Australian Water Accounting Standard (AWAS 1) (BoM, 2012). Both proposals address the link from physical data to economic data sets, providing specific information to water users for them to make and evaluate decisions on the allocation of water resources.

The System of Environmental–Economic Accounting for Water (SEEA-Water) (UNSD, 2012), fully coherent with the broader SEEA, emerged with a similar approach. The SEEA handbook was first published in 1993 (UN, 1993) and was revised in 2003 (EC, 2003). The SEEA 2003 is a large and complex system that covers different types of accounts. Asset accounts are intended to assess how levels of abstraction and water discharge affect the volume of water in a given territory. The water balance proposed in the SEEA-Water describes the stocks of the environmental water resources at the beginning and the end of a period (usually the hydrological year) and their changes (UNSD, 2012). The changes in stocks, in both inlets and outlets, are mainly caused for natural processes (hydrological and other exchanges between water bodies) and human activities (abstractions and returns). The first step in the development of water balances requires the assessment of the environmental water resources by the quantification of the hydrological processes. Human activities also imply exchanges involving the abstraction and return of water from/to the environment. In particular, water is abstracted from the inland water resource system, including surface water, soil water and groundwater, and water from other sources (other territories and seas). All these processes are defined in the asset classification of SEEA-W (UNSD, 2012), particularly in tables VI.1 and VI.2.

In this context, the SEEA-Water asset accounts are applied to one of the largest basins of Spain, the Duero basin. This paper focuses on the development of the physical accounts using the available data series and tools related to water basin management. In this paper, three hydrological and water management models validated for Spain and other countries worldwide were used. Detailed analyses were conducted of key aspects such as inter-annual variability, the selection of spatial and temporal scale, seasonality, disaggregation of human abstractions into use type, and transboundary agreements. Specific targets include the identification of the required information for the SEEAW system, the adaptation of the data to the scope of the environmental accounts, the documentation of the process followed to transfer the information, and the prediction of possible problems related with the lack of information.

2. Materials and methods

In order to process the information and estimate all the data required to fulfill the SEEAW tables, three models developed by different Spanish Water entities were used. The models integrate hydrologic and water resources management and allocation processes. The descriptions of the main characteristics of each model are presented below.

2.1. SIMPA (rainfall-runoff model)

Most data regarding hydrological processes, excluding those linked to snow processes, were obtained from the results of the Integrated System for Rainfall-Runoff Model (SIMPA, by its Spanish acronym) (Estrela and Quintas, 1996) developed by the Centre for Hydrographic Studies, CEDEX. It is a conceptual quasi-distributed model that reproduces monthly the essential processes of a natural hydrological cycle, implementing a classic soil moisture balance model (Témez, 1977), in a distributed way. The model was calibrated over 100 control points of the entire territory of Spain, using stations where stream flows are measured in natural regimes (Álvarez et al., 2004), enabling the monthly series of runoff in such a regime.

The model inputs are the following:

- hydrological parameters: maximum soil storage, maximum infiltration capacity or the aquifer discharge coefficient, among others;
- data on historical flows at the testing points; and
- raster layers with a spatial resolution of 1 km^2 and a monthly time step of precipitation and temperature. The latter is used to determine potential evapotranspiration by combining the Thornthwaite and Penman-Monteith methods.

Then, a water balance based on a collation of transfer flows and storage flows is obtained. Surface water balance is calculated by mass conservation while aquifers are simulated as unicellular models. The structure of model results, provided as data layers of the same cell size (1 km × 1 km), over the period 1940–2010, is shown in Fig. 1.