ADAPTING WATER ACCOUNTING FOR INTEGRATED WATER RESOURCE MANAGEMENT. THE JÚCAR WATER RESOURCE SYSTEM (SPAIN).

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ABSTRACT

An increase in water demands, exacerbated by climate change and the tightening of environmental requirements, leads to a reduction in available water resources for economic uses. This situation poses challenges for water resource planning and management. Water accounting has emerged as an appropriate tool to improve transparency and control in water management. There are multiple water accounting approaches, but they generally involve a very exhaustive list of accounted concepts. According to our findings in this research, one of the best water accounting methodologies is the Australian Water Accounting Standard. However, its implementation for integrated water resource planning and management purposes calls into questioning the amount of information and level of detail necessary for the users of water accounts. In this paper, we present a different method of applying the Australian Water Accounting Standard in relation to water resource management, which improves its utility. In order to compare the original approach and that proposed here, we present and discuss an application to the Júcar Water Resource System, in eastern Spain.

KEYWORDS: Water accounting, transparency, Australian Water Accounting Standard, water resource management, water balance.

1. INTRODUCTION

Following several years of implementing River Basin Management Plans based on the European Water Framework Directive (WFD) (EP, 2000), the European Commission published A Blueprint to Safeguard Europe's Water Resources (EC, 2012), in response to the diverse problems in water resource management that need to be addressed in the various member states. This blueprint highlights key aspects, such as water use efficiency and improved water management governance. Furthermore, it states that there are information gaps and errors in the dissemination and integration of the data necessary for decision-making. It recognises water accounting as a good tool to provide basic information in order to support decision-making in water resource management, in line with other proposed future actions to address these problems. In a broad sense, water accounting can be defined as the development of water balances in a territory which includes elements related with water use (country, river basin, etc.,), reported in a certain format.

There are several water accounting methodologies developed by states and international organisations, with various purposes, physical domains and presentation formats (BoM, 2011; Chalmers and Godfrey, 2012). Many of these focus on the relationship between water use and economy in order to evaluate the costs associated with water services (Ward and Pulido-Velazquez, 2009), the productivity of water, and the environmental costs. Currently, the System of Environmental-Economic Accounting for Water (UNSD, 2007; Vardon et al., 2012) is the most widespread hybrid accounting approach and it is applied in many countries, such as China (Gan et al., 2012), South Africa (Lange et al., 2007) and Australia (Vardon et al., 2007). Other water accounting approaches refer only to physical magnitudes, in this case water volume. Some of these accounts show the state and quantity of water resources for the purpose of achieving better control over them and resolve conflicts between co-riparian regions (Allan, 2012). The International Water Management Institute proposed a water accounting framework (WA) that classifies water consumption and water use to assess water productivity (Karimi et al., 2012). It has recently developed an improved version (WA+) that provides explicit spatial information (Karimi et al., 2013a). Alternatively, the Australian Water Accounting Standard (AWAS) (WASB, 2010; BoM, 2012) governs the implementation of reports that provide specific information to water users for them to make and evaluate decisions on the allocation of water resources.

All the above water accounting methodologies have diverse viewpoints and features. However, they all tend to be very exhaustive in terms of the accounted concepts. This makes them very useful for describing the hydrological processes taking place in the landscape, but it could represent a limitation as regards water resource management transparency and supervision. Water management analysis is performed at a water resource system scale, which is conceptually different to the river basin scale. Some authors define a water resource system as a physical environment comprised of independent water bodies and infrastructures, which is inseparable from a cultural environment with social, political and economic constraints (White et al. 1992; Karamouz et al. 2003). To serve the interests of water users (urban, agricultural and industrial water demands) and society, the information in the water accounts should include elements from both environments (physical and cultural) and be limited to the essential figures, clearly and intuitively presented so that it is readily understandable. What is more, some authors maintain that there are insufficient reliable information sources available in order to complete the various kinds of water accounting methodologies (Hughes et al., 2012). Furthermore, if the values presented are not accurate enough, this thorough accounting of every water volume and flow record in a basin may even have a detrimental effect on the primary purpose of water accounting, transmitting uncertainty about the presented figures rather than assurance.

From a water management perspective, the water accounting methodologies should be applicable at a river basin scale or at a water resource system scale as these are the scales established by the WFD for integrated water resource management. The water accounts should contain complete information about relevant water flows and storages for water users in the accounting domain. Finally, in order to facilitate generalised use, along with information comparison and transfer, the water accounting methodologies should set up standard procedures for calculating and presenting the water accounts. According to these criteria, the WA+ and AWAS are the most useful water accounting methodologies for integrated water resource management, among all those analysed. As the WA+ accounting methodology has already been analysed in depth in scientific literature (Karimi et al., 2013a; Karimi et al., 2013b), we find investigating the AWAS and its explicitly developed conceptual framework (WASB, 2009; Chalmers and Godfrey, 2012) much more convenient.

In this paper we analyse the suitability of the AWAS to improve transparency in water management towards water users, leading to higher efficiency and governance in water resource management. Based on this assessment, we propose a new conceptual approach for the implementation of the AWAS, using it to improve water resource management in terms of accuracy and understanding of the data. Finally, we present an application of both accounting approaches to the Júcar Water Resource System in order to make a clearer comparison of the approaches.

2. MATERIAL AND METHODS

2.1. THE AUSTRALIAN WATER ACCOUNTING STANDARD. ORIGINAL VERSION

As a result of the serious drought that occurred in Australia between 1997 and 2010, known as Australia's Millennium Drought (Kirono et al., 2011; Banerjee et al., 2013), the government brought about extensive reforms related to water management. A key objective of these reforms was the establishment of efficient water markets for the reallocation of scarce water resources. In order to have better control of the evolving markets, they identified the need to create a standard water accounting system. The AWAS is based on a series of documents that define the contents and format of the General Purpose Water Accounting Reports (GPWARs). These reports should be published regularly by the Water Report Entities (WREs). These entities hold and transfer water or water rights, they have other direct or indirect claims to water, or they have inflows and/or outflows of water. Additionally, they have a responsibility to inform their users about the state and variation of the water resources of which they are in charge.

The resulting products of the Australian methodology are not limited to the water accounts. Moreover, the GPWARs include a detailed description of the WRE context; information about the origin and processes used to obtain every value in the accounts and the associated error; other relevant aspects for the water management; and an assurance statement that the report is presented fairly in accordance with the standard (AASB and BoM, 2012). GPWARs have to be presented annually by the WREs and put at public availability, making it possible to analyse the evolution of water management, demands and resources. This information can also be a very useful support in the monitoring of River Basin Management Plans. The water accounts proposed in the AWAS were designed based on the Framework for the Preparation and Presentation of Financial Statements (AASB, 2004). Due to this, there are significant similarities between the terminology and format used in the Australian water accounts and those seen in financial accounts. There are three water accounting statements: Water Assets and Water Liabilities (A1), Changes in Water Assets and Water Liabilities (A2), and Physical Water Flows (A3). Table 1 presents the structure and examples of these water accounting statements.

The equations that relate the different concepts in the accounts, which are based on financial balances, are the following:

$$Changes\ in\ net\ water\ resources = Final\ net\ resources - Initial\ net\ resources \quad (1)$$

$$Changes\ in\ net\ water\ storage = Final\ storage - Initial\ storage \quad (2)$$

$$Changes\ in\ net\ water\ resources = Total\ increase\ in\ water\ resources - Total\ decrease\ in\ water\ resources \quad (3)$$

$$Unaccounted - for\ difference\ 1 = (1) - (3) \quad (4)$$

$$Changes\ in\ net\ water\ storage = Total\ inflows - Total\ outflows \quad (5)$$

$$Unaccounted - for\ difference\ 2 = (2) - (5) \quad (6)$$

$$Unaccounted - for\ difference\ 1 = Unaccounted - for\ difference\ 2 \quad (7)$$

A1 is equivalent to the so-called Statement of Financial Position of a company. This is an accounting document that shows the assets and financial situation of a company at a certain time, usually at the end of the reported period. It consists of two parts: assets and liabilities. The assets in this case would be the water resources owned by a water entity, physically or for vested right. The financial liabilities correspond to the current obligations of the entity, and these debts must be settled on or before the due date. In the water accounts, liabilities refer to water supply duties contracted during the reported period that are to be supplied in the following period. From the assets and the liabilities, the net equity can be deduced as the difference between these two concepts. Similarly, the net water resources are obtained by subtracting the water liabilities from the water assets, which represent the available water resources not compromised by supply duties.

A2 is equivalent to the Financial Performance, which summarises the financial activity of a company, showing the profit or loss obtained in a certain period. In financial accounting, the profit is calculated as the difference between income and expenditure, considering the accrual basis of financial accounting. In the water accounts the accrual basis means that the effects of water transactions and transformations are recognised when the decisions or commitments that give rise to them occur. This may not be the time at which water is physically transacted, consumed or subject to some other event (BoM 2012). Hence, the increase or decrease in water resources refers to the water acquired or lost, physically or for vested right.

The changes in net water resources calculated in A2 (1) must be equal to those obtained in A1 (3). However, these values do not usually match due to errors in measurements and records or the omission of certain water resources or flows in the accounts. In order to better quantify the global error, an unaccounted-for difference value is computed (4), providing an estimate of the reliability of the water accounts. Thus, a high value denotes lack of control over the water resources and flows.

Finally, A3 is analogous to the Cash Flows account in financial accounting, which provides information about the changes in the cash and equivalents of an entity during the reported period. Similarly, the AWAS considers the water inflows and outflows of a WRE. This account refers to the water resources physically owned and managed by the water entity, permitting the calculation of the net water storage as the difference between water inflows and outflows. The resulting variation in the net water storage in A3 (5) must coincide with the one obtained in A1 (2). Nevertheless, for the abovementioned reasons, it does not usually happen this way. Therefore, in order to quantify the error in this account, a second unaccounted-for difference item is introduced (6). This figure must be equal to the unaccounted-for difference in A2 (7), otherwise there is a conceptual error in the global water balance.

2.2. PROPOSAL FOR THE MODIFICATION OF AUSTRALIAN WATER ACCOUNTS

As it has been mentioned previously, the water accounting proposed by the Australian government takes its inspiration from financial accounting, which deals with an easily measurable unit: currency. That is why the AWAS is very exhaustive in the accounting of all the water storage and flow records inside the accounting domain. In contrast, this is not a common practice in water management reports, which mainly focus on water management concepts.

The Australian water accounts are meant to extend the water accounting domain to the physical boundary of the basin, in an attempt to cover all the elements involved in the hydrological cycle. When considering water accounting as a support for water management transparency and supervision, the usefulness of its application to the territorial domain and the hydrological cycle as a whole may be uncertain. In fact, what water users need to know, in order to make decisions or judge water managers’ solutions, is the exploitable water stocks and their allocation and diversion to the different demands, in a simple and reliable way.

Therefore, a balance is needed between the maximisation of the elements regarded inside the accounting domain and the rigorousness of the accounting (Andreu et al., 2012). A key issue is to define the WRE in terms of the information required to satisfy its users' needs, and the boundaries of water accounting (Chalmers and Godfrey, 2012). Note that the order of this process is also important.

The original water accounts proposed by the AWAS cover such different terms as: water storage in the landscape, water storage in rivers, leakages from canals or evaporation from rivers and canals (see Table 1). It is likely that the most part of the errors committed, in absolute terms, come from concepts with much bigger order of magnitude than the other accounted terms. For instance, the infiltration and the evapotranspiration from the landscape reach very high values (6,448.83 Mm^3 and 6,373.36 Mm^3, respectively, in the Júcar water resource system during the hydrological year 2007/2008), while the supply to demands has relatively low figures in comparison (114.30 Mm^3 to urban demands, 549.25 Mm^3 to agriculture and 32.24 Mm^3 to industrial demands, in the Júcar water resource system during the hydrological year 2007/2008). Certainly, new technologies, like earth observation, substantially improve the accuracy of hydrological and related data (Karimi and Bastiaanssen, 2014) and hydrological models benefit from these data for calibration and simulation. However, small errors of 5% in these large figures may reach the same order of magnitude as water demands in the accounting domain. This poses a problem when we are applying water accounting for water management purposes, as the quantification of large terms may increase the unaccounted-for difference balance term, distorting other variables that are smaller in magnitude but more decisive or interesting to the water users. On the other hand, there are concepts such as water storage in rivers or canals that are simply insignificant compared to other water assets. Besides, there are no specific data to obtain them and their calculation has to be based on many assumptions.

Under the above premises, we propose to change the focus of the Australian water accounting. We think that the significance and clarity of information, and unaccounted-for difference terms, can be improved by adjusting the accounting domain to the elements of importance for each water resource system. Therefore, with the aim of supporting water management, we defend that the water accounts should only include the information that refers to the manageable elements (e.g. reservoirs, aquifers, and demands) that can be controlled by water managers and which are essential for the water users.

As a general rule for water accounting in a water resource system, we propose that the assets included in the A1 account encompass only the aquifers and reservoirs, and exclude the landscape of the basin, rivers and canals. Consequently, in A2 and A3 all the accounting terms that refer to increases or decreases in these water assets should also be removed (precipitation, evaporation, leakages, etc.). This way, we maintain the water balance of the river basin. By doing this, the accounts are simplified to show only the relevant information for the users and the accounted terms have higher reliability.

Another feature of the original Australian water accounts is that A2 and A3 are identical except for the application of the accrual basis of the financial accounting. That is, A2 includes the water liabilities and inter-region claims variation, as well as the allocations to the different demands and their adjustments. In contrast, A3 does not contain information about water liabilities and inter-region claims variation, while it reveals the real water supply to the demands. However, the balance of the demands is preserved and the information in A3 can be deduced from the information in A1 and A2 (8). In order to avoid data redundancies, we propose to remove account A3 and maintain the relevant information on the demands, liabilities and commitments contracted by the WRE during the reporting period in A2. In accordance with the above considerations, Table 2 shows the structure and content of the new proposed water accounting statements. Additionally, it also includes the concepts removed from the original version, coloured in grey, to facilitate comparison between the two versions.

$$\begin{aligned}&\mathit{Initial\ allocation\ (A2)} - \mathit{Adjustment\ of\ water\ allocation\ (A2)} + \mathit{Water\ allocation\ announcement\ (A2)} = \\ &= \mathit{Water\ allocation\ diversion\ (A3)} + \mathit{Water\ allocation\ remaining\ (A1)}\end{aligned} \tag{8}$$

Finally, with the aim of summarising the most relevant information for the users of the water accounts, we propose to add an outline table for the water demands. This new table includes water allocations, supplies, returns and deficits or surpluses in the supply to each demand. In this way, the water resources consumed by water demands can also be explicitly shown in the new version of the water accounts. This figure was not presented in the original water accounts, though it shows important data for the water managers and water users of the WREs. This new version of the water accounts is closer to the water management perspective than the original version, which has a financial accounting approach.

2.3. STUDY AREA: JÚCAR WATER RESOURCE SYSTEM

The Júcar Water Resource System (Júcar System from now on), the biggest system in the Júcar River Basin District (see Figure 1), is a complex river system with a huge variety of uses with different supply priorities, and with an intense relationship between surface and groundwater. The total area of the system is 22,378.51 km^2. Figure 2 shows the most relevant rivers: Júcar, Cabriel, Magro and Albaida, and the most important aquifers: Mancha Oriental and Plana de Valencia Sur. The Júcar System includes the Albufera wetland, classified as Natural Park, Special Protection Area, RAMSAR and Site of Community Importance. It receives water resources from the Júcar System and the neighbouring system (Turia), and it is hydraulically connected to the Plana de Valencia Sur aquifer. The Júcar System presents a ratio of 0.84 between total water demands and mean renewable water resources. This value (close to 1) denotes that the water resource exploitation, and therefore water scarcity, is very high. Surface water is mainly used by the cities of Valencia, Sagunto and Albacete (123 Mm^3/year for 1,203,617 inhabitants) and for traditional irrigation demands in the lower part of the system. The remaining urban demands and the majority of agricultural demands are met with groundwater. The total irrigation demand reaches 995 Mm^3/year (158,500 ha). For more information about the Júcar System, consult the web page of the Júcar River Basin District Agency (www.chj.es).

3. APPLICATION TO THE JÚCAR WATER RESOURCE SYSTEM, SPAIN

3.1. IMPLEMENTATION PROCESS

In the case that the WRE is River Basin Agency and the accounting domain is a water resource system, the first thing to take into account in order to apply any water accounting approach is determining the end users of the reports and defining the boundaries of the water accounting to make them compatible with the users' requirements. In the case of a water resource system, not only do the hydrographical boundaries have to be taken into account, but also the availability and reliability of the data and the interaction of the system with its neighbours. The users of the reports should be the stakeholders of the water management authority: urban, agricultural and industrial demands and water-related civil organisations (e.g. NGOs, cultural associations). Through the water accounting, each of them is informed about the water allocated according to their water rights, the state of the reservoirs and aquifers and the water really received from each water source. Apart from this, they can also observe the same data referred to the other water uses and water services, and understand the global functioning of the water resource system.

Secondly, the concepts to be included in the water accounts should be selected. It is important to keep in mind that the aim of water accounting for water management purposes is to describe the allocation and diversion of water to the different users by means of the existing infrastructures; these are the relevant manageable elements of the system. Consequently, the information about demands should be broken down into real water users' associations, and the water sources serving them should also be shown separately. The rest of the concepts included (water resources entering or leaving of the system, river-aquifer relationships, etc.) have to ensure that the global water balance is maintained. Furthermore, the water accounts have to be adapted to the special features of the water management in the region. It is important to highlight that there are no universally standard water accounting approaches, as there are always different management practices and concepts that need to be reflected on the water accounts. For instance, the greatest difference between Australian and Spanish water management is that, in Australia, the fraction of the volume allocated to the demands which is not supplied during the period is considered a carryover, and it is extended to the next period to be used by the same demand (Water allocation remaining in Table 2). By contrast, in Spain, non-supplied water is considered a saving and contributes to the assets for the next period without being linked to any specific demand. Therefore, the accounting concept referred to water allocation remaining in A1 should not be shown in the Spanish versions of the water accounts.

Finally, the different terms of the water accounts have to be quantified. The ideal situation would be having extremely accurate records for each of the accounted terms, enabling genuinely detailed accounting. But, this is not possible in practice. In a real water resource system, the majority of values are not directly known and they have to be indirectly estimated, or obtained from models. For instance, the water stored in aquifers, the groundwater transfers, or the flows between rivers and aquifers are commonly modelled. Other concepts like pumped water are calculated as the pumped flow multiplied by the pumping time, which is derived from electricity bills; and the evaporation and leakages in reservoirs are obtained from balance equations. Whether directly or indirectly calculated, all this information is generated and validated, and stored in different reports and databases by the Júcar River Basin District Agency. Table 3 presents the different data used to fill out the original water accounting and the new proposed version. Note that, depending on the accounting concept, it is presented as a punctual value or an accumulated value throughout the period; hence it requires a different estimation strategy. These examples demonstrate the wide quantity of data sources that need to be used in order to complete all the accounting concepts. Obviously, the variety of data sources could go against the final quality of the water accounting, so that special care has to be taken to ensure that all the information is consistent.

3.2. RESULTS AND DISCUSSION

At this point, we present the comparison between both versions of the water accounts through their application to the Júcar System. The assessment is based on the accuracy of the water balance, reflected on the unaccounted-for difference terms. Additionally, other criteria are considered, such as the relevance of the presented information for water resource management control purposes and the clarity of its presentation.

First, we apply the AWAS to the whole Júcar System as a territory. Therefore, the water accounts include all the elements proposed by the standard (Table 1), as can be seen in the Statement of Water Assets and Water Liabilities, A1, in Figure 3. The other two accounts, A2 and A3, contain the information about water demands, flows and commitments occurring in the Júcar System, which are related to the water assets in the first account; these accounts are included in Appendix A1. Table 4 shows the unaccounted-for difference and its percentage over the total water supplied and over the total water resources of the entity for the Júcar System, together with some examples of the Australian National Account 2010 (BoM, 2013). We consider that the most representative percentage is that calculated with respect to the supplied water (the water diverted to demands), as the entity is responsible for its efficient management and supervision. As can be seen in Table 4, the unaccounted-for difference fogires obtained in the Australian National Account 2010 and in our application to the Júcar System are too high to be accepted in official documents. Thus, it seems that these exhaustive water accounts do not produce satisfactory results, at least for the purpose of achieving transparency in the water resource management.

In an attempt to improve the above results, we build the water accounts according to the new approach proposed in section 2.2. Now, we implement the water accounts in a simplified domain that contains only the relevant manageable elements of the system (see Figure 2), instead of the whole territory. The first water accounting statement (Figure 4) presents the major reservoirs and aquifers, the most relevant demand units (in priority and magnitude) depending on them, and the flows through the boundaries of the entity. The other accounts of this improved version are presented in Appendix A2. In the new version, the unaccounted-for difference term is significantly smaller than in the previous application. The percentage of error referring to the water supplied to demands is 3.29% instead of 17.11%. However, this new value can be misleading. If we obtain the error for the surface and ground water resources separately, we observe that one figure is positive and the other is negative (see Table 5 and Table 6). Thus, it is necessary to analyse the surface and groundwater errors independently for an adequate analysis. If we aggregate both unaccounted-for difference terms in absolute values, the resulting total error is still lower than the value obtained in the original version of the accounts; 12.12% versus 17.11%.

The analysis of the presented results demonstrates that the adjustment of the accounting domain and the elimination of the non-manageable elements enable the use of data with comparable orders of magnitude and accuracy, to provide more faithful results. It is true that the difference between the unaccounted-for difference terms of the two approaches is not very significant (17.11% – 12.12% = 4.99%). Nevertheless, the improvement in the values related to surface water is more relevant. It decreases from 14.19% in the original version to 6.19% in the proposed version of the water accounts. This means that the main part of the error is due to the groundwater estimations, with error values of around 25% in both versions of the accounts. This fact is reasonably logical given the well-known difficulties in measuring and controlling groundwater stocks and flows.

It should also be discussed whether the terms removed from the original version of water accounts are important enough to cause under- or overestimation in the water balance. Actually, none of the terms omitted from the accounts has an impact on the validity of the final water balance. In the case of those concepts with very low values, the effect is absorbed by the errors in other concepts. In fact, the water balances cannot be more precise than the available records and observations in the basin (Andreu et al., 2012). For the removed concepts that have higher magnitudes, the situation is different. In this case, it is crucial to ensure that they are represented by other elements in the accounts, keeping the global water balance. This is the case of precipitation and evapotranspiration from the landscape, whose effect on the water balance of the landscape is considered in the water accounts by means of the total runoff (surface and groundwater). As a result, we consider that the modification of the Australian water accounts produces acceptable unaccounted-for difference results, which ensure the reliability of the water accounting reports.

Moreover, the reduction in the volume of information provided enhances its understanding, and highlights key data for better control and evaluation of the WRE by its users.

Regardless of the kind of information managed in the water accounts, they represent balances that show the state of water resources and water flows during a period; this is the water cycle. This means that they provide a static image of what happened in the region studied. Nevertheless, compared with other tools (such as water resource management models), water accounts do not supply adequate information with the required temporal and spatial resolution to optimise water allocation or perform scenario analyses. On the other hand, the positive aspect of implementing any water accounting methodology in a river basin or water resource system is that it forces the water managers to focus on the most significant management elements. This exercise is positive because it can contribute to a better knowledge of the physical reality of the water entity, to detect scarce or bad data measurements, and to rethink the managed elements. Finally, it should be highlighted that water accounting, periodically applied, reveals the evolution and trends of water assets and demands. This can help small water entities, such as municipalities or irrigation associations, to come up with better ways of managing their water resources by learning from the data.

4. CONCLUSIONS

A deep knowledge of existent water accounting methodologies brings us closer to achieving the objectives established by A Blueprint to Safeguard Europe’s Water Resources, in order to gather and report water information in Europe. In general, even though water accounting has its pros and cons, it can help to improve transparency in water management towards water users and other stakeholders. This facilitates high-quality public participation, as the stakeholders are aware of the global problems of the water resource system and the existing tradeoffs among the different water uses. Furthermore, the information provided is of use to make a broad evaluation of the water management performed during a given period, and to support coordination between water entities in cases like inter-basin transfers, or co-riparian countries.

Some problems arising from the utilisation of water accounting in real water resource management have been identified. Firstly, given the complexity of the water cycle, a simplification of reality is always necessary in the water accounts. Some criteria have been stated to guide the selection of the accounting concepts. Secondly, there are always differences in water management in each country or river basin, which require the adaptation of the water accounting concepts. Finally, it has been proved that the accounting domain, the integration scale and the detail of the accounted concepts have a relevant influence on the final result.

To conclude, we recommend the utilisation of the Australian Water Accounting Standard for water management purposes, with the modified water accounts and scope proposed in section 2.2. Contrary to the original, complete version, which is more useful for a hydrological analysis of water resource systems, the new approach of the accounting methodology contains only the essential information on the water resources, flows and commitments of a water entity, in an easily comprehensible way. All this contributes to clarifying the presented data and facilitates its subsequent use for water management evaluation. The Australian water accounting also includes information on the origin of the data, the methodology, the accuracy, and the final errors. Hence, it is important to consider the potential of water accounting as a support for integrated water resource management, for the purpose of achieving transparency and control over water resource management.

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APPENDIX A

A1. Original Statements of Changes in Water Assets and Water Liabilities and Physical Water Flows.

A2. Improved Statement of Changes in Water Assets and Water Liabilities and Demands outline table.

REFERENCES

Allan, A., 2012. Is there a role for water accounting in the avoidance and resolution of international water disputes?, in: Godfrey, J., Chalmers, K. (Eds.), International Water Accounting: Effective Management of a Scarce Resource. Edward Elgar Publishing Inc., New York, pp 236-254.

Andreu, J., Momblanch, A., Paredes, J., Pérez, M.A., Solera, A., 2012. Potential role of standardized water accounting in Spanish basins, in: Godfrey, J., Chalmers, K. (Eds.), International Water Accounting: Effective Management of a Scarce Resource. Edward Elgar Publishing Inc., New York, pp 123-138.

AASB (Australian Accounting Standard Board), 2004. Framework for the Preparation and Presentation of Financial Statements. Commonwealth of Australia, Melbourne.

AASB and BoM (Australian Accounting Standard Board and Bureau of Meteorology), 2012. Australian Water Accounting Standard 2: Assurance Engagements on General Purpose Water Accounting Reports. Commonwealth of Australia, Melbourne.

Banerjee, O., Bark, R., Connor, J., Crossman, N.D., 2013. An ecosystem services approach to estimating economic losses associated with drought. Ecol. Econ. 91, 19-27.

BoM (Bureau of Meteorology), 2011. International water accounting: Current practice and potential development. Commonwealth of Australia, Melbourne.

BoM (Bureau of Meteorology), 2012. Australian Water Accounting Standard 1: Preparation and Presentation of General Purpose Water Accounting Reports. Commonwealth of Australia, Melbourne.

BoM (Bureau of Meteorology), 2013. National Water Account. http://www.bom.gov.au/water/nwa/.

Chalmers, K. and Godfrey, J., 2012. Conclusion, in: Godfrey, J., Chalmers, K. (Eds.), International Water Accounting: Effective Management of a Scarce Resource. Edward Elgar Publishing Inc., New York, pp 291-308.

EC (European Commission), 2012. A Blueprint to Safeguard Europe's Water Resources. European Commission, 14.11.2012 COM(2012) 673 final, Brussels.

EP (European Parliament), 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Official Journal L 327, 22-12-2000, Brussels.

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

Hughes, D.A., Corral, E., Muller, N.W.J., 2012. Potential for the application of General Purpose Water Accounting in South Africa, in: Godfrey, J., Chalmers, K. (Eds.), International Water Accounting: Effective Management of a Scarce Resource. Edward Elgar Publishing Inc., New York, pp 106-122.

Karamouz, M., Szidarovszky, F., Zahraie, B., 2003. Water resources systems analysis. Lewis Publishers, Boca Raton.

Karimi, P., Molden, D., Bastiaanssen, W., Xueliang, C., 2012. Water accounting to Assess Use and Productivity of Water-Evolution of a Concept and New frontiers, in: Godfrey, J., Chalmers, K. (Eds.), International Water Accounting: Effective Management of a Scarce Resource. Edward Elgar Publishing Inc., New York, pp 76-90.

Karimi, P., Bastiaanssen, W.G.M., Molden, D., and Cheema, M.J.M., 2013 (a). Basin-wide water accounting based on remote sensing data: an application for the Indus Basin. Hydrol. Earth Syst. Sc. 17, 2473-2486.

Karimi, P., Bastiaanssen, W.G.M., and Molden, D., 2013 (b). Water Accounting Plus (WA+) – a water accounting procedure for complex river basins based on satellite measurements. Hydrol. Earth Syst. Sc. 17, 2459-2472.

Karimi, P. and Bastiaanssen, W.G.M., 2014. Spatial evapotranspiration, rainfall and land use data in water accounting – Part 1: Review of the accuracy of the remote sensing data. Hydrol. Earth Syst. Sc. Discussion. 11, 1073-1123.

Kirono, D.G.C., Kent, D.M., Hennessy, K.J., Mpelasoka, F., 2011. Characteristics of Australian droughts under enhanced greenhouse conditions: Results from 14 global climate models. J. Arid Environ. 75, 566-575.

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

UNSD (United Nations Statistic Division), 2007. System of Environmental-Economic Accounting for Water. United Nations Statistic Division, New York.

Vardon, M., Lenzen, M., Peevor, S., Creaser, M., 2007. Water Accounting in Australia. Ecol. Econ. 61, 650-659.

Vardon, M., Martinez-Lagunas, R., Gan, H., Nagy, M., 2012. The System of Environmental-Economic Accounting for Water: Development, Implementation and Use, in: Godfrey, J., Chalmers, K. (Eds.), International Water Accounting: Effective Management of a Scarce Resource. Edward Elgar Publishing Inc., New York, pp 32-57.

Ward, F.A., Pulido-Velázquez, M., 2009. Incentive pricing and cost recovery at the basin scale. J. Environ. Manage. 90, 293-313.

WASB (Water Accounting Standards Board), 2009. Water Accounting Conceptual Framework for the Preparation and Presentation of General Purpose Water Accounting Reports. Commonwealth of Australia, Melbourne.

WASB (Water Accounting Standards Board), 2010. Exposure Draft of Australian Water Accounting Standard 1: Preparation and Presentation of General Purpose Water Accounting Reports. Commonwealth of Australia, Melbourne.

White, I.D., Mottershead, D.N., Harrison, S.J., 1992. Environmental Systems: An Introductory Text, second ed. Chapman & Hall, New York.

Table 1. Structure and examples of accounting concepts in the AWAS water accounting statements.

Table 2. Structure and examples of accounting concepts in the new proposed water accounting statements. To facilitate the comparison with the original version, the removed terms are coloured in grey.

Figure 1. Location of the study area.

Figure 2. Diagram of the Júcar Water Resource System with the most relevant elements for water management.

Table 3. Data sources and estimation strategies employed to fill out the water accounts for the Júcar System.

Figure 3. Statement of Water Assets and Water Liabilities for the Júcar System. Hydrological year 2007/08.

Table 4. Unaccounted-for difference terms for the Australian National Water Account 2010 and the application to the Júcar System 2007/08.

Figure 4. New proposed Statement of Water Assets and Water Liabilities for the Júcar System. Hydrological year 2007/08.

Table 5. Unaccounted-for difference term in the Statement of Physical Flows, for the Júcar System surface water resources.

Table 6. Unaccounted-for difference term in the Statement of Physical Flows, for the Júcar System groundwater resources.

Figure A1. Statement of Changes in Water Assets and Water Liabilities for the Júcar System. Hydrological year 2007/08.

Figure A2. Statement of Physical Water Flows for the Júcar System. Hydrological year 2007/08.

Figure A3. New proposed Statement of Changes in Water Assets and Water Liabilities for the Júcar System. Hydrological year 2007/08.

Table A1. New proposed outline of water allocation, supply, return flow and supply deficit or surplus for each water demand.