

Introduction

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One of the most pressing global issues of the twenty-first century is the scarcity of water of a quality appropriate to ensure economic, environmental and social sustainability. In addressing the issue through policy and management, key stakeholders recognize the critical importance of high-quality information. They also recognize the need for this information to be reported systematically to ensure that it is relevant, reliable, comparable over time and across entities, and understandable. But water scarcity has many implications, and it is possible that different reporting approaches, generally called water accounting systems, can be appropriate to addressing them.

In this book, international experts respond to the question: what role can water accounting play in resolving individual, organizational, industry, national and international economic, social and environmental issues? The book is born of a curiosity as to why different forms of water accounting have emerged, how they are utilized and what problems they can resolve. Our purpose in producing the book is to analyse some of the myriad issues that water accounting can help address, as perceived by authors from diverse disciplines and geographical regions.

As a discipline, water accounting and most of the various systems comprising it are in their infancy. But they are maturing fast. Given the early stage of the discipline's development, theoretical and practical questions need resolution to ensure that any individual system is rigorous enough and robust enough to endure in a form that is effective and efficient.

This book explores the roles that various water accounting systems can play in resolving a broad range of economic, environmental and social issues. It takes an international perspective, with content and authorship spanning the continents of Africa, America, Asia, Australia and Europe. It also addresses the role of water accounting in decision-making at individual, organizational, industry, national and international levels. Consistent with its global and multidisciplinary theme, the book examines the role of water accounting from the perspective of developed and developing

countries, national and international law and policy, the environment, economic and sustainability issues and the role that water accounting can play in social, political and corporate contexts. It also reports analytical and empirical evidence of the efficacy of alternative specific systems of water accounting.

Authors bring academic, policy and practice perspectives. Consistent with an aim to draw out theoretical and practical issues, contributing authors include academics with expertise in relation to various aspects of financial accounting, geography, hydrology, economics, water accounting and water management and high-profile individuals with senior experience in water policy, water accounting and water management. The book melds both academic perspectives and regulatory insights with practical issues.

The book does not advocate or fully critique individual water accounting systems. Rather it exposes the systems for you, as readers, to form your judgements. In our concluding chapter, we provide a cursory overview of some of the comments that the authors have raised in relation to each other's chapters, and trust that they will be useful to your analysis.

ORIGINS

It would be reasonable to ask why we, as professors of financial accounting, chose to produce a book on water accounting. It would also be reasonable to ask what qualifies us to edit a book about water accounting.

To understand the answers to these questions, we take you back to our first engagement with the topic: it is 2006 and Australia is in the grips of its worst-ever drought. After two years of controversial negotiations, the Australian federal government and all state and territory governments have finally signed up to the National Water Initiative, a plan for the management of the nation's water resources. On the assumption that high-quality information is necessary to underpin sound decisions relating to water management, a key recommendation of that plan is the development and implementation of water accounting. However, the system of water accounting is not prescribed.

To capitalize on the potential to draw upon an existing rigorous and accepted system of reporting financial information, it was determined that the Water Accounting Development Committee, which has the responsibility to develop water accounting standards, should include a financial accountant. As researchers, we became involved in the subsequent water accounting activities in several ways. Because of her accounting theory research and financial accounting standard-setting experience,

Jayne Godfrey became a member of the Water Accounting Development Committee and its successor, the Water Accounting Standards Board. Over the subsequent years these bodies developed a system of water accounting known as General Purpose Water Accounting. We both (Keryn Chalmers and Jayne Godfrey) worked with a fellow academic, Brad Potter, to draft the conceptual framework that underpins the work of the Water Accounting Development Committee and the Water Accounting Standards Board. In doing so, we have come to truly appreciate the significance of the work we are doing for future generations – not only because of the role water accounting can play to ameliorate some environmental degradation trends from poor water management, but also because of the role that reporting about water can play in understanding operating, legal and other risks for businesses, governments and industries and, indeed, for society as a whole.

Together with CPA Australia, the Institute of Chartered Accountants in Australia and our academic colleagues Brad Potter, Ken Trotman and Robyn Moroney, in 2008 we received Australian Research Council funding for a project to investigate the potential role of water accounting in an international context. The project required us to conduct experiments to assess the information content of water accounting reports for users of those reports. It also required us to organize a conference of potential contributors to a book on water accounting. Those potential contributors are all authors of chapters in this book.

The conference, 'International Water Accounting: Effective Management of a Scarce Resource', was held at the Monash Centre in Prato, Italy, in late 2010. The papers we discussed at the conference were the drafts of chapters appearing in this volume. The conference was a wonderful experience for us all and served one of the purposes of the grant: to generate greater international cross-disciplinary awareness of the scope of water accounting systems, their benefits and limitations and to provide an opportunity for intellectual and influential exchanges into the future. As such, we are extremely grateful to the Australian Research Council and to CPA Australia and the Institute of Chartered Accountants in Australia for the funding and other support that made the conference and the book possible.

From our brief four-year snapshot, we hope that you understand that we do not profess to be experts on all matters relating to water accounting. Rather, we profess to be fortunate to have worked with some of these experts and to be able to draw upon their knowledge and skills to produce this book. We hope that you will enjoy the book as much as we have enjoyed the journey leading to its production. We also hope that you learn, as we have, from reading the following chapters.

STRUCTURE AND THEMES

The book is divided into three thematic parts. The first part of the book describes several key water accounting systems that have developed to address a range of issues relating to water. Part II then examines whether two of the systems are capable of application in practice and evaluates them from both theoretical and practical perspectives. Part III extends the analysis to explore the role that water accounting in its various forms can play in addressing a range of serious institutional, state, national and international issues. In each part some of the chapters are written from the perspective of a particular country or state. However, the issues are never unique to that geographical region.

Part I Water Accounting Systems

Internationally, a range of methods of recording or reporting water information can be labelled 'water accounting'. Chapters in Part I consider several of the more prominent water accounting approaches that are being adopted, or are approaching adoption, for different but possibly complementary purposes.

Together with Maryanne Slattery, who has been intimately involved in most stages of water accounting development in Australia and extremely influential in orienting its approach towards financial accounting, we co-author Chapter 1, 'Beyond the hydrographers' legacy: water accounting in Australia'. This chapter describes General Purpose Water Accounting, a system developed in Australia, based upon the internationally accepted approach to financial reporting. General Purpose Water Accounting reports include a Statement of Physical Flows, akin to the cash flow statement of financial accounting. The Statement of Physical Flows shows how holdings of water moved during the reporting period. General Purpose Water Accounting reports also include accruals-based statements corresponding to the balance sheet and statement of comprehensive income: the Statement of Water Assets and Water Liabilities and the Statement of Changes in Water Assets and Water Liabilities respectively. The Statement of Water Assets and Water Liabilities reports water, and rights and other entitlements to water, as water assets. It also reports water liabilities, which are obligations to provide either water or water rights or other entitlements to other parties. The Statement of Changes in Water Assets and Water Liabilities shows movements in water assets and water liabilities during the reporting period.

General Purpose Water Accounting is designed to provide information that is useful to stakeholders, who otherwise could not command the

information, for making decisions about the allocation of resources. These resource allocation decisions include, but are not limited to, assessments of accountability for water management and the consequent allocation of economic, environmental or social resources.

Around the same time that Australia was developing its General Purpose Water Accounting system, the United Nations was working on its System of Environmental-Economic Accounting for Water (SEEAW). This system records information about water in a manner similar to the way that most countries' national accounts record information about economic transactions. In Chapter 2, 'The System of Environmental-Economic Accounting for Water: development, implementation and use', Michael Vardon, Ricardo Martinez-Lugunes, Hong Gan and Michael Nagy describe the background and features of SEEAW, implementation of SEEAW and the challenges associated with that implementation. The chapter explains how SEEAW yields tables of cross-sectional or time-series data that can be extracted for research purposes or to prepare reports at national, industry, or organizational level. Most important, it explains how the system aims to link physical water information to social and environmental and economic information in a manner that can influence macroeconomic reform. It also discusses how water accounting can be strategically integrated into the routine duties of government agencies to make it more stable. The chapter discusses the extent to which the system has been globally accepted. Questions about the practicality of the system, because of issues obtaining data and then of obtaining data of sufficient reliability, are also addressed.

Water Footprint Accounting is the third water accounting system considered in Part I. Water Footprint Accounting aims to measure how much water is directly or indirectly consumed in producing particular products. Chapter 3 'Water Footprint Accounting' is authored by Arjen Y. Hoekstra, an ardent advocate of this system. Hoekstra explains that the water footprint concept aims to provide information that raises awareness of the extent to which the production of particular products is water-consuming relative to the production of others. Thus, the system is intended to inform consumption and production decisions based upon assessments of the impact on water consumption. It is analogous to the carbon footprint concept, one difference being that water, unlike carbon, is renewable. At the Prato conference for authors, there was much debate about this approach and in the conclusion chapter, we very briefly summarize that debate, particularly in relation to interpretation of the water footprint of a product produced using water of different qualities and sources and the practical implementation of the system.

In Chapter 4, 'Water accounting to assess use and productivity

of water: evolution of a concept and new frontiers', Poolad Karimi, David Molden, Wim Bastiaanssen and Xueliang Cai write about water accounting at a catchment scale. This approach was developed at the International Water Management Institute (IWMI) and is labelled IWMI WA (for IWMI Water Accounting) in this book. Karimi et al. focus upon the use of accounting for water within a catchment, and how often, it is used. In particular, they explain the importance of accounting for depletion versus withdrawal of water within/from a confined geographic region, given cross-boundary water transfers that mean that water does not always return to the same place or time. Their purpose is to assess the productivity of water that spends some time in a catchment, in order to inform production approaches and economic and other decisions that should reflect an understanding of the renewable features of water use so that water is used most effectively and efficiently. While there are similarities with the General Purpose Water Accounting approach, IWMI WA focuses upon water itself rather than the rights and other claims to water and the productivity of that water use. The chapter examines the need for careful specification of the entity about which the water accounting report is prepared and the distinction between what water is recycled within a catchment and what water is subject to external sourcing or application.

The systems described in Part I reflect different approaches to informing some of the most important issues that the world is grappling with, the need to present that information in ways that will inform decisions and the need for data that can be used in research and to populate reports at macro, micro and product levels. They take very different approaches: General Purpose Water Accounting focuses upon the water report entity that either holds water or water rights, transfers water or water rights, or is obliged to deliver water or water rights. It addresses issues of not only what to report and how to measure information, but also how to disclose the information to be useful for decision-making. The decisions envisaged cover a range including economic, environmental, social and political. SEEAW was developed with the aim of providing a database of information that is useful for research purposes and for incorporation into reports that will guide decisions at a macro level. SEEAW information is also intended to be capable of being drilled down to state, catchment, industry and firm levels and possibly smaller units. Its purpose is primarily to inform economic, environmental and social decision-making. Water Footprint Accounting aims to provide information about products and the amount of water that was consumed in their production, regardless of the source of the water. The issues addressed by IWMI WA at a catchment scale concern assessments of the productivity of water in production,

where water is sometimes recycled within the catchment, but sometimes transferred from external regions.

Part II Application and Evaluation of Water Accounting Systems

While Part I addresses the objectives of particular water accounting systems, Part II examines the practicality of producing reports that apply General Purpose Water Accounting principles or SEEAW principles. It does so across a range of international contexts. These chapters all demonstrate that it is possible to produce reports according to the systems and that the information is useful, but that data accuracy and reliability are an issue. While we do not investigate the matter fully within this volume, we expect that development of water accounting will, over time, foster the development of more rigorous metering and modelling of water volumes. This was certainly a sentiment expressed by participants in the 2010 conference.

In Chapter 5 'Water accounting in mining and minerals processing', Claire M. Cote, Jason Cummings, Chris J. Moran and Kristina Ringwood describe a system of water accounting that has been developed for the Australian mining industry with the support of its peak industry body, the Minerals Council of Australia. This system is a derivation of the General Purpose Water Accounting system described by Slattery et al. in Part I Chapter 1, modified to include additional reporting to satisfy Global Reporting Initiative disclosure requirements. Some mining companies have already started voluntarily adopting this system. Issues addressed in this chapter include determining what information is useful to external users of mining company water accounting reports and internally to mining companies. They also include the barriers to incorporating an industry reporting framework that is based upon General Purpose Water Accounting reports and how to modify or extend this system to a mining industry context. As with all of the systems described in Part I, a key issue, particularly in the early stages of systems development, concerns how to measure complex flows, particularly when water is used in several stages of production and evapotranspiration is significant.

An important feature of this chapter relative to others in the book is its explanation of the mining industry's motivations for adopting water accounting and for engaging early in the development of a system of water accounting. Recognizing that water accounting provides transparent reporting of information that otherwise is not systematically or comprehensively reported to external stakeholders, the authors describe these motivations as including the political benefits of both the industry and individual firms being seen as responsible users of water for both political

and pragmatic reasons. The authors argue that water accounting that satisfies regulatory and perceived best practice reporting of responsible management of a resource that the industry is sometimes accused of wasting or polluting can provide information to assist the granting of a licence to operate. In particular, it can influence public opinion in ways that advantage the industry and firms by demonstrating that the industry uses and manages water more responsibly for the environment and for society than is otherwise perceived. A further, unstated, reason for early engagement with the development of General Purpose Water Accounting is undoubtedly to influence that system's development, rather than passively accept its requirements.

Part II Chapters 6 and 7 report pilot study applications of General Purpose Water Accounting principles in South Africa and Spain, respectively. In Chapter 6 'Potential for the application of General Purpose Water Accounting in South Africa', Denis A. Hughes, Esther Corral and Nikite W.J. Muller investigate whether the General Purpose Water Accounting system developed in Australia can be applied to a South African context. In particular, the authors report a pilot test of the system by a commercial water supplier, Amatola Water, in the Buffalo River catchment that supplies water to a socioeconomically diverse population. The chapter investigates whether data or systems constraints prevent implementation of the system.

The study finds that the proposed General Purpose Water Accounting system provides information that is potentially valuable to planning and water management, although not necessarily at a national level. It finds that the system could be useful for standardization of data sets and for transparent and understandable reporting that is useful to a range of users. It also identifies that for the catchment's particular circumstances, it is important to include a water quality dimension to the accounting and reporting. Furthermore, it identifies that there are sufficient data and systems sophistication to implement a system that enables assessments of water policy implications and can assist reconciliation studies. The chapter investigates implementation barriers, including data quality, and touches on the socioeconomic effects of water accounting using the proposed General Purpose Water Accounting system.

Application of the General Purpose Water Accounting system in a Spanish context is described and analysed by Joaquín Andreu, Andrea Momblanch, Javier Paredes, Miguel Ángel Pérez and Abel Solera, in Chapter 7 'Potential role of standardized water accounting in Spanish basins'. Among other matters, this chapter investigates the role of hydrological modelling tools in providing the basis for measures reported in General Purpose Water Accounting reports for the Júcar Water Resource

System in Spain. The chapter concludes that General Purpose Water Accounting can be a powerful tool to improve transparency of water management. It also identifies some issues in implementation based upon the scope of water accounting and data availability. As noted by participants at the Prato conference, a strength of this chapter is that it identifies the ability of the General Purpose Water Accounting system to identify information that managers should attempt to collect more carefully, or to more accurately measure or refine. This is a benefit, internally, of the system, but also reflects an issue for external reporting: when the system identifies very large unaccounted-for differences between identified and calculated/estimated water balances, this creates a credibility issue for either management or the reporting system. As such, the authors suggest a need to restrict the scope of water accounting to a physical domain where storages and flows are well measured or estimated, while simultaneously working to improve measurement and estimation.

Chapter 8 'Development and application of the System of Environmental-Economic Accounting for Water in China' describes China's experience in implementing its version of SEEAW. Hong Gan, Yu Wang, Qiong Lu, Michael Vardon and Qin Changhai explain how the Chinese Ministry of Water Resources, with assistance from the National Bureau of Statistics and the United Nations Statistics Division, developed a water accounting framework based on SEEAW but adapted to Chinese circumstances. This involved a whole-of-China survey of water by the Ministry and significant provincial and agency collaborations. The primary purpose of SEEAW has been internal water management (in contrast to the external focus of General Purpose Water Accounting) and the development of water accounting is playing an important role in strengthening water resources management in China, particularly by enabling the construction of a range of indicators for use by decision-makers. The chapter identifies challenges of data availability, data reliability (particularly in relation to groundwater) and the need for cooperation between organizational units if SEEAW, or indeed any water accounting system, is to be effective at a national level.

The final chapter in Part II, Chapter 9 'Two perspectives of water resource accounting: comparing the Australian and the United Nations approaches' by Eric Mungatana and Rashid Hassan, addresses whether water resources policy and management can be improved by using either or both SEEAW and General Purpose Water Accounting frameworks. Key features of this chapter include identification of the political nature of water accounting and the complementary nature of the systems in enhancing water resource management. The chapter identifies the perceived differing objectives of the systems. General Purpose Water Accounting is a communication and accountability tool, whereas SEEAW serves to

combine physical water information with financial indicators to inform the understanding of environmental-economic information. The authors identify the strength of General Purpose Water Accounting as providing information for project evaluation and planning purposes. On the other hand, given that SEEAW aggregates information at a national level, it is targeted more at economic modelling and policy analysis.

Part III Contemporary Issues Addressed by Water Accounting

Part III investigates the roles that various systems of water accounting can play in conflict mitigation and dispute resolution within and across state and national boundaries and across time. At the extreme, this refers to mitigation and resolution of what some would argue are the greatest threats to national and international security: water wars. If the same rigorous approach to identifying, measuring and reporting water balances and trans-border flows, rights to water and obligations to deliver water is adopted and understood by parties engaged in transactions that have potential to generate conflict, the shared understanding reduces information asymmetry. In turn, this produces clarity in relation to the exercise of property rights as well as in relation to social and equity impacts of water movements and transactions. It will also provide information to facilitate longer-term water management decision-making for current and future generations' access to this scarce resource.

In Chapter 10 'The impossible planetary trust: intergenerational equity, long-term investments and water governance and regulation', Gordon L. Clark and Claire Woods explore how climate change intersects with intergenerational equity and how important it is that institutions and organizations make decisions for the welfare of future generations. The conflict they study is intergenerational: decisions of the current generation affect future generations. Importantly, they recognize that even long-term institutions fail to meet long-term needs because they are not willing to sacrifice short-term beneficiary needs. To govern for the future and deliver intergenerational equitable outcomes, the authors propose an independent planetary trust model for resource management. Looking through the planetary trust lens, they discuss water management in Australia, in particular the governance and decision-making of the Murray Darling Basin Authority. The case study highlights the conflicts between current and future users of water and the significance of good governance structures and information for governance and risk management. Water accounting, if derived from trusted information sources, will play a vital role in protecting the environment for future generations.

The quality of governance as an important determinant of water

resource sustainability is a theme continued by Muller in Chapter 11 'Water accounting, corporate sustainability and the public interest'. In considering how water accounting can deliver effective water resource management, Mike Muller contemplates who is accounting to whom and for what. Achieving the optimal use of water in the public interest is inherently difficult considering the differing objectives of the actors involved (for example, public policy, corporate and environmental advocacy actors) and the scales, contexts and power mode in which they operate. Any water accounting system needs to be cognizant of such complexity and be capable of delivering information that is relevant, yet neutral. A water accounting system that does so will contribute to sustainable management; one that does not will result in sub-optimal water resource management decision-making.

In Chapter 12 'Water accounting and conflict mitigation', Lise Pretorius and Anthony Turton discuss the role for water accounting in the avoidance and resolution of water disputes. Critical in addressing this issue is understanding water risk. The chapter identifies eight water risk categories applicable to water and applies this risk model to the firm and other level units of analysis. General Purpose Water Accounting, by quantifying flows and stocks, can provide information to inform the risk assessment and thereby introduce an element of certainty into the risk model application. More informed risk assessment should result in more informed decision-making. Pretorius and Turton conclude that General Purpose Water Accounting has the capacity to inform sustainable water reform and mitigate conflict. They also explain a role for water footprint in revealing risk.

The role for water accounting in avoiding and resolving international water disputes is further explored in Chapter 13 'The role of a water accounting system in the avoidance and resolution of international water disputes'. Similar to Pretorius and Turton, Andrew Allan concludes that water accounting does have a role to play in resolving and avoiding transboundary watercourse conflicts. With an expertise in water conventions and treaties around the globe, Allan argues that the collection and regular exchange and communication of data promotes cooperation that at the very least should assist in determining whether or not the use of a transboundary watercourse is equitable and reasonable. However, the chapter stresses that the significance of the role that water accounting can play will be undermined in the absence of harmonized nomenclature, data collection methodologies and standardized reporting. Allan draws an analogy between water accounting and financial accounting to conclude that, just as globalization of financial accounting through International Financial Reporting Standards has assisted the resolution of international financial

conflicts, a globalized water accounting system could reduce conflicts related to water.

Chapter 14 'Water accounting issues in California', is authored by Jay R. Lund. Quoting Lord Kelvin, 'if you cannot measure it, you cannot improve it', Lund reminds us that water accounting systems serve to improve the management of water resources. He also reminds us that water accounting has always been fundamental to managing water under conditions of scarcity. However, it is largely incapable of perfection in practice, particularly at larger regional scales involving more complex hydrologic interactions. The chapter uses a Californian context to review aspects of water accounting and discuss opportunities and prospects for its further development in this US state. Existing water accounting in California is described as 'sparse and rudimentary'. This, combined with an expanding population with increasing and diverse water demands, will demand a more robust and transparent system of accounting. It will be interesting to observe if political, institutional and practical impediments can be overcome to deliver a more desirable water accounting system. The chapter makes an important distinction between water accounting and measurement. While water measurement helps support water accounting, water accounting does not require water measurement if it is impractical to do so. However, with advances in computer modelling, water measurement impracticalities will become less frequent.

In the final chapter of Part III, 'Accounting for water rights in the western United States', Mark Squillace applies the Lund and Muller analyses to highlight the inaccuracy of various measurement techniques applied to water diversions and storages, the personal incentives that can lead to measurement error perpetuation and the individual and aggregate effects of measurement error. He explains how the aggregation of small individual property rights measurement errors can give rise to highly biased measures with severe water appropriation for the environment and for social well-being. Squillace's analysis covers technical, policy and governance measurement accuracy issues. It offers insights into how information about water diversions and use might be made more accurate and how that information might be used to promote a better system for managing water.

CONCLUSION

It is impossible to overestimate the importance of water to the economy, the environment, society and to the very survival of life on our planet as we know it. With competition for water growing, the need to account for

how it is sourced and distributed will only increase. Water accounting has grown out of a demand for information to provide accountability and to assist in decision-making. It is important to acknowledge that in isolation, water accounting will not resolve any water crisis. It is a decision-making tool, not a solution. However, it can play a vital part in the resolution of economic, environmental, social and other issues. After all, good decisions are generally underpinned by good information.

We trust that you will enjoy reading this book and that it will afford insights into the critical role that water accounting can play at international, national and organizational levels. We also take this opportunity to thank our contributing authors for sharing their insights, expertise and their passion for an emerging discipline with us and with you, the reader.

