Water Management Accounting: A Framework for Corporate Practice

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Abstract

Water initiatives for business and in business have ballooned in the 2010s because of concerns over increased uncertainty surrounding water supplies as well as competing demands. The challenge is how to improve accounting given the lack of available granular data on which companies can base their business decisions about water scarcity, water surpluses and water management opportunities. Corporate Water Management Accounting is a recently proposed extension to Environmental Management Accounting designed to support corporate management decisions and improve both economic and environmental water-related business outcomes. The paper identifies relevant water accounting information for decision making is lacking in current literature and water initiatives, which focus on external water reporting. In the light of the finding strengths and weaknesses of water initiatives are assessed and a new framework developed for Water Management Accounting. Based on both the literature and gaps in current water initiatives, the paper concludes with a set of specific research issues in corporate water accounting settings along with ways in which water accounting researchers can contribute to the future management of water by businesses.

Keywords: Water management accounting; Corporate water accounting; Environmental management accounting; Water management initiatives; Framework.

1. Introduction

Environmental management accounting (EMA) was developed in the 1990s to highlight the decision settings, tools and types of information different managers need to manage the combined economic and environmental aspects of their business activities (Burritt et al. 2002). Although EMA has previously been extended to consider specific elements of environmental importance, such as carbon (Burritt et al. 2011; Schaltegger and Csutora 2012; Gibassier and Schaltegger 2015), an explicit focus on corporate water management is only a recent development. The lack of previous attention is remarkable given water is an important part of natural capital (Hoekstra 2009) required to support ongoing corporate activities.

With the growing water crisis and need for better data for water management by corporations (Morrison et al., 2010) the research problem addressed is to examine the importance of accounting in the context of corporate water management. The corporate sector remains careless in relation to precious water management activities and relevant accounting information is needed to support and encourage better decisions. The paper extends the EMA literature to incorporate an explicit focus on water and water management. Thus a sub-discipline, water management accounting or WMA, is established. The paper then considers how WMA can provide a framework for corporate water-related activity and assist in helping managers to understand the decision settings in which different water accounting tools are useful and applicable. This is an important step forward given the lack of consistency and cohesion in current approaches to corporate water accounting many of which focus on transparency and not the management of resources by organisations per se. The lack of tools to support monetary water-related decisions with granular data is also highlighted.

In summary, the paper makes the following contributions. It is one of the first publications to explicitly consider the interplay between EMA and the management of water resources by business. Second, the paper offers a framework by which water accounting tools can be better understood with a view to assisting managers in practice. Existing tools are mapped against the framework and potential shortcomings in existing water accounting approaches identified. Finally, the paper establishes a foundation for future research in the WMA area and highlights how researchers can contribute to this area of increasing importance to the global business community.

The rest of the paper is arranged as follows. Section 2 considers the growing water crisis and how this will impact business. This is followed by a general discussion on the need for water accounting in section 3. Section 4 reviews WMA and discusses the framework it provides in the context of existing water accounting initiatives. Sections 5 and 6 extend this discussion by considering the contribution of a water specific sub-discipline to EMA and future research directions respectively. Section 7 then concludes the paper.

2. Business and the Growing Water Crisis

Water-related risk is one of the biggest threats facing all of society including organisations operating in the business sector. The World Economic Forum's 2017 Global Risks Report, a comprehensive document based on a survey of 750 members of the international stakeholder community, cites 'water crises' as the third biggest threat currently facing the global population in terms of overall impact (World Economic Forum 2017). Water crises are defined in this report as 'A significant decline in the available quality and quantity of fresh water resulting in harmful effects on human

health and/or economic activity' (World Economic Forum 2017: 62). Although classified primarily as a societal risk the environmental implications of water crises are also recognised. In addition global demand for freshwater is expected to exceed sustainable supply in 2030 by as much as 40%, a situation that will be further exacerbated by population growth and anthropogenic climate change (Boccaletti et al. 2009, Signori and Bodino 2013). This situation will impact business activities worldwide in ways that are only just becoming apparent as will be discussed below.

Water is a shared resource with activities by one user having the ability to have a negative impact on the activities of other users. Thus water use embodies an element of shared risk and as a result the onus is on governments, the community and business all to be responsible with regard to their use of freshwater resources (Chapagain and Tickner 2012). The pressure for sustainable and transparent water use is expected to be especially prominent in the corporate sector (Ernst & Young 2012). The corporate sector is one of the largest users of freshwater in modern society with irrigated agriculture making up 70% of total freshwater withdrawals worldwide (Fogel and Palmer 2014; WBCSD-SIUCN 2012). However, beyond irrigation water is also needed for manufacturing, mining, oil and gas, and food production activities, as well as for the generation of electricity to support undertakings in each of the aforementioned areas (Lambooy 2011; Signori and Bodino 2013). Far from the free good of past decades water is now an increasingly valuable asset and needs to be treated as such. Organisations can also be exposed to water-related risks through their supply chains and the other companies with which they do business.

Recognising the complexity and interdependence of water availability and use, the World Business Council for Sustainable Development grouped business-related water risk into five categories which can be reduced through water accounting and cleaner production involve (WBCSD-SIUCN 2012: 4):

- financial risk (restriction to capital, higher loan rates and insurance premiums)
- operational risk (increased production costs and disruptions)
- product risk (loss of market share due to increasing consumer concern and customer preference)
- reputational risk (potential for community conflict and loss of license to operate), and
- regulatory risk (chance of new fees, regulations, fines and even lawsuits if the company's activities are seen to conflict with the public interest).

Each of these risk categories has potential to put downward pressure on an organisation's financial bottom line (Larson et al. 2012). The absolute cost of freshwater is also increasing with water trading schemes and similar initiatives becoming more widespread (Larson et al. 2012; SustainAbility 2014). Water quality is also a concern for business with treatment of poor quality water often required before it can be used for production purposes. Thus (in)efficient and (in)effective management of water resources is becoming, and in some cases already is, an economic issue as imperative as any other the corporate management team must deal with on a daily basis. The importance of water as a basis for investment decisions is also being recognised by shareholders (Barton 2010). For example, recent years have seen a significant increase in shareholder resolutions on water-related matters and some institutional investors, like

the Norges Bank Investment Management which is responsible for investing the assets of the Norwegian Government Pension Fund Global, have established water management expectations which are directed at the boards of companies with which they interact and conduct business (CDP 2015; Schulte et al. 2011; Signori and Bodino 2013).

Reports from McKinsey & Company (Boccaletti et al. 2009: online) and other organisations suggest ‘standing on the sidelines is no longer an option’ and that no sector or industry will escape the need to manage water more sustainably (CDP 2015; Daniel and Sojamo 2012; Lambooy 2011; Signori and Bodino 2013). Thus the situation necessitates tools to support more effective practice which stimulates the need for water accounting, a new discipline characterised by burgeoning academic and professional literature and interest (WBCSD-SIUCN 2012). But what is water accounting? The next section will consider the general nature of this question.

3. Need for Water Accounting

In order to manage water resources for effective, efficient, sufficient and consistent decision making companies require access to appropriate data. This could be volumetric information relating to the amount of water used in operations, it could relate to resources and stores available for current and future use, or it could be more complex data relating to the various aspects of water quality. Although there is currently a lack of consensus as to what constitutes water accounting in the corporate context, Morrison et al. (2010: 10) suggest the term refers to a company’s ‘ability to measure and account for their water use and wastewater discharges throughout the value chain’. Emphasis is given to risk management and mitigation, the implications of water use, and potential

for operational efficiencies. Thus effective water accounting is an important part of corporate water management for cleaner production and ‘allows companies to determine the impacts of their direct and indirect water use and discharges on communities and ecosystems, evaluate material water-related risks, track the effects of changes in their water management practices, and credibly report their trends and impacts to key stakeholders’ (Morrison et al. 2010: 11). The importance of water accounting information becomes even more apparent upon considering extant research in the area of corporate water management which has shown many organisations to be basing water-related business decisions on ad hoc and incomplete data or sometimes even guesswork (Ernst & Young 2012; Morrison et al. 2010; Ridoutt et al. 2009).

The rationale for water accounting can also be viewed in relation to the water management risks (and opportunities) identified by the WBCSD-SIUCN (2012) in five stages proposed for holistic water management. The *Water for Business* publication was designed to support development of a common language to help preserve the sustainability of water resources, the fundamental purpose being to ‘to advance understanding of how tools can be combined to yield a practical and effective approach to corporate water management’ (WBCSD-SIUCN 2012: 1). The combination is considered necessary to achieve holistic management of water through five stages in which the importance of water accounting for management is pervasive. First, is the need for information to help assess global and local water situations facing companies because increasing variability of water supplies can be affected for example by global rainfall and evaporation patterns as well as local geography (Koehler 2008). Second, accounting is needed to help identify water supply and consumption and the actual and expected local impacts on volumes and qualities of water (Morrison et al. 2010). Third,

corporate water risks (Money 2014) and opportunities (Wu and Pagell 2011) require assessment as they vary from site to site, catchment to catchment, and country to country. In the fourth stage of holistic water management, setting water risk and opportunity targets and initiating action to achieve these is part of the corporate planning and management control process for which water management and measurement tools are necessary (Hoekstra 2014; Lambooy 2011). The final stage is monitoring and communicating the effectiveness, efficiency, sufficiency and consistency of water performance both inside and outside the organization, for which a system of environmental accounting disclosure is essential (see Wessman et al. 2014).

One implication to emerge from the WBCSD-SIUCN publication is that comprehensive management of, and accounting for, water at the corporate level requires activity that goes beyond any one tool or instrument. As observed by Chapagain and Tickner (2012: 575) in critiquing the water footprint method, to date water accounting methodologies are ‘imperfect and evolving’. Thus acknowledging the divergent backgrounds and focus of different water accounting tools it can be argued ‘business needs an array of water management initiatives’ if it is to manage its use of water resources effectively (WBCSD-SIUCN 2012). Indeed, it is only through such an approach that managers will be able to meet the contemporary challenges of corporate water management especially in relation to closing the loop in a circular economy through reducing use, more water efficient product design, extending product life, and recycling waste.

It cannot be denied the five stages of holistic water management proposed by the WBCSD-SIUCN (2012) represent a positive step in helping managers understand how different water accounting tools interact and can be used in practice. Yet interestingly

the role for management accounting, and more specifically environmental management accounting, in this area has gone largely overlooked. Given management accounting is associated with all five stages identified by the WBCSD-SIUCN (2012) and can be used to further clarify the decision settings in which different tools are likely to be useful it can be argued the role of accounting merits more detailed attention (Table 1). The following section will introduce EMA and link it through to water accounting in more detail.

4. EMA/ WMA and Water Accounting Initiatives

In accord with the need to take the long-term into account in decision making, stimulated by the Brundtland Report (UNWCED 1987) on the need for sustainable development, a comprehensive framework for EMA was introduced (Burritt et al. 2002). Developed at a time when environmental issues were becoming recognised in practice as a major concern to business and society the comprehensive framework provided a logical foundation for classifying the various environmental tools being used in management accounting (Table 2). Burritt et al.'s framework was based on different decision settings and management decision makers associated with environmental impacts of companies as well as the impact of companies on the environment. While many traditional EMA tools (e.g. material flow cost accounting and material and energy flow accounting) predominantly focused on the short-term, growing concern about the environment also highlighted the need for integration with a suite of accounting tools to support long-term decisions (e.g. monetary environmental investment appraisal and physical environmental investment appraisal) (Herzig et al. 2006). In a further development of relevance to the current paper, Burritt et al. (2011) extended the

framework to show how it can be used to address specific environmental issues by examining carbon management in a selection of German companies.

To date although accounting tools are emerging to assist with water management little effort has been devoted to the explicit incorporation of water specific issues into EMA (Christ 2014). Indeed, EMA has largely been ignored in the key water management initiatives being promoted and current tools are criticised for having a 'one dimensional and external focus, past orientation, oversimplification of complex issues, lack of emphasis on future management, and lack of monetary information' (Christ 2014: 381-2; Carbon Disclosure Project 2012; Launiainen et al. 2014). WMA is a recently proposed extension to EMA designed to support corporate water management decisions and improve both economic and environmental water-related outcomes for business (Christ 2014). WMA extends the early generic work on EMA by providing a comprehensive framework which identifies specific water accounting tools along four decision making dimensions: type of information – whether the information is primarily physical or monetary in nature; time frame – whether the information relates to past, current or future activities; length of time frame – whether the focus of the specific tool is on short- or long-term decision making; and routineness of the information collected – whether the information relating to specific WMA tools is routinely generated or whether it relates to ad hoc, decisions based on specific decision needs. The EMA framework was developed with the intention of linking accounting tools with decision making settings rather than considering the details of any single tool. For example, while it is explicit that monetary environmental investment appraisal provides monetary, long-term, future-orientated, ad hoc data it is merely implicit that the tool can be applied using appropriate techniques, such as net present value, accounting rate of

return and portfolio analysis with its assumption of trade-offs between various risks, including water risks, and returns.

WMA is, however, largely concerned with providing environmental accounting support for management decisions about the five different business-related water risks identified by the WBCSD-SIUCN (2012). The last decade has seen a growing number of corporate water management tools developed mainly to increase external stakeholder awareness of the risks associated with water scarcity and sometimes in addition to support better decision making by managers (Table 2, Column 4). Using their five stage process the WBCSD-SIUCN (2012) synthesises and reviews 18 water management tools and initiatives. Table 3 identifies current water initiatives, start date, intended scope (e.g. corporate or site) and target (i.e. internal management or external reporting) of application. Although decisions involving water risks and opportunities have physical and monetary aspects, short- and long-term dimensions, involve regular and ad hoc data gathering and need predictive information about the future based on the past for practical management purposes, these have not previously been systematically considered but have been added to Table 3.

A number of observations on Table 3 can be made. The majority of water initiatives are very recent, coming into effect in the 2010's, which reflects upon the seachange in opinion and desire from different groups to get businesses (and other organisations) to incorporate water-related thinking about supply and demand costs and opportunities in their strategies and practices. Many of the initiatives remain in the process of development, but there is a growing need for best practice to emerge in order that the plethora can be harmonised for business to be able to minimise the costs of certification,

standardisation and guidelines in relation to water. Variety in the scope of the initiatives reflects the emerging concerns at product and process levels, site and corporate accounting, supply chain and catchment entities. It also reflects the diverse needs for data required by different decision makers (WBCSD-SIUCN 2012).

Target audiences (Table 2, Column 4) include a mix of external users of reports (e.g. GRI Water Performance Indicators), and a combination of internal and external decision makers (e.g. UNEP Finance Initiative: Chief Liquidity Series). Of interest is that not one of the tools focuses solely on internal decision making reflecting the importance of external stakeholders in the current corporate water accounting debate. Internal management decisions have a subsidiary role in many of the initiatives. On the face of it reporting in many initiatives is seen as driving internal management. Such an outside-in or stakeholder driven approach to water management accounting is likely to fall short of the inside-out business case for thinking about water promoted through effective internal management (Schaltegger et al. 2015). However, it tallies with the call by Schaltegger and Burritt (2010: 382) for a pragmatic twin-track approach which:

> ‘encourages broad understanding about possible indicators of corporate sustainability, but remains focused on the need to gather information to help implement emerging solutions which are appropriate in the changing strategic settings in these turbulent times and which help inform management practice.’

Many initiatives are orientated towards externally reported information while EMA looks towards primary support for management decision making, or reporting which moves towards performance improvement through behavioural change within

corporations (Schaltegger and Burritt 2010). Such tools can still be categorised using the EMA framework dimensions as even though a tool is externally focussed it generates information that can be used for internal decision making. Improved water management/outcomes will only arise through internal management efforts, even though these may sometimes involve collaboration with external parties, and internal EMA information can be used as a rich source to support accountability to external parties but the key focus is on adaptive capacity and action not disclosure (Pahl-Wostl et al. 2011).

In contrast with application of the EMA framework many of the water initiatives focus solely on the acquisition of physical data, for example water footprints, with a notional reference to the business case, or monetary information (mostly costs but sometimes opportunities), and rarely touch on the notions of eco-effectiveness or eco-efficiency (corporate or sector) which bring environmental and monetary performance together (Burritt and Saka, 2005; Figge and Hahn 2013; Egilmez and Park 2014).

An important observation given the rapid development of communication technology is that several WMA initiatives are already, or plan to be, based on real-time disclosure, based on interactive (user with computer) (Alles and Piechocki 2012), monologic (user to external stakeholder) input of data. However, some initiatives continue to focus solely on gathering past data (described as current) (Water Stewardship Australia Ltd).

Sustainability issues involving water might be expected to have a long-term orientation (Burritt and Schaltegger 2010) (e.g. Water Use Assessment within Life Cycle Assessment), but from a decision making perspective many existing initiatives in relation to water take a short run, periodic approach to information. Note for example

that respondents to the Carbon Disclosure Project's questionnaire feel that water risk is something they need information about in the short run because one third believed the negative impacts associated with this risk would materialise within the next 12 months (CDP 2014). Managers need a seamless interface between decisions about the series of short runs from which sustainability actions occur and the long run in which integration of the environmental, economic and social emerges. Hence, the large number of initiatives addressing both the short and long runs is a positive outcome and encouraged by the EMA framework.

Finally, tools have been devised, such as the GEMI Local Water Tool™, which can be used in an ad hoc manner when the need arises, this also being a characteristic of interactive tools as well, while others e.g. European Water Stewardship Standard, require routine, periodic gathering of data over time.

Given the growing significance of water risk and rapid rise in the number of water initiatives orientated towards business the next section considers the different contributions that WMA would provide as a foundation for better water management.

5. Contribution of WMA

The purpose of WMA as proposed here is to provide a comprehensive framework to support corporate water management decisions which are beginning to be seen as increasingly important by society. In recent years it can be argued water has taken a back seat to carbon on corporate and political agendas. WMA and the framework developed here are important as they provide a foundation for countervailing power, or voice, to water managers to balance the focus on corporate carbon reduction such that if quality water becomes as scarce as predicted the surprise value of such an outcome for

business will be reduced and resilience increased (Fisk 2002; Shackle 1969). Thus WMA can increase awareness of water risk and opportunities as a foundation for action to be taken towards water-related risk reduction and, where appropriate, the taking of opportunities.

There are many benefits to be gained for business, those who manage business and the corporate water accounting community by adopting the WMA framework. First, it encompasses a comprehensive set of management decision settings within which tools for management decision making sit. Thus the framework organizes water accounting initiatives in a more logical way that will appeal to higher level managers who are likely to be time poor and require information presented in a concise and easy to understand way. In addition the framework organises the internal decision analyses aspects of water management initiatives in a way which clarifies the specific corporate decisions being affected in practice. It provides for comprehensive mapping of the users of the different water accounting tools facilitating communication of relevant information to managers and encouraging teamwork across business functions. The last point is especially important given water accounting, as with most forms of environmental accounting, is inherently transdisciplinary requiring those from different areas of the business to work together.

With regard to water accounting tools themselves the WMA framework will provide an understanding of the interlinkage of tools implemented over time and how they can be used together to improve corporate water management. The framework will also facilitate easy assessment of the incremental benefits of new water management initiatives as they develop and help avoid duplication of effort by highlighting scope for

convergence of initiatives as identified by the CEO Water Mandate (United Nations 2013) (e.g. between Water Stewardship Australia Ltd and the Alliance for Water Stewardship, and the sets of water footprint orientated initiatives).

However, further to the benefits outlined above one of the greatest advantages associated with development and adoption of a WMA framework is the incorporation of monetary information and the framework's ability to highlight and encourage the integration of economic and environmental performance through measurement and indicators of eco-effectiveness and eco-efficiency, as well as consistency (replacing toxic inputs) and/or sufficiency (reviewing the need for certain products). With a singular focus on physical aspects of water some of the recent initiatives, although well intentioned play down the importance of the economic success dimension and lose balance for business which apart from better water management is looking for increased sales, cost savings, an improved competitive position, higher margins, better profitability and durable, sound investments (Rappaport 1998). Ignoring business realities in the absence of command and control regulation will not lead to improved water-related outcomes. Thus the WMA framework embraces the business case for sustainable action highlighting the possibility of win-win outcomes in relation to water – something existing initiatives have overlooked.

The points outlined above show WMA as a sub-discipline of EMA is both needed and important. However, in order to realise the full potential of WMA more research is needed as will be discussed in the following section.

6. Future Research Directions in WMA

Findings from the literature and initiatives reviewed above indicate a number of fruitful directions that can be followed in relation to furthering research in WMA and to establishing its role as a pragmatic foundation for improved practice.

One thing that is immediately apparent upon reviewing available initiatives is that tools suitable for use by small and medium sized enterprises (SMEs) are in short supply. Rather than fall back on water accounting methods that are not fit for purpose traditional EMA tools such as Material Flow Cost Accounting (or in this case Water Flow Cost Accounting) might be more appropriate given their use by smaller organizations has already been established, at least with regard to more generic environmental issues. This specific possibility requires further investigation.

Second, given the growing number of water management tools and initiatives developed and recommended for implementation (Table 3) there is a growing need for specific research into identification of the incremental value added for decision making by each new initiative and the possible removal of duplication (see Table 3) e.g. with water footprinting. Similar research that examines the potential for specific traditional EMA tools and their application to water management would also be welcome. This research would act to counter the current tendency of tools to focus on external reporting and provide a balanced approach which recognizes the pragmatic importance of combining WMA for decision making and internal and external communication.

One way in which EMA, or WMA as proposed here, differs from existing water accounting approaches is that there is need for specific research into an explicit focus on the monetary aspects of water management and use. In contrast existing water management tools and initiatives largely ignore monetary aspects of decision making at

the corporate level (e.g. water footprints). This is problematic given economic imperatives remain the primary driver of decision making by managers in practice. Thus there is considerable scope for development of tools which include this monetary aspect of the business case in accounting for water management. Case studies of different decisions, such as for the sixteen settings outlined in the WMA framework developed, as well as systematic research, are needed to demonstrate the contribution of monetary WMA to increased water effective and efficient operating and investment outcomes e.g. in relation to product pricing, marketing, budgetary control, investment decisions.

The WMA framework incorporates different decision making settings and it is expected there will be a number of tools that may be appropriate in relation to each of the 16 settings presented in Table 2. Thus there is a need to understand in more detail how different EMA/WMA tools combine to affect performance in different settings.

For illustrative purposes take Boxes 1, 3, 9 and 11 in Table 2. Companies with a focus on the regular production of data about effectiveness and efficiency of water use and discharge can, as part of their budgeting process, estimate the expected use of water and expected discharge back to the water source based on a required or subjectively assessed quality standard (Box 11, physical water budgeting). As part of a management control system regular (e.g. real-time, daily, weekly, monthly) short term data can be monitored and collected about the actual waterflows and compared with budgeted expectations (Box 3, water flow accounting). For short-term measurement of eco-efficiency the estimated and actual physical data will be compared and related to the estimated and actual monetary results. Hence, Box 9, monetary water operational budgeting, will provide the expected financial impact of regular, periodic water flows

e.g. expected costs and revenues and Box 1, water flow cost accounting, the actual revenues and costs of the period. Together eco-efficiencies of products, processes, sites and the whole company can be calculated and water flows managed in terms of closeness of monetary and physical results of water performance to targets, as part of a routine management control system, perhaps with continuous improvement over time built in. Each tool and combinations of tools can be used to emphasise the economic and environmental performance in respect of water.

Studies with a sound theoretical foundation e.g. contingency theory and new institutional sociology (Christ and Burritt, 2013; Mokhtar et al., 2016) that examine the relative importance of links between different sets of WMA tools and different water risks in different industries – agriculture, mining, manufacturing, services, etc. would be helpful to indicate how holistic corporate water management (WBCSD-SIUCN 2012) can best be introduced. Specific research could also consider how these tools and the information they provide relate to other environmental issues such as the water-energy nexus (Herzig et al. 2006).

Current literature on water management is not strong in relation to traditional forms of environmental accounting, or identification of the different roles of managers and their information needs. Research would be welcomed into identification of which managers supply and which use different types of WMA data, their perceptions of the usefulness of the data, and how WMA data are involved in integration across professions towards effective, efficient, sufficient and consistent water management outcomes. For example, examination of WMA (Table 2, Box 1) of greatest use to managers for performance improvement, communication, planning and control, motivation, coordination of

activities, etc., and the best WMA data to support investment in improving stocks and flows of water in droughts, floods, climate change conditions, etc.

Finally, the works examined indicate that research into the relative significance of indirect water consumption and wastewater generation in supply chains, especially through virtual water (Allan 2003), is needed to indicate the importance of integrating WMA with suppliers and purchasers. As with carbon accounting (Burritt et al. 2011) the research agenda for WMA can include search for an appropriate information system to identify and support management decisions about supply chain water risks e.g. application of water flow cost accounting to zinc plating by suppliers of parts to the car industry (Daylan 2013).

In relation to research methods that might be appropriate in the initial investigation of WMA and its potential for practice there are many options that can be summarized as follows:

- *Case studies:* Literature shows there are few examples of WMA tool use and it would be helpful for best practice case studies to be published about the experience of companies that have commenced implementation of WMA tools. The special value of such research relates to the geospatial aspects of water management and associated water risks and accounting. There is also a need for gathering of qualitative data case based information about benefits and complexities of corporate WMA in different industries, sectors, cultures, political systems, legal settings, geographical areas, supply chain arrangements, and stages of economic development.

- *Benchmarking studies.* Comparative studies between companies considering WMA in different industries would be of value for providing measurement, target-setting, benchmarking and budgetary control. The studies would be able to demonstrate what does and does not work as companies look towards engaging with water crisis and how it affects the various parts of their businesses.
- *Large database studies*. As development is in a very early stage, the literature studied reveals very little systematic evidence about the success or otherwise of particular WMA decision tools. Experience from EMA research indicates the importance of physical material flow and cost based material flow, and physical investment appraisal and monetary investment appraisal tools (Herzig et al. 2006). As an initial research step it would be constructive to examine WMA use in relation to these tools in different industries, with the intention of identifying contingent variables leading to successful implementation and improvement in water management.

The areas for potential research listed above are by no means exhaustive and could also include e.g. survey work about water management accounting in companies within a specific area related to existing water sources. What they do represent is a starting point for researchers interested in investigating the interface between the economic and environmental aspects of water management by business. The next section will now conclude the paper.

7. Conclusion

The purpose of this paper was to examine the relationship between accounting and corporate water management in the face of a widely acknowledged and growing water crisis and the lack of available relevant data having appropriate granularity on which company managers can base their different decisions. The evidence examined confirms the role for environmental management accounting in corporate water management has been largely overlooked, with the emphasis instead on external reporting. Existing corporate water accounting approaches are confusing and it is difficult to distinguish how available techniques differ or to determine the tools that are most appropriate in different situations. With this in mind and building on prior research into EMA a new comprehensive corporate WMA framework is developed highlighting the data needed for different tools in different decision settings. For management the framework will help with assessment of the set of emerging water management initiatives and tools in the context of the value of water to business, especially through measures of eco-effectiveness and eco-efficiency of water. The framework highlights that if corporate water management is to improve managers will also need granular monetary information as well as the tools already being developed to provide data about physical flows of water. Collection of data in line with the framework will also help raise awareness of existing EMA tools that might be applied to the management of water and with the additional focus on monetary information provide a basis for better business decisions about water.

WMA is a step forward for businesses grappling with water management issues. A set of research questions is identified with regard to how WMA and the framework can be applied in practice. However, one limitation of the framework is that specific studies are still required in order to reveal the dynamic and innovative nature of corporate water

management accounting applications. It is hoped this paper will act as a catalyst that will encourage other researchers to engage with this area of increasing global importance to both business and the community.

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Table 1 Stages of Holistic Water Management and WMA.

Stage No.	Focus of stage	WMA link
1	Assess global and local water setting facing the company	Accounting for the impact of geographical, climate, technological, socio-political, economic and regulatory aspects of water on the company and its sites, supply chain relationships, etc. Data: largely physical, but monetary aspects of water markets.
2	Identify company impact on water supply, consumption and quality	Accounting for the impact of the company on water – sources, storage, consumption, and wastewater, non-product output, etc. Data: largely physical.
3	Identify water risks and opportunities	Accounting for detailed water risks. Data: physical and monetary.
4	Determining action and setting targets	Accounting for planning, budgeting and control of water. Data: physical and monetary.
5	Monitoring and communicating performance	Accounting for internal and external accountability in relation to water management.

Source: Based on WBCSD-SIUCN (2012).

Table 2 Corporate Water Management Accounting (WMA) Comprehensive Framework.

Water Management Accounting (WMA) Framework					
		Monetary Water Management Accounting		**Physical Water Management Accounting**	
		Short term	**Long term**	**Short term**	**Long term**
Past oriented	**Routinely generated information**	1. Water flow cost accounting (e.g. recording the revenues and costs from water acquired and fines incurred)	2. Water capital expenditure accounting (e.g. collection of data about actual annual capital expenditure on water reduction technologies)	3. Water flow accounting (e.g. collection of daily blue, green and grey water flow information related to production processes, to identify hotspots)	4. Water capital impact accounting (e.g. wine company's calculation of the bottling department's annual water footprint over the last five years)
	Ad hoc information	5. Ex post assessment of short term/ relevant water costing decisions (e.g. calculation of the cost of water and treatment of wastewater allocated to production of a new electric car)	6. Ex post assessment of water reducing investments (e.g. ad hoc assessment of the cost savings for an agribusiness from investment in a variable rate centre pivot irrigation system)	7. Ex post assessment of short term water impacts (e.g. collection by a coal mining company of volumetric and quality information about a spill from a failed tailings dam)	8. Ex post assessment of physical water investment appraisal (e.g. review of physical benefits from installation of water storage covers necessitated because of increased evaporation caused by rising temperatures)
Future oriented	**Routinely generated information**	9. Monetary water operational budgeting (e.g. expected weekly net gains from trading of water rights by a paint manufacturer)	10. Water long term financial planning (e.g. forecasting the future financial benefits to be gained from planning to permanently reduce the company´s water footprint)	11. Physical water budgeting (e.g. projected monthly reduction in waste water volume by a large accounting firm as an accredited environmental management system is introduced)	12. Long term physical water planning (e.g. forecast of expected mix of water sources available to a coastal tourist resort in an arid region)
	Ad hoc information	13. Relevant water costing (e.g. calculating the direct and indirect cost of water as a one-line item added by a butcher to the price of steak charged to a special order customer)	14. Monetary water project investment appraisal (e.g. appraisal of expected cost savings from a commercial banking chain investing in dual flush toilets)	15. Water impact budgeting (e.g. consideration of the expected water reduction effect of recycling of green water as blue water in a construction project)	16. Physical water environmental investment appraisal (e.g. calculation of the total water increase from an investment in rainwater recycling tanks by an organic beauty products manufacturer)

Source: Based on Schaltegger and Burritt 2000 and Burritt et al. 2002.

Table 3 Comprehensiveness of Water Initiatives for Decision Making

Water accounting initiative	Start Date/ Standard or Guidance	Scope	Target	Environmental Management Accounting Decision Information			
				Physical/ monetary	Past, current / future activities	Short / long term focus	Routine / ad hoc
Alliance for Water Stewardship	2009	Site, Catchment	External	Physical Monetary	Past Future	Short term Long term	Routine
BIER Water Footprint Working Group	2011	Site Corporate, Supply Chain	Internal/ External	Physical	Past	Long term	Ad hoc
CDP Water Program	2009	Corporate	External	Physical Monetary	Past Future	Short term	Routine
Ceres Aqua Gauge	2011	Corporate	Internal/ External	Physical Monetary	Past Future	Short term Long term	Regular Ad hoc
Ceres SEC Sustainability Disclosure Search Tool (supersedes Ceres Water Risk Disclosure Tool 2015)	2016	Corporate	External	Physical	Past	Short term	Regular
European Water Stewardship Standard	2011	Site	Internal/ External	Physical Monetary	Past Future	Short term Long term	Routine
GEMI Local Water Tool™	2012	Site	Internal/ External	Physical Monetary	Past Interactive	Short term	Ad hoc water tool
GRI Water Performance Indicators	2002	Corporate	External	Physical	Past	Short term	Routine
ISO Water footprint: Requirements and Guidelines	2014	Products, processes, organisations	Internal/ External	Physical	Past	Short term Long term	Routine
UN CEO Water Mandate	2014	Corporate	External	Physical	Past Interactive Planned	Short term Long term	Routine
UNEP Finance Initiative: Chief Liquidity Series	2009	Corporate Sectors	Internal / External	Physical Monetary	Past Future	Short term Long term	Ad hoc
Water Accounting: An Australian Framework for the Minerals Industry	2005	Site	Internal/ External	Physical	Past	Short term Long term (planning)	Routine reporting
Water Footprint Network	2009	Products, processes, organisations	Internal/ External	Physical	Past	Short term Long term	Ad hoc
Water Impact Index	2011	Product, Processes, organizations	Internal/ External	Physical	Past Interactive	Short term Long term	Ad hoc
Water Risk Filter	2014	Corporate	External	Physical Monetary	Past Online Future	Short term	Ad hoc
Water Stewardship Australia Ltd	2014	Site Catchment	External	Physical Monetary	Past Future	Short term Long term	Routine
Water Use	2008	Product,	Internal/	Physical	Past	Long term	Routine

Water accounting initiative	Start Date/ Standard or Guidance	Scope	Target	Environmental Management Accounting Decision Information			
				Physical/ monetary	Past, current / future activities	Short / long term focus	Routine / ad hoc
Assessment within Life Cycle Assessment		Processes, organizations	External				Ad hoc
WBCSD Global Water Tool	2011	Site	Internal/ External	Physical Monetary	Past	Short term Long term	Ad hoc water tool
WRI Aqueduct Water Risk Atlas	2010	Site	Internal/ External	Physical	Past Interactive Future	Short term Long term	Ad hoc water risk atlas

Source: Based on WBCSD-SIUCN 2012 and Burritt et al. 2002.