

**CORPORATE WATER DISCLOSURE
AND MANAGEMENT:
A SELF-REGULATION PERSPECTIVE**

*A Thesis Submitted
In Fulfilment of the Requirements for the Degree of
Doctor of Philosophy
by*

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DECLARATION

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.

STATEMENT OF AUTHENTICATION

The work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not submitted this material, either in full or in part, for a degree at this or any other institution.

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To the examiners of my thesis, I thank you most sincerely for your time and effort to review my thesis and look forward to your feedback.

DEDICATION

To My family and My Friends

Thank You for Your Love and Support

REFEREED CONFERENCE PAPERS

Linhan Zhang, Qingliang Tang, 2013, 'Corporate Responses towards Water Information Disclosure: Evidence of Global 500', paper presented at the 12thA-CSEAR Conference, Hamilton, Newzeland, 1-3 December,2013

Linhan Zhang, Qingliang Tang, 2015, 'Voluntary Water Disclosure and Corporate Sustainability', paper presented at the 38th Annual conference of European Accounting Association (EAA), Glasgow, United Kingdom 28-30 April,2015

ABSTRACT

Worldwide, increasing population and economic growth have provoked an increased demand for water, and global warming has aggravated the instability of water supplies. In the fight for a better environment, water management will soon become a central focus, following the management of carbon emissions. The efficient use of freshwater is essential for sustainable economic development, but a review of the literature reveals that few studies have addressed water management issues at the level of the corporation. Using updated information, gathered from a variety of corporate organizations worldwide, this thesis is timely in addressing water management practices in the business sphere among different industries. Specifically, the central issues of this study are how companies are reacting to increasingly rigid legal requirements in regard to water usage, and what stimulates companies to improve the quality of their water management and ultimately to increase the efficiency of their water usage.

To pursue this objective, this study investigates self-disclosed water management practices among corporations worldwide, using data from CDP (previously Carbon Disclosure Project), a non-profit organisation that collects information using questionnaires from hundreds of companies throughout the world on water-specific information, as well as carbon-specific information. In this thesis, three research questions are addressed: why do companies voluntarily participate in the CDP program and disclose information publicly; what causes companies to practice good water management; and does good water management bring benefits to companies.

A new theory of self-regulation is proposed and justified by research findings to rationalise corporate attitudes towards water management and disclosure. Three research questions are explored in two chapters, using different methodologies. The first question explores the motivation of participating companies for the choices they make with regard to disclosure of water-management information among public, private, and no disclosure. Logistic regression models are used to test relationships among corporate character and propensity for information disclosure, using 1587 observations. A self-regulation index is constructed, with four pillars: committee of environmental or corporate social responsibility, water policy, actions for water efficiency, and performance evaluation. Findings show that higher levels of self-regulation will lead to public disclosure of information. Firms are more likely to publicly disclose water information if they belong to water-intensive industries or are domiciled in countries with more stringent regulatory environments or stronger investor protections. Moreover, self-regulation regimes may stimulate public disclosure more effectively in less stringent legal environments.

The second and third research questions investigate whether the drivers of superior water management have improved and whether self-regulation mechanism will improve water efficiency, respectively. Drawing on detailed, publicly available water information, a preliminary water management system is constructed with a quality-evaluation methodology. Results generated from multiple regression models demonstrate that firms perceiving a high physical water risks and a strong recognition of water opportunities tend to have better-quality water management. Consistent with the self-regulation proposition, better-quality water management is associated with the recognition of low regulatory risks. Empirical results further imply that companies will pre-empt external regulatory pressure by proactively adopting self-regulation regimes if they can expect stringent legal requirements in the future. The comparison of water usage and efficiency between firms with high- and low-quality water management confirms that self-regulation incentive in water management may not effectively reduce water usage in the short-term.

The contribution of this thesis is threefold. First, few studies have specifically focused on corporate water management to the present time. The present study will

fill this gap by providing up-to-date evidence on how companies manage water, in an international setting. From a theoretical perspective, a self-regulation theory is proposed to explain how companies are able to maximize self-interest through disclosure and water management. This study complements the literature by adding new perspectives, with empirical evidence. The self-regulation index and a water-management system are constructed as proxy for self-regulation efforts. Through this study, we will have a better understanding of contemporary sustainable practices in water use, as well as its links to carbon management and long-term sustainability. The results also have practical implications for sustainable water management, which can be used by the government, researchers, and corporations.

Key words: Water Disclosure, Water Management System, Self-regulation

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List of Abbreviations

CDP	Carbon Disclosure Projects
CMS	Carbon Management System
CSR	Corporate Social Responsibility
EMS	Environmental Management System
SME	Small and Medium-sized Entities
SRC	Voluntary Self-regulatory Codes
VA	Voluntary Agreements
WMS	Water Management System

Key Internet Sites Used in the Research

Australian Government Water Information Standards

<http://www.bom.gov.au/water/standards/index.shtml>

CDP website

<https://www.cdp.net/en-US/Pages/HomePage.aspx>

Ceres

<http://www.ceres.org/issues/water>

SustainAbility

<http://www.sustainability.com/library/trust-us#.VpEewf195D8>

The CEO Water Mandate

<http://ceowatermandate.org/>

Chapter 1 Introduction

1.0 Overview

Water resources are precious and have important implications for sustainability. This thesis attempts to explore sustainable contemporary practices in water management and to cast light on the tension between businesses and society at large (Woodward *et al.*, 1996). By examining corporate attitudes and practises as reflected by data from the Carbon Disclosure Project (CDP) water program, this thesis aids the understanding of contemporary water-management issues among large international companies worldwide. Specifically, this study adopts a self-regulation perspective to explain the motives and the outcomes of water-management practices.

This chapter addresses the motivation for the research, the research methods, and the three research questions, as well as the ultimate potential contribution to existing knowledge.

1.1 Research background

Fresh water is one of the Earth's most important and accessible resources, and it may seem to be virtually unlimited in supply. However, notwithstanding how vital fresh water is for the survival of life on Earth as well as for economic development, it is a small part of the Earth's total water resources, accounting for only 3% of all water; this has been further reduced by ongoing pollution (UNESCO, 2003). Water pollution crises and water-supply shortages have been exacerbated due to climate change, overuse, and other human activity (Ceres, 2013). The private business sector is a substantial water user,¹ and is also considered a major contributor to water pollution (Lambooy, 2011). In the fight for a better environment, the World Economic Forum (2016) recently surveyed 750 experts and published the "Global Risks Report". It

¹ Globally, industrial annual water use is expected to increase from an estimated 725 km³ in 1995 to approximate 1,170 km³ by 2025. During this time, water used by business sectors will represent 24% of all water abstraction. This proportion of industry water use varies with national wealth, from 10% among low- and middle-income countries, to 59% in high-income countries UNESCO 2003. Water for people, water for life, united nations world water development report,.

ranks water risks as the number one risk for the next 10 years in terms of impact and likelihood, followed by climate change risks (World Economic Forum, 2016). Compared to the issue of carbon pollution, water-related disasters such as drought and flood are more unpredictable and immediate, and have more physical, direct, and significant impacts on businesses.² As a result, corporate water stewardship and management are becoming important dimensions in corporate sustainability. A business strategy that aims to meet the needs of its enterprises will consider protecting, sustaining, and enhancing natural resources. If managed strategically, water can also bring business-related opportunities, such as sales of water-efficient products and cost savings. Moreover, water consumption control and reduction are not only a social responsibility intended to secure the social contract of a firm with its stakeholders, but they also represent true economic, cost-saving, and risk-hedging benefits, particularly in some sensitive regions and water-intensive industries such as in the sectors of food, beverage, mining, and power (Ceres, 2010). In general, water is a strategic element that needs to be managed for both the purpose of risk reduction and value creation.

With little standardised instruction from local authorities but increased expectations from the public, companies voluntarily undertake proactive water withdrawal reduction and water-management disclosure, adopting reporting regimes to communicate their water issues (Moroney *et al.*, 2012). With no specific legitimation requirement, this behaviour is mostly optional in almost all countries in the world at this time. To the best of my knowledge, no published papers to date have attempted to analyse whether this can actually improve water use, or is simply a gesture, and what motives may be behind such behaviour.

1.2 Motivation for the research

Motives for this thesis come from the growing global effort to combat climate change and the prominence of sustainable development (Perez-Batres *et al.*, 2012a). This study is timely, as water-management disclosure is an emerging practice, an extension of research in environmental accounting after carbon. Prior studies have treated water

² Anecdotal evidence supports such a claim. For example, a flood destroyed the second largest factory in Thailand for hard disk drives in 2011. Consequently, a global shortage of production boosted the price of electronics throughout the supply chain Chongvilaivan, A. 2012. Thailand's 2011 flooding: Its impact on direct exports and global supply chains. Available: <http://www.unescap.org/sites/default/files/AWP%20No.%20113.pdf>.

as a component of a basket of general environmental concepts (Al-Tuwaijri *et al.*, 2004), and specific research on corporate water management is relatively scarce (Lambooy, 2011). However, the water supply crisis is ranked amongst the top risks facing companies in terms of impact (Ceres, 2009). Although there have been studies on carbon management and general environmental performance, there has been no large-scale empirical study on water management to date. In addition, water management is a distinct dimension, due to its unique attributes, legal requirements, and special governance mechanisms. For example, the impact of water consumption on business sustainability can be complex. That is, the quantities of water used in arid areas versus areas with sufficient water can be quite different, as can the quantities used in seasons of drought versus at normal times, which adds major layers of unpredictability to the issue. Given the various social and environmental opportunity costs of the consumption of a given amount of water,³ gaining a clear understanding of the impact of water use is likely to be much more challenging than mastering other major issues, such as carbon emissions. Carbon dioxide (CO₂) emissions may have the same effect on global warming regardless of where the emissions are released. The same is not true of water pollution, which is geographically specific. Thus, plans for water management are likely to differ from other environmental issues in terms of regulation, culture, and monetary return; thus, they deserve to be studied separately from holistic environmental management.

Although the literature on corporate sustainability is growing (Chalmers *et al.*, 2008, Huang and Watson, 2015, Hahn and Kühnen, 2013), some important research questions such as whether transparency will improve accountability and legitimacy are still unclear (Auld and Gulbrandsen, 2010, Schaltegger and Burritt, 2010); whether and how corporate social responsibility (CSR) may benefit corporations remains unanswered (Cheng *et al.*, 2014). Among all related topics, what motivates corporations to disclose such non-financial information to the public, and what determines the extent and the quality of reporting, are the main themes (Hahn and Kühnen, 2013). These research questions have not been widely examined in the context of water, especially using quantitative research methods. In practice, many organisations still lack a systematic and concrete mechanism for improvement (Ceres,

³For example, one ton of beef requires roughly four million gallons of water to produce Milgrom, PR, North, DC & Weingast, BR 1990. The role of institutions in the revival of trade: The law merchant, private judges, and the champagne fairs. *Economics & Politics*, 2, 1-23.

2010, Lambooy, 2011) but are eager to participate or to obtain a simple appraisal or certification from a non-state organisation (Auld and Gulbrandsen, 2010). It remains unknown what the consequences of these sustainability programs are, or if they are in fact only an illusion (Schaltegger and Burritt, 2010). In particular, there has been limited research on how firms strategically manage the timing, type, and level of voluntary public disclosure of water use (Magness and Bewley, 2012).

This thesis tackles these issues in an attempt to fill a gap in the literature and explore the managerial incentives to be transparent and sustainable in regard to water management. This issue is important, as concerned stakeholders may use water-management information when making decisions on the dependency of corporate operations on natural resources. Some companies strive to be sustainable, voluntarily integrating environmental strategies into their core business strategy. Therefore, it is important to understand the motives for the disclosure of such strategies and the truth underlying the disclosures. In addition, from a practical viewpoint, studies on the motivations behind the management of water use, water performance, and the linkage between water and carbon management support the sharing of knowledge among industry peers and support policy-making for the government and related parties. The results of this dissertation also shed light on some important issues such as the range of corporate responsibility and cost-bearing between corporations and governments.

This study is related the work of Tang and Luo (2010) on carbon management. These researchers have made a bold attempt to solve climate change issues using accounting and other management techniques. The significance of their paper will be explored more completely in the following chapters. Following a similar approach, this dissertation aims to tailor a management system to water issues, filling in gaps as needed.

In undertaking this study into the CDP water program, this thesis aims to:

- provide insight on the motives for emerging practices of water accounting, disclosure, and management,
- extend and supplement extant theories of voluntary CSR disclosure and proactive environmental protection with a theory of self-regulation, and
- develop a conceptual framework for a corporate water-management system.

1.3 Research questions

This thesis is timely in addressing water-management practices in business among different industries. Three related research questions focusing on key issues in sustainability are addressed. Specifically:

- What motivates companies to voluntarily disclose water usage and management practices to the CDP?
- What stimulates companies to improve the quality of water management?
- Will a firm with an environmental management system (EMS) reduce water usage or improve water efficiency?

A framework underpinning the whole thesis is proposed below in Figure 1.1, explaining the interconnections within these questions. Those questions help rationalise corporate approaches to water risks and opportunities (Money, 2014). More developed frameworks are shown in later chapters.

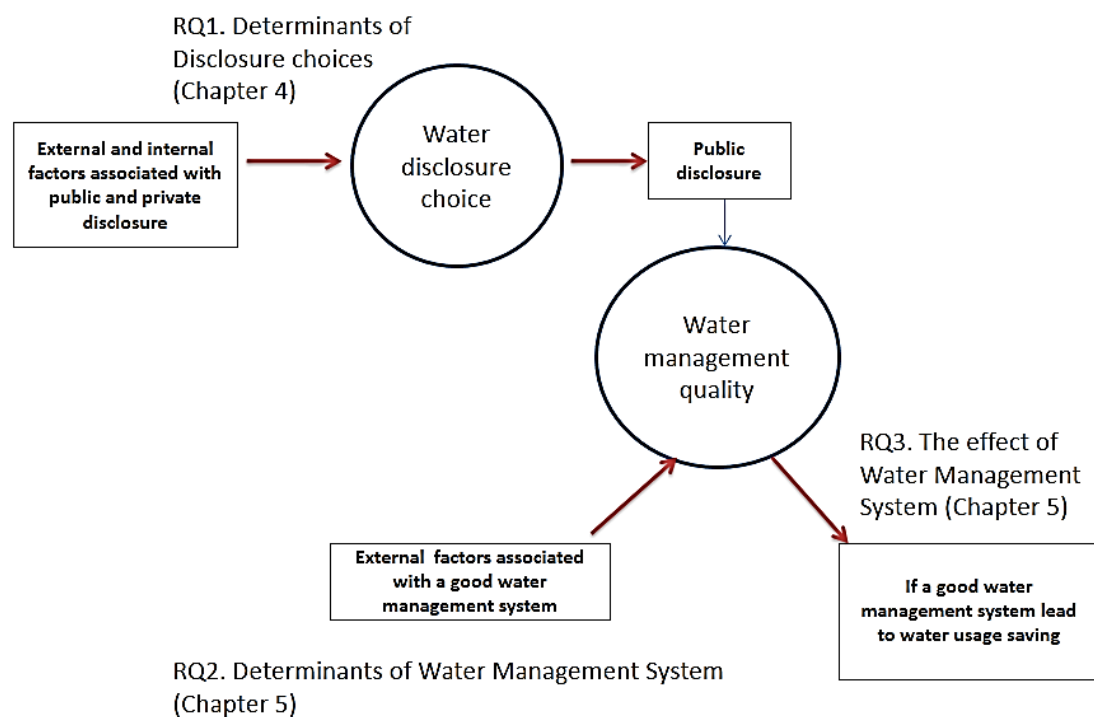


Figure 1.1 Conceptual framework

1.4 Data used in the study

The main source of the data used in this study is the CDP⁴, a non-profit organisation based in the UK, committed to improving sustainability in climate change, water efficiency, and other environmental aspects in the modern business world. To encourage efficient utilisation and transparency of information, the CDP is beginning to specialise in water programs, pressuring large firms worldwide that are deemed to be exposed to water-related business risks (i.e., physical, regulatory, reputational risks) to participate (CDP, 2013a)⁵. This program is voluntary in nature. If a company decides to participate, it is required to respond to a standardised questionnaire on water governance, water consumption, risks and opportunities, water accounting, and management information. Firms are also provided with alternative options, such as private disclosure, if they do not favour public disclosure. In this way, their information will be partially confidential, available only to institutional investors who are signatories of the CDP. By leveraging the power of the capital market, the CDP has successfully made itself the possessor of the world's largest database of self-reported environmental information from businesses (Anyanova, 2012).

The conventional platform for environmental disclosure is through annual reports or sustainability reports (Aerts and Cormier, 2009, Davis, 1960), which not only present limited information on water, but also allow managers greater discretion in determining the content and form of disclosure. Executives often take advantage of this flexibility to emphasise the positive aspects of performance or to alter or influence perceptions of the firm's performance. Such disclosure is not strictly comparable between firms and is less consistent over time; this obfuscates rather than clarifies sustainability performance (Cho *et al.*, 2012). This is perhaps one reason why results of previous studies are mixed and often obscure or debatable. By contrast, the CDP uses standard methodologies and questionnaires. Manipulation of water information is more difficult under such schemes, because managers have fewer opportunities and incentives for "greenwashing", which is aimed at misleading the general public with

⁴ The development of CDP organisation is described in Appendix A

⁵ In 2013, 530 institutional investors, with assets of US\$57 trillion, became signatories to the CDP's water information program CDP 2013b. Understanding and assessing the relative maturity of corporate water stewardship practice. *In*: LAMB, C. (ed.). Prior research holds that a major incentive for participation in the CDP is the reward to innovative firms, and the predominance of the CDP program is due to its ability to leverage the power of institutional investors.

self-claimed environmental practices of a company through deceptive advertising and marketing (Delmas and Cuere Burbano, 2011). Despite the fact that there are no internationally recognised water-reporting standards, the CDP has provided globally consistent and comparable data, reducing ambiguity.

Several studies have already used the CDP as the main data source for the study of the motivation of carbon information disclosure from the perspective of the incentives for disclosure (Luo *et al.*, 2013, Luo *et al.*, 2012, Stanny and Ely, 2008), corporate governance (Liao *et al.*, 2014, Lewis *et al.*, 2014, Rankin *et al.*, 2011, Ben-Amar and McIlkenny, 2014), value relevance of carbon emissions information (Matsumura *et al.*, 2013, Lee *et al.*, 2013, Luo and Tang, 2014, He *et al.*, 2013), carbon management systems (Tang and Luo, 2014, Weinhofer and Hoffmann, 2010), and institutional evolution (Knox-Hayes and Levy, 2011). The works mentioned are not exhaustive but are indicative of the breadth of study that the CDP has promoted. Although it has been criticised for not addressing the cognitive and value dimensions (Kolk *et al.*, 2008), as well as being insufficient to reduce resource consumption or emissions (Money, 2014), the CDP has provided unique and systematic information on carbon and water management. Therefore, the use of this database in the present study may strengthen the findings.

Financing data mainly comes from DataStream and Thomson ONE banker. Other data sources include the World Bank and the World Economic Forum.

1.5 Data analysis methods

The empirical design consists of two parts. The first part of the research uses information from the CDP water program, from 2010 to 2013. The sample covers companies operating in eight industries deemed by the CDP to be exposed to water-related risks (CDP, 2013a) and includes 1,587 firm-year observations worldwide. The second part uses 94 observations from Global 500 companies that publicly disclosed their water-management information in the CDP water program in its first year. Indeed, the companies investigated are large, influential, international companies. Some have already established water stewardship, providing abundant implications for this study.

In the first part, the primary decision of a corporation is whether or not to comply with the request. The factors considered to have an influence include self-regulation,

stringency of environmental regulations, water consumption, water availability, and legal systems. To measure the effort taken for self-regulation, a rough self-regulation score is developed based on information available in annual reports and sustainability reports. Logistic and multi-logistic regression analyses are employed to predict the responses of sample firms to the CDP by identifying the main drivers leading to disclosure. Moreover, this scoring also takes into account companies that choose non-public disclosure.

The second part combines a quantitative research model with qualitative research techniques. A new water-management system (WMS) has been designed to evaluate the quality of self-regulation by assessing the content of responses. Using classification, content analysis, and a scoring methodology, the WMS score gives a more accurate measurement of the effort taken for self-regulation as well as the quality of water management. Using multiple regression analyses and the t-test, the hypothesised determinants are tested to find the most significant motives for self-regulation. Next, water withdrawal data are extracted from corporate reports and used together with CDP data to test whether self-regulation helps reduce water use and improve efficiency.

1.6 Main results

The results of both Chapter 4 and Chapter 5 are grounded in self-regulation theory, a theory from political economy that has recently been applied in the area of water management and accounting. Self-regulation theory suggests that the purpose of corporate self-regulation is to forestall governmental regulation so as to avoid costly direct control of environmental protection activity on the part of the government. Based on extant theories, the results in Chapter 4 show that companies making the highest self-regulation efforts are more willing to publicly disclose their water information. Stringent environmental regulation will also stimulate disclosure. Companies prefer private disclosure in countries where information asymmetry is high and protection of small investors is weak. Self-regulation works better in a less stringent regulatory environment and in less intensive industries. These results indicate that companies may use self-regulation in negotiation for less rigid environmental regulations in water-related operations. It further implies that managers may utilise discourse through various channels to achieve their strategic purpose.

Chapter 5 explores other motives for good self-regulation of water management and its consequences. The results show that perceived physical water risk, recognition of water opportunities, and reduced perceived regulatory risks are the main factors related to good self-regulation of water. Companies with low water productivity put more effort towards water management. However, water usage and productivity in successive years do not show great improvement among companies that have implemented good self-regulation. These results suggest that self-regulation in water management is directly or indirectly influenced by multiple factors and that self-regulation is not driven by a single motivator. Consonant with results of the first part, self-regulation may not demonstrate much accountability; it may merely serve as a tool to achieve favourable results, such as the pre-emption of governmental regulation, improved reputation, and opportunities for future profit.

1.7 Significance of the thesis

Investors now worry about non-financial risks to which companies might be exposed, due to the direct effects of water shortages via changing weather and ever-increasing sea levels and indirect regulations such as protections against water pollution and liability costs. How companies manage such external risks is key for this study. One of the key debates in CSR studies is whether corporate disclosure can establish accountability (Auld and Gulbrandsen, 2010). This dissertation tackles this issue using a corporate WMS, a less studied area in sustainability. The adoption of self-regulation theory can contribute meaningful insight to the importance of transparency of non-financial performance. CSR and sustainability have increasingly been considered more of an investment in the sustainable growth of firms than a cost or loss (Park *et al.*, 2015). Many researchers have advocated the integration of CSR and corporate strategy, and firms may be able to reach business goals and improve social welfare at the same time (Jamali and Mirshak, 2007, Porter and Kramer, 2006). Whether such conclusions can be drawn in the context of water management remains to be determined. Therefore, it is important to justify this proposition with empirical evidence.

The significance and originality of this thesis are threefold. First, this work responds to the call for solutions to water shortages from a management approach. Unlike carbon issues, there is a lack of international consensus or discussion on what and how

water information should be provided. Prior studies have proposed EMSs and carbon management systems (Tang and Luo 2014). However, to date, there is limited research on the feasibility of corporate WMSs. Thus, the first contribution of the thesis is an introduction of a proposed WMS based on a comprehensive review of CDP water disclosure reports. The thesis defines a WMS and identifies some basic elements of the system, which is an innovative attempt according to the literature.

Second, the originality of this work also lies in the application of a new theory in answering an important question in this area. Previous studies on the motivations of disclosures have mostly used legitimacy theory, stakeholder theory, and voluntary disclosure theory, which mainly focus on the demand side. Incentives from the managerial perspective are often neglected (Huang and Watson, 2015). This study integrates incentives from the supply side and proposes a self-regulation theory to explain different choices with regard to disclosure and to what extent they incorporate the management of water. The empirical evidence enhances the validity and applicability of self-regulation theory in water management. The results suggest that corporations may self-regulate to pre-empt stringent regulations, not necessarily to improve water efficiency. The adoption of self-regulation theory can complement extant theories and contribute meaningful insights into the transparency and credibility of non-financial disclosure.

The originality also lies in the methodology and design of this study. For disclosure and its motivation, most studies consider disclosure only to exist as a binary: i.e., yes or no. This dissertation includes private disclosure, not grouping it with either public disclosure or lack of disclosure. Although few companies choose private disclosure, the acknowledgment of the existence of this third option may shed light on a unique motivation and alternative theory. As orientation to self-regulation is not directly observable, different ways to proxy for such an orientation are discussed and tested in both parts of the thesis. In particular, the second part develops a systematic, detailed procedure to evaluate the quality of water management, arguably the most important aspect of this study. The quantitative design allows the comparison and examination of new theories on water information disclosure.

Last but not least, this thesis is an early study examining the extent, quality, and nature of a comprehensive set of corporate water disclosures in an international setting. Water

issues are complex; sectorial and national differences, as well as cultural and regulatory factors are found to influence disclosure practices (Cotter and Najah, 2012). Thus a showcase of current corporate water management will be useful for interested parties (policy makers, entrepreneurs, academia, and the general public) to make decisions and work out effective solutions together.

In summary, the present study will potentially fill this gap by providing up-to-date information about corporate motivations for water-management disclosure in an international setting. This thesis adopts a holistic approach, taking into consideration several factors that have not been documented in prior literature and that may potentially affect the incentives and the practices of water management. It has wide application, providing an alternative perspective to and a narrow focus on a challenging topic in corporate environmental management.

1.8 Structure of the thesis

Based on a discussion of relevant theories and hypotheses, Chapter 2 develops the theoretical framework. Chapter 3 reviews the literature related to water disclosure and management. The empirical designs for the three research questions are developed in Chapter 4 and Chapter 5: the motivation for disclosure is discussed in Chapter 4, and the determinants of WMS and its effectiveness are addressed in Chapter 5. Both chapters include descriptive statistics and interpretations of econometric analyses of the tests, conclusions, as well as a robustness test. Chapter 6 summarises the whole thesis and concludes with a discussion of the limitations of this thesis and its implications for future studies.

Chapter 2 Theoretical Framework

2.0 Introduction

The concepts of CSR and sustainability have been developed over more than four decades (Margolis *et al.*, 2009, Russo and Perrini, 2010). This chapter discusses the social role of accounting and reviews the dominant theories in environmental accounting studies and their new developments. Enlightened by previous theories, self-regulation theory is introduced to explain voluntary pro-environmental actions in regard to water. More importantly, it will illustrate how self-regulation theory fits into this landscape.

Section 2.1 sets the research theme and maps the territory where self-regulation theory sits. Section 2.2 briefly encapsulates the fundamental theories that explain the motivations for voluntary disclosure and other pro-environmental activities. Section 2.3 provides the definitions, forms, motives, and justifications for self-regulation. Section 2.4 develops the theoretical framework underpinning the whole thesis. Section 2.5 concludes with a brief summary.

2.1 Research themes

It is necessary to select an approach and establish the context before conducting research of any kind. Environmental accounting falls into the theme of CSR. The concepts of CSR and sustainability have been developed over more than four decades (Margolis *et al.*, 2009, Russo and Perrini, 2010). There are many diverse approaches for analysing CSR and sustainability with different emphases. A lot of researchers try to classify such issues from 20 years ago. Gray, Kouhy, and Lavers (1995) categorise two approaches from the accounting literature in the field of CSR. The first approach builds on conventional accounting activities and applies the same assumptions and preconceptions underlying most mainstream accounting research. These notions include accounting's primary function as a tool for providing useful information for decision-making and as a means to make rational business decisions that maximise profit. This approach is well reflected in Friedman (1970), which states that "the only

one responsibility of business towards society is the maximisation of profits to the shareholders within the legal framework and the ethical custom of the country". An alternative approach takes a wider social perspective and moves beyond conventional accounting theories. This approach is more sophisticated and philosophical and reflects deeply on the organisation and society (Gray *et al.*, 1995b). From another perspective, different principles and theories define the diverse motivations behind CSR. Swanson (1995) suggests three perspectives to explain motivations for CSR commitment. First, the utilitarian perspective views CSR as a means to achieve financial performance objectives such as increased sales revenue and profitability. It is consistent with Friedman's belief. Second, the negative duty perspective perceives social responsibility initiatives as instruments to conform to stakeholder norms. Third, according to the positive duty approach, businesses may have a moral sense of responsibility to conduct CSR initiatives, regardless of pressure and incentives. In that vein, CSR principles define the corporate identity. Garriga and Melé (2004) explore the landscape of theories in CSR research and come up with a more specific way of grouping theories and identify four pillars of theories in this area. First, instrumental theories consider that the primary objective of companies is wealth creation, and their social activities are only a means of achieving economic results. This is in line with the conventional accounting approach of Gray *et al.* (Gray *et al.*, 1995b) and Swanson's (1995) utilitarian viewpoint. Second, political theories propose that companies represent a power in society and are actively involved in political issues. Third, integrative theories assume that corporations focus on achieving social expectations. Both political theories and integrative theories are in line with Gary *et al.*'s social approach and Swanson's negative duty perspective. Finally, ethical theories are based on the moral commitments of corporations to society (Garriga and Melé, 2004). This fits in with Gray *et al.*'s social approach and Swanson's positive duty approach. However, the boundaries among these four approaches are often controversial, complex, and unclear (Garriga and Melé, 2004). Hence, to integrate these four dimensions, it is necessary to develop a new theory.

The literature on sustainability and accounting is divided into four camps by Bebbington and Gray (2001): literature arguing that accounting should stay away from nature, ecology, and sustainability; papers illustrating that accounting cannot offer anything other than destructive malignity; non-analytical but professionally orientated

managerial literature assuming that environmental accounting and environmental management will have effective results; and research suggesting that accountants and accounting may be able to support the search for sustainable development. As supported by Vollmer (2003), the debate over the relationship between accounting practices and economic development is a general one and in fact far from settled. The involvement of calculations in social conflict might provide a suitable setting for empirical research to demonstrate the calculative function of accounting in sociology.

Bebbington and Gray's (2001) classification reflects the complex nature of studies in this field. As theories develop, they may come to overlap with other theories, which is the case with the present topic (see the subsection on stakeholder theory below). The following section reviews some of the dominant theories in the CSR field and, more importantly, how self-regulation theory can fit in this area and potentially fill the gaps in knowledge.

2.2 Main theories in the CSR field

Recent years have witnessed a proliferation of theories in the CSR field. Among them, legitimacy theory and stakeholder theory are frequently implemented. Both theories originate from a broader theory called "political economy theory" (Gray *et al.*, 1996), which posits that society, politics, and economies are inseparable. Following this perspective, Guthrie and Parker (1990) state that corporate reports are not neutral and unbiased. They represent dynamic interactions with outside environment to mediate interests from different parties. There are two sub-classifications of political economy theory, classical and bourgeois. Classic political economy theory is concerned with the notion of "sectional (class) interests, structural conflict, inequity, and the role of the state at the heart of the analysis" (Gray, Owen, & Adams 1996, p. 47). According to this theory, accounting reports and disclosures are perceived as a means of strengthening a favoured position; companies send signals through discretionary reports to gain wealth and power and at the same time undermine competitors. In contrast to the classic approach, bourgeois political economy theory tends to explain society from a pluralistic perspective; the main difference is that the interests of particular groups do not necessarily dominate the interests of others (Deegan and Blomquist, 2006). Accounting and reporting are considered means of interaction

among those groups. In the following subsections, several theories are explained in detail with empirical evidence.

2.2.1 Legitimacy Theory

Prior research in the area of CSR and sustainability suggests that the primary reason for reporting is to gain legitimacy (Deegan and Gordon, 1996a, Brown and Deegan, 1998, Campbell, 2003). Legitimacy theory is often suggested to depict external pressures to perspectives in motivation studies (O'Donovan, 2002, Wilmshurst and Frost, 2000, Brown and Deegan, 1998, Tilling and Tilt, 2010). This implies that organisations are not perceived to have any inherent right to access natural resources, or in fact, to exist (Deegan, 2002). Therefore, organisations are compelled to adopt social responsibility initiatives, including disclosure, to demonstrate their adherence to such norms and to impress stakeholders (Maignan and Ralston, 2002, Luo *et al.*, 2012, Aerts and Cormier, 2009). If companies fail to maintain a high standard of environmentally friendly operations, they could face a legitimacy threat from powerful stakeholders. According to this logic, poor sustainability performers are predicted to have more incentive to disclose more information to alter the public's perception of their environmental image. Supported by this theory, it has been found that firms with poor environmental records tend to disclose some information (Deegan, 2002, Patten, 2002a, Gray *et al.*, 1995b). In other words, legitimacy theory predicts a negative correlation between environmental performance and disclosure. Such disclosure is intended to enhance the perception of compliance and improve public reputation and recognition, rather than to make actual changes to strategies and operations (Dowling and Pfeffer, 1975, Hopwood, 2009, Gray, 2010, Milne and Gray, 2007).

Legitimacy theory is found to be well supported by empirical evidence. Empirical studies on legitimacy theory are often analysed from a managerial perspective in that they focus on various strategies managers may choose to “gain, maintain, and repair legitimacy” (O'Donovan, 2002). Deegan and Rankin (1996) find that firms prosecuted by the Australian state will increase positive disclosures. Patten (1992) reports an increase in environmental disclosures in annual reports of peer firms of Exxon after the Exxon Valdez oil spill, and points out that social disclosure can be viewed as a method of responding to the changing perceptions of a corporation's relevant public.

Drawing on legitimacy theory and media agenda setting theory, Brown and Deegan (1998) find a positive association between media attention and environmental disclosures in annual reports. Legitimacy theory also applies to developing countries such as China. It has been found that Chinese firms operating in industries that emit high levels of CO₂ tend to disclose more related information (Chu et al., 2012). Such findings generally indicate that companies use communication strategies to legitimise their actions and support the arguments that social and environmental disclosures are merely powerful legitimacy devices and that firms do not necessarily engage in real efforts and accountability toward concrete environmental protections (Cho, 2009). Although with widespread adoption throughout environmental studies, there is some counter evidence from some industries. For instance, Guthrie and Parker (1989) investigate 100 years of reporting records of the company of BHP and fail to confirm legitimacy as the primary reason for their social reporting. There are different aspects in environmental studies, and previous studies did not distinguish them on purpose. Water issues such as pollution are also more traceable and identifiable than air pollution and thus are associated with higher legitimacy risks. As a result, previous studies on pollution control are often discussed under legitimacy theory to capture the tension between government and polluters (Khanna and Damon, 1999). While this thesis attempts another theory to solve water issues.

2.2.2 Stakeholder Theory

Stakeholder theory emphasises that managers should make decisions so as to take into account the interests of all stakeholders in a firm, including not only investors who have financial claims in the company but also employees, customers, communities, and governmental officials (Jensen, 2010). The theory describes how stakeholders directly impact companies' activities (Roberts, 1992). There are two primary approaches of stakeholder theory: ethical or normative and managerial or instrumental (Deegan, 2002, Orts and Strudler, 2002). The ethical/normative approach emphasises the ethical principles for the organisation (Orts and Strudler, 2002). Stakeholders should be provided with information about how an organisation is impacting them (e.g., through community sponsorship, pollution, and so forth) (O'Dwyer, 2005). Stakeholders are thus defined as those who have "a stake" in an organisation (Huang and Kung, 2010, Collier, 2008).

In contrast with the normative branch, the positive or managerial branch of stakeholder theory tends to be more “organisation-centred” (Gray *et al.*, 1996). It is concerned with how companies may meet the expectations of powerful stakeholders who are likely to have a direct impact on the firm’s survival. Hence, information is often employed as a means to manage the relationship with stakeholders to either gain their support or to distract their opposition (Baas, 2007). Therefore, corporate disclosure is designed for the information requirements of powerful stakeholders, who control resources that are essential to the operation of the company. As a result, environmental disclosures may serve to alleviate the often tense relationship with stakeholders (Wilmshurst and Frost, 2000, Khanna, 2001). In contrast with the survival premise of legitimacy theory and ethical stakeholder theory, managerial stakeholder theory is developed on the premise that companies disclose information to mediate the relationship with powerful stakeholders (Chu *et al.*, 2012).

A “stakeholder” is a broad and abstract concept and scholars have different ways to classify it. Clarkson (1995) proposed a framework that examines CSR through a company’s relationships with outside bodies. He classifies stakeholders into a primary and secondary group. The former includes entities that are vital for a company’s survival such as shareholders and investors, employees, customers, suppliers, and other entities that engage in transactions with the companies. Secondary stakeholders influence and/or are influenced by companies but do not affect their survival. Examples are media and a wide range of special interest groups. Another classification groups stakeholders into external and internal ones (Harrison and St. John, 1996). Huang and Kung (2010) categorise three groups of stakeholders, namely, external, intermediate, and internal; each creates pressure to disclose environmental information and each influences the strategies of managers. External stakeholders include the government, debtors, and consumers. Shareholders and employees are internal stakeholders, and accounting firms and non-governmental organisations (NGOs) such as environmental protection organisations are intermediate stakeholders.

Guided by a sense of pragmatism, much empirical research has been conducted from the perspective of stakeholders. Bendheim *et al.* (1998) shows how to determine good practice in terms of maintaining stakeholder relationships. Berman *et al.* (1999) construct two different stakeholder models and test how they influence financial performance differently. Perez-Batres *et al.* (2012) explore how corporations react

strategically to different sets of stakeholder pressures. Studies (Russo and Perrini, 2010) suggest that stakeholder theory is better able to address the CSR approach of large firms instead of small and medium-sized enterprises.

All these empirical results reveal the importance of stakeholders in accelerating corporate environment management to some extent. However, whether those stakeholders can push or pull companies into meaningful pro-environment activities is still unknown (Perez-Batres *et al.*, 2012b). In this context, the CDP is an NGO that encourages and pressures companies to take actions and disclose their specific information. As a stakeholder, the CDP also leverages the power of other stakeholders such as public and institutional investors. The empirical results of this thesis, although from a self-regulation perspective, can also shed light on the actual outcome of stakeholder pressure.

2.2.3 Other theories

Another theory that sits in the realm of political economy theory is institutional theory. This theory is considered more specific than legitimacy theory because it views disclosure as a means to cope with institutional pressures while legitimacy theory focuses on reducing the legitimacy gap (Amran and Haniffa, 2011). Another theory is called resource constraint theory and it views CSR activities as a “valuable, rare and imitable” resource to gain competitive advantage (Park *et al.*, 2015). Companies with those resources can maintain good relationships with customers and rivals by providing more socially responsible products (Porter and Kramer, 2006). From an internal view, the capacity and resource has some explanation power to determine whether and how to disclose environmental information (Luo *et al.*, 2013). Voluntary disclosure theory is developed from the perspective of conventional accounting theory. Shareholders and debtors represent powerful stakeholders in the financial market (Cormier *et al.*, 2005). Failure to disclose decision-making-relevant information could result in wider information asymmetry and increase the cost of capital (Healy and Palepu, 2001). Disclosure is thus used as an instrument to reduce information asymmetry and the cost of capital (Guidry and Patten, 2012). Other constructs, such as neo-Gramscian theory (Daniel and Sojamo, 2012), have been applied elsewhere in an attempt to account for the dynamics of governance, power, and so forth in corporate

disclosure strategies (Levy and Newell, 2005). Due to the scope of this thesis, those theories will not be reviewed one by one in detail.

2.2.4 Summary

Theories are constructed to illustrate the complex and ever-changing reality (Van der Laan, 2009). Therefore, no single theory can well explain the diverse motives that may simultaneously drive corporate disclosure (Wilmshurst and Frost, 2000). The motivations for social and environmental information disclosure attract considerable research attention (O'Donovan, 2002). Many theories derived from financial information disclosure have been applied in this field, and frequently cited theories such as legitimacy theory, stakeholder theory, and others are interrelated and overlap (O'Donovan, 2002). The implicit social contract is the integral part of those social theories (O'Donovan, 2002). The validity of using one theory instead of another depends mostly on the research design (Adams, 2002).

To provide a more thorough picture of disclosure behaviour, this thesis utilises multiple theories to explain the results. The next section proposes a new theory that leads to arguments from a regulatory perspective.

2.3 Self-regulation Theory

2.3.1 Definition and forms of self-regulation

Environmental issues have long been considered externalities that are thus mainly the government's responsibility (Baumol and Oates, 1971, Bromley, 1991). Related policies, common legislation, and regulations are forced onto businesses to restrict their pollution (Segerson and Miceli, 1998). An alternative form of action has been widespread in Europe since 1990, namely, voluntary agreements (VAs) with industry (Communities, 2002). Considered a new instrument in environmental governance, this self-regulation regime is believed to be less expensive and more efficient than the mandatory approach (Segerson and Miceli, 1998, Jordan *et al.*, 2003, Solomon, 2010) and can complement governmental regulations (King and Lenox, 2000).

Voluntary self-regulation refers to the self-stated (self-claimed) actions and disclosures that go beyond the minimum requirements by law (Berchicci and King,

2007; Perez-Batres *et al.*, 2012). Lyon and Maxwell (2004) refer to “beyond compliance efforts” of for-profit organisations as “environmentally friendly actions not required by law”. Perez-Batres *et al.* (2002 p. 168) refer to self-regulation as a “certification vehicle”. Studies also refer it as soft environmental policy instruments (Rehfeld *et al.*, 2007). Unlike other forms of regulation, it does not involve a legislative act, and thus it is also considered “private” (versus public) regulation (Perez-Batres *et al.*, 2012b). According to the European Commission (2002), self-regulation practices take various forms including common rules, codes of conduct, and VAs. In the area of environmental management, industries voluntarily accept stricter environmental and social rules through “self-regulation institutions”, which are normally initiated by economic actors, social players, NGOs, and other stakeholders (Communities, 2002, Perez-Batres *et al.*, 2012b, Berchicci and King, 2007). There are various forms including voluntary compliance agreements, environmental labels, EMSs, and voluntary disclosure (Blackman *et al.*, 2012).

Self-regulation decisions may not always be determined by internal managers; they may be pushed by industrial peers. Industry self-regulation is described as the alignment among firms to control their behavior (King and Lenox, 2000, Lenox, 2006). Organisation behaviour is in fact caused by collective human thought. Therefore, industry self-regulation conforms to those characters mentioned above. The case of the Exxon Valdez oil spill demonstrates how the negative effects of one accident can spread to the whole industry (Patten, 1992). A few accidents may lead to stringent environmental regulations of the industry as a whole (Telegraph, 2010, Deegan *et al.*, 2000). As a result, companies may be compelled to join together to solve a mutual problem (King and Lenox, 2000). Therefore, the practice of self-regulation tends to be more consistent among firms in a given industry facing similar physical and regulatory risks.

Meanwhile it is not uncommon for the private sector to get involved in political decision-making (Gamper-Rabindran, 2006). For example, before the establishment of Securities and Exchange Commission (SEC) in 1934, the form of self-regulatory organisations have already begun as a private sector membership organisations of securities industry professionals in US (Jordan *et al.*, 2003). In the field of environmental policy, VAs are a major policy innovation of the last two decades aiming to pre-empt legislation (Glachant, 2004). Such agreements vary in purpose,

form, and sanction. Classified by Lyon and Maxwell (2003), VAs with an aim of solving environmental problems fall into three major categories: unilateral agreements, public VAs, and negotiated agreements. Unilateral agreements refer to self-regulatory actions in which firms initiate a public pledge to improve their environmental performance. Public VAs have explicit incentives to receive technical assistance and/or favourable publicity from the regulatory authority. Therefore, participating firms devote effort to meet the goal set by the government. Unlike public VAs, in negotiated agreements a company and the authority jointly set the goal. One common feature shared by these different instruments is that entities voluntarily commit to certain activities such as pollution abatement (Glachant, 2004). Recently, new derivatives have been invented and may not necessarily fit into one of the three categories. Voluntary self-regulatory codes (SRCs), with prominent examples being the United Nations Global Compact and Global Reporting Initiative, have been enacted and developed over the past 20 years (Perez-Batres *et al.*, 2012b). Companies definitely perceive pressure from stakeholders to join self-regulation codes and make commitments towards self-regulation goals (Perez-Batres *et al.*, 2012). Resource abundance and pollution-intensive industries are positively associated with substantial self-regulation codes. SRCs are divided into two groups: symbolic and substantive. Symbolic self-regulation is normally more flexible and has less oversight or enforcement than substantive regulation, which has more specific guidelines and more rigorously stimulates real effort (Perez-Batres *et al.*, 2012a). Global Reporting Initiative (GRI), for example, is considered a substantive self-regulation code. Nevertheless, it seems that companies can shop around the options and join one that suits their needs and maximises their benefits.

Beyond VAs, government authorities may retain some control by emphasising a range of compliance-monitoring activities such as scrutinising reports filed with agencies. Agencies provide various incentives to encourage firms to have an effective internal regulatory system designed to produce regulatory outcomes (Carroll and McGregor-Lowndes, 2002). For example, Securities and Exchange Commission (SEC) used to be the early form of private membership of securities industry professionals before it is integrated into the scheme of federal sector regulation. There are also some self-regulatory organisations that are designed to regulate the operations and standards of practice and business conduct of its members and their representatives with a view to

promoting the protection of investors and the public interest (Commission, 2009). Examples include the Investment Industry Regulatory Organization of Canada and the Mutual Fund Dealers Association of Canada. Private memberships also represent the collective power of self-regulation and may have more bargaining power with regulatory authorities. The next section explains the drivers or the motivations behind self-regulation.

2.3.2 Motivations and theory of self-regulation

Bandura (1991) explains self-regulation in detail from the perspective of social cognitive human decision-making. It is described as a purposive behaviour regulated by forethought. One of the purposes of action is to mediate the effects of external influences. Specifically,

“People form beliefs about what they can do, they anticipate the likely consequences of prospective actions, they set goals for themselves, and they otherwise plan courses of action that are likely to produce desired outcomes.”. (Bandura 1991, p.248)

However, this motive is implicit and abstract (Perez-Batres *et al.*, 2012b). Therefore, the theoretical foundation of self-regulation needs to be demonstrated well to be justified and generalised. Heritier and Eckert (2008) identify two possible causes of the emergence of self-regulation. One is when the government has taken steps to legislate or tighten legislation. The more credible this threat is, the more likely it is that industry will resort to voluntary action to pre-empt such measures (Glachant, 2004). Another is when NGOs have led a campaign against the environmental record of a specific industry. They can run campaigns that are against the use of a particular substance, production process, or product, jeopardising the reputation of an industry. Therefore, the potential risk triggered by NGOs may prevent firms from taking no action and instead come to an agreement of self-regulation. Although Heritier and Eckert's (2008) empirical results only support the former, the potential threat of an NGO can be an influential factor in some cases.

There are research interests in understanding the strategic purpose of this behaviour. Strategic choice analysis and principle-agent theory lay the groundwork for the development of self-regulation (Gamper-Rabindran, 2006, Gunningham, 1995). Different actors have different preferences to maximise their utility. Governments are assumed to prefer legislation over self-regulation by private actors. Secondarily, they

would prefer co-regulation or negotiated agreements in which the government retains the final say in the establishment of the plan and also controls its implementation. Third in priority would be self-regulation and the last option would be no action. The industry prefers no regulation or action at all, followed by self-regulation and then legislation (Gunningham, 1995). According to principle-agent theory, the government would be the principle in this case, and the company would be the agent. Because environmental management depends on private knowledge of management (Lundholm and Van Winkle, 2006), information asymmetry exists because the industry has more expertise than government in matters of regulation. The principal may want expertise for policymaking and then delegate this task to the private actor who is outside of the political legislative stream of decision-making. The private actor may readily engage in such a contractual relationship with a governmental actor, but may do less than the principal expects and increase its own benefits. To motivate the agent, the principle may offer incentives in the form of self-regulation, which offers more automation than stringent regulatory tasks. Therefore, information plays a key role in solving this issue. Based on the analysis above, if the government has taken steps to legislate or tighten legislation, the industry will be more willing to engage in self-regulation to pre-empt registration. This implies that one of its purposes is to get the government to back off of traditional enforcement strategies, so as to avoid costly government-run direct control of environmental protection activity.

The notion of self-regulation has been mentioned in the context of other accounting theories. Deegan, Rakin, and Tobin (2002) examine legitimacy theory but also describe a self-regulation scenario as a legitimacy tool because if corporate legitimising activities are successful, the government may have less arguing power to enforce mandatory legislation. As a result, managers will have more discretion over their social and environmental reporting practices. Their findings indirectly support self-regulation theory.

2.3.3 **Relationship between self-regulation theory and other theories**

The self-regulation theory that this thesis proposes overlaps with some existing theories to some extent. Garriga and Melé (2004) mention that instrumental theories assume that CSR activities are used to maximise shareholder value or to achieve competitive advantages by advancing pro-environmental markets. Such theories only

consider the economic aspects of the interactions between business and society while ignoring other forms of benefits gained through CSR activities. Self-regulation adds a new dimension in that sense. Dominant examples of popular theories include legitimacy theory, stakeholder theory, and voluntary disclosure theory. Legitimacy theory emphasises that the social contract is maintained by companies responding to the demands of divergent interest groups. The perceptions held by relevant groups and society are central to the concept of legitimacy. According to strategic legitimacy theory, organisations utilise tools such as annual disclosures and press releases to create the impression of being legitimate (Aerts and Cormier, 2009). Although the main assumption of legitimacy theory is that higher pressure leads to more disclosure or compliance, self-regulation provides a complementary scenario where less pressure leads to more compliance, at least on appearance. Therefore, self-regulation theory is an extension and completion of this social contracting theory.

Economic theories such as voluntary disclosure theory apply signalling theory. The proposition is that good companies will make an effort to distinguish themselves from poor performers through disclosures and other activities. In doing so, more sustainable companies will be rewarded, thus maximising their own utility. Self-regulation theory, on the other hand, provides an alternative reason. Companies also send signals through disclosures to regulators to make an impression that they have regulations in place. The major difference is that voluntary disclosure theory suggests that environmental disclosure is primarily aimed at the market (Guidry and Patten, 2012) while self-regulation theory notes that regulators are the target.

Stakeholder theories also consider divergent interests from various stakeholders but the purpose is not to legitimise oneself but rather to obtain favour from powerful stakeholders. Powerful or core stakeholders are those who can directly affect the current business. They may control key resources that the company needs, have a right to permit operations, and so forth. In satisfying their demands, the relationship between the company and the stakeholder are strengthened to protect the existing business (Hart and Sharma, 2004). Self-regulation can be seen as an application of stakeholder theory to reality, which sees the regulatory authority as interested stakeholders but the ultimate motive is to satisfy self-interest rather than the demands of stakeholders.

2.3.4 **Justification of self-regulation in water management**

As mentioned in Chapter 1, the topics of corporate motivation of disclosure of water information and all related water-management initiatives are undeveloped compared to other related aspects such as carbon emissions reduction, pollution control, and general environmental protection. The complexity of this topic also presents opportunities to apply alternative theories.

According to the utilitarian approach, corporations can achieve self-benefiting goals via environmental campaigns. These incentives motivate companies to move from reactive management approaches to more proactive strategies and to voluntarily adopt firm-structured EMSs. Such a trend towards self-regulation has made “business-led” initiatives widespread; such initiatives include participation in trade association programs emphasising environmental codes and norms and the adoption of international environmental certification standards (e.g., International Organization for Standardization) (Lyon and Maxwell, 1999). Water, as an important aspect of environmental management, attracts more attention in the industry. Comprehensive WMS or similar self-regulated practices are becoming contemporary business norms (Lambooy, 2011).

It has been argued that water management requires a combined effort from governments and businesses (Lambooy, 2011, WHO, 2006). Increasingly, investors are paying attention to environmental risks. Therefore, it is not impossible to regulate corporate environmental management with market instruments. If the market can punish bad performers and reward good ones, companies will be more motivated to improve their environmental performances. For instance, the CDP plays an important role in creating new institutions to facilitate self-regulation mechanisms. By inviting large corporations to participate and disclose their performance, the CDP provides the market additional and comparable information to assess the sustainability of the companies. In this sense, a company that refuses to disclose the requested information may look bad and may suffer a reputational loss, a drop in their stock price, and ultimately attract close scrutiny from local authorities. Therefore, it can be argued that the CDP can be a unique example of self-regulation. As the CDP states on its homepage, “we motivate companies and cities to disclose their environmental impacts, giving decision makers the data they need to change market behaviour”. Thus, it can

be argued that the environmental self-regulation orientation will stimulate decisions related to the consumption of water resources. More specifically, firms with a strong self-regulation orientation tend to participate in the CDP water program and disclose their water information publicly. This is because firms that often engage in self-regulation activities have a strong incentive to disclose their efforts. Such disclosure allows the government, the stakeholders, and the community at large to better understand the real status of the company in terms of water information, such as their consumption and waste. Thus, firms that participate in the water program are more likely to have conducted more self-regulation activities.

Water pollution is one of the most frequent risks faced by businesses. Water pollution has many different sources, including sewage, nutrients, waste water, chemical waste, oil pollution, radioactive pollution, and so forth, and this is one of the reasons why it is such a difficult problem to solve. Furthermore, its trans-boundary nature makes regulation more difficult. For example, polluted water created in one country with poor environmental standards can transfer to neighbouring nations regardless of the stringency of those other countries' regulations. Countries that import products associated with high water intensity consume high amounts of water indirectly. Therefore, it is necessary to have international consensus on water regulations, such as those provided by the 1982 UN Convention on the Law of the Sea, the 1972 London (Dumping) Convention, the 1978 MARPOL International Convention for the Prevention of Pollution from Ships, and the 1998 OSPAR Convention for the Protection of the Marine Environment of the North East Atlantic, European Union 1976 Bathing Water Directive (Anyanova, 2012). Most countries issue regulations and rules to protect their water resources. For instance, the United States issued the 1972 Clean Water Act and the 1974 Safe Drinking Water Act to ensure the safety of water. However the stringency varies even among developed countries. For example, Australia's 2014–2015 budget confirmed that government's decision to close the National Water Commission (NWC) at the end of 2014 to achieve a net savings of \$20.9 million over the next 4 years. As of April 2014, the Commission has only 38 permanent staff and 2 part-time staff. In sum, water management through regulation itself is difficult to implement. There are a lack of guidelines as to how to report water in sustainability reports. The water information provided in annual reports is diverse

in scope, format, and frequency. It is necessary to have an international water accounting system to protect water resources globally (Chalmers *et al.*, 2012).

In the near future, it is expected that water management will evolve into a more mandatory public regulation mechanism. The evidence presented in this thesis implies that even in a public water resource management system, public regulation will not always cover all aspects of water management. Thus, public regulations cannot replace or substitute private self-regulation activity. Hence, a question is emerging about how government should encourage firms to take non-governmental environmental protection initiatives. This thesis provides some insight into this important issue.

2.3.5 Pros and cons of self-regulation

Are self-regulatory mechanisms necessary? Some of the justifications are that the complex legal and regulatory mechanisms created by federal, state, and/or local governmental agencies are often intrusive and/or inefficient (King and Lenox, 2000). Effective solutions to environmental problems may require a “middle way” between government regulations and laissez-faire prescriptions (Newson and Deegan, 2002). Proponents of self-regulation regard it as an effective alternative or complement to government-mandated programs, which may be difficult to enforce at the supranational level (Alvarez-Larrauri and Fogel, 2008). Moreover, the public disclosure mechanism compels firms to improve their social and environmental performance as they expose their practices. Free riders that make untruthful statements will be punished with a sabotaged reputation and possibly exposure to litigation (Milgrom *et al.*, 1990, Perez-Batres *et al.*, 2012a, Runhaar and Lafferty, 2009). In addition, self-regulation can support the emergence of new norms and values that change members’ preferences for collectively valued actions (Gunningham, 1995, Cherry and Sneirson, 2010, Perez-Batres *et al.*, 2012a). The emergence of new forms of regulation could advance the debate between regulation and deregulation, and bring opportunities for regulated entities to take the initiative and set the standards (Solomon, 2010). It may also bring in new players such as third parties to monitor and enforce the process while regulators may facilitate and oversee the process (Solomon, 2010). In doing so, self-regulation can accelerate the emergence of new norms and values that change society’s cognition and preferences (Gunningham, 1995, Hoffman and Ventresca, 1999). Finally, when collectively valued actions are also privately

beneficial, a self-regulating organisation can facilitate knowledge-sharing through best practices, aggregate learning, and collective performance (Kraatz, 1998). Public environmental policy may rely more on market-based incentives and thus may be superior to voluntary one due to the low cost and inclination toward technological innovation (Kolstad, 1986). This form of self-regulation is gradually recognised as an essential component of most regulatory regimes (King and Lenox, 2000) because of its speed, flexibility, sensitivity to the market, and low cost (Gunningham, 1995). Such approaches are particularly widespread in the field of climate change and waste policies.

The motives of utility maximisation highlight an important theoretical question: Given limited legislative control, can such incentives be effective? Some evidence indicates that proactive environmental management strategies can effectively improve corporate environmental performance. Firms that engage in this tend to incorporate ecological concerns into business decisions, and environmental practices eventually become institutionalised. Such a change allows firms to identify cost-effective and self-initiated strategies for pollution control (Anton *et al.*, 2004). A small but growing body of academic literature has analysed this self-regulation regime as a novel tool toward environmental protection. It has been found that self-regulation may increase demand from consumers as it reduces uncertainty about product quality and enhances employee satisfaction by improving the safety or other quality aspects of the workplace. Moreover, it may also serve more strategic purposes, such as softening competition or pre-empting stricter government regulations that are less cost-effective (Maxwell, Lyon, and Hackett 2000). Lyon and Maxwell (2003) explore the different motivations of self-regulatory actions and whether they increase social welfare. They find that unilateral VAs, designed to pre-empt stricter future regulations, increase social welfare more than other VAs. However, more evidence needs to be provided to justify the advantage of self-regulation.

Some scholars, however, have been quite sceptical about the effectiveness of self-regulation, arguing that companies can create a favourable impression simply by complying related standards, achieving rewards and obtaining membership. Voluntary standards and polices established by self-regulation institutes can hardly bind companies as laws and regulations do. Instead, they may serve to disguise enrolled companies, which claim but shirk real actions (moral hazard) but free ride with honest

ones (adverse selection) (Communities, 2002, Hoffman and Ventresca, 1999, King and Lenox, 2000, Hess, 2008). Some opponents of self-regulation argue that it is simply an attempt to create the appearance of compliance (Gunningham, 1995). Research and debate on this matter is far from conclusive. More evidence is needed to support either of the arguments. Clarify this issue is also one of the objectives of this thesis.

2.3.6 Summary

One theory can be more dominant when applied to any given research design or topic than over another. For example, voluntary disclosure is considered a device to achieve legitimisation, according to legitimacy theory; stakeholder theory, which overlaps to an extent with legitimacy theory, better explains solicited corporate social disclosure (Van der Laan, 2009). Little is known about the process of disclosure from the perspective of internal management. Moreover, these theories lack the explanatory power to explain why companies deliberately choose not to disclose. This in turn may influence corporate decisions in how information will be disclosed.

The new self-regulation theory introduced in this thesis applies a critical approach that adds new perspectives to explain the motivations of environmental disclosure and management. According to its notion, corporate self-initiated disclosure is not purely “voluntary” as it seems since many agreements serve to prevent alternative legislative intervention. This new theory has intimate linkages with extant theories. Self-regulation is likely to remain a key component of most regulatory regimes and a widespread and influential force. Its sound theoretical foundation and proliferation in practice make it applicable to the water scenario. The next section will integrate these theories into the research design of the thesis.

2.4 Theoretical framework of this thesis

Figure 2.1 illustrates the logical flow of the research design and provides a guideline for the following empirical chapters. The first part of the empirical design answers the first research question about the motivation of voluntary disclosure. According to legitimacy theory, companies under threat of external regulations tend to disclose more. The rationale is that firms are under pressure to maintain a high standard of environmentally benign operations; otherwise, they could face a legitimacy threat from

powerful stakeholders. This is more evident in firms operating in environmentally sensitive industries. Therefore, this part will refer to legitimacy theory. Mostly seen as a local issue, corporate pollution and over-consumption of water is entwined with the social contract that gives companies permission to operate. In this case, poor sustainability performers are predicted to have more incentive to disclose their water use to alter the public's perception of their environmental image. External regulations will pressure firms to disclose more. According to stakeholder theory and voluntary disclosure theory, good performers have more incentives to signal to external stakeholders or the markets. In doing so, they can be distinguished from poor performers and achieve competitive advantages. Disclosure is used as a communication tool to mitigate information asymmetry and convey a green image. However, the daily performance of a firm is difficult to observe by outsiders, and thus whether self-regulation in fact reflects a commitment to water issues or is simply a claim of such performance remains ambiguous. This thesis will test the hypothesis about the positive link between self-regulation and proactive disclosure.

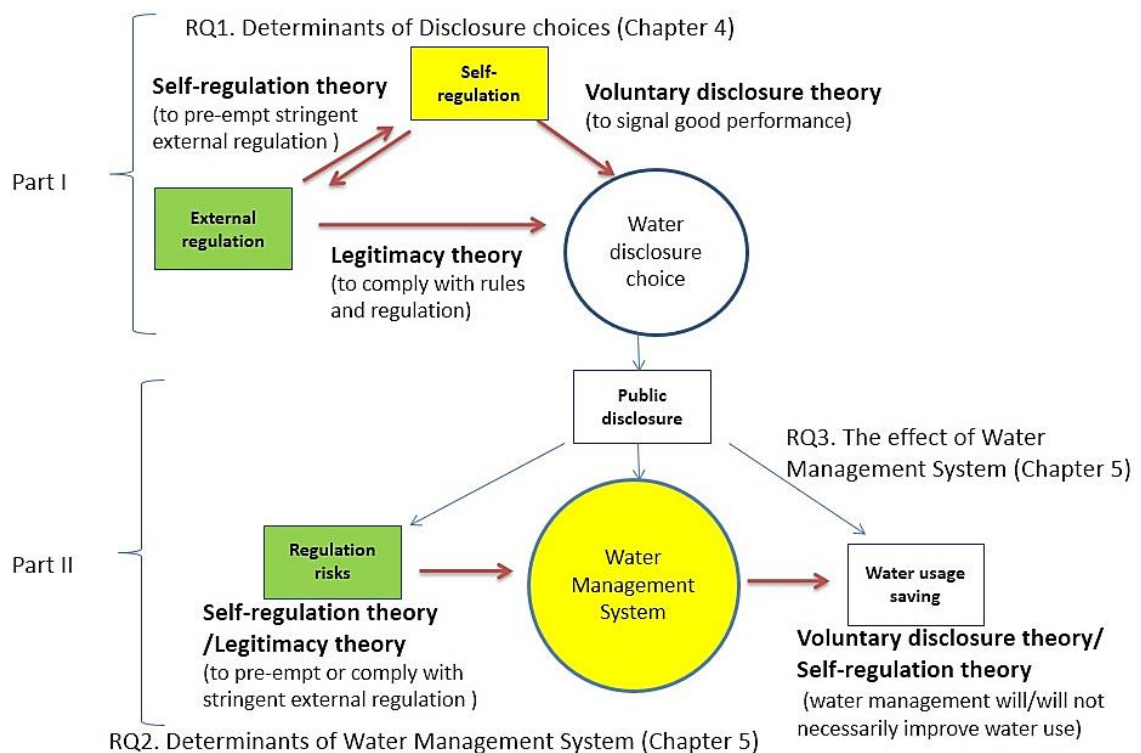


Figure 2.1 Theoretical framework of the thesis

The highlight of theory proposed in this thesis is the interaction between, and mutual effects of, external regulatory pressure and internal regulation. Self-regulation theory mainly focuses on the interplay between these two forces. Specifically, when external regulation is perceived to be strong, companies are compelled to meet requirements. They have more incentive to regulate themselves when regulations are not stringent, to avoid future legislation. As self-regulation theory predicts, the two forces are competing rather than complementary. Therefore, the effects of self-regulation motives will increase as external regulations weaken in an attempt to replace external ones. The interplay between the two drivers is demonstrated in Chapter 4.

The second part of the empirical test explores the second and third research questions about the drivers and outcomes of water-management practices. Different that disclosure, water-management practices reflect the substance of self-regulation. However, it can hardly be observed and can only be reflected through public disclosures. In Chapter 5, a WMS is proposed to construct self-regulation initiatives in a more systematic and comprehensive way. As for the determinants of a WMS, legitimacy theory predicts that good practices are driven by pressure from external legislation. Self-regulation theory argues that companies will be more motivated to engage in proactive practices when external regulations are not stringent at the moment but have the potential to get tougher in the future. Therefore, this thesis creates the opportunity to test the two competing notions in the context of water issues.

The third research question tests whether self-regulation can achieve concrete results. No theories have firmly predicted a positive relationship between performance and disclosure. Therefore, this thesis assumes that self-claimed water management is an attempt to self-regulate corporate water issues, and tests its actual effect. Self-regulation, as stated above, may be more of an instrument to avoid further regulation; in this context, it may not necessarily lead to actual improvement.

In summary, this thesis unearths the motives of self-regulation and provides an alternative explanation of corporate behaviour towards environmental management and disclosure.

2.5 Concluding marks

The debate over the purpose of firms has been longstanding and getting more fierce in the face of global warming and climate change (Margolis *et al.*, 2009). The assumptions and theories of this thesis are primarily drawn from positive approaches of social and economic theories that assume that entities are self-interested. Self-regulation takes the supply-side perspective of information rather than the user perspective to reveal how companies utilise voluntary disclosure for favourable self-representation. The central proposition is that companies pre-emptively take measures to improve their disclosure and management of environmental resources so as to forestall external regulations. As a form of “dialogue”, accounting can be considered as a means from managers to construct an alternative reality they desire (Hines, 1988, Parker, 2012, Lawrence *et al.*, 2013). And the water accounting tools is one example this thesis makes of to reflect this organisational thinking.

The context that is relatively less explored offers opportunities that can utilise different forms of theories. The approach of this thesis incorporates the new phenomenon of environmental accounting and reporting from the traditional lens of extant theories in conventional accounting research, making this study more standardised in a strictly economic context. It is also more practice-base and widely applicable. Therefore, this thesis adopts mainly a quantitative research method with some qualitative techniques, which will be covered in later chapters.

Chapter 3 Literature Review

The purpose of this comprehensive literature review is to identify gaps in the existing literature to which the current study can contribute new insights. However, because water accounting for corporations is an emerging area of academic research, there is a dearth of literature (Christ and Burritt, 2017). This chapter explores the scope of prior research and outlines the themes most relevant to the current research project. The focus of the literature review is on conceptual issues and as well as the research approaches adopted in prior qualitative and quantitative studies.

In the remainder of this chapter, Section 3.1 describes both long-standing and current conceptual frameworks and the dominant debates in social and environmental accounting, in which this thesis is anchored. Section 3.2 reviews studies on what motivates corporate environmental disclosure, which provides valuable insight for the first part of the research design. Section 3.3 reviews extant environmental management systems and how they differ from water management systems, which is the focus of this thesis. Specific water-related issues are discussed in section 3.4, followed by a discussion of the limitations of previous studies and a brief conclusion in section 3.5.

3.0 Research scope

A clear definition of the scope of the present research will help reveal gaps in the literature and determine the potential contribution of this thesis. In recent decades, the economic success of the accounting profession has been largely driven by its capacity and willingness to expand into new and financially rewarding areas of business, even when such initiatives depart from the traditional accounting base of financial reporting, auditing, and taxation (O'Dwyer et al., 2011). The practice of accounting for carbon emissions and water, intended to provide information relevant for decision making, is therefore very much in the domain of accountants and business professionals (Chalmers et al., 2009).

Several studies have explored the scope of the accounting discipline and how it has changed over time. Social and environmental accounting (also commonly known as

corporate social responsibility and sustainability accounting (Schaltegger and Burritt, 2010) has been becoming more and more important (Bebbington and Gray (2001). The practice of social reporting first appeared in the 1970s as a complement to conventional financial reporting in the West. Then in 1980 there was a shift from the disclosure of social information to environmental information; this area has been popular for research debate since the late 1990s (Hahn and Kühnen, 2013). Compared to conventional accounting, environmental accounting is more conceptual and lacks concrete practice. To make environmental accounting more applicable at the corporate level, researchers and related organisations such as the United Nations who are striving to promote this practice have introduced environmental management accounting for corporate use (UNSD, 2000). A lot of frameworks and taxonomies have been developed to map these managerial tools for different purposes.

Bebbington and Gray (2001) classify divergent attitudes on sustainability and accounting into four camps, and Vollmer (2003) believe that many debates about the relationship between accounting practices and economic development are far from settled. In addition, the literature of academics and practitioners on environmental accounting at the level of the individual company or business draws from several different approaches. For example, the very term *environmental accounting* is used loosely and ambiguously. Bartolomeo et al. (2000) identify a taxonomy of four broadly conceived but distinct approaches to environmental accounting from the extant literature, namely, external financial reporting, social accountability reporting, energy and materials accounting, and environmental management accounting. These different approaches to environmental accounting can be most effectively distinguished in terms of (1) their balance between financial and nonfinancial data and (2) the degree to which the principal objective is to supply information for making internal management decisions or for external reporting. Burritt et al. (2002) distinguished generic environmental accounting from conventional financial reporting in that the former provides an explicit and separate record of environmental impact and is used for decision making specific to the environment. Accordingly, they modified the previous taxonomy as shown in Figure 3.1 with the intention of easy adoption by practitioners. Among the four categories, Monetary environmental management accounting (MEMA) is based on conventional management accounting to record the economic impact of corporate environmental activities. Different from MEMA, Physical

environmental management accounting (PEMA) tracks environmental information and records in physical units. Both tools provide useful information specifically for internal decision making. As the two components of Environmental accounting, monetary external environmental accounting and reporting (MEEA) and physical external environmental accounting (PEEA) are mainly used by managers to communicate with external stakeholders Burritt et al. (2002). It is based on this taxonomy that the CDP water disclosure program is analysed in this thesis.

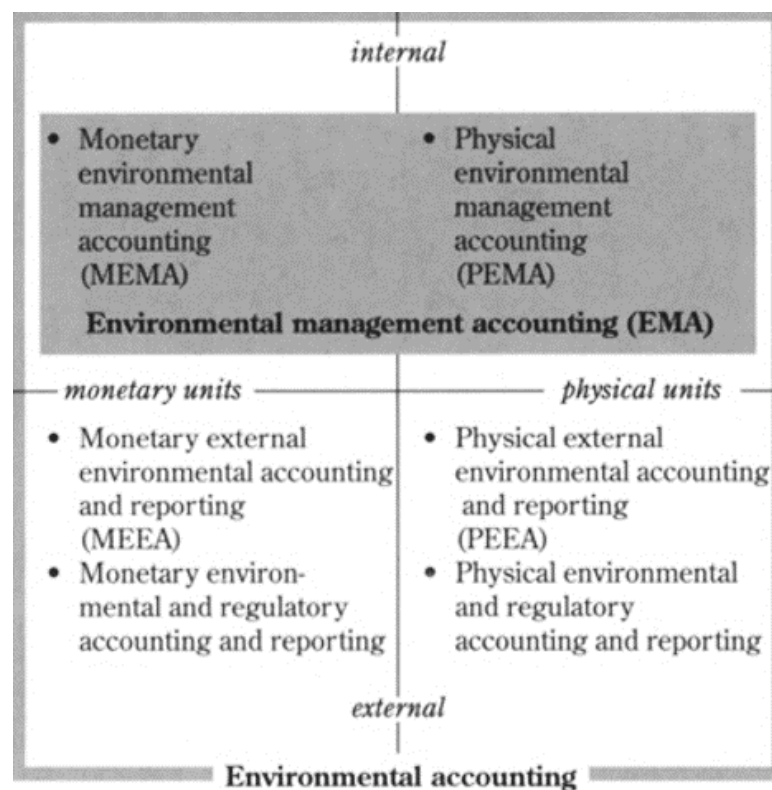


Figure 3.1 Environmental accounting system modified from Bartolomeo et al. 2000 by Burritt et al. (2002)

More specifically, the CDP noted that the purpose of its water program is to encourage companies to disclose and reduce their environmental impacts by using the power of investors and customers. The data CDP collects helps influential decision makers to reduce risk, capitalize on opportunities and drive action towards a more sustainable world. (from website of CDP: <https://www.cdp.net/en/water>)

It seems that the CDP water program has an external focus because water information is provided to stakeholders such as investors and customers. Meanwhile, this

information can be utilised by companies themselves for internal purposes, such as to increase awareness of water-related risks and opportunities and take informed actions to reduce their environmental impacts. In terms of quantitative information, the CDP water management questionnaire consists of both monetary and non-monetary questions. The comprehensive classification in Figure 3.2 illustrates the divergent orientation of the CDP water program. Figure 3.2 lists a sample of quantitative questions in the initial CDP water questionnaire. As can be seen, the CDP water program hardly fits into one specific environmental accounting category. Rather, it is a comprehensive integrated system that helps companies improve their overall water resource management. Obviously, the majority of the questions have an external and physical focus. Figure 3.2 shows that a sound water management system requires both physical and monetary measurement to support decision making. For instance, Question 16.1 asks about a relative measure of intensity ratio using water usage and financial measures such as sales and net income. However, the CDP water program does not appear to be a solid internal management accounting system because it only asks general questions rather than detailed ones tailored to companies in various industries. Moreover, internal monetary measures such as water-related budgeting and performance evaluation are not common practice yet, and there are also some confidentiality concerns. Nevertheless, the CDP does ask a lot of qualitative questions, such as the highest level of responsibility regarding water governance issues (Question 1.3) and actions taken to reduce water impact (Questions 1.5 and 1.6). This implies that the CDP water program would encourage firms to adopt proactive water initiatives for internal decision making in the long run. In sum, the CDP water program at this stage is more of a physical external environmental accounting tool according to Burritt et al. (2002). However, it still has the potential to be developed for internal management. The second part of this research design makes an effort to evaluate the feasibility of this.

Internal

	<p>1.4 the policy, strategy or plan specify water reduction, quality or efficiency targets or other water-related goals</p> <p>16.2 financial intensity measurements for the water use (water unit / financial unit).</p>
<p>16.1 financial intensity measurements for the water use (water unit / financial unit).</p>	
<p>Monetary</p>	<p>Physical</p>
<p>3.4 the financial implications to the identified physical and regulatory risks</p> <p>10.1 financial impacts of detrimental impacts to business related to water the company has faced in the past five years</p> <p>15.3 significant penalties or fines in respect of breaches of regulations relating to discharges from the operations during the reporting period</p>	<p>2.2 the percentage of the operations located in water-stressed regions.</p> <p>6.2 the percentage of the key water-intensive inputs that come from water-stressed regions.</p> <p>13.2 total water withdrawal by source type</p> <p>14.2 report the total volume of water recycled and reused in the operations (in cubic meters per year and as a percentage of the total water withdrawal reported in question</p> <p>17.1 what percentage of the withdrawals and discharges have been verified or assured.</p>

External

Figure 3.2 A mapping of CDP water program questions in the environmental accounting system developed by Burritt et al. (2002)

After defining the nature of the CDP water program and the scope of existing research, this section identifies research gaps and ongoing debates to which the current study can make a specific contribution. The growth in the study of environmental accounting during the past decades envisions the debates outlined in Figure 3.3 that enlighten this study. Based on the literature, there four categories of research topics and six interconnections among them. The four categories are environmental management, environmental reporting, environmental performance, and financial performance. For example, the question “Is going green good for profits?” falls into the categories of financial performance and environmental performance and is represented in Figure 3.3 as interconnection 4. Several studies have concentrated on pairwise associations, and the results have been mixed (Ullmann, 1985). Recent studies have taken a holistic approach, incorporating three categories (Al-Tuwaijri et al., 2004). Another stream of studies focuses on the consequences of environmental disclosure based on managerial incentives for environmental protection. Regarding interconnection 3, research in social and environmental studies normally hypothesises a positive relationship

between the extensiveness of a firm's social disclosure and its social performance (Belkaoui and Karpik, 1989). The general rationale is that investment and expenditure in environmental disclosure are expected to result in the achievement of social and environmental performance goals. Thus, the purpose of disclosure is to advertise superior performance to concerned stakeholders. Another variable often tested is the value relevance of environmental disclosure, that is, whether corporations can successfully achieve financial benefits (interconnection 5) through disclosure strategies. According to agency theory, disclosure may have a negative effect on current financial performance. If a firm discloses information, it may indicate that investment and expenditure are justified in terms of future social or economic benefit. Voluntary disclosure theory predicts that disclosure can mitigate information asymmetry and increase firm value through a lower cost of capital. Except for external reporting purposes, divergent management tools have been developed to solve the practical issues in this area. Generally speaking, these systematic tools are commonly referred to as *environmental management accounting*; some of these tools focus on a specific area, such as carbon management systems, and others are more encompassing. Details of environmental management systems are discussed in section 3.3.

Because this study falls into the general category of environmental management, it is possible to choose a standard approach, well grounded in prior studies. The empirical study in Chapter 4 explores whether self-regulation of environmental management triggers more disclosure (and thus whether it falls under interconnection 2 in Figure 3.3). Chapter 5 investigates whether self-regulation of water management leads to improved water performance (and thus belongs under interconnection 6). The direction is unilateral in both chapters. The following two sections review prior studies that have worked along the lines of the interconnections demonstrated in Figure 3.3.

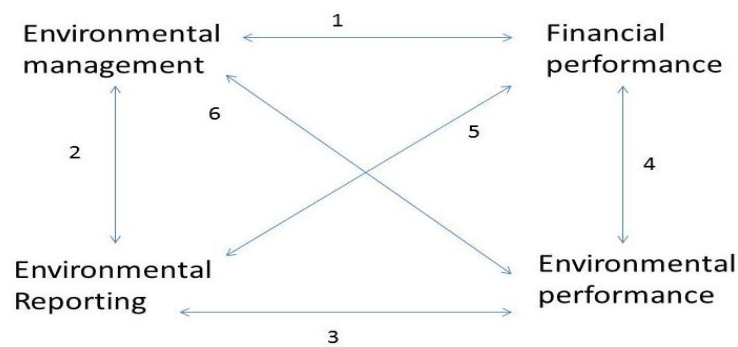


Figure 3.3 Environmental research topics and their interactions

3.1 Disclosure of environmental information

There is growing evidence that environmental disclosure and reporting has become a common practice worldwide. For instance, reports show that more than 72% of S&P 500 companies disclose their sustainability performance (Clark et al., 2015). The diverse needs of different groups of stakeholders (e.g., advocacy groups, stockholders, governments, customers) are frequently utilised to explain the demands for such reporting (Hahn and Kühnen, 2013). This section reviews studies on environmental reporting and related issues in contemporary research.

3.1.1 Motivation behind corporate environmental disclosure

As more and more companies disclose environmental information, an emerging body of literature explores the reasons behind this practice. Many factors have been positively associated with disclosure according to different research perspectives. Factors such as social, financial market, economic, regulatory, and institutional pressure are associated with managerial incentives to disclose environmental information (Luo & Tang 2012). Yet influence and motives need to be carefully distinguished (Bebbington and Gray, 2001). *Motives* are the reasons why executives choose to disclose environmental or any other information to the public. *Influence*, in contrast, refers to potential factors that may trigger disclosure behaviour if an executive perceives or believes that there is a change in those factors (Bendheim et al., 1998). One example that illustrates the difference is the environmental campaign promoted by non-governmental organisations. Threat of these organisations can be regarded as a source of influence; however, it does not necessarily bring about change in corporate behaviour. However, companies may be stimulated to assuage or deflect

such pressure when they perceive the threat as evident and as likely to sabotage corporate legitimacy. Disclosure is the strategy to achieve that motive. According to this distinction, influence or pressure may come from community concerns, negative media attention, a major social or environmental incident, concerns of lobbyist groups, or proven environmental prosecutions (Newson and Deegan, 2002). Firm characteristics are also influential. For example, environmental disclosure is related to country of origin (Newson and Deegan, 2002), industry of operation (Newson and Deegan, 2002), percentage of female members on the board (Liao et al., 2014), and other variables as articulated in the following section.

As Hibbitt (2004) noted, motives are hard to observe. He identified motives for both disclosing and not disclosing CSR information. These are summarised in Table 3.1.

Table 3.1 Possible motives for voluntary environmental disclosure and nondisclosure

Disclosure		Nondisclosure	
1	Compliance	1	No need/motivation to do so
2	Positive impact on share price	2	Wait and see
3	Brand management	3	Cost
4	Financial, legal, and reputational risk management	4	Data availability
5	Satisfy “green” and ethical investors	5	Secrecy
6	Ethics (of the firm or its top management)	6	(Perceived) absence of demand
7	Individual commitment (e.g., top management)	7	No legal requirements to do so
8	Build up expertise in advance of regulation	8	Not previously considered
9	If disclosure is not done voluntarily it may become mandatory	9	Priority given to other areas of disclosure
10	Legitimise activities, influence perceptions, forestall regulation and/or legislation		
11	Stimulate internal developments		
12	Maintain position of power/stay ahead of competitors		
13	Experimentation		
14	Forestall disclosure by other parties		

Adapted from Gray et al. (1996), Gray and Bebbington (2001), O’Dwyer (2001), and Hibbitt (2004).

The list of motives in Table 3.1 is not intended to be exhaustive but indicates the very diverse range of potential motives/influences. Sometimes disclosure can be driven by multiple motives, which makes the research design critical. This thesis, for instance, is grounded in self-regulation theory. Its central proposition is consistent with Disclosure motives 8, 9, 10, and 11. In other words, self-regulation can help companies

achieve those advantages through proactive management and disclosure. As stated in Chapter 2, the precondition for self-regulation is lax environmental regulation. To verify self-regulation theory, the external legal environment that can exert significant influence therefore needs to be captured.

For example, Patten (2002) used the toxic release inventory index as a proxy for environmental performance and discovered that it is negatively associated with environmental disclosure. Moreover, Zuber and Berry (1992) argued that a company's environmental policies and activities have a long-term impact on the company's financial position, which is consistent with Disclosure motive 2 (Wilmshurst and Frost, 2000).

Note that there are some challenging issues in this stream of studies. For example, financial investment plus managerial mechanisms are committed to facilitating implementations that may not generate short-term or immediate outcomes. Thus, the previous literature has made many attempts to empirically test the relationship between economic performance and environmental performance. It has found mixed results: a positive impact, a negative impact, and no effect (Al-Tuwaijri et al., 2004, Aupperle et al., 1985, Russo and Fouts, 1997). Inasmuch as prior studies have failed to reach a definitive verdict, the effectiveness of the win-win sustainability strategy is still an unresolved empirical issue.

3.1.2 **Forms of disclosure of environmental information**

Corporate environmental disclosure is an emerging practice. Firms make disclosures via traditional and nontraditional channels. Among the various voluntary regulatory regimes, the CDP enjoys considerable popularity among large international corporations worldwide. A discussion of the unique characteristics of environmental disclosure in the form of the CDP should help explain the distinction between public and private disclosure as well as mandatory and voluntary disclosure.

3.1.2.1 Mandatory vs. voluntary disclosure of environmental information

Public disclosure of water management can be either mandatory or voluntary. A key difference between the two is that voluntary disclosure introduces selection effects in the sense that firms can choose whether to disclose. Research has found that voluntary disclosure gives more discretion to managers to communicate information about

valuable opportunities in the future. Voluntary disclosure theory posits that firms tend to disclose voluntarily when they perform better than market expectations (Milgrom, 1981, Verrecchia, 1983). The voluntary participation of a firm in the CDP may be seen as a positive signal indicating superior environmental performance. This analysis is grounded in the economic theory of voluntary disclosure.

3.1.2.2 Public vs. private disclosure of environmental information

Instead of disclosing publicly, companies may choose to pass along material information privately (i.e., to disclose information only to a limited audience or stakeholders, such as analysts and financial institutions, prior to disclosing it publicly; (Gomes et al., 2007). Another type of private disclosure is by means of institutional investors that distribute specialised questionnaires to investee companies (Solomon and Solomon, 2006). In addition, some companies maintain secrecy because of competitive or commercial sensitivity or management disadvantages as well as constraints such as company culture, option status, and circumstances. Diverse communication channels also indicate differences in motivation. Holland (1999) built a dynamic model to explain different scenarios wherein companies choose different channels to make disclosures concerning intangible assets and risks to diverse audiences. He found that different levels of disclosure come with different priorities. Companies maximise the use of public disclosure to resolve information asymmetry among fund managers, analysts, and shareholders by following voluntary good practice guidance and market benchmarks; therefore, these tell only part of the story (Holland, 1999). The use of private voluntary disclosures, such as one-on-one meetings with fund managers and analysts, supplements public disclosure only when it communicates fragmented elements to create a whole picture of a company's status. Private disclosure is more likely to be optimistic and to communicate little or no information on areas of downside risk. In sum, managers strategically use different forms of disclosure, weighing the costs and benefits under different circumstances, to achieve a desired outcome. The extant literature predicts that the cost of not disclosing increases when there is more scrutiny from the public (Stanny and Ely, 2008). Because it can be controlled most readily by companies, private disclosure has advantages over public disclosure and no disclosure.

At the current time, public disclosure is the dominant communication channel between companies and external stakeholders, for whom the annual report is the most important source of information on financial performance. Despite this fact, the U.S. Securities and Exchange Commission (SEC) has categorised additional channels for transmitting information from firms to markets. That is, in addition to making mandatory disclosures, firms can perform selective disclosure via phone calls or one-on-one meetings, sell-side analysts can release reports to the public, and private information can be provided by informed traders (Delmas and Cuerel Burbano, 2011).

Specific regulations limit private disclosure for the consideration of minority shareholders. For instance, the SEC passed the Regulation Fair Disclosure to mitigate selective disclosure by firms. However, Gomes, Gorton, and Madureira (2007) asserted that private disclosure helps improve market efficiency, comparing the cost of capital before and after passage of Regulation Fair Disclosure and concluding that the loss of financial information due to cancelation of selective channels can hardly be compensated.

A further research question is what factors determine the level and form of disclosure. One notion is that superior environmental performers will convey their type by pointing to objective environmental performance indicators that are difficult for inferior firms to mimic. Inferior performers will choose to disclose less or to be silent on their environmental performance, thus being placed in a pool of firms to which investors and other users ascribe an average type. What sustains this partial disclosure equilibrium is the proprietary costs associated with disclosure of environmental performance (Verrecchia, 1983) and uncertainty as to whether a firm has informed regarding its type (Dye, 1985).

This thesis takes into consideration both public and private disclosure because the CDP provides a unique setting that facilitates this research design and has not been examined in prior studies. Previous studies using CDP data have not considered private disclosure as a distinctive form of disclosure, instead grouping it either with public disclosure or with no disclosure. This differentiation is especially meaningful for the CDP water program because corporate water disclosure remains voluntary in most countries even though some countries have mandatory carbon emissions disclosure regulations for corporations. Therefore, some carbon response may no longer be

voluntary in nature. The mixed results from prior studies may stem from the failure to carefully distinguish voluntary and mandatory disclosure (Gray et al. 2001). Managers are reluctant to publicly disclose information to investors because it is costly (Nagar et al., 2003). It is also a great opportunity to see whether CDP mitigate this disclosure agency problem by facilitating a private communication channel.

3.1.2.3 The CDP and self-regulation

With the increasing demand for human access to water, as well as the threats to water supply from by climate change, the widening gap between supply and demand has triggered increased risks for corporations. Efficient water use is a challenge for both academics and practitioners, and little evidence of improved water efficiency has been found in mines (Mudd, 2008). Aware of the impact of climate change on water, the CDP is beginning to demand information specifically on water risks to capture overall climate change risks since 2010. In the context of competing demands, companies have a strong incentive to address water management issues, hedging risk and securing a contract to operate, in particular, in eco-sensitive regions or industries in which the primary activity or product relies heavily on water. Thus, a substantial number of large companies have started to reveal their water management practices.

Every year, the CDP sends out questionnaires on both water and carbon to multinational companies, developing as a result the largest repository of corporate carbon and water data in the world. Resulting as they do from both voluntary and solicited disclosure, CDP data have unique features and advantages compared to traditional forms of disclosure. This provides a good opportunity to examine the incentives behind water disclosure in the absence of regulation and public policy.

Based on its definition, the CDP program seems to fall into the category of a unilateral self-regulation regime, as no definite regulatory rewards are given. On behalf of its signatory organisations, the CDP leveraged the influence of large institutional investors to push companies to disclose environmental information. To increase the accessibility of the information collected, the CDP publishes each individual firm's response with its approval. The CDP discloses the names of firms that ignore its request on its website to simulate response. Among academics, views diverge as to the extent to which the CDP information is useful. The CDP provides new information

that is relevant to investors and interest groups for decision-making (Matsumura et al., 2013, Choi et al., 2013, Luo and Tang, 2014, He et al., 2013). Although there is no systematic evidence that participation increases shareholder value, Kim and Lyon (2011b) found that participation in the CDP increased shareholder value when the chance of climate change regulations being introduced increases (i.e., when Russia ratified the Kyoto Protocol, which caused it to go into effect), and the total increase in shareholder value from participation in the CDP was estimated to be U.S. \$8.6 billion, about 86% of the size of the entire carbon market in 2005. These findings suggest that the activism of institutional investors with regard to climate change helps create value, especially when the general public becomes more environmentally conscious. The CDP is not perceived as typical institutional investor activism, which aims to create shareholder benefits. Moreover, investor activism is more often associated with solicited disclosure, such as one-on-one meetings and phone calls (Van der Laan, 2009). The CDP accelerates the release of information not directly due to demand from investors but instead through a flexible mechanism concerning how information will be presented.

CDP data collection has several advantages over other voluntary forms. Managerial control over the extent and nature of the discourse is diminished. For example, greenhouse gas emissions reported in firms' annual reports were lower than those disclosed in their CDP reports for the same year (Depoers et al., 2016). This is probably because managers have great autonomy over standards and calculations and are able to present a satisfying picture in the annual report. The CDP reports increase comparability among companies and limit the ability to cherry-pick, using standardised questions with a substantial number of closed questions. The CDP has an incomparable advantage in terms of maintaining discretion over how information will be shared. Companies can choose to make their submitted surveys public or visible only to institutional investors. Such choices can be attributed to different motivations.

In its water program, CDP questionnaires focus specifically on water management, including such aspects as water-related risks and opportunities, water governance, and withdrawal and recycling of water resources, to name a few. CDP questionnaires make it difficult for managers to hide bad news: They ask specific questions concerning matters and issues such as regulatory penalties, physical risks, and so on. Responses

to the questionnaires allow researchers to distinguish among corporate attitudes toward water risk management by observing firms' response statuses and water-related behaviour. This is the main reason why the CDP was chosen as the source of the present data. Another advantage of the CDP is that it furthers a right to know (Schaltegger and Burritt, 2010), pushes companies to disclose more quantitative information and limits the use of discretion in disclosing qualitative information. The growing data provide opportunities for more in-depth investigation of corporate responses to climate change, both more generally and specifically with regard to water accounting and reporting. However, some technical processes for water utilisation, such as purification and recycling, may be complex and difficult for non specialists to understand, so standardisation and simplification of disclosures is needed to further improve water reports.

In sum, a review of the existing literature suggests that there are very few studies on water disclosure, in particular private disclosure of corporate water information. However, private environmental disclosure is emerging as a choice companies are making to share information with targeted stakeholders and audiences. This study identifies this gap and provides empirical results that can contribute new evidence on this dimension of environmental disclosure to the extant literature. The next section focuses on public disclosure of environmental information.

3.1.3 Theories and factors influencing environmental disclosure

Disclosing corporate environmental information is an important dimension of a company's environmental management strategy. A growing number of researchers have developed various social, economic, corporate governance, and institutional theories to explain the phenomenon and what drives companies to disclose environmental information (e.g., Tang, Qingliang, 2016; Le Luo and Qingliang Tang, 2016; Tang, Qingliang, Le Luo, 2016; Tang et al. 2016). As indicated in Figure 3.2, the relationship between disclosure of environmental information and environmental management has been tested often; the empirical results are mostly positive. Before conducting this study on water disclosure, it is necessary to consider extant findings as well as other factors that may have a significant influence on environmental disclosure.

3.1.3.1 Governmental regulation

Protecting the environment is in the public interest, and thus there is a long tradition of the government addressing environmental issues. Governments in every country have made a lot of effort to clean up the aquatic environment by controlling pollution from industry and sewage treatment plants. Thus, consistent with institutional theory, it is natural to expect governmental regulation to have a far-reaching influence on corporate environmental activity. Unmanaged environmental risks imperil the sustainability of business in the form of litigation, fines, a damaged image, and other harms. Organisations need to pay water fees and charges for storing and treating water, for distributing water to customers, and so on. However, these water usage rates rarely reflect the actual value of the water resource. Rates for surface water are low because historical average costs are low and marginal scarcity rent is rarely included. The water price is too low to reflect the scarcity and therefore not able to promote efficiency (Tietenberg and Lewis, 2012). Even with the ever-increasing emphasis on environmental protection from the government and the community, there is still a lack of regulations and legislative reform requiring companies to save water resources and release water information through annual reports or other channels (Craig and Michaela, 1996).

Setters of accounting standards and securities regulators are increasingly being made aware of deficiencies in corporate environmental disclosures (Beets & Souther, 1999; Chan-Fishel, 2002; Franco, 2001). Now the U.S. government is concerned about the impact of environmental regulations on the competitiveness of U.S. industry in the international arena (WHO, 2006). The SEC also notes that “significant physical effects of climate change, such as effects on the severity of weather (for example, floods or hurricanes), sea levels, the arability of farmland, and water availability and quality, have the potential to affect a registrant’s operations and results” (SEC 2010, p. 26). The SEC’s that climate-related risks that should be disclosed where material include “... decreased agricultural production capacity in areas affected by drought or other weather-related changes” (SEC 2010, p. 27). It is expected that these new reporting standards will facilitate more disclosure of environmental and water information by companies.

The impact of climate change has made companies more accountable. For instance, related regulation tends to internalise this externality through carbon taxes and

purchases of permits in carbon trading. From a long-term perspective, industries will face more stringent regulations in social and environmental practices and disclosures. Although there is no specific legal requirement at this time to disclose water-related information, potential water-related risks may be reflected in contingent liability in the form of, for example, lawsuits in communities. If legislation specifies the liability of managers, pressure and responsibility will be transferred from the corporate level to the individual. In this way, corporate disclosure through the annual report may serve the purpose of due diligence (Patten, 2002b). However, prior studies have often considered disclosure merely a consequence of strict regulation according to legitimacy theory and have failed to consider the dynamic interplay between policymakers and managers. This thesis may fill this gap by involving both internal and external regulatory forces and exploring how lax regulation may influence different disclosure strategies.

3.1.3.2 Legal system

Researchers have rarely explored the influence of country of origin as well as legal system on environmental disclosure (Hahn and Kühnen, 2013). In theory, the legal system is an important element of the institutional framework for environmental protection, directly or indirectly influencing accounting systems and disclosure. Measurement and disclosure policies can also be influenced through tax laws, particularly in civil law countries. The nature and structure of existing water-related regulations and laws vary widely across countries.

Both corporate disclosures and water-related regulations are under the influence of a generic legal system. The different impact of common law and civil law systems on corporate disclosure is one of the issues commonly tested by researchers. Opinions vary as to how legal systems influence corporate decisions on environmental disclosure. La Porta et al. (2000) claimed that the legal structure of a country and the origin of the law fundamentally determine the nature of investor protection and more generally of the regulation of financial markets. Of the two major types of legal system, common law tends to maximise shareholder value by having stronger legal protection for small investors than civil law (La Porta et al., 1998).

The opposing argument is that firms in civil law countries face additional pressure from the potential imposition of regulatory interventions and therefore will be more

likely to disclose social and environmental information. Firms in common law countries face lower social expectations because the legal system does not define rules within legislative acts (Williams, 1999). Other studies seem to comport with La Porta's views on investor protection (Simnett et al., 2009, Clarkson et al., 2008). An examination of the extant literature shows that researchers have not explored the impact of legal system on corporate water disclosure. This motivates this study to test this issue. Based on prior literature, it can be argued that people in civil law countries emphasise the protection of individual investors less than people in common law countries do; therefore, companies in civil law countries are more likely to communicate with large and powerful investors through private disclosure. The direction of influence between the legal system and disclosure of water information is investigated in the following chapter.

3.1.3.3 Degree of economic development

From the perspective of resource availability theory, the cost of environmental investment would reduce the likelihood that firms engage in environmental protection initiatives (Luo, Lan and Tang 2013). Such a commitment requires financial resources, and the return and benefit would be long term and would largely go to the community and society. Thus, the level of economic development is another factor that should be taken into account when it comes to water resource management and disclosure. More specifically, the quality of environmental and water management could be weak in developing regions where economic growth and increasing populations add more pressure on the water resources and lack of sanitation infrastructure (Ceres, 2010). It can also be argued that more developed countries are better positioned to finance large investments in infrastructure, such as dams, sewage systems, water recycling techniques, and waste treatment facilities (Williams, 1999). From the perspective of legitimacy, economic development will be accompanied by a greater demand for better living conditions and growth in the number and strength of pressure groups (Gordon, 1990; Moaddel 1994). Therefore, economic development, for with gross domestic product or gross domestic product per capita is often considered a proxy, is considered in related studies, particularly ones with an international setting.

3.1.3.4 Industry membership

Institution theory also suggests that companies in the same sector tend to adopt similar environmental policies; thus, industry appears to be an important factor explaining environmental disclosure in annual reports (Halme and Huse, 1997, Adams et al., 1998, Cowen et al., 1987, Gray et al., 1995a). Researchers seem to have reached a consensus on classifying industries into polluting or less polluting types. For instance, a body of empirical literature has associated the metal, resources, paper and pulp, power generation, water, and chemical sectors with high environmental impacts (Brown and Deegan, 1998). Perez-Batres et al. (2012) developed a more precise classification to determine an industry-of-origin effect, following the work of Gamper-Rabindran (2006). This scheme scores industries in a range from 1 to 3, where 3 represents the most polluting industries. Industries such as petroleum refineries, iron, steel, paper and products, glass and products, and wood products are coded 3. Textiles, leather products, beverages, fabricated metal products, and electric machinery are classified as moderately polluting and are coded 2. The least polluting industries include clothing apparels, footwear, printing and publishing. Ceres (2010) defined water-sensitive industries as those that require significant quantities of water and discharge wastewater from their own operations, supply chains of raw material, and use of their end products. In fact, the category of water-sensitive industries overlaps with most water-sensitive industries. The CDP (CDP, 2009) has identified water-sensitive sectors such as forestry and paper products, food and beverage, mining, pharmaceuticals, and power generation as industries most likely to be affected by water scarcity and quality. Following previous approaches adopted in the literature, this study defines substantial corporate water consumers based on industry characteristics.

3.1.3.5 Investors

According to organisation theory, managers of a company will adopt environmental policy that align with shareholders' preferences and information demands. So investors' response to climate change could explain why companies voluntarily disclose proenvironmental information. Socially responsible investing is increasing rapidly in the United States, and in 2016 more than \$8.72 trillion was invested in environmental, social, and governance projects (US SIF Foundation, 2016). Therefore, it is plausible that corporate directors would act to impress or satisfy ethical investors

if they are influential. Studying firms on the European and U.S. stock markets, Ziegler et al. (2011) found that investors value positively companies that respond to climate change. This is in line with Husch and Hoffmann's (2011) finding that reducing carbon emissions improved firms' financial performance.

Institutional investors are normally financial organisations that hold substantial numbers of shares in companies. As a result, they can influence managerial decisions and represent a powerful and legitimate stakeholder group. Their portfolios are inevitably exposed to growing and widespread costs resulting from environmental damage caused by companies. Such investors can positively influence the way business is conducted, reducing externalities and minimising their overall exposure to such costs. For instance, institutional investors lobbied US Securities and Exchange Commission (SEC) for six years before an interpretative guidance on disclosures related to business or legal developments regarding climate change was established in 2010 (SEC, 2010, ACCA, 2010). The Social Investment Forum Foundation (2012) estimated that \$3.74 trillion of the \$33.3 trillion being professionally managed in the United States in 2012 was invested using criteria based on social responsibility; the amounts invested using such criteria grew 22% from 2009 to 2012, such that by 2012 more than 720 investment funds incorporating socially responsible criteria were available.

Institutional investors now care more about long-term economic well-being and should act collectively to reduce financial risk resulting from environmental impacts (Cotter and Najah, 2012). They have expressed a desire for high-quality information about corporate exposure to risks associated with climate change (Lash and Wellington, 2007, Stanny and Ely, 2008). Research has found that institutional investors encourage companies to adopt higher corporate social and environmental standards, which drives transparency and in turn enhances reputation (Clark, 2005).

In light of this, institutional investors are increasingly seeking information from companies on how they address and manage material water risks and opportunities. For instance, in August 2009, Norges Bank Investment Management announced its campaign to evaluate the water risk management practices of the 1,100 companies in which it was invested (Ceres, 2010). In the same year, the CDP launched a new

investor-driven water disclosure initiative that provided the raw data for the current study.

3.1.3.6 Financial variables

In this section, we discuss firm characteristics that might be associated with water management and disclosure decisions.

Firm size

Firm size is a comprehensive variable that can be used as a proxy for several corporate characteristics, such as competitive advantage and information production costs (see Buzby, 1975; Firth, 1979; Leftwich et al., 1981; Ball and Foster, 1982;). In most of the literature, the size of a firm has a significant positive relationship with voluntary participation in environmental campaign. Because implementing an environmental plan may initially require a great deal of financial capital, the deeper the pockets a firm has, the more able it will be to support these costs. This also suggests that firms in more concentrated industries can more easily pass on increased costs to consumers. Hence, they are more able to afford costly voluntary over-compliance (Arora and Cason, 1996).

Financing and information asymmetry

It is well established in the literature on voluntary disclosure that information asymmetry increases the cost of capital. Consequently, managers are motivated to lower that cost through voluntary disclosures (Healy and Palepu, 2001). It is generally accepted that firms that finance activities through debt and the equity markets are more likely to voluntarily disclose nonfinancial information to lower their cost of capital (Frankel et al., 1995, Francis et al., 2005). Empirically speaking, firms with increased disclosure of environmental initiatives appear to be able to raise more capital (Gamerschlag et al., 2011). From another perspective, disclosure is

It is believed that disclosure complements corporate governance (Craighead et al., 2004, Denis et al., 2010). As to the measurement issue, there are some common proxies used in prior studies such as market-to-book ratio (Nagar et al., 2003), bid-ask spread, share price volatility and stock liquidity

Several approaches coexist for the purpose of assessing a firm's information asymmetry. Francis et al. (2005), Leuz and Verrecchia (2000), Healy et al. (1999) and Welker (1995) show that disclosure quality lowers information asymmetry – as proxied by bid-ask spread, share price volatility or stock liquidity. Other studies rely on Tobin's Q or market-to-book ratio (e.g. Aerts et al., 2007; Clarkson et al., 2008), for assessing the impact of voluntary disclosure on information asymmetry.

Return on assets

Financial theory (Lang and Lundholm (1993) predicts that firms with a superior earnings performance have a higher propensity to disclose to release their good news to investors. In the previous literature, the ratio of return on assets has often been used as a proxy for earnings performance. Companies with a high return on assets are predicted to be more willing to release this favourable information.

Leverage

The proportion of debt in capital structure represents level of bankruptcy or going concern risks. Firms that borrow more money will have higher agency debt costs (Jensen and Meckling, 1976). To reduce information asymmetry and the cost of capital, companies will disclose more information. Thus, voluntary disclosures are expected to increase with leverage.

Advancements in technology

According to resource dependence theory, firms with newer, more advanced technologies are better positioned to invest in environmentally friendly programs. Therefore, their environmental performance is more likely to be superior. According to voluntary disclosure theory, they are keen to send signals to stakeholders about this good news and distinguish themselves from others through voluntary disclosure (Simnett et al., 2009, Clarkson et al., 2008).

Capital expenditures

Similarly, consistent with the resource dependence theory perspective, firms will spend more on new and efficient equipment if they have a strong sense of protecting the environment (Clarkson, P. M. et al. 2008). More sustaining capital expenditures

are implicit signals to investors and other stakeholders about this commitment, and this is often associated with more explicit voluntary disclosure (Simnett et al., 2009, Clarkson et al., 2008). Indeed, prior evidence shows that the level of capital expenditures is positively associated with disclosure (Luo et al. 2016).

Other factors

Prior studies have also considered other factors, such as media exposure and research and development. The public can cause the media to target irresponsible corporate behaviour that runs counter to social norms. This in turn creates huge pressure and undercuts a positive brand image. The ability to innovate and to develop new technologies and approaches to production is a great determinant of competitiveness and economic success (Ameer and Othman, 2012). Because it is difficult to obtain a water-specific variable for media or research and development, this study does not include one. Environmental lobby or pressure groups are one prominent community force that triggers more pressure on proactive action on environmental issues (Elkington, 1994). For instance, Deegan and Gordon (1996b) found that companies with membership in environmental lobby organisations tend to release more environmental information, consistent with stakeholder theory.

3.1.4 Summary

A review of the above literature indicates that corporate disclosure is an important research topic in accounting because it is critical to reduce information asymmetry and to maintain the functioning of an efficient capital market (Healy and Palepu, 2001). The majority of the literature in this area focuses on how to use economic mechanisms and institutions to facilitate credible disclosure between managers and investors and mitigate agency problems (Mahoney, 1995). This information asymmetry has been expanded to include other stakeholders. As the number of external users increases, companies are facing more pressure to disclose credible environmental information on a timely basis (Cohen et al., 2011). Thus, this important issue has both theoretical and practical implications. The current work is an extension of the existing research to the area of water management and disclosure.

3.2 Environmental management

The existing literature demonstrates that corporate environmental management practices, strategies, and performance are not homogeneous. There are two basic sustainability strategies, each with different competitive advantages: market-driven and process-driven sustainability strategies. Market-driven sustainability strategies provide firms with competitive advantages by differentiating their products and/or markets environmentally from their competitors. A number of different stratagems (organisational tactics that constitute the content of a particular strategy) have been suggested in the literature for market-driven sustainability strategies: redesigning product packaging, encouraging reverse logistics (e.g., companies try to return empty containers to differentiate their products from their competitors (González-Torre et al., 2004), advertising the environmental benefits of a product (Davis, 1993), redesigning products to be more environmentally sensitive, developing new environmentally sensitive products, entering new environmentally sensitive markets, and selling or donating scrap once considered waste. These practices provide companies with important savings in cost as well. Some subsectors within the food and drinks industry have begun to initiate more intensive cooperative actions in this sense to differentiate their products in their search for a competitive edge in the market.

Process-driven sustainability strategies, in contrast, provide firms with competitive advantages by reducing costs via improvements in environmental efficiencies in production processes. Process-driven stratagems that have appeared in the literature include redesigning pollution control systems, waste disposal systems, and air and water treatment systems; using recycled resources derived from external sources, from scrap materials, or from defective end products in production processes; redesigning production processes to be less polluting and more energy and resource efficient; and using renewable energy sources in production processes. The following section illustrates several systematic management practices.

3.2.1 Forms of environmental management

3.2.1.1 *Environmental management systems*

An environmental management system is abstract and defined with different emphases. For example, Steger defines it as “a transparent, systemic process” (2000, p. 24) with the purpose of “prescribing and implementing environmental goals, policies and

responsibilities, as well as regular auditing of its elements” (2000, p. 24). It is a “self-motivated effort” and aims at “internalising environmental externality” according to Khanna and Anton (2002, p. 409). Environmental management systems overlap to some extent with environmental management accounting, although the latter emphasises the role of monetary and physical quantitative recording (Burritt et al., 2002). Examples of environmental management systems include ISO14001 and the Eco-Environmental Management and Auditing Scheme (Lenox, 2006). Environmental management practices take the form of establishing environmental policy, setting internal standards and environmental assurance, providing training and financial incentives for employees to save energy and prevent pollution, and implementing total quality management in environmental management (Anton et al., 2004).

3.2.1.2 Carbon management systems

The primary objective of carbon management systems is to control and mitigate greenhouse gas emissions (Klassen and McLaughlin, 1996, Tang and Luo, 2014). Such systems can increase the efficiency of input use, reduce carbon emissions, avoid compliance expenditures, and thus achieve competitive advantage (Tang and Luo, 2014). Tang and Luo (2014, p. 84) identified a carbon management system as having 10 elements, namely, (1) board function, (2) carbon risk and opportunity assessment, (3) staff involvement, (4) reduction targets, (5) policy implementation, (6) supply chain emission control, (7) greenhouse gas accounting, (8) greenhouse gas assurance, (9) engagement with stakeholders, and (10) external disclosure and communication. The quality of overall carbon management is expected to increase with the strength of these 10 elements.

3.2.1.3 Water management systems

Despite the fact that community groups, governments, and academics have gradually come to recognise the importance of water management (Godfrey and Chalmers, 2012), such issues and problems have not been discussed well from a practical or theoretical perspective, probably because of the lack of data, particularly at the firm level (ACCA, 2010, Cotter and Najah, 2012). Slattery, Chalmer, and Godfrey (2012) discussed the development of the Australian water accounting conceptual framework, a set of common premises for recognising and quantifying the elements of water accounting reports. Vardon et al. (2012) considered the system of environmental-economic

accounting for water proposed by the United Nations (United Nations Statistics Division, 2007). Mungatana and Hassan (2012) compared and elaborated on nuanced differences in purpose and content between the Australian and United Nations versions of water resource accounting. In addition, it has been contended that water management and accounting can play important roles in the assessment of water productivity (Karimi et al., 2012) in tracking water footprints (Hoekstra et al., 2012) for the efficient utilisation of water resources in specific industries such as mining and minerals (Cote et al., 2009).

The development and application of water systems in developing countries such as China (Gan et al., 2012) and developed countries such as the United States (Squillace, 2012) have also been examined. Finally, Muller (2012) found that water accounting plays a role in corporate social responsibility activities. Taken together, it appears that most of the research related to disclosure is descriptive or prescriptive and that the literature mainly addresses the role of water accounting reports from a macroeconomic perspective. Although the aforementioned studies significantly enhance understanding of water resource management and accounting at the country and regional levels, they do not specifically consider water management and disclosure practices at the firm level. This is a research gap that this dissertation aims to explore.

Following the environmental accounting framework in Figure 3.1, water management and water accounting issues can also be discussed from managerial and reporting dimensions. Christ and Burritt (2017) focused specifically on the managerial perspective on corporate water accounting and defined effective water accounting according to five important aspects: level of analysis, data, water risks, timeframe, and trans-discipline. They contended that water accounting data should be collected and analysed at the site or facility level because water information is closely linked to local spatial conditions. The type of data is critical to supporting sound water management. Water accounting systems should at least provide quantitative physical data on water use. Qualitative assessment of water quality is permissible if companies are incapable of assessing water quality quantitatively. Because water issues should be included as ongoing business concerns, water accounting information should be collected regularly and evaluated for both short-term and long-term risks concerns. Water risks attract most of the attention because there are many different types and they can be

passed off as negative externalities. Corporations in sensitive industries should utilise tools to help identify and evaluate water risks throughout the whole value chain. Because water issues are interrelated with hydrology, laws, engineering, and other disciplines, water policies should be developed with efforts from various departments so as to achieve multiple goals. Water accounting should function as a communication tool to integrate different departments from different levels. Christ and Burritt (2017) concluded that to improve the efficiency of water usage, top managers need to put water management at a higher level on the corporate agenda. In other words, the success of water management systems requires bottom-up data with top-down command and control.

In addition to CDP Water Disclosure, a growing number of water management tools and systems aim to evaluate water management practices, enhance decision making, and implement strategies for dealing with water risks and achieving water stewardship. Larson et al. (2012) grouped these tools into four general categories based on their objectives and main characteristics. This thesis modifies their categories to summarise existing water initiatives as shown in Table 3.2.

Table 3.2 Water management tools, protocols and initiatives

	Category	General functions	Examples
1	Water use accounting tools	Provide quantitative water metrics, such as volume of water withdrawn and consumptive use in direct use or supply chains	General Purpose Water Accounting in Australia
2	Business risk assessment frameworks	Assess multiple water risks in the local context	Aquaduct GEMI's Local Water Tool
3	Reporting and disclosure protocols	Mainly improve communication internally for managers and externally for stakeholders	CDP Water Disclosure, Global Reporting Initiative
4	Management tools and stewardship strategies	Offer active water management and leading practices that help to achieve water stewardship	CEO Water Mandate, Aqua Gauge
5	Standards and certification frameworks	<ul style="list-style-type: none"> • Set the standards and criteria of an effective environmental management system • Evaluate environmental impact and serve as assurances to the company and its stakeholders 	ISO14000 Eco-Management and Audit Scheme

Generally speaking, the literature lacks studies on water management systems and disclosure; this was a motive for undertaking the current study. Based on the findings of carbon management systems, a water management system is proposed in Chapter 5. The proposed water management system is innovative and can be used by corporate executives to improve the efficiency of water usage. The system can also be used to analyse water data for research purposes. This is a contribution of the present thesis to the literature.

3.2.1.4 Environmental auditing

A new service performed by financial auditors and accountants is conducting nonfinancial assurances, such as environmental auditing (Power, 2003). The concepts and terminology underpinning traditional audits have been leveraged in this new market of assurances on sustainability reports and other nonfinancial information (O'Dwyer, 2011). Active players include certification bodies, specialist consultants, and the Big Four professional services firms (O'Dwyer, 2011).

3.2.2 Environmental performance

The purpose of environmental management is to improve environmental performance and mitigate or at least control the negative impact of corporate operation on the natural environment. It is a challenge for a firm to implement an effective environmental management system. Okereke (2007) noted that the actual reasoning behind pro-environmental activities and performance depends on a firm's location, industry, area of operation, historical experience, and focus area and the unique barriers faced by companies. He also distinguished motives from drivers, in that motives are the "innate concern" for profit and advantages, whereas drivers are "rooted in wider societal pressures" (Okereke 2007, p. 475). In his research, motives of companies from the Financial Times Stock Exchange 100 index undertaking carbon management programs include profit, credibility and leverage in climate policy development, fiduciary obligation, guarding against risk, and ethical considerations. The drivers or the social pressures include energy prices, market shifts, regulations and government directives, and investors' pressure on technological change.

In addition, a growing body of research has identified sustainability strategies that simultaneously reduce the negative effect of firms' activities on the environment and contribute to creating monetary value (Christmann, 2000, Dechant et al., 1994, Swanson, 1995, Shrivastava, 1995, Stead and Stead, 1995). For example, firms may obtain competitive advantages by adopting process-driven sustainability strategies that can reduce processing costs while improving environmental efficiencies (Porter, 1980). The environmentally benign process includes redesigning pollution control systems, waste disposal systems, and air and water treatment systems; using recycled resources or renewable energy; and redesigning production processes to be less polluting and more resource efficient (Christmann, 2000). Alternatively, firms may use market-driven strategies designed to differentiate their products from their competitors'

(Cacioppe et al., 2008). These tactics include advertising the environmental benefits of products (Davis, 1993), redesigning product packaging, developing new environmentally friendly products, penetrating or expanding new environmentally sensitive markets (Dechant et al., 1994, Reinhardt, 1998, Stead and Stead, 1995), and using reverse logistics (González-Torre et al., 2004).

However, there are some limitations to the existing corporate social responsibility literature. For example, existing studies focus largely on promoting general principles for responding to environmental and social issues but lack practical guidance on how those principles can be applied to daily operations, such as new product development (Sperry and Jetter, 2012). Another challenge concerns the diverse methods used to measure environmental management, ranging from the reputational scales of the Business and Society Review to citizenship awards and the CDP pollution performance index.

3.3 Water management–related studies

3.3.1 Overview of the literature related to water management

Water is an essential resource for human beings. Recent years have witnessed the growth of interdisciplinary studies that focus on water issues from managerial and ethical perspectives. Such studies are generally classified according to three themes: water management, motivation behind disclosure, and usefulness of water information. The majority have used an empirical methodology to investigate the status quo of water management practices in various geographic contexts. For instance, to deal with the irregular water shortage and flood in Australia, the Water Accounting Standards Board initiated a unique water accounting standard that leverages financial accounting concepts (Water Accounting Standards Board, 2009). In this innovative practice, water consumption is recorded and reported in terms of volume rather than monetary value. Moreover, concepts such as water assets and water liabilities also reflect conventional accounting accruals, taking water rights and claims to water into consideration. Doing so helps define the boundaries and accountability of water entities such as catchments, water user companies, and water suppliers and also assesses the water risks of those entities (Chalmers et al., 2012). This innovation has stirred a lot of debate and related research. For instance, it is argued that this uniform water accounting still lacks quality and valuation data (Ahmad et al., 2010). Tello, Hazelton, and Cummings (2016)

investigated potential users' evaluation of the recent Australian water accounting standards initiative. (Plummer and Tower, 2010) expressed some concern over this new type of water accounting and listed several limitations from a scientific viewpoint. Leong et al. (2014) compared voluntary and mandatory disclosure content from mining industries located in New South Wales, Australia, and made suggestions for future improvement.

Other studies have explored how water information disclosure can contribute to the efficiency of the economy. In other contexts like China, pollution is at the top of the agenda of environmental management. Huang and Chen (2015) found a positive relationship between corporate reporting and "three waste" pollution (including water pollution) in China. Hazelton (2014) focused on water footprint information provided at the product level to inform ethical decision making among consumers. The Drinking Water Act in the United States requires mandatory disclosure among water companies, and consequently the violations of these acts have decreased (Benneer and Olmstead, 2008). A lot of empirical studies have been conducted to address the issue of how accountability is established through water information disclosure. For instance, Egan (2014) conducted a case study on water accountability within an Australian university. Hazelton (2013) provided theoretical support for the disclosure of water information and articulated how disclosure and the sharing of water information is treated as a human right that can be a driving force that changes the culture and politics. One important research question concerns the motivation behind managers' water disclosure. Burritt, Christ, and Omori (2016) explored firm characteristics associated with reporting practices in a less water-stressed context like Japan. The water industry in the United Kingdom was motivated to impress customers through extensive reporting on water after it was privatised (Ogden and Clarke, 2005).

All of these studies were conducted in various geographic regions and jurisdictions and support the practical significance of water information from different theoretical perspectives. Table 3.3 summarises these papers based on their topics. These studies have important implications for this thesis; therefore, the next section elaborates on the main content of these papers.

Table 3.3 Summaries of related studies

	Author and Year	Title	Main Findings or Ideas	Research Methods	Country Context	Journal
1	Lambooy (2011)	Corporate social responsibility: Sustainable water use	Corporations are expected to be accountable for their impact on water resources.	Exploratory analysis	The Netherlands	<i>Journal of Cleaner Product</i>
2	Hazelton (2013)	Accounting as a human right: the case of water information	Water information as an important human right should be thoroughly reported and regulated.	Literature review and theoretical discussion	Australia	<i>Accounting, Auditing & Accountability Journal</i>
3	Bennear and Olmstead (2008)	The impacts of the “right to know”: Information disclosure and the violation of drinking water standards	Mandatory provision of information can reduce violations of the Drinking Water Act.	Difference-in-difference model	US	<i>Journal of Environmental Economics and Management</i>

4	Huang and Chen (2015)	Does Environmental Information Disclosure Benefit Waste Discharge Reduction? Evidence from China	Information disclosure is not as effective as regulatory punishments in reducing waste emissions in China.	Multiple regression and content analysis	China	<i>Journal of Business Ethics</i>
5	Tello, Hazelton, and Cummings (2016)	Potential users' perceptions of general purpose water accounting reports	Government agencies are the main users of general purpose water accounting.	Mixed methods	Australia	<i>Accounting, Auditing & Accountability Journal</i>
6	Leong et al. (2014)	Mine site-level water reporting in the Macquarie and Lachlan catchments: a study of voluntary and mandatory disclosures and their value for community decision-making.	Mandatory disclosure is already extensive and provides useful information to make sound decisions. Voluntary disclosure lacks information about the impacts of water.	Case study	Australia	<i>Journal of Cleaner Product</i>

7	Ogden and Clarke (2005)	Customer disclosures, impression management and the construction of legitimacy: Corporate reports in the UK privatised water industry	The evidence shows that water companies intend to impress the customers through disclosure to gain legitimacy after being privatised.	Content analysis	UK	<i>Accounting, Auditing & Accountability Journal</i>
8	Burritt, Christ, and Omori (2016)	Drivers of corporate water-related disclosure: evidence from Japan	Corporate water disclosure is associated with size, water-sensitive industries, and ownership concentration.	Ordinary least squares multiple linear regression	Japan	<i>Journal of Cleaner Product</i>
9	Egan (2014)	Making water count: water accountability change within an Australian university	A network with clear measurement and connection to accountability is necessary to facilitate efficient water usage.	Case study	Australia	<i>Accounting, Auditing & Accountability Journal</i>
10	Hazelton (2014)	Corporate water accountability- the role of	Water footprint labelling for a simpler product is realistic and can help improve public water	Literature review and interviews	Australia	<i>Pacific Accounting Review</i>

		water labels given non-fungible extractions	literacy and inform consumer decision making.			
11	Christ and Burritt (2017)	What Constitutes Contemporary Corporate Water Accounting? A Review from a Management Perspective	A five-element framework is developed to define effective water accounting from an internal managerial perspective.	Literature review		<i>Sustainable Development</i>
12	Larson et al. (2012)	Mitigating Corporate Water Risk: Financial Market Tools and Supply Management Strategies	A decision framework is developed to advise corporate water risk response in the context of water resource management strategies and with financial market tools.	Literature review and conceptual framework		<i>Water Alternatives</i>

3.3.2 Empirical studies

The Australian context

In Australia, the innovation of general purpose water accounting has triggered many related studies. It is considered an experimental application of financial accounting principles to natural resource management. For example, Tello, Hazelton, and Cummings (2016) conducted a survey of potential users and suggested that this new type of water accounting is more useful for government agencies than for the general public. Although the ability of this type of water accounting to help the general public make useful decisions is limited, its innovative form diversifies the communication strategy and implies the necessity to improve the disclosure of water information. Similarly, Leong et al. (2014) conducted a case analysis among mine sites to investigate whether mandatory or voluntary water information disclosure can benefit potential users. Comparing to corporate-level water information disclosure, their study provides a different perspective on how mine sites, local residents, and local environmental authorities interact with one another and how accountability is formed through water reporting. It is true that more detailed water reporting at a less consolidated level can be potentially more relevant for specific decision making, especially for local residents. However, the lack of standardised guidelines and comparability are the challenges. The implication for this thesis is that although mandatory reporting is necessary, it should be tailored to local users' needs, case by case. Corporate-level water reporting is still the best source available to provide a grand view of the current debate. Egan (2014) conducted a case study investigating how an Australian university, as a large water consumer, developed leading practices and informed water accountability. The findings provide concrete knowledge about how an organisation's response to the issue of water scarcity provides the opportunity to shape politics and culture. He reinforced the importance of measurement in establishing accountability, especially the merits of the utilities information system for providing timely organisation-level information on water usage. This resonates with this thesis's notion of corporate water management systems. I agree with Egan's concern that despite these achievements, water accountability still has a long way to go to link to core accountability because of its financial significance to the organisation. However, it is meaningful to observe the evolving process how water information creates a dialogue and informs accountability among related parties. Hazelton (2014)

asserted the importance of water labelling for products to corporate water accountability at the level of the supply chain. Although one cannot guarantee the accuracy with which water allocations to products are measured, especially given issues of water recycling, water metering, and other technical problems, water information is meaningful in representing the market forces driving sustainable outcomes.

The U.K. context

Cooper and Slack (2015) investigated water leakage disclosure among water and sewerage companies in the United Kingdom. Water leakage information is considered a key regulatory metric for this industry, and almost all companies voluntarily disclose it in their annual reports. Therefore, it provides an interesting context for studying the impressions of management by comparing the annual report and government official record. This research setting is innovative because water information is still not widely disclosed in annual reports and is not a key metric for evaluating corporate performance. Cooper and Slack's (2015) paper investigated the impressions of management from the narrative sections of annual reports, whereas this study has more of a quantitative focus. Moreover their study does raise a pertinent question about the increasing regulatory force to improve water management at every possible level.

The U.S. context

The mandatory disclosure of water quality information has also been explored among U.S. water supply companies. Existing findings on public benefit disclosure programs suggest that mandatory information disclosure educates consumers to reward environmentally friendly companies; therefore, companies that produce goods directly for consumers will be more likely to change their behaviour. Based on this notion, Benneer and Olmstead (2008) studied the requirement for water suppliers in the United States 1996 to mail their consumers directly about the quality of their drinking water. They compared the behaviour of 517 water suppliers in the United States before and after the mandatory information disclosure rule took effect and found a significant reduction in violations of drinking water standards. The implication of their research for this thesis is that water information is becoming more strategically important to some industries, like beverages, because their products are closely linked to consumers.

Other contexts

Water issues such as regulation and water quality issues tend to be site specific (Institute, 2009). Implications can be drawn from different jurisdictions. Huang and Chen (2015) conducted an empirical study investigating how information disclosure will affect “three waste”⁶ reduction in China. They found that the national industrial wastewater per unit industrial gross domestic product declined by 43.84% from 2005 to 2010. However, this reduction was not significantly driven by voluntary environmental disclosures made by listed companies in related provinces. Their findings suggest that regulatory mechanisms such as administrative penalties and forced closed and migrated dirty enterprises are more effective at reducing the discharge of waste. Moreover, compared to gas waste and solid waste, wastewater reduction is more influenced by complaints and is associated with the proportion of state-owned enterprises.

Burritt et al. (2016) explored the drivers of water information disclosure among 100 Japanese companies. They found that large companies with less concentrated ownership that operate in water-sensitive industries tend to release more information. Their findings support the managerial branch of stakeholder theory which argues that stakeholders are the main source of pressure. Although Japan does not face severe water risks, many Japanese companies are large virtual water importers. Sharing water-related information with suppliers facilitates better water management through the value chain.

Regarding the research methodology adopted, some researchers have taken a qualitative approach because of a lack of quantitative data. For instance, Christ and Burritt (2017) conducted a literature review on corporate water accounting and specifically focused on internal water management rather than external water reporting. They used Google and Google Scholar engines to search and select related academic and nonacademic studies and reports. In addition, they distinguished corporate water accounting from corporate external reporting to emphasise the managerial function. Also relying mostly on a literature review, Larson et al. (2012) summarised the financial tools and contemporary management practices that can help companies to mitigate water risks.

⁶ The three wastes are wastewater, gas waste, and solid waste.

3.3.3 Challenges to water management–related studies

A review of the recent published literature suggests that the majority of water studies aim not only to resolve environmental problems such as water shortages or water contamination but also to address social and economic concerns more broadly. This is because water is essential and valuable for public health, economic growth, as well as the living environment. Parties with different interests interact with each other around water issues, and there are thus unavoidable inequalities and conflicts in water resource disputes. How information can facilitate efficient resource allocation and what soft science such as management innovation can do to improve the situation are at the centre of this thesis. This thesis uses a renewed global focus to explore the pattern of general corporate disclosure among different industries. The objective of the study is to explore why some companies take the initiative to manage their water use and what deters others from doing so. Thus, it follows a line of research investigating why and how companies disclose water information and management practices and what the consequences are.

Although the extant literature provides useful insights into issues such as what constitutes contemporary water accounting (Christ and Burritt, 2017), existing studies have also attempted [corporate environmental communication](#) to tackle challenges to water management from different perspectives. Some scholars, such as Hazelton (2013), have expressed concerns that water reporting at the corporate level is problematic and meaningless and therefore provides less relevant information for solving real environmental issues. From the perspective of regulation and governance, it is far from settled whether soft law or the implementation of global standards can improve reporting quality (Hahn and Kühnen, 2013). As water disclosure is largely voluntary, the credibility of the information is a major concern. *Credibility* refers to the congruence between a source's verbal claims and corresponding acts and events. A number of environmental reporting studies have hinted at credibility issues with regard to corporate environmental communication (Aerts and Cormier, 2009, Cotter and Najah, 2012).

Criticisms of current practices also include the lack of regionally disaggregated information as well as standardisation (ACCA, 2010). The CDP is a general reporting

framework that is not helpful for developing strategies for reducing area-specific risks (Larson et al., 2012). This thesis takes these concerns into account, but its focus is different from that of existing papers. Water disclosure at the level of the corporation remains voluntary. But the importance of this issue cannot be denied. Water management and disclosure are relatively less explored and have the potential to be significant topics given the development of technology and the worsening environment. Thus, the current research is expected to have implications for the development of mandatory public disclosure policies for specific industries. This thesis provided empirical evidence on water disclosure and management that would help regulators and corporate directors to understanding the current practice in water disclosure and water resource control and improve water consumption efficiency.

3.4 Concluding remarks

This chapter has served as a road map for this thesis, with its comprehensive review of the literature on general environmental and water management–related studies. This review suggests that water accounting and water disclosure are emerging as important management tools, though there is a lack of empirical research in the literature (Christ and Burritt, 2017). Based on the existing framework and theory, this thesis takes the perspective of governance and regulation and utilises information of corporate voluntary disclosure through the nongovernmental institution the CDP. By doing so, it contributes empirical evidence to the conceptual issues such as how much authority should be given to companies themselves to manage their water and how to empower external stakeholders other than governments to regulate external reporting. This study chooses the CDP as its research focus because its international coverage facilitates study of the influence of country of origin and different regulatory environments that are rarely explored (Hahn and Kühnen, 2013). This chapter has focused on a range of prior research and themes that are most relevant to the current research project. From a practical sense, to improve the efficiency of water usage, top managers need to prioritise water management higher up on the corporate agenda. In other words, the success of water management systems relies on bottom-up data with top-down command and control. This chapter has considered both long-standing as well as current conceptual frameworks for water reporting and the controversies surrounding social and environmental accounting. The complicity of water issues breeds new theory and ideas that shed light on current practices. Prior studies provide strong

evidence of what motivates managers to take environmental initiatives. Although a lot of studies focus on environmental and carbon disclosure, there is limited empirical evidence on how companies disclose water information and what main incentives drive proactive water management activity and disclosure. The extant literature in section 3.4 provides useful insights into issues such as what constitutes contemporary water accounting. In addition, this study adopts some new techniques, such as distinguishing different types of disclosure, which has rarely been done in prior literature. Overall, this thesis attempts to extend this stream of research to water accounting, management, and disclosure, a new area of study, by using CDP data to undertake a comprehensive investigation of the topic.

Chapter 4 considers factors that have been identified as positively associated with disclosure according to the research discussed in section 3.2 and considers new factors, such as governance structure, to supplement current research. Prior studies have focused on material business risks brought about by pollution, but there is limited evidence of how water risks are mitigated and water opportunities are utilised strategically at the management level (ACCA, 2010). To fill these gaps in the literature, Chapter 5 develops a water self-regulation system based on carbon management systems and carbon management systems reviewed in section 3.3 and develops more practical hypotheses. The CDP's framework shows promise as a template that can be tailored according to corporate needs to become an efficient self-regulation strategy (Dubbink et al., 2008). Chapters 4 and 5 together explore the link between transparency and self-regulation.

Chapter 4 Motivations of Voluntary Water Information Disclosure

4.0 Introduction

The previous chapters have justified the research design and discussed related studies in this area. Chapters 4 and 5 each address three research questions, respectively, with different designs and methods. The purpose of this chapter is to determine influencing factors associated with the voluntary disclosure of water information. Specifically, how do internal and external regulations influence corporate decisions? And how do they interact with each other?

This chapter begins with a description of what motivates this study and then develops hypotheses, using multiple theories, in Section 4.2. The research design and sample selection are explained in Section 4.3. Empirical models and definitions of variables are presented in Section 4.4, and empirical results and concluding remarks are given in Section 4.5.

4.1 Motivations of the study

As mentioned in Chapter 2, one advantage of the CDP is that it provides discretion on the sharing of information. Specifically, companies are allowed to choose whether to make their submitted data public or only available to institutional investors (hereafter “private disclosure”). Such choices themselves are caused by different motivations. Previous studies on motivation simply treat private disclosure as partial disclosure, grouping it either with no disclosure or with public disclosure (Luo *et al.*, 2012, Luo *et al.*, 2013). Although transparency is often the stated aim of these disclosures, many earlier researchers have argued that the process of disclosure enables a somewhat falsified representation of an organisation (Hines, 1988). Thus, this study concentrates on the corporate attitude towards the audience with whom that information will be shared. In other words, it focuses on the manner of disclosure, rather than the content.

As stated in Chapter 2, legitimacy theory and stakeholder theory are often used in such research. However, little is known about other incentives that may lead to the more sophisticated forms of self-regulation and disclosure. Particularly, the emergence of sustainable self-regulation and voluntary disclosure with regard to water-related information is a complex notion, with reference to which the motivation of disclosure needs to be addressed. Correspondingly, this empirical test aims to provide evidence in support of self-regulation theory, in the context of water information disclosure choice.

4.2 Hypotheses development

4.2.1 Self-regulation (H1)

This section develops hypotheses according to external and internal theories mentioned before. As mentioned in Chapter 2, self-regulation theory depicts how the environmental orientation toward water efficiency determines the type of disclosure. The motivation of self-regulation is to pre-empt ever-tightening legislation (Glachant, 2004). Although there are a lack of regulations and legislative reforms requiring companies to save water resources and release water information through annual reports, water-resource protection, and especially water information, is now regulated through national acts in developed countries. Therefore, it is plausible to adopt voluntary disclosure practices such as CDP reports to signal good water management and thus bargain for less stringent mandatory regulations. According to voluntary disclosure theory, being a member of a group of self-regulating institutions is meant to reflect leadership in sustainability (Cho *et al.*, 2012, Fowler and Hope, 2007). The CDP's link to financial markets manifests the investors' emphasis on long-term sustainable profitability. Because the CDP has a reputation in carbon management and recently established another comprehensive water disclosure program, it attracts companies that already have good self-regulation practices to continue to promote their sustainable advantages and establish consistency.

Firms that disclose water information tend to be aware of environmental problems and to have a conscience of ecology protection. Because water is one dimension of environmental issues, managers must have an overarching philosophy and pro-environmental orientation that leads the management team to take action against exposure to water risks and liabilities. Such an environmental orientation is important but is not directly observable and thus an empirical proxy must be identified. Corporate environmental issues are not solved alone but are often integrated into the environment, social, and governance (ESG) theme to promote sustainability. Therefore, this study constructs a self-regulation index with four concrete aspects and a main focus on water management. This leads to the following hypothesis:

H1: All other things equal, firms with the highest levels of self-regulation will participate fully in a water program.

4.2.2 Environmental regulations (H2)

The central point of this thesis, as well as the purpose of self-regulation theory, is to show how regulation influences business decisions regarding water. As depicted in Chapter 2, regulations are often discussed in terms of legitimising, and can influence disclosure directly, while self-

regulation provides a way for companies to use voluntary disclosure as a tool to avoid potential strict regulations. Water-resource management is an important issue of overall environmental regulation. To test the legitimising effects of regulation, the first regulatory element selected at the national level is the stringency of environmental regulation. The degree of the stringency of regulation requirements varies between countries. To find the relationship between the propensity for water disclosure and the stringency of environmental legislation and regulation, an international setting is required, as no comparison between levels of environmental legislation and regulation is possible without it.

As mentioned in Chapter 3, studies have found that environmental policy may influence the economic performance of companies. A regulatory threat may negatively impact a firm's expected cash flow, which may in turn reduce its market value because that firm may incur future contingency liabilities and implicit compliance costs (Blacconiere and Patten, 1994, Freedman and Patten, 2004). Corporate policy, due to pressure from the society, has to ensure full compliance with the law. Intuitively, companies located in regions with more stringent laws have higher regulatory risks and are more likely to make public disclosures. Therefore, as legitimacy theory predicts:

H2: All other things equal, companies operating in a country with a higher level of stringent environmental institutions are more likely to produce public reports on water usage.

4.2.3 Water consumption (H3)

Apart from self-regulation, this study also considers other factors that may also impact decisions concerning water disclosure. Many studies have identified factors such as chemical waste, environmental damages, carbon emissions, and other firm-specific variables associated with disclosure (Halme and Huse, 1997, Adams *et al.*, 1998, Cowen *et al.*, 1987, Gray *et al.*, 1995a). Water consumption is a dominant factor in water management, which has not been widely tested. This element is important, in that it is indicative of regulatory emphasis. The author of a prior study (Ceres, 2010) has suggested that firms in water-sensitive industries require significant quantities of water and have large wastewater discharges, varying with respect to their own operations, the supply chain of raw materials, and the use of the end products of such materials; therefore, these firms can be more severely affected by water crises and are exposed to higher contingent liability. It is plausible that such firms are more inclined to mitigate the negative impact of the unsustainable use of environmental resources. The operation of these companies, in return, causes more substantial influence on the climate; therefore, they are subject to more stringent regulations. It can be inferred that companies experiencing more pressure will legitimise themselves as well as their industrial performance

by increasing disclosure (Deegan and Gordon, 1996a). For example, the Minerals Council of Australia (MCA) has developed a water-accounting framework to assist its members to account for, report on, and compare site water-management practices. One of its purposes is to help “regulators to quantify water quality and therefore support water-access pricing arrangements” (Baas, 2007).

The CDP (2010) identified eight water-intensive sectors. Among these, this study has further identified the five most water-intensive industries, based on average water intensity: energy; materials; food, beverage, and tobacco; pharmaceuticals, biotechnology, and life sciences; and utilities. The following hypothesis is presented:

H3: All other things equal, companies operating in water-intensive sectors are likely to produce public reports on water information.

4.2.4 Investor protection (H4)

Water-information reporting supports investor decision procedures. This demand is stronger in a country that has a tradition individual investor protection. A large number of studies document evidence showing that investor-protection mechanisms are positively associated with environmental disclosure. Companies are embedded in a wide array of political, economic, and social institutions that affect their behaviours (Campbell, 2007), and they respond to external pressures from multiple sources. The legal system forms an institutional framework that directly or indirectly influences corporate disclosure. The nature and structure of existing water-related regulations and laws may vary substantially between countries. Potential water-related risks may be reflected in contingent liability in the form of, for example, lawsuits with communities. The impact of climate change has made companies more accountable: regulations related to carbon tend to internalise this externality through carbon taxes and the trade of carbon permits. From a long-term perspective, industries will face more stringent regulations in social and environmental practice and disclosure. As both water-related regulations and investor protections fall under the influence of the generic law system, the distinction between common law and civil law is used as an external regulatory element. As discussed in Chapter 3, opinions vary on how the legal system is able to influence corporate decisions with regard to environmental disclosure. Hypothesis 4 is developed following La Porta’s view.

H4: All other things equal, companies operating in a country with strong legal protections for individual investors are more likely to report on water information to the public.

4.2.5 Water source (H5)

It is estimated that demand for water will outstrip supply by 40%, and half of the population of the world is likely to live in areas of high water stress by 2030 (CDP, 2010). Therefore, corporate decisions regarding water transparency should be linked to the availability of water resources at the country level. Companies are responsible for their impact on water resources, particularly when operations directly impact public access to water in regions with water scarcity and slack regulations (Lambooy, 2011). Access to safe drinking water is a basic human right (Ceres, 2009). The US Safe Drinking Water Act mandates that water companies report water-quality issues to consumers (Benear and Olmstead, 2008). Based on legitimacy theory, companies therefore make efforts to communicate water information to impress the general public and regulators (Ogden and Clarke, 2005). This means that if a company's fresh water consumption pattern deprives local people of access to fresh water it would be a human rights' violation, which could be grounds for corporate liability. It can be argued that if a company is located in a country where local people have difficulty accessing safe water, the company is likely to be under great pressure to account for the impact of its operations on water resources. In these countries, the public, stakeholders, the government, and the community at large will demand more water information from local companies. Thus, an inverse association is expected between the degree of access to safe water resources and the propensity for voluntary water disclosure. Conversely, if a nation has abundant water resources, residents may not show as much concern over water shortages, and thus they may not desire water information.

In this study, the variable WATERSOURCE measures the degree of access to fresh water. Its coefficient is conjectured to be negative. Thus Hypothesis 5 is as follows:

H5: All other things equal, companies operating in a country where less people have access to water resources are more likely to disclose water information publicly.

4.2.6 Institutional investors and private disclosure (H6)

There is a large body of literature on corporate governance emphasising the role of institutional investors in corporate decisions. As stated in Chapter 3, institutional investors have increased incentive to be concerned about managerial decisions; they often have more inside information about the company through private disclosures. As a result, they should have additional channels to influence management. From the perspective of managers, institutional investors are often important stakeholders, and their demand for information is actively responded to. In

this context, the signatories of the CDP organisation are large institutional investors who sponsor CDP for carbon- and water-disclosure programs. Thus, these signatory companies will receive additional private disclosures together with public disclosures. Secondly, companies that have disclosed water information only to CDP sponsors through private disclosure are more likely to have better self-regulation records than non-disclosing companies. This is because firms with poor self-regulation records have less or no incentive to advertise their real performance or impress the public. However, if firms have average self-regulation records, they may be willing to disclose their reports to institutional investors privately. In doing so, they convey a genuine attempt at participation without releasing an imperfect record that may otherwise irritate large stakeholders and the public. Their reporting will also distinguish them from the worst performers. Thus the last hypothesis is that:

H6: All else equal, companies with average self-regulation efforts prefer to disclose information privately rather than not to disclose.

4.3 Research Method

4.3.1 Construction of the self-regulation index

As stated in Chapter 2, self-regulation practices take various forms including common rules, codes of conduct, VAs, and so forth (Communities, 2002). As a result, it is difficult to capture and measure self-regulation orientation directly. The self-regulation index is based on a variety of theoretical perspectives. As voluntary disclosure theory predicts, management effort is a key determinant of disclosure. Therefore, the strategy of this study is to construct a system that can be used to evaluate the effort or initiatives taken by companies to manage their water resources. Conceptually, there are many perspectives that can represent corporate self-regulation effort. In this study, four subsets of overall environmental activities are selected to construct the overall orientation of self-regulation. Intuitively, these aspects show the emphasis that management has placed onto environmental (including water) issues, which may have a positive influence on the decision to disclose.

Because this part of the study uses data from firms with no disclosure, water information can only be gathered indirectly from self-disclosed sources, such as annual reports, sustainability reports, and corporate websites. Based on this publicly available information, a self-regulation index, or a preliminary evaluation of the WMS, is constructed, composed of four pillars. These are as follows: the existence of an environmental or CSR committee, water-efficiency policies,

initiative to improve water efficiency, and the integration of water into performance evaluations. The following section rationales the selection of variables from both theoretical and theoretical perspectives. The construction of variables is explained in later sections. To operationalise water-management practices, companies need to define objectives to mobilise employees, make financial and managerial investments, and reward successful performance (Ameer and Othman, 2012). Intuitively, these aspects reflect the emphasis put on sustainability and water, which may have a positive influence on the decision to disclose in CDP water programs.

4.3.1.1 CSR committee

One pillar of regimes of self-regulation falls into the realm of corporate governance. Ownership structures and boards of directors are often cited as important elements in the governance of large corporations, for every facet (Fama and Jensen, 1983, Eisenhardt, 1989). Specialised committees are in a better position to gather water-specific data, and firms possessing these readily disclose required information to external institutions. Roberts (1992) has suggested that social responsibility disclosures and corporate political action committee contributions may be aspects of a comprehensive corporate scheme for managing government stakeholders. The existence of a CSR committee has been found to be associated with human resource disclosures (Cowen *et al.*, 1987). Because water is merely one aspect of environmental issues, some companies may not necessarily make commitments or create specialised departments and staff for water. While the presence of a social responsibility committee has not been cited explicitly in the literature as a reason for water-responsibility disclosure, it is arguable that the existence of such committees at the board level is strong evidence for a self-regulation orientation supporting the sustainability strategy and taking into account water-related risks and opportunities. A specialised environmental committee is likely to be authorised by the board of the directors to develop self-regulation policy, oversee the environmental strategy, and manage climate risks and opportunities in general (Roberts, (1992), even having a direct impact on environmental and water disclosures (Cowen *et al.*, 1987). Such a sustainability committee would probably address overall environmental issues and be responsible for gathering water-specific data on the corporate level. Thus, it is expected that these firms more readily disclose required information to external institutions, and a positive relation is expected between the existence of a sustainability committee and voluntary water disclosure.

4.3.1.2 Policy

A strategy declared by a committee without a clear and explicit policy will be difficult to implement. To put water management into effect, managers at higher levels need to define objectives to mobilise employees, make financial and managerial investments, and reward

successful performance (Ameer and Othman, 2012). As an important dimension of strategy, water-specific policies set explicit water strategies, targets, and goals leading to positive actions. Some companies use both qualitative and quantitative goals to achieve efficiency. It has been found that 83%⁷ of respondents in the 2013 CDP survey set concrete targets that focus on reducing water consumption and/or increasing water recycling (CDP, 2013b). This is evidence of a strong commitment to transparency. Firms declaring such targets tend to report their results and to fulfill their promises. Therefore, it is hypothesised that firms with water-specific policies tend to be more transparent with disclosure policy.

4.3.1.3 Actions or initiatives

Setting water-saving policies and targets is the first step to water management; companies must also take actions to achieve these stated goals. The existence of water actions and initiatives is another indicator of a commitment to self-regulation. Water actions include all activities and programs, such as water reuse, leakage control intended to improve water resource efficiency, reducing waste of water resources, and enhancement of water-management quality. Large water-saving projects often involve substantial financial investment, which may not have direct and short-term monetary benefits. This is a significant activity of self-management for water protection. Putting it another way, the adoption of such water initiatives is strong evidence of a self-regulation orientation.

4.3.1.4 Performance evaluation

Eco-efficiency has been well recognised as a practical criterion for the use of natural capital, such as water (Dyllick and Hockerts, 2002), and thus some firms include water efficiency as an indicator of overall performance, directing managerial effort toward productive efficiency. Companies use compensation packages to encourage decision makers to set a better balance between the goals of growth and sustainability. It would make sense for a CEO to earn a payout based on achieving a planned growth rate while reducing environmental costs by a planned percentage (Kotler, 2011). Water efficiency is usually measured as the ratio of water consumption to financial or operational data. The evaluation of water performance is used to guard against undesirable behaviour and to encourage constructive actions, so as to unlock the potential of employees and managers. Thus, if a company integrates water-efficiency evaluation into an overall management evaluation system such as the Balanced Scorecard (BSC) or the Key Performance Index (KPI), it will be treated as an evidence of the orientation towards self-regulation in water utilisation. Outcomes of the evaluation will not only provide the

⁷ This compares favorably to the results of a previous study published in Ceres (2010) which found that only 21 (15) out of 100 large companies investigated disclosed quantified targets to reduce water use (reduce wastewater discharge).

feedback for the direction of future water management but also have a direct impact on the disclosure of water information, as such a process makes water-use, recycling, and consumption data available for the preparation of the CDP water report. Correspondingly, a theoretical link is conjectured between self-regulation and a water-performance evaluation.

The arithmetic summation of four individual measurements of the self-regulation orientation forms an overall self-regulation index. For example, if a firm creates an environmental committee in its board of directors, adopts water policy, takes initiative in water efficiency, and incorporates water-performance evaluation, it will be assigned a full four for its value of the self-regulation index. According to stakeholder theory and voluntary disclosure theory, it is to be expected that firms with better water management are more likely to have lower marginal costs of participating in the CDP program. This is because such firms are better positioned and staffed to provide the exact information to the CDP on its request.

Another important and difficult question is whether there will be dishonest responses, or an intention to “greenwash” the record. The discourse of self-regulation can be motivated differently, such as by the desire to pre-empt regulation or to signal improved performance and the reduction of future risk; there may be free riders that have not devoted effort to such serious activities, while desiring the same benefit as participants. Prior studies are based on the assumption that the CDP provides an effective mechanism to defeat selection bias (Luo *et al.*, 2012). The standardised questions used by the CDP will easily expose companies with low-quality water management. Free riders, in this case, may find the marginal benefit of participation in the CDP’s data collection too slight compared to the risks of scrutiny by the public and institutional investors. As a result, higher performers believe they can be distinguished from poor performers by participation. For the same reason, we predict that firms with the highest level of self-regulation will participate fully in the water program. A firm with the lowest level of water management will have the highest marginal costs to achieve real water sustainability; thus, it would be rational for it to reject the invitation and hide its water activity. Average firms thus would choose private disclosure, a middle course. In doing so, they manage to show commitment without granting the public full exposure.

4.3.2 Sample selection

As mentioned earlier, the data comprise all companies invited to participate in the CDP water program from 2010 to 2013. Before the formal establishment of the CDP water program, a pilot study is conducted with a few notable companies involved. Because the design of the questionnaire was quite different in 2009 and there were few participants, data from that year

are excluded. The year 2013 is the last year data are available for this thesis⁸. Large firms⁹ receive greater attention, because they often consume a substantial quantity of water and have high pressure and expectations from the public. In this thesis, the data are sourced from the CDP water program for the years 2010 to 2013, during which time more than 700 companies from about 40 countries were invited to participate. After excluding 18 subsidiary companies, more than 300 companies with missing data, 6 companies in the financial industry, and 27 in countries with less than five observations, the final sample contains 1,587 firm-year observations. The sample-selection process is illustrated in Table 4.1.

Table 4.1 Sample selection

Year	Observations	Total
2010	302	
2011	421	
2012	652	
2013	<u>646</u>	2021
Excluded Subsidiary company	(18)	
Missing data	(383)	
Finance industry	(6)	
Remaining companies in countries with less than five	(27)	
Total deduction		<u>(434)</u>
Sample used		<u>1587</u>

4.3.3 Model specification

In this section, different methods are developed to predict corporate decisions with regard to different types of disclosure. Many studies have used binary logistic regression to test whether or not a company will disclose its information (Luo *et al.*, 2012). Following prior literature, the first model will be examined through binary logistic regressions because of the categorical

⁸ If possible, this thesis will be updated to include more observations in the future.

⁹ The companies invited are among the largest listed companies worldwide in eight water-sensitive industries, including companies from the Global 500, the top 500 in the USA, the top 100 in Australia, and the top 100 in South Africa, based on market capitalisation.

nature of the dependent variable. No binary logistic model is formulated for the “No disclosure” category, resulting in two groups of models (n-1) (Bazarova and Choi, 2014).

$$\begin{aligned} \text{Pr (TRANSPARENCY)} = & \beta_0 + \beta_1 \text{SELFREGULATION} + \beta_2 \text{STRINGENCY} + \beta_3 \text{WATERINTENSIVE} \\ & + \beta_4 \text{INVESTORPROTEC} + \beta_5 \text{WATERSOURCE} \\ & + \beta_6 \text{GDP} + \beta_7 \text{SIZE} + \beta_8 \text{FIN} + \beta_9 \text{ROA} + \beta_{10} \text{LEV} + \beta_{11} \text{CAPIN} + \beta_{12} \text{NEW} \\ & + \beta_{13-21} \text{IND} + \beta_{22-24} \text{DYEAR}_{2010-2012} + \varepsilon_{it} \end{aligned}$$

4.3.4 Dependent variable

To compare the effects of conditions on the probability of a company choosing a specific response status versus all other statuses, a set of binary logistic models are constructed in the following tables. The dependent variable TRANSPARENCY is a binary variable proxying choice of water disclosure. This variable is coded differently in each pair comparison. In the first set of models, firms with public disclosure are compared to those with private and no disclosure; therefore, this variable is coded as 1 if the company opts to disclose publicly and as 0 for private and no disclosure (no response, declined to participate, or provided limited information). In the second set of models, firms with private disclosure are compared to those with no disclosure and public disclosure. Private disclosure here is coded as 1 and 0 if public or no disclosure. In the last set, no disclosure is coded as 1 and public and private disclosure as 0. This design is consistent with Bazarova and Choi (2014).

4.3.5 Explanatory variables

4.3.5.1 Self-regulation (H1)

Self-regulation is the main explanatory variable measuring the orientation to corporate self-regulation. Four pillars of internal self-regulation are employed to represent managerial effort to improve environmental management in general as well as water-specific performance. The self-regulatory effort is measured by four drivers, including *Governance*, *Policy*, *Initiatives*, and *Evaluation*. Each of the four dependent variables are sourced from the Thomson Reuters ESG database. For this analysis, SELFREGULATION1 is set equal to 1 if the company has an environmental committee as governance. SELFREGULATION2 is coded as 1 if the firm has some water-related policies and 0 otherwise. SELFREGULATION3 is another dummy variable, coded a 1 if the firm has claimed to have taken initiatives to improve water efficiency. SELFREGULATION4 is coded as 1 if the firm has claimed to use KPIs or the BSC to monitor and evaluate water performance. SRINDEX is the algorithm summation of the four individual

self-regulation variables without applying any weights. This variable is constructed to test H1 that self-regulation effort is positively linked to higher transparency of water disclosure. This integration method is common in evaluating performance and efforts (Niemeijer, 2002), as well as CSR commitment (Clarkson *et al.*, 2015).

4.3.5.2 Stringency of environmental regulation (H2)

STRINGENCY is a proxy for the level stringency of the environmental law of a specific country and is designed to test H2: whether regulation will influence voluntary water disclosure. This variable is obtained from the Travel & Tourism Competitiveness Report issued by the World Economic Forum. It is based on the average of the responses from the questionnaires question “How would you assess the stringency of your country’s environmental regulations?” The range is from one to seven (one being very lax; seven being among the world’s most stringent) (Lyon and Maxwell, 1999). This approach is valuable in a cross-country context and is used in many studies on the stringency of environmental regulations, such as its association with economic success (Esty and Porter, 2005), foreign direct investment (Spatareanu, 2007), and technological innovation (Johnstone *et al.*, 2012).

4.3.5.3 Water consumption (H3)

WATERINTENSIVE is a proxy for the level of water consumption. It is a dummy variable coded as 1 if the firm belongs to an industry that requires a large volume of water in operation. Such industries include energy, materials, food, beverage, tobacco, pharmaceuticals, biotechnology, life sciences, and utilities, as suggested by the CDP water program. This classification is consistent with other studies (ACCA, 2010).

4.3.5.4 Investor Protection (H4)

INVESTORPROTEC is a dummy variable used to denote the protection of individual investors. It is measured by the legal system of the country where a company’s headquarters is domiciled, and is coded as 1 for common law and 0 for civil law.

4.3.5.5 Water source (H5)

WATERSOURCE¹⁰ is a variable measuring the percentage of the rural population using an improved drinking water source (Alvarez-Larrauri and Fogel, 2008).

¹⁰Improved drinking water sources include piped water on premises (piped household water connection located inside the user’s dwelling, plot, or yard), and other improved sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection).

4.3.6 Control variables

4.3.6.1 GDP

Control variables are selected based on prior literature on financial disclosure and on environmental disclosure. Intuitively, there is a positive impact on the level of disclosure and reporting practices in a given country as the level of economic development increases (Doupnik and Salter, 1995). Because of the international setting of this study, variable GDPP, measured as the natural logarithm of GDP per capita, controls for country-specific effects on public disclosure. The period considered here is 2009 to 2012.

4.3.6.2 Size

As mentioned before, size is an important factor for disclosure and most related research controls for firm size (Lang and Lundholm, 1993). This is based on the assumption that larger firms will achieve economies of scale and have lower costs for information production. Following Clarkson *et al.* (2008), the variable *SIZE* is measured here as the natural logarithm of total assets as of the end of the previous fiscal year.

4.3.6.3 Finance

FIN denotes the debt and equity financing raised by the firm in the fiscal year before the CDP water program. Following Clarkson *et al.* (2008), FIN is calculated as the sale of common stock and preferred shares minus the purchase of common stock and preferred shares plus long-term debt issuance minus long-term debt reduction. The amount is scaled by the amount of total assets at the end of the previous fiscal year.

4.3.6.4 Earning performance

ROA is used as a proxy for earning performance. It is calculated as the ratio of income before extraordinary items to total assets at the end of the previous fiscal year.

4.3.6.5 Leverage

LEV is the leverage ratio. Consistent with Clarkson *et al.* (2008), it is measured as the ratio of total debt scaled by total assets at the end of the previous fiscal year.

4.3.6.6 Capital expenditure

CAPIN is the capital intensity, measured as the ratio of capital spending scaled by total sales revenues at the end of the previous fiscal year (Clarkson *et al.*, 2008).

4.3.6.7 Newness of fixed assets

The variable NEW is constructed to control for the newness or the average age of a firm's equipment. NEW is measured as the ratio of net properties, plants, and equipment, divided by the gross properties, plants, and equipment at the end of the previous fiscal year (Clarkson *et al.*, 2008).

4.3.6.8 Industry and year effect

Industry is an important factor on disclosure. Clarkson *et al.* (2008) assert that industry serves as a measure of proprietary costs, because pollution propensity and related monitoring by opponents is known to vary by industry. As mentioned earlier, the practice of self-regulation tends to be more consistent among firms in the same industry facing similar physical and regulatory risks. To control for different proprietary costs and other unidentified factors, this setting uses eight industry dummy variables. Because the research setting uses pooled observations, the year effect is controlled using four dummy variables.

A summary of the variables and corresponding hypotheses is shown in Table 4.2. All non-binary variables are winsorised at the 5% level.

Table 4.2 Description of variables of motivation

	Name of Variable	Definition	Prediction	H
Dependent variable	<i>TRANPARENCY</i>	category variable; coded 1 if the firm has publicly disclosed water information		
Independent variables firm-level	<i>SELFREGULATION1</i>	whether the company has established a Corporate Social Responsibility committee	+	H1
Self-regulation initiatives	<i>SELFREGULATION2</i>	dummy variable, coded 1 if the firm has some water-related policies and 0 otherwise	+	H1
	<i>SELFREGULATION3</i>	if the companies take some water-efficiency initiative that year, its ACTION will be 1 and 0 otherwise	+	H1
	<i>SELFREGULATION4</i>	dummy variable, coded 1 if the firm has claimed to use key performance indicators or the balanced scorecard to monitor water efficiency	+	H1
	<i>SRINDEX</i>	the algorithm summary of SELFREGULATION1–4	+	H1
Environmental Regulatory pressure	<i>STRINGENCY</i>	index measuring the stringency of environmental regulation in one country; it ranges from 1 (very lax) to 7 (among the world's most stringent)	+	H2
	<i>WATERINTENSIVE</i>	dummy variable, 1 represents membership to one of the water-intensive industries and 0 otherwise	+	H3
Country-level factors	<i>INVESTORPROTECTION</i>	dummy variable, coded as 1 if the firm's headquarters is based in a common-law country and 0 otherwise	+/-	H4

	<i>WATERSOURCE</i>	the percentage of the rural population using an improved drinking water source in a specific country	–	H5
Interaction	<i>STRINGENCY_SR</i>	STRINGENCY*SRINDEX	–	
	<i>WATERINTENSIT Y_SR</i>	WATERINTENSIVE*SELFREGULATION	–	
Control	<i>GDP</i>	natural logarithm of GDP per capita	+	
	<i>SIZE</i>	natural logarithm of total assets	+	
	<i>FIN</i>	debt and equity financing raised by the firm, scaled by the size of total assets	+	
	<i>ROA</i>	ratio of income before extraordinary items and total assets	+	
	<i>LEV</i>	leverage ratio, measured as total debt divide by total assets	+	
	<i>CAPIN</i>	capital intensity measured as the ratio of capital spending to total sales	+	
	<i>NEW</i>	measured as a ratio of net properties, plants, and equipment divided by the gross properties, plants, and equipment at the end of the previous fiscal year	+	
	<i>INDUSTRY</i>	industry dummy variable based on GICS two-digit industry classification		Control
	<i>YEAR</i>	year dummy variables for 2011–2013		Control

4.4 Results

4.4.1 Descriptive results

Table 4.3 shows the descriptive statistics of the variables. The mean of the dependent variable TRANSPARENCY differs among the three sets of models. If we take the 2013 CDP water survey for example, 39.67% of companies answered the questionnaire and disclosed their water information to the public, and 8.75% chose to privately disclose to the CDP and signatory institutional investors only (“private disclosure”). The remainder and majority (53.27%), however, either declined to participate, provided quite limited information, or did not respond.

Table 4.3 Descriptive statistics of motivation

Variables	N	Mean	Standard deviation	Min	p25	Median	p75	Max
SELFREGULATION1	1587	0.79	0.41	0	1	1	1	1
SELFREGULATION3	1587	0.71	0.46	0	0	1	1	1
SELFREGULATION2	1587	0.62	0.49	0	0	1	1	1
SELFREGULATION4	1587	0.39	0.49	0	0	0	1	1
SRINDEX	1587	2.50	1.38	0	1	3	4	4
STRINGENCY	1587	5.32	0.56	3.3	5.2	5.4	5.5	6.6
WATERINTENSIVE	1587	0.53	0.50	0	0	1	1	1
INVESTORPROTECT	1587	0.73	0.44	0	0	1	1	1
WATERSOURCE	1587	97.27	5.10	63	98	98	100	100
GDP	1587	10.61	0.54	9.00	10.70	10.79	10.79	11.13
SIZE	1587	9.80	1.22	7.53	8.87	9.85	10.70	11.88
FIN	1587	0.00	0.05	-0.11	-0.03	0.00	0.02	0.12
ROA	1587	0.08	0.06	0.00	0.04	0.07	0.12	0.21
LEV	1587	0.22	0.14	0.00	0.12	0.21	0.32	0.49
CAPIN	1587	0.10	0.11	0.01	0.03	0.05	0.12	0.44
NEW	1587	0.54	0.14	0.32	0.43	0.54	0.66	0.79

Statistics are presented for the full sample of 1,587 firms. *SELFREGULATION1* is a dummy and at 1 means the firm has a corporate social responsibility or environmental committee and 0 otherwise. *SELFREGULATION2* is coded as 1 if the company has some water-related policy and 0 otherwise. If the companies take some water-efficiency initiative that year, its *SELFREGULATION3* will be 1 and 0 otherwise. *SELFREGULATION4* is 1 if the firm has claimed to use key performance indicators or the balanced scorecard to monitor water efficiency. *SRINDEX* is the self-regulation index adding up *SELFREGULATION1* to 4. *STRINGENCY* is an index measuring the stringency of environmental regulation in one country. It ranges from 1 to 7. *INVESTORPROTECTION* is a dichotomous variable, being 1 if the firm's headquarters is domiciled in a common-law country and 0 if in a code law country. *WITHDRAW* is a dummy variable, being 1 if the firm operates in a water-intensive industry and 0 otherwise. *WATERSOURCE* is the percentage of the rural population with access to an improved water source. *SIZE* is the logarithm of market value and is calculated as the natural logarithm of the total asset value measured at the end of the previous fiscal year. *FIN* is the amount of debt or equity capital raised in the previous fiscal year divided by total assets. *ROA* is return on assets. *LEV* is the leverage ratio, measured as total debt divided by total assets. *NEW* is asset newness, measured as the ratio of net PPE to gross PPE. *CAPIN* is capital intensity measured as the ratio of capital spending to total sales.

The mean and median of other variables depict the basic trend in the sample. Among the four pillars of self-regulation variables, the first pillar, measuring the existence of a CSR committee in the company, has the highest popularity rate (79.1%), followed by the second element, the existence of a water policy (70.7%). A slightly lower proportion (61.5%) of firms have initiatives or actions for water efficiency (the third self-regulation element). The least common

practice is the last element, which evaluates water performance; only 38.5% of firms integrate water performance evaluations into KPI or BSC systems. The decreasing popularity rates of the four aspects of self-regulation imply that firms may adopt self-regulation following sequential steps, as mentioned previously. The sample average of INVESTORPROTECTION is 0.751, indicating that 75.1% of the sampled firms are domiciled in countries with strong protections for individual investors. The mean of WATERINTENSIVE suggests that 53.4% of the sample firms belong to industries that consume large amounts of water in their operations. Consistent with previous studies that use large firm samples (e.g., Luo et al. (2012), firm size, measured by the logarithm of total assets (SIZE), is 9.8, implying average total assets of US \$17.94 billion. The average firm has a negative financing variable, meaning that it reduces debt or repurchases shares more than it raises new financing. In addition, on average, the ROA is about 8.4% and the average leverage (LEV) is 22.4% of total assets. The average GDP per capita is US\$33,658.

Table 4.4 lists the response rates among different countries. In general, European countries have a higher disclosure rate than the rest of the world, consistent with previous findings that European companies are found to outperform other regions and countries in Asia and America (Ho *et al.*, 2012). The United Kingdom has the highest public-disclosure rate (71.25%). Germany has the second highest response rate for public (65.12%) as well as private (27.91%) disclosure among all countries. Switzerland (62.5%) and Canada (61.36%) follow close behind. None of the Chinese firms invited chose public disclosure. Mexico also has a low public-disclosure rate (12.5%). Thailand has the highest private-disclosure rate (37.5%). Several regions and countries such as Hong Kong and India have no private disclosure.

Table 4.4 Summary of disclosure rates by country

Country	Public disclosure	Private disclosure	No disclosure	Total	Public response	Private response	Stringency
Australia	52	9	72	133	39.10%	6.77%	5.70
Belgium	4	0	0	4	100%	0.00%	5.85
Brazil	4	2	3	9	44.44%	22.22%	5.14
Canada	27	1	16	44	61.36%	2.27%	5.15
Chile	0	0	2	2	0.00%	0.00%	4.70
China	0	2	12	14	0.00%	14.29%	4.06
Colombia	0	3	0	3	0.00%	100%	3.57
Czech	0	0	2	2	0.00%	0.00%	5.20
Finland	2	2	0	4	50.00%	50.00%	6.25
France	29	10	20	59	49.15%	16.95%	5.19
Germany	28	12	3	43	65.12%	27.91%	6.51
Hong Kong	6	0	22	28	21.43%	0.00%	4.14
India	10	0	12	22	45.45%	0.00%	3.85
Ireland	2	1	5	8	25.00%	12.50%	5.49
Israel	3	0	4	7	42.86%	0.00%	4.86
Italy	3	2	4	9	33.33%	22.22%	4.32
Japan	39	27	37	103	37.86%	26.21%	5.90
Luxembourg	4	0	3	7	57.14%	0.00%	6.06
Malaysia	0	0	2	2	0.00%	0.00%	5.35
Mexico	1	1	6	8	12.50%	12.50%	4.06
Netherlands	9	0	10	19	47.37%	0.00%	6.04
Norway	3	0	2	5	60.00%	0.00%	5.94
Peru	0	0	4	4	0.00%	0.00%	3.75
Russia	5	0	12	17	29.41%	0.00%	3.34
Singapore	0	0	2	2	0.00%	0.00%	5.70
South Africa	35	5	29	69	50.72%	7.25%	4.67
South Korea	5	3	14	22	22.73%	13.64%	4.34
Spain	8	1	6	15	53.33%	6.67%	4.80
Sweden	2	1	4	7	28.57%	14.29%	6.27
Switzerland	20	4	8	32	62.50%	12.50%	6.35
Taiwan	6	3	11	20	30.00%	15.00%	4.80
Thailand	2	3	3	8	25.00%	37.50%	3.84
USA	333	47	396	776	42.91%	6.06%	5.35
UK	57	3	20	80	71.25%	3.75%	5.50
Total	699	142	746	1,587	44.05%	8.95%	5.32

Table 4.5 depicts the status of disclosure among different industries. The highest public-disclosure rate (73.28%) is found in the food, beverage, and tobacco industries, followed by pharmaceuticals, biotechnology, and the life sciences (70.33%). No firms in media disclose information publicly. Automobiles and components have the highest private disclosure rate among industries (26.92%), followed by semiconductor equipment (21.05%). In general,

water-intensive industries have a higher public disclosure rate and a lower private disclosure rate.

Table 4.5 Disclosure rate summary among industries

GICS	GICS group	Water intensive	Public disclosure	Private	No disclosure	Total	Public disclosure rate	Private disclosure rate
1010	Energy	Yes	80	19	137	236	33.90%	8.05%
1510	Materials	Yes	138	27	91	256	53.91%	10.55%
3020	Food, Beverage, and Tobacco	Yes	89	3	29	121	73.55%	2.48%
3520	Pharmaceuticals, Biotechnology, and Life Sciences	Yes	64	7	20	91	70.33%	7.69%
5510	Utilities	Yes	63	4	75	142	44.37%	2.82%
2010	Capital Goods	No	66	19	100	185	35.68%	10.27%
2020	Commercial and Professional Services	No	4	0	6	10	40.00%	0.00%
2030	Transportation	No	2	0	3	5	40.00%	0.00%
2510	Automobiles and Components	No	14	14	24	52	26.92%	26.92%
2520	Consumer Durables and Apparel	No	13	8	39	60	21.67%	13.33%
2530	Consumer Services	No	15	4	8	27	55.56%	14.81%
2540	Media	No	0	1	8	9	0.00%	11.11%
2550	Retailing	No	19	3	63	85	22.35%	3.53%
3010	Food & Staples Retailing	No	28	3	29	60	46.67%	5.00%
3030	Household and Personal Products	No	19	3	6	28	67.86%	10.71%
3510	Health Care Equipment and Services	No	11	2	29	42	26.19%	4.76%
4510	Software and Services	No	18	4	35	57	31.58%	7.02%
4520	Technology Hardware and Equipment	No	33	13	30	76	43.42%	17.11%
4530	Semiconductors and Semiconductor Equipment	No	21	8	14	43	48.84%	18.60%
5010	Telecommunication Services	No	2	0	0	2	100.00%	0.00%
Total			699	142	746	1587	44.05%	8.95%

Table 4.6 presents Pearson correlation matrixes; the directions of the correlation coefficients of the key variables are generally consistent with expectations. Except for the SR INDEX and the four individual self-regulation variables, there are no correlation values greater than 0.6 between pairs of independent variables, suggesting that multicollinearity is not a serious issue in the empirical model.

Table 4.6 Correlations between variables of motivation

	STRNGN CY	WATERI NTENSI VE	INVEST ORPROT ECTION	SELFRE GULATI ON1	SELFRE GULATI ON2	SELFRE GUALTI ON3	SELFRE GULATI ON4	SR INDEX	WATERS OURCE	GDP	SIZE	FIN	ROA	LEV	CAPIN	N E W
STRNGNCY	1															
WATERINT ENSIVE	-0.062*	1														
INVESTORP ROTECTION	-0.137***	-0.01	1													
SELFREGUL ATION1	0.042*	0.156***	-0.075***	1												
SELFREGUL ATION2	0.011	0.208***	-0.151***	0.377***	1											
SELFREGU ALTION3	-0.005	0.184***	-0.157***	0.354***	0.688***	1										
SELFREGUL ATION4	0.042*	0.112***	-0.170***	0.316***	0.369***	0.352***	1									
SR INDEX	0.026	0.206***	-0.179***	0.610***	0.766***	0.793***	0.759***	1								
WATERSOU RCE	0.591***	0.020***	-0.414***	0.082***	0.103***	0.103***	0.168***	0.189***	1							
GDP	0.449***	-0.01	0.351***	-0.066***	-0.085***	-0.058**	-0.087***	-0.092***	0.158***	1						
SIZE	0.033	0.122***	-0.421***	0.258***	0.333***	0.293***	0.233***	0.349***	0.224***	-0.2098*	1					
FIN	-0.046*	0.239***	-0.093***	0.053**	0.053**	0.051**	0.024	0.044*	0.134***	-0.082***	0.139***	1				
ROA	-0.188***	-0.065***	0.074***	-0.077***	-0.039	0.013	0.006	-0.008	-0.188***	-0.132***	-0.226***	-0.235***	1			
LEV	0.027	0.166***	-0.022	0.114***	0.078***	0.04	0.064**	0.079***	0.067***	-0.012	0.217***	0.197***	-0.341*	1		
CAPIN	-0.120***	0.483***	-0.085***	0.067***	0.191***	0.153***	0.024	0.129***	0.025	-0.103***	0.200***	0.307***	-0.103***	0.145***	1	
NEW	-0.217***	0.323***	0.135***	-0.03	-0.001	-0.019	-0.086***	-0.052**	-0.075***	-0.016	0.016	0.244***	-0.054**	0.107***	0.429***	1

4.4.2 Main results

This thesis tests hypotheses using logistic regression and reports the odds ratios for the independent and control variables. This thesis also uses marginal effects to interpret the magnitude of the coefficient estimates. Table 4.7 contains the main results of a set of seven models. Model 1 (M1) through Model 7 (M7) compare the choices for public disclosure with those for private and no disclosure. A positive *Z* score indicates that one factor has a positive influence on the company choosing public disclosure rather than private or no disclosure. Model 1 includes control variables. Model 2 through Model 4 include either external or internal factors. Model 5 and Model 6 combine both, and Model 7 adds interaction variables.

Table 4.7 Binary logistic regression: public disclosure vs. other disclosure (private & no disclosure)

<i>Variable</i>	M1	M2	M3	M4	M5	M6	M7
SELFREGULATION1			4.188***		4.024***		
			-7.48		-7.11		
SELFREGULATION2			1.414*		1.259		
			-1.85		-1.2		
SELFREGULATION3			1.387**		1.479**		
			-1.97		-2.31		
SELFREGULATION4			2.077***		2.216***		
			-5.76		-6.1		
SR INDEX				1.833***		1.832***	3.456**
				-11.51		-11.25	-2.15
STRNGNCY		1.589***			1.464**	1.554***	2.004*
		-2.78			-2.18	-2.58	-1.91
WATERINTENSIVE		2.905***			2.422***	2.198***	4.634***
		-4.25			-3.3	-2.96	-3.82
INVESTORPROTEC		2.658***			2.971***	3.030***	3.108***
		-5.7			-6	-6.22	-6.33
WATERSOURCE		0.98			0.998	1.003	1
		(-0.81)			(-0.08)	-0.1	0
STRNGNCY_SR							0.908
							(-0.90)
WATERINTENSIVE_SR							0.773**
							(-2.47)
GDP	1.25**	0.91	1.39***	1.39***	0.92	0.84	0.87
	-1.99	(-0.34)	-2.84	-2.81	(-0.27)	(-0.57)	(-0.44)
SIZE	1.649***	1.930***	1.263***	1.263***	1.520***	1.510***	1.530***
	-9.55	-10.58	-3.99	-4.02	-6.07	-6.06	-6.18
FIN	0.252	0.366	0.26	0.283	0.405	0.432	0.4
	(-1.21)	(-0.86)	(-1.10)	(-1.05)	(-0.72)	(-0.67)	(-0.74)
ROA	24.77***	34.31***	37.66***	28.21***	42.31***	33.92***	40.41***
	-2.87	-3.06	-3	-2.8	-2.99	-2.85	-2.99
LEV	0.811	0.612	0.793	0.85	0.574	0.635	0.612
	(-0.45)	(-1.02)	(-0.46)	(-0.33)	(-1.07)	(-0.89)	(-0.96)
CAPIN	30.20***	27.23***	31.19***	22.37***	29.98***	19.85***	16.93***
	-4.8	-4.55	-4.47	-4.13	-4.32	-3.88	-3.71
NEW	0.157***	0.0907***	0.246***	0.238***	0.141***	0.138***	0.147***
	(-3.92)	(-4.80)	(-2.81)	(-2.90)	(-3.73)	(-3.80)	(-3.68)
Year effect	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Industry effect	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Constant	-7.221***	-7.207***	-7.868***	-7.348***	-8.341***	-7.595***	-9.697***
	(-5.11)	(-4.90)	(-5.38)	(-5.07)	(-5.45)	(-5.03)	(-4.09)
Number of observation	1587	1587	1587	1587	1587	1587	1587
Log-likelihood	-965.89	-934.28	-876.71	-890.95	-849.17	-863.09	-859.78
Chi-square	245.7	308.92	424.05	395.58	479.14	451.31	457.93
Pseudo R2	0.113	0.142	0.195	0.182	0.22	0.207	0.21
Correct classification	0.683	0.694	0.685	0.682	0.71	0.707	0.706

In Table 4.7, most of the odds ratios of individual self-regulation variables are positive and significant (in Model 3 and Model 5), confirming H1. Among the four self-regulation pillars in M5, SELFREGULATION1 (CSR committee) has the highest odds ratio, indicating that companies with CSR committees would publicly disclose water information by a factor of 4.024 ($p < 0.01$) while SELFREGULATION2 (policy) has the lowest odds ratio, of 1.259. This implies that the establishment of an environmental committee can more effectively facilitate public disclosure than adopting water-efficient policies. The odds ratios of the SRINDEX (overall self-regulation orientation index) in Model 4, Model 6, and Model 7 are all positive and significant, showing the best predictor of public disclosure. In Model 6, for example, the improvement of one aspect of self-regulation increases the chance of public disclosure by 13% on average, setting all other variables to their means. These results are consistent with H1, namely that firms with a stronger self-regulation orientation tend to have more incentive for transparency about water information.

Supporting H2, almost all variables measuring the external regulatory environment are positively significant in Models 1 through 7. For example, the coefficient of the variable STRINGENCY is significantly positive across all four models, which is consistent with the notion of legitimacy theory that water disclosure propensity is stronger in nations with a more stringent regulatory landscape. Similarly, in Model 6, the odds ratio of STRNGNCY is 1.554 ($p < 0.01$), indicating that being in a jurisdiction with stringent environmental laws can significantly increase the odds of a firm publicly disclosing water-related information. This shows that firms exhibit great sensitivity to the external legal environment. This result is consistent with legitimacy theory that firms exposed to regulatory pressures are more likely to actively participate in self-regulation programs (Reid and Toffel, 2009).

As H3 predicts, companies operating in energy, materials, food, beverage, tobacco, pharmaceuticals, biotechnology, life sciences, and utilities are expected to be more transparent with the general public. Setting all other variables to their means, firms operating in water-intensive sectors have a 51% probability of complying with the CDP and allowing public access, versus 31% for firms in non-water-sensitive sectors (M6). This result supports legitimacy theory in that operating in industries that demand great quantities of water will have a greater influence on locals, requiring such firms to disclose more information to the public.

Model 2 to Model 7 indicate support for H4. In Model 6, the odds ratio of INVESTORPROTEC (legal protection for investors) indicates that firms with headquarters located in common-law countries would publicly disclose water information through the CDP by a factor of 3.03. In other words, firms operating in common-law countries would be more likely (49%) to disclose than firms in other countries (24%), with all variables at their means. This result is consistent with H4 and confirms La Porta (1998), that common-law countries emphasise the protection of individual investors and the reduction of information asymmetry. This adds new evidence that the legal protection of investors increases the probability of corporate disclosure of environmental-management information, including water management.

Failing to prove H5, companies located in countries with easy access to fresh water do not differ from others. This measure unavoidably contains some limitations. As mentioned before, it can be difficult to attribute the deprivation of access to water to one cause. On the contrary, in a case of a company polluting fresh water sources, human rights violations would probably be easier to demonstrate, e.g., right to life, access to water and food (Lambooy, 2011). This is why a large number of studies focus on polluting incidence and polluters' behaviour.

Among control variables, firm size, profitability, and capital intensity have a positive influence on public disclosure. This result is consistent with prior studies in this field. Holding all other things constant, large or profitable firms are more likely to disclose, probably because they have a lower marginal cost of abatement due to economies of scale and the availability of human resources. These firms may also experience greater benefits from environmental stewardship and have a greater ability to comply with pressure from regulators and the public (Clarkson *et al.*, 2008). According to voluntary disclosure theory, firms with capital investment in green technology would like to signal their responsible performance. For similar reasons, these companies will have newer and high-tech equipment to facilitate efficient resource use. However, the results in Table 4.7 only partially support this notion. Firms with newer equipment seem to be reluctant to publicly disclose water information. This inconsistency is also seen in other studies.

In the last model, two variables representing the interactions between internal and external regulations are constructed to explore the precise pathways through which the

influence of self-regulation is exerted. All mentioned relationships held in M7. It is assumed that the effects of self-regulation on the water-disclosure propensity vary under different institutional conditions. Generally speaking, following the logic of the forestallment of external regulations, firms are more willing to disclose water information publicly after improving self-regulation efforts when the external regulatory pressure is not high. Thus, the relationship between self-regulation and the disclosure proxy would be more pronounced in countries with less stringent environmental regulations than in more countries with more stringent regulations. Similarly, a firm's effort in self-regulation increases its propensity to report water management, and this effect should be more pronounced in sectors with lower water consumption. This is because industries with high water consumption are highly regulated. There is less room for even more stringent requirements than in other, non-water-intensive industries. On the other hand, people pay less attention to industries with lower water consumption, leading to a potential of increased waste, increasing the possibility that regulation of water will accelerate in the future. As a result, companies under suspicion may take proactive moves for self-regulation; the effects of self-regulation on voluntary disclosure may be stronger in these industries.

This interactive relationship between self-regulation and external regulation in Model 7 in Table 4.7 is depicted in Figure 4.1. Companies in water-sensitive industries have weaker negative correlations between the effort of self-regulation and voluntary water information disclosures. However, companies in non-water-intensive industries face lax external regulations and have significant positive correlations between the effort of self-regulation and voluntary water information disclosure. This result proves that the association between self-regulation effort and public disclosure is more pronounced among firms facing lax external regulations such as less stringent environmental laws.

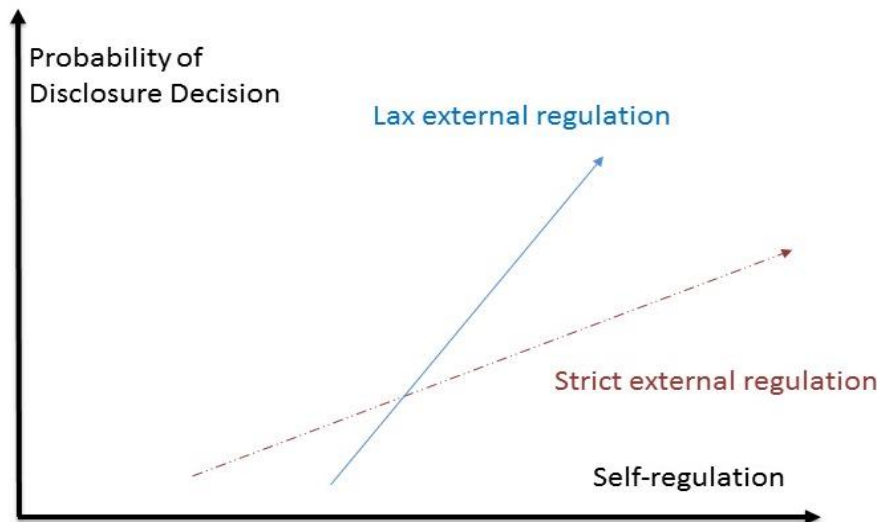


Figure 4.1 Gradient diagram of interaction terms of external regulation regarding water

Table 4.8 summarises the odds for private disclosure vs. public and no disclosure. Based on 1,587 observations, the stringency of environmental regulations and investor protection have significant explanatory power for determining whether firms choose to disclose water information to institutional investors privately. Based on Models 2 to 6, the odds ratio of INVESTORPROTEC indicates that firms operating in code-law countries prefer private disclosure over other response statuses. Setting all variables at their mean, firms in code-law countries had a 15% probability of choosing private disclosure, four times the odds of firms in common-law countries (M6). This further implies that a reduced level of protection for individual investors will stimulate firms to make private disclosures rather than public release or evade disclosure entirely. Private disclosure increases information asymmetry and puts small investors in a disadvantageous position. After controlling for other influences, Table 4.8 shows that privately disclosing firms have no superior self-regulation orientation than other firms with different disclosure strategies. The possible reason may be the average self-regulation index, as confirmed in Table 4.8. This notion is also consistent with the findings in Table 4.8 that the self-regulation index of privately disclosing firms is significantly lower than that of publicly disclosing firms. Therefore, firms that are responsive to institutional investors may not necessarily have superior or inferior performance. Public disclosures benefit a larger range of investors, while private disclosure aims to please solely the more influential institutional investors. Therefore,

the lack of emphasis on protecting general investors rather stimulates more private disclosure. This notion is supported by one control variable, FIN, measuring the debt and equity financing of a firm. The positive and significant odds show that firms with large amounts of external financing are more willing to share private information with institutional investors, consistent with stakeholder theory. In sum, private disclosure of information is chosen by companies located in countries with weak investor protections and strong financing demand. In addition, because of the reduced protection for individual investors, privately disclosing firms have fewer incentives to reveal their relatively unsatisfactory water record to the general public. In other words, private-disclosure firms may have average self-regulation effort compared to others.

This result also illustrates the influence of institutional investors on water disclosure practices. Without the request of the signatory institutional investors sponsoring the CDP water program, these companies may not disclose at all. To some extent, private disclosure has the merit of stimulating a certain level of transparency.

Table 4.8 Binary logistic regression: private disclosure vs. other status (public & no disclosure)

<i>Variable</i>	M1	M2	M3	M4	M5	M6
SELFREGULATION1			-0.06		0.013	
			(-0.23)		(0.05)	
SELFREGULATION2			0.287		0.376	
			(0.94)		(1.20)	
SELFREGULATION3			0.341		0.275	
			(1.24)		(0.97)	
SELFREGULATION4			-0.204		-0.262	
			(-1.00)		(-1.25)	
SR INDEX				0.105		0.112
				(1.34)		(1.37)
STRNGNCY		0.399*			0.440*	0.413*
		(1.69)			(1.82)	(1.75)
WATERINTENSIVE		-0.409			-0.492	-0.473
		(-0.82)			(-0.98)	(-0.94)
INVESTORPROTEC		-1.293***			-1.286***	-1.282***
		(-5.13)			(-5.01)	(-5.10)
WATERSOURCE		-0.013			-0.007	-0.009
		(-0.41)			(-0.22)	(-0.26)
STRNGNCY_SR						
WATERINTENSIVE_SR						
GDP	-0.253	-0.202	-0.236	-0.235	-0.259	-0.231
	(-1.47)	(-0.49)	(-1.37)	(-1.37)	(-0.62)	(-0.56)
SIZE	0.251***	-0.006	0.189**	0.197**	-0.074	-0.066
	(3.10)	(-0.06)	(2.10)	(2.18)	(-0.71)	(-0.63)
FIN	4.489**	3.603*	4.537**	4.457**	3.668*	3.526*
	(2.41)	(1.85)	(2.43)	(2.39)	(1.87)	(1.80)
ROA	0.502	0.695	0.467	0.457	0.877	0.713
	(0.28)	(0.38)	(0.26)	(0.26)	(0.48)	(0.39)
LEV	-0.423	0.062	-0.372	-0.394	0.165	0.153
	(-0.54)	(0.08)	(-0.48)	(-0.50)	(0.21)	(0.20)
CAPIN	-1.637	-1.500	-1.823	-1.771	-1.682	-1.647
	(-1.33)	(-1.22)	(-1.46)	(-1.43)	(-1.34)	(-1.33)
NEW	-0.780	0.189	-0.770	-0.673	0.202	0.277
	(-1.05)	(0.25)	(-1.03)	(-0.90)	(0.26)	(0.36)
Year effect	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Industry effect	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Constant	-2.914	-1.111	-2.733	-2.851	-0.920	-1.001
	(-1.33)	(-0.47)	(-1.24)	(-1.31)	(-0.39)	(-0.43)
Number of observation	1587	1587	1587	1587	1587	1587
Log-likelihood	-453.38	-431.85	-450.34	-452.47	-428.41	-430.9
Chi-square	49.66	92.7	55.74	51.47	99.59	94.61
Pseudo R2	0.052	0.097	0.058	0.054	0.104	0.099
Correct classification	91.05%	91.05%	91.05%	91.05%	91.05%	91.05%

4.4.3 Robustness checks

Several robustness tests are conducted to see whether the results are sensitive to the research design. The first is to retest using multinomial logistic, as there are only finite unordered types of responses. Because the decision of whether to disclose is often tested using probit or binary logit regression, this study follows commonly accepted methods and compares each response with the others. The following multinomial logit regression adds the robustness of binary logit regression. One contribution of the thesis is to distinguish private disclosure as a special category of communication, not as some form between the spectrum of public and no disclosure. Therefore, ordered logistic regression is not suitable. Instead, a multinomial logistic model is constructed, which is common for solving a wide range of discrete choice problems in marketing and economics (Choi and Bazarova, 2015, Bazarova and Choi, 2014). It simultaneously compares $n-1$ groups of category with a baseline or reference category. This approach has some advantages over the previous model, as sequentially running multiple tests may lead to poor estimations of standard error (Bolton and Chapman, 1986). Table 4.9 shows that results are generally consistent with the binary model. In addition, it is more evident that the self-regulation index is somewhere in-between public and no disclosure, confirming Hypothesis 6. One common practice of testing the robustness of the empirical model is to change the model specification and compare the coefficients (Testa *et al.*, 2014). As shown in Table 4.7, the first model (M1) only includes control variables. M2–M6 include external factors, four self-regulation perspectives, the self-regulation index, and their combinations respectively. The interaction effect is tested in M7. Because there are four subcategory variables of the self-regulation index included in a model, an erratic estimation of the predictor variable may exist if they are highly correlated (Testa *et al.*, 2014). To detect multicollinearity, a variance inflation factor (VIF) is calculated for each variable in different models. The mean of all VIFs (untabulated) is less than 3, with no individual VIF being greater than 6, suggesting that no serious multicollinearity problem exists (Taylor and Richardson, 2014).

Table 4.9 Multinomial logit regression

Variable	Public vs. No disclosure			Private vs. No disclosure			Public vs. Private		
	M5	M6	M7	M5	M6	M7	M5	M6	M7
SELFREGULATION1	1.44***			1.07***			0.36		
	-7.21			-3.56			-1.4		
SELFREGULATION2	0.27			-0.16			0.44		
	-1.39			(-0.49)			-1.4		
SELFREGULATION3	0.48***			0.019			0.46		
	-2.72			-0.06			-1.6		
SELFREGULATION4	0.83***			0.62***			0.21		
	-5.95			-2.89			-0.9		
SR INDEX		0.66***	1.03*		0.36***	0.31		0.30***	0.72
		-11.82	-1.71		-4.25	-0.41		-3.3	-0.88
STRNGNCY	0.59***	0.65***	0.71*	0.75***	0.76***	0.58	-0.2	-0.11	0.14
	-3.15	-3.53	-1.9	-2.9	-2.97	-1.2	(-0.62)	(-0.42)	-0.25
WATERINTENSIVE	0.92***	0.82***	1.73***	0.14	0.14	1.01	0.78	0.68	0.72
	-3.26	-2.94	-4.15	-0.26	-0.27	-1.44	-1.5	-1.31	-0.99
INVESTORPROTEC	0.88***	0.89***	0.91***	-0.86***	-0.85***	-0.83***	1.73***	1.74***	1.74***
	-4.54	-4.73	-4.77	(-3.10)	(-3.11)	(-3.00)	-6.2	-6.29	-6.22
WATERSOURCE	-0.00	0.00	-0.00	0.01	0.00	-0.01	-0.00	-0.00	0.00
	(-0.03)	-0.13	(-0.12)	-0.14	-0.12	(-0.26)	(-0.15)	(-0.02)	-0.17
STRNGNCY_SR			-0.04			0.04			-0.08
			(-0.34)			-0.27			(-0.50)
WATERINTENSIVE_SR			-0.33***			-0.34**			0.01
			(-3.02)			(-2.11)			-0.08
GDP	-0.21	-0.297	-0.202	-0.49	-0.49	-0.31	0.28	0.194	0.11
	(-0.64)	(-0.92)	(-0.62)	(-1.09)	(-1.11)	(-0.68)	-0.6	-0.43	-0.24
SIZE	0.46***	0.45***	0.46***	0.14	0.15	0.16	0.32***	0.30***	0.30***
	-6.27	-6.28	-6.31	-1.24	-1.34	-1.41	-2.8	-2.65	-2.63
FIN	-0.27	-0.20	-0.34	3.32	3.25	3.06	-3.59*	-3.45*	-3.40
	(-0.20)	(-0.15)	(-0.26)	-1.62	-1.58	-1.48	(-1.72)	(-1.65)	(-1.63)
ROA	4.32***	4.10***	4.29***	3.22	3.08	3.42*	1.1	1.023	0.873
	-3.26	-3.14	-3.27	-1.63	-1.57	-1.74	-0.60	-0.52	-0.44
LEV	-0.55	-0.44	-0.51	-0.00	0.01	-0.07	-0.50	-0.46	-0.43
	(-1.01)	(-0.83)	(-0.94)	(-0.00)	-0.01	(-0.09)	(-0.65)	(-0.55)	(-0.51)
CAPIN	3.52***	3.11***	2.90***	-0.12	-0.20	-0.39	3.64***	3.31**	3.29**
	-4.28	-3.86	-3.66	(-0.09)	(-0.15)	(-0.30)	-2.7	-2.48	-2.48
NEW	-2.10***	-	-2.03***	-0.66	-0.62	-0.58	-1.44*	-1.49*	-1.45*
	(-3.80)	2.11***	(-3.70)	(-0.81)	(-0.76)	(-0.72)	(-1.73)	(-1.81)	(-1.75)
Year effect		Controlled			Controlled			Controlled	
Industry effect		Controlled			Controlled			Controlled	
Number of observations	1587	1587	1587	1587	1587	1587	1587	1587	1587
Chi-square	602.97	574.35	585.83	602.97	574.35	585.8	603	575.38	585.83
Pseudo R2	0.204	0.194	0.198	0.204	0.194	0.198	0.204	0.194	0.198

4.5 Summary and Discussion of the Results

Recent trends show that external parties, such as intergovernmental organisations and non-profit NGOs, tend to request the reporting of specific detailed environmental information. With the increase in public interest, such organisations are establishing themselves as influential stakeholders, driving and stimulating changes and actions among corporations with regard to environmental protection (Den Hond *et al.*, 2015). Apart from conventional reporting channels, such as annual reports and sustainability reports, specialised information is released through a mediator organisation such as the CDP, which establishes a multi-stakeholder dialogue through the design of various levels of disclosure. Unlike self-disclosure, the CDP has explicit questions and instructions about what information should be covered and how it should be articulated.

Utilising CDP data, this paper explores how strategies of water disclosure are shaped by internal self-regulation and external factors at the level of the industry and country in which the firms are domiciled. The underlying premise is that companies are taking proactive moves through self-regulation to disclose water information, mainly to forestall external regulation. Of course, even if firms respond to all queries, it is very difficult to ascertain whether any relevant information is omitted (Kim and Lyon, King and Lenox, 2000). As a result, this study focuses on whether and how information is released, rather than what precisely is released. In general, the results are consistent with the six hypotheses developed. As H1 predicts, companies with a higher self-regulation index tend to disclose information publicly and privately. As for the components of this index (SELFREGULATION1 and 4 representing sustainability or environmental committees and performance evaluation towards water) the values for them are significant in models in Table 4.7 and Table 4.9. This indicates that the establishment of policies and targets for water management and water initiatives are less effective for driving both public and private disclosure of water information than board committee and evaluation performance. Consistent with H2 and H3, both stringency of environmental laws and being part of a water-intensive industry are significant factors that lead to public disclosure. These results are in line with legitimacy theory that companies facing high regulatory pressure tend to disclose more. Companies headquartered in civil-law countries tend to participate fully in the CDP water program, indicating that protection and emphasis from investors are powerful forces that can improve transparency (H4). However, the index for water abundance,

as measured by the percentage of a population with access to safe water, is not significant in this study. Therefore, H5 is rejected. As shown in Table 4.9, self-regulated companies prefer private disclosure than no disclosure, confirming H6. Overall, Tables 4.7, 4.8, and 4.9 present generally consistent evidence; all test models show satisfactory predictive accuracy. Therefore, the research design is adequate and effective for predicting disclosure behaviour.

This chapter tests the determinants of different forms of disclosure. A total of 1,587 firm-level observations are grouped into three categories, and two pair-wise binary logistic regressions and one multinomial logistic regression are conducted. The findings are summarised in Table 4.10. The first column lists all internal and external factors that may influence a firm in regard to different disclosure choices. This showcases how those factors influence companies differently. In particular, public disclosure is influenced by multiple factors: strong internal self-regulation, stringent environmental regulations, large water consumption, and strong investor protections are associated with public disclosure intention. This result is reasonable, because the gesture of public disclosure demonstrates a strong commitment to protect water resources. Companies must devote a great deal of effort to gather information and expose their internal information to public scrutiny, risking the release of confidential information to peer companies. Apart from those pressures, companies with satisfactory water-management practices are motivated to impress stakeholders through public disclosure. This conjecture is reconfirmed by control variables, indicating that public disclosers appear to be, in general, large in size, more profitable, and equipped with newer facilities. Capital expenditures are higher, indicating that a corporate strategy of expansion does not conflict with an environmental protection strategy.

Table 4.10 Different motivations of three types of disclosure

Potential influencing factors	Public disclosure	Private disclosure	No disclosure
Internal self-regulation	Strong	Average	Weak
Stringency of environmental regulations	Stringent	Stringent	Lax

Water consumption	Intensive	Average	Not intensive
Protection of investors	Strong	Weak	Average
Water access	No influence		

When examining the column of private disclosure, it is evident that this behaviour is driven by stringent regulations and weak protections for individual investors. Some such firms, although facing stringent external regulations, are able to choose private disclosure mainly because they are based in civil-law countries, which do not emphasise protections of institutional investors as much as common-law countries do. Other reasons include average water-management practices and reduced public pressure, since such companies are operating in a less water-intensive industry. The last group, no disclosure, has the least pressure and incentives, as well as weak self-regulation. Overall, these results make economic sense in a water context.

In summary, firms with an environmental committee, water policies, actions taken to improve water-efficiency, and an evaluation system that considers aspects of water are positively associated with the tendency to disclose. If these four aspects are combined and the self-regulation index is developed to capture the overall level of water management, the self-regulation index shows a significant association with both public and private disclosure, compared to no disclosure. The findings also confirm that disclosure behaviour is influenced by water consumption and water-resource availability. In addition, the effects of self-regulation weaken as external regulations strengthen. In other words, self-regulation and external regulations are competing rather than complementary forces. This study further supplements previous work showing that investor protection can reduce information asymmetry.

This is the first study to utilise self-regulation theory to explain corporate decisions on water management. This paper contributes to the literature on environmental disclosure and adds a new perspective to the motives for disclosure. The theory of self-regulation is newly applied to voluntarily disclosed information. From the perspective of methodology, previous work has often neglected to distinguish private disclosure from public disclosure or silence and thus fails to reveal the motives for private disclosure. Although there exist normative discussions and case studies on the reasons

for private disclosure, until now, no large empirical studies have analysed private disclosure of water, due to a lack of available data. This study adopts a holistic approach to compare and contrast all three disclosure statuses to avoid simply treating private disclosure as an intermediary status between public and no disclosure. The rigorous analyses of both binary logistic and multinomial logistic regression help determine the motivations for private disclosure.

Water strategy, reporting, and management are different concepts, albeit correlated ones. Whether the motivation for disclosure is an economic reaction to stakeholder needs, or politically motivated, is probably a function of top management's particular perception of the world it faces (Wilmshurst and Frost, 2000). Therefore, responsiveness does not necessarily guarantee responsible action. Disclosure itself is a strategy to influence and shape disclosure regulation as well (Andrew and Cortese, 2011). Still, it may help to some extent to gradually form a management philosophy through continuous learning. Such disclosure is also likely to bring some tangible benefit for the reporting firm, such as an improved green image and the promotion of legitimacy, and help it evade or minimise the threat of harsher governmental direct control of water use. The information disclosed is subject to public scrutiny and forms the basis of public expectations, which in turn spur regular disclosure. The disclosed content also facilitates future studies further exploring the practices of water management. The construction of the self-regulation index forms the foundation of a more detailed WMS.

Chapter 5 Water Management Levels and the Consequences

5.0 Introduction

The previous chapter explores the first research question about determinants of disclosure behaviour. Evidence shows that companies increase their transparency mainly because of incentives for self-regulation and the external regulatory environment. However, how external regulation influences self-regulation has not yet been fully examined. To further investigate why some companies have good self-regulation, as well as the dynamics between self-regulation and external regulation, this chapter constructs a preliminary model of a WMS. Such a WMS features a series of practical steps that can be adopted to improve water management. Scrutinizing the content of water information publicly disclosed by 94 large firms, this chapter addresses the second and third research questions of this dissertation, namely, what is associated with good water management and does adopting it help reduce water consumption in the succeeding years? These two questions are critical for understanding the true incentives behind pro-environmental claims and gestures. The interpretation of the results will provide empirical support for the theory of self-regulation.

The remainder of the chapter is organised as follows. Section 5.1 describes the construction of a WMS. Hypotheses are developed in Section 5.2. Section 5.3 describes the research design, including the sample selection, models, and the definition of variables. Section 5.4 reports empirical results and concluding remarks follow at the end of the chapter.

5.1 Design of a WMS

5.1.1 Importance of a WMS

Water is an important but scarce resource. However, the importance of water conservation is often ignored by many companies. Water management and protection is largely considered the responsibility of local authorities (Lambooy, 2011). However,

corporations may profess better resources and a better ability to resolve social issues than governments (Hillman *et al.*, 2009). Although water is not widely recognised as an asset among those tabulated in financial statements, the importance of water should not be ignored. The CDP's Global Water Report 2012 stated that usual water-management practices will put 45% of the projected global GDP at risk by 2050, or about 1.5 times the size of the current global economy (Amran and Haniffa, 2011). Recently, the adoption of serious state-of-the-art practices such as water accounting and water auditing have shown a trend towards a more systematic approach to water management. A WMS first measures, collects, and stores data on water consumption, discharge, withdrawal, and even waste. Then data are extracted for analysis from every product line, department, district, and period. This analysis will support decision-making in relation to investments in R&D on optimal mechanism design with more recycling. It will also help with the development of new products that are more water efficient, supervision of waste management, and rewarding of staff for achieving water savings plans. In a word, it is time to transform and take advantage of the potential of a WMS.

Second, water is closely connected with every aspect of business. Due to the complexity of water accounting and the fact that many companies have only recently recognised the urgency of water management, the practice of water management may currently be pursued only by some elements, instead of the whole (Amran and Devi, 2008). For instance, it may be common for companies to focus merely on water usage in production while ignoring trivial losses of water. This study will demonstrate why it is essential to have a holistic WMS with wide coverage.

Last, but not least, the implementation of a WMS has more strategic and intangible implications. Companies are currently facing upward pressure from the public, governments, and non-profit NGOs to disclose water information and practices. If a company faces potential water risks, they can implement a better WMS. This gesture will demonstrate a strong commitment and establish good water stewardship. Consequently, companies will make a good impression on the public, obtaining rewards and support from their governments. It is extremely important to take the initiative, before others get wind of such a strategy, to avoid a passive position. Therefore, this thesis will provide a guideline for the step-by-step implementation of this strategy.

This chapter develops a WMS based on previous studies and the CDP 2010 water program (CDP, 2010). The purpose of such a design is twofold: first, to build a conceptual framework to inform practical exercises and second, to measure the propensity of self-regulation among a sample of selected companies publicly disclosing water information to the CDP. This particular version of a WMS consists of six perspectives and 10 elements. Though corporate water-management processes vary from company to company, they can be generalised as being iterative, with the following fundamental components. Previous studies on environmental accounting only consider environmental management or carbon management systems (CMS), but very limited research has been conducted on water. A comprehensive water accounting concept framework has a role in informed decision making, improved efficiency, and pollution abatement (Christ and Burritt, 2017). This chapter aims to fill this gap by introducing a preliminary WMS model.

The six perspectives of a WMS are water strategy, water-risk management, water accounting and auditing, water-policy implementation, supply chain water management, and communication. Each perspective comprises a number of elements that further perform a specific managerial function with distinct methods and procedures. In addition, a set of proxy variables are developed to measure the quality of each element. This design can enable measurement for illustration and empirical testing (Tang and Luo, 2014). Table 5.1 summarises the 10 elements within the six perspectives.

Table 5.1 Theoretical structure of a WMS

Water Strategy Perspective

Elements		Purposes	Proxy Variables
1	Governance	To supervise and coordinate overall water-management issues	<i>Governance</i>
2	Target	To set up specific, measurable, achievable, realistic and time-bound targets for water reduction, quality, or efficiency	<i>Target</i>

Risk Awareness Perspective

3	Materiality	To identify the water risks in operations and the supply chain	<i>Materiality</i>
4	Risk Assessment	Follow specific procedures to measure and monitor the identified water risks	<i>RiskAssessment</i>

Accounting and Auditing Perspective

5	Water Accounting	To measure the physical water usage, the cost, and revenue of related management practices	<i>Accounting</i>
6	Water Auditing	To assess the accuracy of the information obtained both internally and externally	<i>Auditing</i>

Water Initiative Implementation Perspective

7	Water Action	To take preventive measures to mitigate the water risks identified	<i>Action</i>
8	Opportunity Investment	To invest in the opportunities embedded in water issues	<i>OpportunityInvestment</i>

Supply Chain Management Perspective

9	Supply Chain Management	To manage water issues and engage suppliers in the supply chain	<i>SupplierEngagement</i>
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Communication Perspective

10	Disclosure	To communicate water issues internally to all levels of staff and externally to stakeholders	<i>Disclosure</i>
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Adapted from Tang and Luo (2014)

5.1.2 Strategy perspective

The environmental orientation of a company is a significant component that should be integrated into overall functional strategies (Klassen and McLaughlin, 1996). Thus,

the first perspective of the WMS is a water-strategy perspective, concerning a systematic approach for managing water issues, including water governance approaches, water efficiency targets, and the assessment of water risks and opportunities. Evidence of orientation and strong commitment includes key indicators such as the commitment of senior corporate official for policy implementation, specifically goals and measurable evaluation plan, and adequate resources have been invested and allocated to execute the program (Feldman *et al.*, 1997). In the case of WMS, two important elements are selected within this perspective.

Element 1: Water governance (proxy variable: *Governance*)

A company should first establish a water governance mechanism; the purpose of the mechanism is to define the objective of its cohesive water strategy, determine a water-related budget, create an appropriate organisational structure, design an operating policy, and set the cornerstone for water management (Solomon, 2010). This element plays a crucial role in the effectiveness of a WMS. To measure the quality of this element, the proxy variable *Governance* is developed based on observable and calculable data disclosed in CDP water reports.

The rank of the staff appointed to take overall responsibility for water management is an indicator of the importance of water to the firm. If ultimate responsibility reaches the top level, such as the chairman of the board, a high level of commitment is recognised, and more effort and funds are expected to be devoted to water management. To ensure the development and implementation of strategies in a holistic and integrated manner, senior leadership, such as a board committee, with more resources and power, must show involvement. The lower levels of management in charge of daily chores such as water will regularly report to the next level managers while the top ranks supervise and assign a mandate and clear responsibility for staff at all levels. Clear responsibility and facilitative dialogue will improve communication and interaction and also save time and cost in this area.

In the 2010 CDP water survey, the majority of companies (73 out of 94) appointed a board member or other executive body to catalyse efforts to strengthen water policies. A few (14 out of 94) had officers or managers reporting directly to the board committee or a board member about water issues. Less than 10% did not have authority in water issues. To measure the quality of governance, two points are awarded if the answer is

“Board committee or other executive body” for the highest level of responsibility within the company for water policies, strategies, or plans in question 1.3. One point is awarded for the answer “Officers or managers”, and zero points are awarded otherwise.

Element 2: target (proxy variable: *Target*)

Setting appropriate targets and goals is critical for the improvement of water management over time. To be effective, targets need to be specific, measurable, achievable, relevant, and time-bound (SMART) and linked closely to corporate strategy. Such targets give a direction for explicit efforts (Deegan *et al.*, 2002). Quantitative targets are easier to measure and evaluate than qualitative ones and therefore can motivate action more effectively. Targets also need to be realistic and achievable. Some psychological studies indicate that the highest level of effort occurs when the task is moderately difficult, and the lowest levels occurs when the task is either very easy or very hard (Ceres, 2013). Ultimately, targets are designed to achieve a certain performance. Therefore, these targets must be specifically relevant to the strategy. Goals and targets vary for different stages of the strategy. Short-term targets subdivide a long-term target into small and doable tasks along a timeline. A long-term target is essential, as it provides a clear statement of the commitment made to society. It gives a metric to guide nearer-term measures and to gauge progress over time (Deegan *et al.*, 2002). Once targets are set and performance measurements are determined, staffs who are held accountable will clearly understand their roles and responsibilities. Some companies provide incentives for the successful attainment of a goal. In an organisation where leaders and employees have many competing priorities and budgets are limited, linking targets to remuneration can be essential to encourage successful achievement.

According to 94 responses submitted to the CDP water program in 2010, most companies already had water targets set. Only 19 companies (20.2%) did not set water targets; 31 (33.0%) had some targets but they were not SMART; the remaining 44 (46.8%) companies had more concrete targets for water-use reduction, quality, or efficiency. The scoring method is that two points are awarded for inclusion of a goal’s measure of success and deadline, one point is awarded for qualitative description, and no points are awarded for those without any target.

5.1.3 Risk awareness perspective

To be more responsive to the water crisis, clear awareness and accurate assessment of potential risks are critical for controlling and reducing risks. The impacts of water vary among different sectors depending on the degree of water-risk vulnerability and the probability and the potential damage of water risks. Therefore, first a materiality process is needed to identify and prioritise issues at the heart of long-term viability (KPMG, 2013). Based on the materiality level, every risk is assessed with a recommended method to reduce it to an acceptable level. Therefore, prospective risk awareness includes two main elements.

Element 3: materiality (proxy variable: *Materiality*)

Prevention is cheaper than recovery. Companies must acknowledge uncertainty in water issues and the vulnerability of the full range (Solomon, 2010). Given the high natural unpredictability of environmental accidents and the long period required for investment in recovery, companies must prioritise prevention. The element of materiality determines whether companies are able to identify correct issues (KPMG, 2013). This depends on companies' understanding of what is truly material to them. High uncertainty and rapid developments in the legal environment make a company more vulnerable with regard to indirect damages. For instance, water may be contaminated by chemical waste in soil that seeps into the groundwater through rainfall. Knowing both the degree and the scope of potential exposure can help firms quickly react to identified risks. This element is important because it gives guidance on the next element, namely risk assessment in water action decisions, as well as disclosure decisions.

According to the CDP 2010 questionnaire, 83 out of 94 corporations that submitted information had identified and provided the percentage of their own operations located in water-stressed regions. Only 21 out of 94 companies, however, were able to provide the proportion of key water-intensive inputs generated in water-stressed regions. In fact, water risks in the supply chain are more uncertain and far-reaching, but their significance is often neglected. The measurement of *Materiality* ranges from zero to two. One point is awarded if the company was able to identify the percentage of operations located in water-stressed regions; another point is awarded if the company

was able to identify the percentage of key water-intensive inputs located in water-stressed regions.

Element 4: risk assessment (proxy variable: *RiskAssessment*)

When materiality is determinant, a thorough and scientific assessment follows to scrutinise and control the risks identified. The risks identified have a financial impact; thus, they must be accounted for to quantify the value at stake. A holistic and overall assessment needs to incorporate views from stakeholders into the process (KPMG, 2013). There are many scientific methods and tools available to assess water risk. External tools provide more objective results. According to CDP 2010, the most popular ones were publicly available mapping tools (such as WBCSD Global Water Tool). Some firms simply relied on internal company knowledge, which may be more relevant and is easier to implement. Only 13 had no specific method to assess water risks. The majority (68 out of 94) of firms had no specific methods for risks assessment in the supply chain. Again, this shows the necessity of developing additional management tools to control supply chain risk in the future. The measurement of *RiskAssessment* ranges from zero to two. One point is awarded if the company used specific methods to characterise water-stressed regions in their own operation; another point is awarded if the company used specific methods to characterise key water-intensive inputs located in water-stressed regions.

According to the CDP 2010 questionnaire, 83 out of 94 firms identified and provided the percentage of their own operations located in water-stressed regions. However, only 21 out of 94 companies were able to provide the percentage of the key water-intensive inputs located in water-stressed regions. In fact, water risks in the supply chain are more uncertain and far-reaching, but, again, their significance is neglected.

5.1.4 Accounting and auditing perspective

Element 5: water accounting (proxy variable: *Accounting*)

What is measured becomes managed. To fully achieve sustainable water management, companies should understand and ideally have quantified risks and opportunities (KPMG, 2013). Water accounting keeps record of water usage, not only in the production process but also in almost every function of a company. It helps allocate water costs from the overhead cost pool to every product line and department. With

this information, managers are better informed of which products may be more water-intensive. Accounting also provides other analytical functions, turning risks and opportunities into financial costs and revenue. Moreover, it supports performance evaluations and helps compare results with targets set. Efficiency targets often combine financial performance with water usage. Moreover, accounting helps assess whether to seize which opportunities, quantifying impacts on the bottom line. Water accounting is the central link for a WMS, supporting and connecting other elements.

Based on the 2010 CDP water program, most firms (82 out of 94) disclosed water withdrawals, and most (80 out of 94) also disclosed water-discharge information. However, less than half (37 out of 94) knew or disclosed water-recycling information. This indicates that water recycling is still not a common practice among companies. Water prices are not yet high enough to stimulate water recycling. Investment in such a capability may be expensive at this stage.

The variable proxy *Accounting* ranges from zero to three. If a firm discloses all three aspects of water usage, discharge, and recycling, it receives three points. Two points are awarded if only two aspects are disclosed. Likewise, one point is given if only one aspect is reported and zero for none. In this case, about one-third of companies (32 out of 94) disclosed three aspects; around half of them (43) scored two in *Accounting*, and 5 companies scored zero.

Element 6: water auditing (proxy variable: Auditing)

In the literature, external or internal audits are recognised as an important element in sustainability controls and reporting systems (Tang and Luo 2014). It has been found that many companies cherry-pick what environmental information to disclose and exaggerate satisfactory achievements while providing limited discussion of challenges and setbacks (KPMG, 2013). In other words, corporations often use voluntary reporting as a vehicle for “greenwashing” or window dressing. Auditing (particularly external auditing) plays a critical role in increasing the credibility of the information disclosed.

A good WMS needs comprehensive, consistent, and fair auditing or assurance. Environmental assurance and auditing take different forms and have different merits. External, third-party assurance ensures consistent compliance across facilities and

allows for greater expertise in the auditing function; it can improve the credibility of the information provided to external users (Solomon, 2010). Based on KPMG's (2013) survey of CSR reports, around 59% of the global top 250 responding companies adopted external assurance. This has increased from 46% in 2011. Moreover, two-thirds of reviewed companies chose to engage major accounting firms. Self-assessment, or internal, auditors are more familiar with each facility and therefore may more effectively identify primary problems without negative interactions.

Based on the CDP water program, 41 companies employed external assurance for their water-usage records. The remaining 53 either simply used water bills for their internal audit or performed no audit. The measurement of *Auditing* is simple, scoring one if the company employed third-party assurance of its water information and zero otherwise.

5.1.5 Policy implementation

Actions speak louder than words. Despite apparent good intentions, most companies only express a commitment to good environmental management. Though some have created special departments, employing specialists to deal with their water issues, these are often either too low in the corporate hierarchy to wield real power or too understaffed and underfunded (Solomon, 2010). It is through real initiatives rather than rhetorical statements that a company can convey its commitment towards water. Such actions can be categorised in two groups, namely water action and opportunity investment.

Element 7: water action (proxy variable: *Action*)

A WMS without enforcement and implementation has no effect. Water actions include the installation of equipment for water-efficiency improvements (e.g., for the recycling of water), R&D activities for water programs, and the adoption of low-water technology. It also includes soft investments such as staff training programs to enhance the awareness of water issues and to improve knowledge and skills for employees. This element also supports decisions and actions on whether and how to mitigate assessed water risks. In the CDP 2010 water program, 85 companies (90.4%) declared their action for the mitigation of water risks. One point is allocated if the firm provides

action for water management and zero otherwise. The value of the variable *Action* reflects the level of actions in which the company engages.

Element 8: opportunity investment (proxy variable: *Investment*)

Unmanaged environmental risks imperil business sustainability through litigation, fines, image damage, and other hazards. While inherent risks can become opportunities if managed properly. It is encouraging to see that substantial numbers of large corporations already view sustainability through the lens of opportunity as much as, or more than, through the lens of risk. As we noted earlier, there are benefits to practices of water management, such as improved productivity and quality and reputation enhancement as well as potential entry to new markets. Opportunities identified through a materiality test cannot create an advantage for a company unless that company chooses to invest in it. As the implementation of a WMS is costly and time-consuming, managers must justify its value to their shareholders and investors, who mostly focus on short-term profitability.

Approximately two-thirds of companies investigated recognised water opportunities and exploited them. The measurement of this element is similar to *Action*; one point is allocated if the firm claims to have performed action for water management and zero otherwise.

5.1.6 Supply chain management

Element 9: supplier and partner engagement (proxy variable: *SupplierEngagement*)

It is often found that significant water impacts exist in the value chain of a company rather than within its own operation (KPMG, 2013). Upstream, a shortage of qualified raw materials from suppliers directly affects production. Downstream, strong demand for green products and services from responsible customers also influences corporate decisions on whether or not to invest. The concept of a water footprint can describe and estimate how much water is consumed to produce a product. Water accounting can be implemented using activity-based costing (ABC) to identify which line of product is the most water-intensive. Assessing water impacts in the supply chain is more complex than measuring the water impact on companies themselves. Measurement methodologies are subject to uncertainty (KPMG, 2013). Therefore, companies should work harder to partner with suppliers to improve the availability of

data and information sharing. For example, Cisco has set an example for its suppliers by being transparent about their own emissions and asking their suppliers to do the same. Internal auditors can then audit suppliers against their code of conduct. The company can set targets to reduce the impact of supply chain risks and assess the risks over time.

In this study, it is encouraging to see that most firms (82 out of 94) actively engaged their suppliers in the sharing of water-usage information. The scoring for this element is one point if the company requires its key suppliers to report on their water use, risks, and so on, and zero otherwise.

5.1.7 **Communication**

Element 10: disclosure (proxy variable: *Disclosure*)

Finally, an element of disclosure is proposed as part of a WMS from the communication perspective. It is believed that disclosure complements corporate governance (Craighead *et al.*, 2004, Denis *et al.*, 2010). Adequate communication between internal and external players is crucial for the successful operation of a WMS. The Internet and social media are accelerating the growth of active and engaged stakeholders on environmental issues. Managing such relationships has become a core strategic competence in an interdependent world. Compared to climate change, water has a direct impact on the local community; therefore, it has stakeholders who are easily identified. Companies need to develop strategies to engage stakeholders for continuous improvement by means of corporate water disclosure, either in corporate reporting (annual reports or sustainability) or an intermediary such as CDP. Improved transparency and assurance help build trust and credibility among stakeholders. The content of disclosure should cover most elements in the WMS as well as how they will affect key stakeholders. Corporate reporting through annual reports and sustainability reports is a common tool for engaging with stakeholders. Internal communication facilitates learning and sharing of knowledge among staff. At the current time, this area is less developed. As an increasing number of developing countries are experiencing severe water issues, and stakeholder demand is becoming more difficult to navigate and monitor.

The content of the disclosure needs to provide a balanced view of performance. It has been found that many companies exaggerate satisfactory achievements while providing limited discussion of challenges and setbacks (KPMG, 2013). Data comparable with the previous year's performance should be provided. The criticism is often that corporations use reporting as a vehicle for "greenwashing" or window dressing. To overcome this, external assurance plays a critical role for increasing the credibility of the information disclosed.

In a WMS design, Disclosure measures the extent of disclosure in the questionnaire. One point is awarded if the company responds to more than 50% of the questionnaire and zero if less than 50%. As the sample consists of the largest global companies, 93 out of 94 companies provided a high quality of disclosure. Full disclosure in turn makes the measurement of other elements consistent and comparable.

5.1.8 Summary

Figure 5.1 illustrates the structure of a theoretical WMS model and the links among the structural elements. Table 5.2 summarises the detailed explanation of each element and their connections. It can be seen that all elements are interconnected and demarcation may be blurred. No matter what form is taken in the final analysis, a good WMS should effectively combine all efforts from different perspectives. Ideally, companies work to concurrently advance all elements of water-management activity. However, the implementation of a comprehensive WMS can be expensive, time-consuming and burdensome (Solomon, 2010). Due to the complexity of accounting for water and the fact that many companies are only recently recognizing the urgency of water management, the practice of water management may currently involve only some elements instead of the whole (Amran and Devi, 2008).



Figure 5.1 Theoretical water management system

Moreover, there may be no exclusive and universally applicable WMS with an identical format and structure. The theoretical WMS proposed here is based on the generic character of water-management practice and the experience of some of the world's largest companies. Note that this theoretical model of a WMS represents general water-management practices, but the application of the model in specific industry or firm may require modification, appropriate to the unique circumstances of the underlying context. Some soft elements in water management that may be relevant, such as corporate culture, employee morale, and so forth, are not considered in this study. Therefore, when investing in a WMS, a company should tailor the theoretical model developed here, creating detailed modalities and procedures in the light of its local circumstances, such as its sector membership, firm size, resource availability, organisation culture, current risk status, and so forth. When applying these to reality, it may need yet more specifications and considerations. A decentralised approach with separate targets is more suitable for large and diversified companies, while centralised governance model may be optimal for small and business entities (Solomon, 2010). If we take governance, for instance, to be the recognition of the importance of water issues from the top managers may complement existing support for water management.

However, disagreements among members of the board of directors may block the entire system.

Therefore, when investing in a system like this, a company should tailor it according to its own size, resource availability, organisation culture, current risk status, and so forth. It will be too much for a small or medium-sized company to have a comprehensive WMS, with 10 elements. Manufacturing companies may have more elements to implement in their WMS than banks might. Therefore, it is difficult to justify whether the elements of a WMS are adequate in the abstract. These elements are simply conceptual at this stage. When applying them to reality, more specifications may be necessary. If we take governance, for instance, recognition from top managers may be helpful. Different organisational structures may also influence the 10 elements. Training of employees will make the WMS more responsive and practicable.

5.2 Hypothesis development

As mentioned before, this chapter explores two research questions. One is the determinants of the quality of a WMS and the other is the effectiveness of a WMS in saving water. Based on the theoretical framework and literature review in previous chapters, this chapter develops four hypotheses with regard to the first question and one with regard to the second. This study identifies new drivers for water management that have not yet been tested in the literature. It is feasible to proxy for such factors in the current study, because of the comprehensive design of the CDP questionnaire.

5.2.1 Physical water-risk exposure (H7 & H8)

Water is an essential ingredient in production processes. Managers face challenges due to increasing uncertainties in water supply caused by global climate change and the fast-changing socio-economic boundary conditions (Pahl-Wostl, 2007). To educate managers about water impact, KPMG has identified and categorised six key types of risks. Physical water risks cover, for example, exposure to water shortages, storms, floods, and increases in sea level (KPMG, 2013). Although relatively rare, these may cause significant loss and damage. In addition, as globalisation connects business in different regions where the water situation may not be as familiar to managers, and companies may ignore the necessity of using WMS to combat physical risks. For example, around 50% of investigated companies in the sample are unable to identify whether their supply chains are subject to water-related risks (CDP, 2010). Once any link of the chain breaks due to physical water risks, every entity on the range may be affected. Managers should have good knowledge and accurate perception of physical water risks existing at the business site and along the whole supply chain.

To implement the test for how real and perceived physical water risks affect a WMS, two proxy variables are created. One is the managerial perception of physical water risks obtained from the corporate response in the CDP. Perceptions of risk are influenced, as are culture, shared experiences, values, and beliefs relevant to the evaluation of environmental risks. Only when companies feel they are affected by certain physical risks can they take measures to mitigate them. Accordingly, the first hypothesis is that:

H7. All else equal, companies perceiving physical risks in the operation of the firm and its supply chain have a better water-management system.

The second proxy for physical water-risk exposure is the intensity of water withdrawals, measured by sales divided by water withdrawals.¹¹ This variable presents actual physical risks, because water withdrawn for industrial processes, if not returned to the same water body in its original quantity and quality, may contribute to the depletion of rivers and lakes and the lowering of groundwater tables (Heritier and Eckert, 2008).¹² Compared to the perception of risks, this is a more objective measure of exposure to physical water risks: it takes both physical water input and economic outputs into consideration.

These variables are complementary rather than duplicate, because management in firms with actual high risks may not perceive them. Firms with higher levels of water intensity are likely to draw the attention of environmental protection organisations and the public. These firms also have contingent water liability, as they are often the focus of water regulations. In other words, the higher the intensity, the higher the actual physical water risks. As stated in Chapter 3, a large amount of water consumption triggers the disclosure of water information. It may be possible for this factor to first spur the establishment of a WMS and then disclosure. Intuitively, it can be expected that firms with higher levels of water consumption will adopt good water-management practices to reduce exposure and minimise the legitimacy threat (Williams and Adams, 2013). Thus, this argument leads to the following hypothesis:

H8. There is a positive association between actual physical water-risk exposure and the quality of the water-management system.

¹¹ Water intensity can be defined alternatively. For instance, the OECD database measures water intensity as total water intake divided by the normalisation factor. Here this normalisation is sales in this case.

¹²In *The Handbook of Water Use and Conservation*, Amy Vickers (2001) defines water withdrawal as “water diverted or withdrawn from a surface water or groundwater source”. Consumptive water use, on the other hand, is defined as “water use that permanently withdraws water from its source;” Here, water usage takes two form, withdrawal and consumption. This study however does not specify the difference and uses the three interchangeably.

5.2.2 Perception of regulatory threat (H9)

The institutional background may influence managerial behaviour from a different perspective. Institutions in this case include water legislation, regulations, industrial water standards and norms, and so on. Currently, pressure from the public, academia, and other forces has increased the chance that the government will issue new and more rigid water regulations and dramatically expand the sphere of contingent liability (Hunt and Auster, 1990). Even in less water-sensitive industries, companies now face “higher tariffs, redistribution of water rights, and more stringent rules and standards governing water quality” (KPMG, 2013). Rigid external regulations unintentionally undermine corporate motivations to take the initiative, since proactive companies can be distinguished from reactive ones only with difficulty. As the company Apache responds to the CDP, “potentially the legal and reputational risks may lead to more regulatory oversight or reduced exploration opportunities for our industry” (CDP, 2010). Therefore, firms have the incentive to take proactive rather than reactive approaches.

The corporate perception of regulatory threat stems from complex and rapid changes in the regulatory landscape that may significantly increase operational risk and uncertainty, particularly for water-intensive organisations. Failure to acknowledge and respond to regulatory authorities may lead to serious issues, such as significant penalties or fines in respect of breaches of regulations related to pollution incidents, affected habitats, and other issues. Based on legitimacy theory, it can be argued that perceived regulatory threats press the company to develop a high-quality WMS, assuming the gesture of self-regulation as a compliance strategy. From a new perspective grounded by self-regulation theory, firms in a laxly regulated environment tend to have more incentive to undertake self-regulation practices, such as WMS. In doing so, companies appear more responsible and less suspicious, reducing the probability of the introduction of more rigid water legislation and regulations in the future. Therefore, companies with less perceived regulatory threat are more motivated to implement WMS, no matter what their true intention may be. Based on the discussion of two opposing theories, a third hypothesis is proposed, with two opposite predictions:

H9_a. All else equal, companies with a greater regulatory threat identified in the operation of the firm and its supply chain have better water management.

H9_b. All else equal, companies with a lower regulatory threat identified in the operation of the firm and its supply chain have better water management.

5.2.3 Water opportunities (H10)

The changing availability of water resources, particularly for fresh water, may also bring opportunities to companies through the demand for water-efficient products and services. Many respondent companies in the research sample have identified such opportunities and have leveraged their water technologies and expertise to seize opportunities within or beyond their own sector. In doing so, companies differentiate themselves by the provision of innovative water-efficient goods and services and boost their share of niche markets. Anecdotal empirical evidence from previous studies suggests a positive association between financial profitability and environmental performance (Klassen and McLaughlin, 1996). It is possible that customers have an increasingly strong sense of responsibility, leading them to make green purchases (Miles and Covin, 2000), and water-saving products often represent a significant potential high profit margin when customers are willing to pay more. Building trust and reputation through environmental and water conservation allows companies to gain investor loyalty and have better access to capital. Accordingly, the recognition of water opportunities by corporate executives will stimulate a better WMS. Thus, the tenth hypothesis is:

H10. All else equal, companies that recognise water opportunities have better water management.

5.2.4 Water carbon synergy (H11)

Both water and energy are precious resources. There is growing scientific evidence suggesting that water scarcity and global warming caused by climate change did not develop in isolation from each other. Instead, they are interlinked in a complex system (KPMG, 2013). For example, on the one hand, it often takes large amounts of water to produce and distribute energy; on the other hand, substantial energy is consumed in purifying and distributing water, as well as to heating it for various uses. This interconnectivity is called the energy–water linkage. Thus, saving one resource may increase the other and vice versa; therefore, the utilisation of water and energy needs simultaneous consideration. In this case, good resource management should aim to minimise the overall consumption of water and energy. Changes in the physical, regulatory, and market environment are likely to increase pressure to consider both water and energy use {CDP, 2010 #153}. Companies often have to balance the consumption of these two types of resources, because there are many complex linkages, and trade-off decisions must be made in water management. It can be argued that a better WMS would help firms recognise the issue of water–energy linkages and trade-offs, enhancing the linkage and creating synergy between water and energy management. Thus, the hypothesis is:

H11. All else equal, companies identifying linkages and trade-offs between water and carbon in their water report tend to have better water management.

5.2.5 Overall WMS (H12)

An EMS is an applicable tool for organisations to maintain sustainability in natural resource consumption, compliance to the law and efficiency improvement. As mentioned in Chapter3, there are many different kinds of EMS that serve different sustainability purposes. An important and unsettled issue is whether such systems are effective for achieving goals such as pollution reduction. Positive effects have been observed in EMS such as ISO140001. However, it is still unknown whether WMS can affect actual water usage empirically. So two hypotheses are developed as follows:

H12a. Companies with good overall water-management system will reduce water withdraw in the following years.

H12b. Companies with good overall water-management system will not reduce water withdraw in the following years.

5.3 Research design

5.3.1 Sample section

As mentioned earlier, the data only consists of companies that publicly disclosed information to the CDP in 2010. In the first year of the CDP water program, 302 large global companies were invited to participate. As this study will depict changes in water withdrawal in the following 3 years, firms with any missing observations of water withdrawals from 2010 to 2013 will be eliminated. To avoid losing substantial amount of observations, these data are obtained from two different sources. Corporate reports are the primary references for water withdrawal for all 4 years; these data are obtained from the Thomson Reuters ESG database.¹³ If some observation year is missing, that data will be obtained from its CDP report in the corresponding year. If data obtained from two different sources are consistent,¹⁴ then the water withdrawal data will be corrected or deleted in the final sample. Among the 124 companies which publicly disclosed information, 94 are selected, after excluding those with missing or inconsistent data.

Table 5.2 Sample selection

		observations
	2010 All invited	302
	Publicly disclosed	124
Exclude	Missing data	(13)
	Inconsistent data	(17)
	Sample used	94

5.3.2 Empirical model specification

The second research question concerns the finding the determinants of a good WMS. The quality of an EMS depends on the costs of implementation and the benefits of performance improvements such as reduced carbon emissions, reduced water

¹³ The Thomson Reuters ESG Data collects more than 500 environmental social and governance variables from over 1000 global companies over 13 fiscal years.

¹⁴ This study assumes changes in water withdrawal between -50% to 50% to be consistent and credible.

withdrawal, and other improvements (Lenox, 2006). As the costs and benefits are not observable, this study follows (Tang and Luo, 2014) in measuring the overall quality of a WMS, using the scoring of 10 constituent elements, as in Table 5.2. This part specifies a multiple regression in the following equation, with a continuous dependent variable.

$$\text{WMS} = \beta_0 + \beta_1 \text{PercptPhysicRisk} + \beta_2 \text{ActualPhysicExposure} + \beta_3 \text{PercptRegulatThreat} + \beta_4 \text{PercptOppo rtunity} + \beta_5 \text{Carbonlink age} + \beta_6 \text{SIZE} + \beta_7 \text{ROA} + \beta_8 \text{LEV} + \beta_9 \text{CAPIN} + \beta_{10} \text{NEW} + \varepsilon_{it}$$

The third research question tests whether a good-quality WMS will lead to an improvement in the reduction of water usage. Prior studies (Lundholm and Van Winkle, 2006) suggest that the outcome of a sustainability strategy is largely private knowledge of the management. Due to information asymmetry, it is difficult for outsiders to assess the efficiency or assign economic value to sustainability performance. Nevertheless, this study will make an attempt to evaluate the outcome through self-disclosed water-withdraw data.

5.3.3 Dependent variable

The dependent variable in this theory is the quality of water management system. The next session will discuss how to measure the quality of water management based on carbon management system developed by Tang and Luo (2014).

5.3.4 Water-management system (second research question)

As stated previously, this thesis identifies and tests factors influencing a good WMS. The CDP does not specify which factors are related to performance and which are reasons for such a performance. Therefore, this study tries to distinguish the two aspects to test the relationship. This thesis develops a framework and scoring methodology after Tang and Luo (2014) to measure the quality of a WMS. Ten elements with corresponding questions are presented in Table 5.2. The performance or the quality of the WMS is developed using questions describing the managerial behaviour of the company. For instance, four variables are constructed using questions that describe corporate perception of the institutional environment where they operate, such as the perception of physical and regulatory risks, the belief in future significant

opportunities with financial implications, and the knowledge of the water–carbon linkage. Similarly, these variables are also developed using a descriptive and scoring methodology similar to WMS. For example, the first one measures the perception of physical water risks from three perspectives using three relevant questions in the CDP water questionnaire (3.1, 4.1, and 5.1). Each response of “Yes” will be counted as one, and an index of the degree of the perceived physical risks is developed, ranging from zero to three. The fourth one, concerning the water–carbon linkage and its trade-off, is evaluated using content analysis to identify if any linkages and/or trade-offs have been mentioned in the statements. If both the linkage and the trade-off are mentioned, this variable is two; if only either the linkage or the trade-off is mentioned, one point is assigned; if neither the linkage nor the trade-off identified, this variable is zero. Table 5.3 summarises the definition and the measure of dependent and independent variables with corresponding hypotheses.

Table 5.3 Water-management system scoring methodology

Perspective	Elements	Map to question(s) in the CDP 2010 water questionnaire	Measure	Range
Water Strategy	1 Water Governance	WQ1.3 Where is the highest level of responsibility within your company for the policy, strategy or plan?	Two points are awarded if the answer to Q1.3 is “Board committee or other executive body”, one point is for the answer “Officers or managers” and zero otherwise	0–2
	2 Target	WQ1.4 Does the policy, strategy, or plan specify water reduction, quality, or efficiency targets or other water-related goals?	The target needs to be specific, measurable, achievable, realistic and time-bound (SMART); score 2 points if the measure of success and deadline of the goal has been described, 1 point for just qualitative description, 0 for no targets at all.	0–2
Water Risk Awareness	3 Materiality	W2.1 Are you able to identify which of your operations are located in water-stressed regions? W2.2 Please state (or estimate) the percentage of your operations located in these regions. W6.1 Are you able to identify which of your key water-intensive inputs come from water-stressed regions? W6.2 Please state (or estimate) the percentage of your key water-intensive inputs that come from water-stressed regions.	One point is awarded if the answer to W2.1 is “Yes” and the company is able to provide the percentage of its own operation in W2.2. One point is awarded if the answer to W6.1 is “Yes” and the company is able to identify the percentage in the supply chain in W6.2.	0–2
	4 Risk Assessment	W2.3 Please specify the method used to characterize water-stressed regions in questions 2.1 and 2.2. 6.3 Please specify the method used to characterise water-stressed regions in questions 6.1 and 6.2.	One point is awarded if the company has formal methods to assess the operational risks in W2.3. One point is awarded if the company has formal methods to assess the supply chain risks in W6.3.	0–2

Table 5.4 Water-management system scoring methodology (cont.)

Water Accounting and Assurance	5 Water Accounting	<p>W13.1 Are you able to provide data for the total water withdrawn in your own operations?</p> <p>W14.1 Please report the water withdrawals within your operations for the reporting year.</p> <p>W15.1 Are you able to identify your planned and unplanned discharges of water from your own operations by destination, by treatment method, and by quality in terms of effluent using standard effluent parameters?</p>	<p>One point is awarded if the company's answer to W13.1 is "Yes" and it reports the water withdrawals.</p> <p>One point is awarded if the company's answer to W14.1 is "Yes" and it reports water recycling/reuse.</p> <p>One point is awarded if the company's answer to W15.1 is "Yes" and it reports water discharged.</p>	0–3
	6 Water Auditing	17.1 Please indicate what percentage of your withdrawals and discharges have been verified or assured	One point is awarded if the company has external assurance on water withdrawals or discharges in W17.1.	0–1
Water Initiative Implementation	7 Water Action	W1.5 What water-related actions has your company taken in respect to its own operations?	One point is awarded if the company has implemented the system in W1.5.	0–1
	8 Opportunity Invest	W.11.5 Please describe any actions your company has taken or plans to take to exploit the opportunities identified, including the investments needed to take those actions.	One point is awarded if the company identifies opportunities and takes actions to explore it in W11.5.	0–1
Supply chain management	10 Supplier Engagement	W6.4 Do you require your key suppliers to report on their water use, risks, and management? Please comment.	<p>One point is awarded if the company's answer to W6.4 is "Yes".</p> <p>One point is awarded if the company has taken some action in W1.6.</p>	0–2
Communication	10 Disclosure		One point is awarded if the company has answered more than 50% of the questions in the questionnaire.	0–1
Total Water Management Score				1–17

Change in water withdraw (third research question)

This variable is calculated to capture the real environmental performance to test the effectiveness of the WMS. If water is managed effectively with good implementation of the WMS, then the proposition of self-regulation may be rejected. This yearly water withdraw data are obtained from the Thomson Reuters ESG database as well as CDP self-disclosure reports.

5.3.5 Explanatory variables

Table 5.5 Description of variables of WMS

	Name of variable	Definition and measure	Predict sign	Hypotheses
Dependent variable	<i>WMS</i>	Quality of Water-Management System (See Table 5.1)		
Independent variables	<i>PercptPhysic Risk</i>	Measurement of the identified physical risks in the operation and supply chain. Two points are assigned if the company answers “Yes” in both W3.1 and W7.1. One point is assigned if either W3.1 or W7.1 is answered “Yes”. Zero otherwise. W3.1 Is your company exposed to significant physical risks related to water in its own operations? W7.1 Is your supply chain exposed to significant physical risks related to water?	+	H7
	<i>ActualPhysic Exposure</i>	This variable proxies the actual physical water risks from the water withdrawal perspectives. Ratio of sale to water withdrawals of a firm in 2009 (US dollar/L). Water withdrawal is from the Thomson Reuters ESG database: ENRRDP054–Water Withdrawal Total.	+	H8
	<i>PercptRegulatThreat</i>	Measurement of the perception of regulatory risks in the operation and supply chain. Two points are assigned if the company answers “Yes” in both W4.1 and W8.1. One point is assigned if either W4.1 or W8.1 is answered “Yes”. Zero otherwise. 4.1 Is your company exposed to significant regulatory risks related to water in its own operations? 8. Regulatory risks 8.1 Are the companies in your supply chain exposed to significant regulatory risks related to water?	+/-	H9a H9b
	<i>PercptOpportunity</i>	Measurement of the identified water opportunities. Two points are assigned if the company answers “Yes” in both W11.1 and W11.3. One point is assigned if either W11.1 or W11.3 is answered “Yes”. Zero otherwise. 11.1 Do water-related issues present significant opportunities for your company? 11.3. Are there financial implications associated with the identified opportunities?	+	H10
	<i>Carbonlinkage</i>	Measurement of the relationship with carbon management. Two points are assigned if the firm has identified both linkages and trade-offs in W12.1. One point is assigned if the firm has only identified either linkages or trade-offs in W12.1. Zero otherwise. W12.1 Has your company identified any linkages or trade-offs between water and carbon emissions in its operations or supply chain?	+	H11

Table 5.6 Description of variables of WMS (Cont.)

Control	<i>SIZE</i>	Natural logarithm of total assets	+
	<i>ROA</i>	Ratio of income before extraordinary items and total assets	+
	<i>LEV</i>	Leverage ratio, measured as total debt divide by total assets	+
	<i>CAPIN</i>	Capital intensity measured as the ratio of capital spending to total sales	+
	<i>NEW</i>	Measured as a ratio of net properties, plants, and equipment divided by the gross properties, plants, and equipment at the end of the previous fiscal year	+
	<i>INDUSTRY</i>	Industry dummy variable based on GICS two-digital industry classification	Control

5.4 Results

5.4.1 Descriptive results for the second research question

Both Chapter 4 and Chapter 5 make an effort to measure the propensity of self-regulation differently due to different sample sizes and data availability. To demonstrate the consistency and validity of the two measurements, Table 5.4 gives the mean of the WMS scores for each level of the self-regulation of the 94 companies. The incremental means of WMS along each score of self-regulation suggests that the quality of the WMS is consistent with the self-regulation index. The first element, “Governance”, echoes the first two pillars of the self-regulation index “CSR committee” and “Policy”. The fourth is “Policy implementation”, which relates to the third pillar, “Initiatives”, from Chapter 4. The last one is “Water Accounting and Auditing”. This element serves the function of “Performance Evaluation”, which is the fourth pillar of the self-regulation index. The measurement also differs from Chapter 4, where the four pillars are measured with rough estimation, using one and zero. In this chapter the quality of water management is quantified using a more sophisticated method. This combines some content analysis skills. For instance, the qualitative content analysis method is used to evaluate the specificity of the water target. A water target with a measure of success and a quantitative description will score two points while a qualitative description only scores one. The total possible score for the WMS is 17, while the self-regulation index ranges from zero to four. As a result, this can be seen as an updated version of the self-regulation index to proxy for management effort.

Table 5.7 Comparison between the self-regulation index and WMS

Self-regulation index in Chapter 4	Mean of WMS score	Frequency
0	3.50	2
1	8.80	5
2	10.50	16
3	11.10	31
4	12.41	37
Total	11.23	91 ¹⁵

Table 5.6 provides the description of the scores for each element. Among the 10 elements, the elements of Governance, Accounting, Investment, Supplier Engagement, and Disclosure have high scores, while Audit is the weakest, compared to the rest. This imbalance among elements suggests that different organisations may be at different stages in developing their own WMS and have their own priorities for implementation.

Table 5.8 Description of the 10 elements

	N	mean	sd	min	p25	p50	p75	max
Governance	94	1.70	0.60	0	2	2	2	2
Target	94	1.27	0.78	0	1	1	2	2
Materiality	94	1.09	0.60	0	1	1	1	2
RiskAssessment	94	1.14	0.60	0	1	1	2	2
Accounting	94	2.12	0.81	0	2	2	3	3
Auditing	94	0.44	0.50	0	0	0	1	1
Action	94	0.90	0.30	0	1	1	1	1
OpportunityInvest	94	0.70	0.46	0	0	1	1	1
SupplierEngagement	94	0.87	0.34	0	1	1	1	1
Disclosure	94	0.99	0.10	0	1	1	1	1
WMSTotal	94	11.21	3.01	0	10	12	13	16

Table 5.7 provides the description of the variables in the second research question. The dependent variable WMS has an average of 11.21; the highest score available is 17. Two companies (Nestle and Basf SE) achieve 16 in this sample, and Basf's response

¹⁵ Three companies in the sample of Chapter 5 are deleted in Chapter 4 because of missing data.

is provided in Appendix B as an example.¹⁶ Among the independent variables, four variables that proxy corporate perception of the environment illustrate a trend. For instance, when comparing the mean and the quartiles of *PercptPhysicRisk* and *PercptRegulatThreat*, both variables have a mean around 0.8, for a full score of 2. More than 25% of companies recognise regulatory threat from both their own operations and supply chain. More than half of companies recognise significant water opportunities and financial impact. The least recognised is the linkage and trade-off with carbon management.

Table 5.9 Descriptive statistics of WMS

	N	Mean	Standard deviation	Min	P25	P50	P75	Max
WMS	94	11.21	3.01	0	10	12	13	16
PercptPhysicRisk	94	0.80	0.76	0	0	1	1	2
ActualPhysicExposure	94	2.61	3.36	0.01	0.13	0.71	4.78	10.55
PercptRegulatThreat	94	0.81	0.85	0	0	1	2	2
PercptOpportunity	94	1.30	0.90	0	0	2	2	2
Carbonlinkage	94	0.77	0.72	0	0	1	1	2
Size	94	10.27	0.96	8.32	9.60	10.33	10.93	11.86
ROA	94	0.10	0.08	-0.01	0.05	0.09	0.14	0.33
LEV	94	0.25	0.13	0.01	0.15	0.24	0.33	0.53
CAPIN	94	0.09	0.08	0.02	0.04	0.05	0.12	0.31
NEW	94	0.53	0.12	0.35	0.43	0.51	0.62	0.76

Table 5.8 describes the average of the score for WMS among different industries. Companies operating in health care and consumer staples have the highest scores, on average. Utility companies have the lowest average score. This may be because utilities companies are under stringent regulation, because their operation needs huge amounts of water and some processes are polluting. The cost to implement a full WMS

¹⁶ The lowest score, of zero, comes from the Dow Chemistry Company, which did not provide concrete data, except for some comments and links to their sustainability reports.

is greater than the benefit. Health care companies, on the other hand, are not huge water consumers. The cost of implementation can be quite small.

Table 5.10 Average score of WMS among industries

Industry	Average Score of WMS	Frequency
Consumer Discretionary	9.60	10
Consumer Staples	12.47	19
Energy	10.2	5
Health Care	12.5	10
Industrials	12.27	11
Information Technology	12	7
Materials	11.48	23
Utilities	9.22	9
Total	11.44	94

Table 5.9 shows Pearson correlations between variables. The directions of correlation coefficients of the key variables are generally consistent with expectations. Apart from *PercptPhyiscRisk* and *PercptRegulatThreat*, there are no correlation values greater than 0.6 between the pairs of independent variables, suggesting that multicollinearity is not a serious issue in the empirical model.

Table 5.11 Correlation between variables of WMS

	WMS	PercptPhysicRisk	ActualPhysicExposure	PercptRegulatThreat	PercptOppportunity	Carbonlinkage	Size	ROA	LEV	CAPIN	NEW
WMS	1										
PercptPhysicRisk	0.45***	1									
ActualPhysicExposure	-0.1	-0.18*	1								
PercptRegulatThreat	0.44***	0.20*	0.27***	1							
PercptOppportunity	0.25**	0.17	0.22**	0.22**	1						
Carbonlinkage	-0.14	-0.18	-0.04	-0.23	0.15	1					
SIZE	0.05	-0.13	0.01	0.04	0.15	0.10	1				
ROA	0.03	0.06	0.02	-0.01	-0.10	-0.06	-0.26**	1			
LEV	-0.02	0.05	0.15	0.14	0.05	-0.09	0.20*	-0.26**	1		
CAPIN	-0.11	0.04	-0.03	0.19*	-0.15	-0.46***	0.00	0.06	0.08	1	
NEW	-0.04	0.16	0.08	0.03	-0.14	-0.18*	-0.2*	-0.04	0.25**	0.46***	1

5.4.2 Main results for the second research question

The second research question tests what determines a high-quality WMS. Before OLS regression, a t-test is conducted to determine how firms with higher-quality WMS differ from their counterparts. In Table 5.10, firms are categorised into two groups based on their WMS score. The group “High WMS” has 43 observations, with the average mean being 13.8 points. The remaining 51 firms, classified as having a low-quality WMS, have an average of 9.5 points. The t score for the mean difference in WMS score is significant. Perception of the physical risks perceived by the group High WMS are significantly greater than those perceived in the group “Low WMS” while actual physical exposure shows contradictory results. This provides evidence for H7 that companies that feel pressure are more motivated to implement good WMSs. In contrast, firms have less complete water management even if they consume large amounts of water to generate revenue. H8 is not supported since companies with lower water efficiency claim to have superior WMS. Regulatory risks are generally equal between the two groups, which seems to reject H9a and H9b. As predicted by H10, the group High WMS identified more opportunities and more linkages with carbon management. The control variables do not differ significantly.

Table 5.12 Mean comparison among the two groups

	High WMS (43)	Low WMS (51)	Two sided t score
WMS score	13.8	9.5	9.30***
PercptPhysicRisk	1.04	0.51	3.58***
ActualPhysicExposure	2.05	3.28	-1.78*
PercptRegulatThreat	0.88	0.72	0.92
PercptOpportunity	1.61	0.93	3.90***
Carbonlinkage	0.90	0.60	2.01**
Size	10.33	10.20	0.65
ROA	0.10	0.11	-0.82
LEV	0.24	0.26	-0.85
Capin	0.10	0.09	0.50
New	0.52	0.55	-1.13

Table 5.11 contains the main results of the second research question in the OLS regression. Model 1 includes only control variables. Model 2 adds ActualPhysicExposure as the main explanatory variable. This explanatory variable is believed to be more objective because this ratio is calculated using data obtained from the annual report, not the questionnaire. Model 3 includes all explanatory and control variables. In M3, PercptPhysicRisk is positive and significant at the 1% level. This confirms H7 that perceived physical water risk is a primary reason to have a preventive WMS. Managers reach consensus on the importance of climate change, water shortages, floods, and so forth. This is not in conflict with self-regulation theory because it makes economic sense to mitigate physical water risks.

In Model 2, the coefficient ActualPhysicExposure is negative and significant, indicating that water-intensive companies have lower-quality WMS. Contrary to H7, companies with large water consumption fail to take measures to manage their water usage, rejecting H8. This result is in line with self-regulation theory that real environmental issues such as intensive water use fail to motivate companies to take action. This issue may often be neglected, particularly in firms without a sustainability committee that educates employees about the importance of this issue. Therefore, it is not surprising to see a contradiction between H7 and H8, following self-regulation theory. However, in M3, this variable is still negative but no longer statistically significant, after the introduction of other variables. M3 adds another four motives derived from the questionnaire. The adjusted R² increases from 0.07 in M2 to 0.40, indicating that the four motives have significant explanatory power for the quality of the WMS. ActualPhysicExposure is not as significant as PercptPhysicRisk, indicating that water consumption is just one aspect of physical risk and that perception or managerial incentives can capture the risks better. H9, PercptRegulatThreat, in contrast, is negative and significant at 5%. However, in the previous correlation analysis, this positive association between regulatory risk and the quality of WMS is weak. This may be explained by the fact that when faced with the same level of physical risk, perceived high regulatory risks help improve water management, because proactive management will soon become a common requirement, as suggested by H9a. From the perspective of self-regulation theory or H9b, if a company feels less

pressure from the government, it will improve water-management practices to pre-empt regulation and implement a differentiation strategy. The result again confirms that self-regulation theory is dominant in explaining the motivation of WMS, therefore H9b is supported. Consistent with voluntary disclosure theory and utilitarian theory, PercptOpportunity is positive and significant at 1%. This indicates that sustainability is recognised more readily if it integrates well into corporate strategy. Companies are more willing to implement good practices if they are shown potential profitability and other opportunities. Therefore, H10 is supported in this model. The last variable, Carbonlinkage, is, however, not significant in this case. Thus this thesis fails to provide strong evidence for H11. Although climate change and reduced carbon emissions are the main factors influencing corporate decision-making on carbon management, these are not the domain drivers for a high-quality WMS. The control variables are not significant in this model. Possible reasons include limited observations because only 124 companies publicly disclosed information. In general, the results are consistent with the t-test and correlation tests.

Table 5.13 Determinant of the quality of WMS main results

	M1	M2	M3
PercptPhysicRisk			0.28*** (4.57)
ActualPhysicExposure		-0.05** (-2.23)	-0.02 (-1.31)
PercptRegulatThreat			-0.15** (-2.29)
PercptOpportunity			0.22*** (3.87)
Carbonlinkage			0.08 (1.42)
Size	0.07 (0.95)	0.08 (1.18)	0.08 (1.50)
Roa	0.14 (0.18)	0.23 (0.29)	0.01 (0.01)
Lev	-0.09 (-0.16)	-0.12] (-0.21)	-0.17 (-0.37)
Capin	0.51 (0.47)	-0.23 (-0.21)	-0.81 (-0.87)
New	0.19 (0.30)	0.24 (0.38)	0.33 (0.63)
Constant	-1.30 (-1.48)	-1.31 (-1.52)	-1.24* (-1.78)
Observation	94	94	94
R2	0.14	0.20	0.51
Adjusted-R2	0.02	0.07	0.40
Prob>F	0.33	0.13	0.00
	* p<0.1	** p<0.05	*** p<0.01

5.4.3 Main results for the third research question

Continuing the grouping used in the second question, the mean of water withdrawal is summarised in Table 5.12. Surprisingly, the group with a high-quality WMS withdrew more water in the following year.

Table 5.14 Average water withdrawal between two groups for 4 years

	High-quality WMS	Low-quality WMS	T score
Y2010 withdrawal	510	418	0.22
Y2011 withdrawal	511	577	-0.12
Y2012 withdrawal	571	563	0.01**
Y2013 withdrawal	570	549	0.04**

(in million litre)

Table 5.13 shows that the proportion of firms that reduce water withdrawal changes among the following 3 years. For example, 20 out of 43 (47%) firms in the high-quality WMS group reduced water consumption in 2011 while 26 out of 51 (51%) firms in the low-quality WMS group reduced water consumption. In the high WMS group, this number slightly increased in 2012 and 2013. In the low-quality WMS group, the number stayed the same in 2012 and dipped slightly in 2013. These results indicate that not as many firms with a high-quality WMS immediately, in the next year, reduced water consumption. In the second and third year, the high-quality WMS group catches up with and even surpasses the group with a low-quality WMS. The next column describes the percentage of change relative to the prior year. On average, the 43 firms with a high WMS increased 4.84% of their water withdrawals in 2011 compared to 2010. This reduction is only 0.15%, among the 51 firms in the low WMS group in 2011. The extent of the increase shows a downward trend within the high-quality WMS group, while the rate in the low-quality WMS group increases in 2012 and 2013. In summary, firms with high-quality water management increased their water withdrawal more than their counterparts. However, the difference is not significant. Hence, the last hypothesis, H12b, is supported.

To sum up, companies with better-quality WMS may not necessarily reduce water withdrawal in the 3 years following the year in which their WMS is measured as having a high quality.

Table 5.15 Reduction of water consumption in two groups

WMS	Year	Total firms	Number of firms reduced	% of firms reduced	Withdrawal change%
	Y2011	43	20	47.51%	4.84%
High-quality WMS	Y2012	43	21	48.84%	3.09%
	Y2013	43	23	53.49%	2.00%
	Y2011	51	26	50.98%	0.15%
Low-quality WMS	Y2012	51	26	50.98%	1.43%
	Y2013	51	25	49.02%	1.50%

5.4.4 Robustness test

The score measuring the quality of the WMS is calculated as the average equal-weighted sum of the standardised value of 10 proxy variables. When using the score by simply adding the 10 elements, without standardisation, the results are in general the same. The measurement of consequent improvement uses another proxy, water intensity, and shows a consistent result with absolute withdrawal.

5.5 Conclusions

This chapter explores the second and third research questions in this thesis: what determines a good WMS and does it bring about superior water savings. To measure the quality of water management or the extent of the effort devoted, a WMS is constructed, with 10 elements, within six perspectives: water strategy, water risks identification, water accounting and auditing, water policy implementation, supply chain water management, and communication. Each element focuses on one aspect and is interconnected with the others. The quality of the WMS is measured through a systematic scoring methodology. It is only a preliminary model of WMS, which may evolve into a more effective self-regulatory scheme in the future (King and Lenox, 2000)

The sample used to analyse the second research question consists of 94 companies that publicly disclosed their water-management practices in 2010. An OLS multiple

regression is conducted to determine prominent drivers of higher levels of WMS. The results are summarised in Table 5.14. Companies improve self-regulation when they perceive higher physical water risks and less regulatory threats, and identify water-related opportunities. This indicates that better management is influenced by external threat of physical risks such as floods and water shortages. However, a high intensity of water withdrawal does not impact the decision to implement a high-quality WMS. More interesting and surprising, firms that perceive low regulatory risk seem to be more motivated to implement a good WMS. This testifies to the theory of self-regulation that firms have incentive to pre-empt external regulation by improving internal management. In addition, the higher recognition of opportunity in water also boosts the efforts devoted to water management. This indicates that some companies believe they can benefit financially from having more sustainable water practices.

This reconfirms self-regulation theory that companies have more incentive to construct a good self-regulatory image when external regulations are lax. Surprisingly, the water-carbon nexus is indifferent in this case.

Table 5.16 Different motivations for the water-management effort

Potential influencing factors	WMS score	
	High WMS	Low WMS
Perception of physical water risks	High	Low
Perception of regulatory threat	Low	High
Water-related opportunities	More	Less
Water-carbon nexus	Does not differ	
Water usage	Does not differ	

The last research question investigates whether commitment will bear satisfactory results in the short term. Companies are divided into two groups, according to their WMS score. Real environmental performance is observed through absolute water withdrawal. The group with a high-quality WMS does not show a significant difference in either aspect. In other words, the results fail to prove the effectiveness of

a WMS in the short run. However, this is not the end of the story. One possible reason is that a WMS takes effect in the long term and the eventual outcome is not yet certain. Another reason is that there is an implicit performance that is difficult to observe, such as an increase in awareness of water issues, a culture valuing water-savings, or an enhanced reputation. From a theoretical perspective, the primary motive for self-regulation is a strategy to ward off governmental intervention in water issues at this stage. Therefore, such an organisation may just talk the talk while not walking the walk. Another interpretation of this result may involve using both legitimacy theory and self-regulation theory. As indicated in Chapter 4, companies that publicly disclose information may do so mainly because of high levels of legitimacy threat as well as the high motivation of self-regulation. In this chapter, these two groups are distinguished through the quality of their WMS. Companies with a high-quality WMS are motivated to forestall external regulations while companies with a low-quality WMS may take a compliance strategy. These results may only suggest that self-regulation does not necessarily trigger improvements in environmental performance. It also confirms the possible limitation of self-regulation as being weak, its enforcement being ineffective, and punishment being secret and mild (Gunningham, 1995). Another reason for the potential weakness of self-regulation may be lack of a significant coincidence like BHP oil spill or one or more external pressures such as a new regulation, that lead to the coincidence (Gunningham, 2007). As emphasised before, water issues are geographically specific and are normally dealt with in one jurisdiction; no international event like the Kyoto Protocol can provide increasing incentives for self-regulatory water management. Nevertheless, self-regulation may be effective in the near future, driven by climate change as well as more international collaborations. However, how to report and manage water remain in their formative stages. The model presented in this paper provides a practical starting point for businesses around the world to improve the water efficiency of their production processes and products in a way that may contribute to sustainable development and green growth. There is a long way to go before achievement can catch up with aspirations in water management.

Chapter 6 Summary and Conclusions

6.0 Introduction

Demand for water and need for water information are increasing as the population grows, combined with changed precipitation patterns brought about by climate change (Morrison et al., 2010, Christ, 2014). Consequently, in many corporate sectors, additional attention is being paid to environmental issues, particularly water management. The emergence of sustainable self-regulation and discretionary disclosures of water-related information motivates this study. Water management provides a unique setting for testing a new theory. The complex nature of water issues requires different approaches that combine effort from both government and business. This thesis reveals how companies perceive external pressure and translate incentives into strategic actions through a preliminary water and environmental system.

This chapter summarises the whole thesis and concludes with discussions. The remainder of this chapter is organised as follows. Section 6.1 reviews the design of the thesis and connections between chapters. Section 6.2 and Section 6.3 present key theoretical and methodological contributions, respectively. The implications for managers, accountants, accounting educators, policymakers, and the CDP are discussed in Section 6.4. Section 6.5 lists limitations and Section 6.6 discusses opportunities for future research. Concluding thoughts are to be found at the end.

6.1 Overview of the thesis

Information is the key for both knowledge and management. It is also a mirror that reflects managerial incentives. This thesis aims to capture and understand the phenomenon of the voluntary disclosure of water-related information and how it is influenced by both internal and external factors. Chapter 2 provides the theoretical framework used in this study, while Chapter 3 reviews prior studies and identifies limitations and gaps in the literature. Chapter 4 and Chapter 5 provide empirical evidence addressing three research questions. In Chapter 4, the first research question is as follows:

- What motivates companies to voluntarily disclose their water usage and management practices to the CDP?

The approach to address this first research question is unique. The CDP has successfully leveraged the power of institutional investors, allowing for private disclosure, if a company does not favour public disclosure. In doing so, companies that have an incentive to impress only institutional investors will choose private disclosure rather than disclosing nothing. To fully utilise this characteristic, this thesis takes a holistic design, targeting three types of disclosure: public disclosure, private disclosure, and no disclosure. Private disclosure, which has often been neglected in prior studies, is treated as a unique disclosure status in this thesis. Self-regulation and external regulation are the key factors that this thesis proposes influence forms of disclosure. However, these factors do not act on disclosure individually. According to self-regulation theory, strong external regulations may undermine the effects of self-regulation and weak regulations may encourage self-regulation. To prove the self-regulation proposition, Chapter 4 tests the interactions between both factors of disclosure.

This study has shown the different incentives behind different disclosure choices. As implied by the results, public disclosure is a strategy for the advertisement of good self-regulation practices to impress stakeholders. However, it may also be a strategy of compliance for external regulation. The interplay of the two factors suggests that companies in less-stringent regulatory environments are more willing to disclose water information publicly, after improving self-regulation. This is consistent with the notion of self-regulation theory, that companies have an incentive to pre-empt external regulation by first claiming to have good internal management practices. Private disclosure stems from the incentive to establish close relationships with powerful stakeholders. This is consistent with the literature, which states that companies can benefit by withholding some information from the public (Berchicci and King, 2007). This proves the importance of a valid legal system to protect individual investors from information asymmetry. In addition, the results further imply the usefulness of water information for decision-making.

Clearly, water efficiency goes beyond compliance and focuses a firm's activities on the dramatic reduction negative environmental impacts (Melnyk *et al.*, 2003). Due to its importance, water regulation is predicted to be more stringent in the future. The CDP, CEO water mandate, and other NGOs are actively promoting campaigns about

water management. If this continues, companies are likely to adopt self-regulation schemes to react to external pressure, according to legitimacy theory. Thus, it can be argued that the environmental self-regulation orientation will stimulate decisions related to the consumption of water resources. More specifically, firms with a strong self-regulation orientation tend to participate in the CDP water program and disclose their water information publicly.

Still, some propositions are not fully verified in the first part. For example, what is the motivation for self-regulation? Will self-regulation be influenced by external regulations and will self-regulation effectively improve environmental performance? Chapter 5 addresses these issues.

Actions speak louder than words. Chapter 5 focuses on public disclosure and how self-regulation is motivated. Accordingly the second research question that Chapter 5 addresses is:

- What stimulates companies to improve their level of self-regulation in water management?

Chapter 4 measures the self-regulation index through four pillars extracted from corporate annual reports and sustainability reports. These are the establishment of a CSR committee, existence of water policies, actions or initiatives with regard to water, and performance evaluation related to water. These four, however, are far from sufficient to provide a complete picture of self-regulation practices. Therefore, the second design takes a more systematic and holistic approach, constructing a WMS. A WMS includes a set of formal water policies, goals, strategies, and administrative procedures for improving water performance. There are six perspectives identified in water management: water strategy, risk identification, water accounting and auditing, water actions, disclosure, and supply chain management. Each element in turn consists of further elements, with a scoring methodology. Thus the WMS provides a more accurate portrayal of a self-regulation initiative.

As suggested by the theory of self-regulation, companies in a less-stringent regulatory environment may worry about the law becoming more rigid in the future. Therefore,

they take the initiative in claiming (through public disclosure) that they have good water management in place, to negotiate with authorities for reduced requirements. As the main reason for self-regulation is to pre-empt external regulation, can self-regulation be more effective for preventing waste and pollution than external regulations? The third research question is as follows:

- Will a firm with an EMS effectively reduce its water usage?

Consistent with Chapter 4, some companies disclose information publicly due to regulatory pressure. Their primary motivation is to gain legitimacy and discretion; therefore, they have less incentive to actually improve the quality of their water management. Because this distinction between high and low WMS can also be a proxy for the two different motivations, the third research question examines whether a self-regulation regime can effectively reduce water consumption better than legitimation. In other words, is self-discipline more effective than regulatory interference?

Chapter 5 tests the actual water management outcome through the lens of water withdraw reduction. Unfortunately, the reduction amount and proportion do not differ between the two groups. This suggests that self-regulation may not help improve real water performance better than legal requirements, at least in the short run.

6.1.1 Connection between Chapter 4 and Chapter 5

Although the sample size, design, and methodology differ between Chapter 4 and Chapter 5, the two parts of the empirical study are closely connected. Figure 6.1 integrates the research design into the theoretical framework developed in Chapter 2 and shows the links between Chapter 4 and Chapter 5. The first research question about the motivation for three disclosure choices is tested in Chapter 4, with both binary and multiple logit regression analyses. The self-regulation proposition is tested through the interaction variable of proxies for self-regulation and external regulations. To provide a more thorough measurement of self-regulation incentives, Chapter 5 utilises the content of public disclosure material from 94 companies that participated in the 2010 CDP water program for the first time. Through the questionnaire, a WMS is constructed to proxy self-regulation effort. As the yellow colour in Figure 6.1 indicates,

the WMS and self-regulation index are both proxies for self-regulation; the index is more abstract and can be easily generalised while the WMS is more specific and only available for companies that choose public disclosure in the CDP. Similarly, external regulation and regulatory risk (green in the figure) suggest a connection between the two proxies. External regulation in Chapter 4 is proxied using stringency of environmental regulations and water consumption. Regulatory risk in Chapter 5 is assessed based on corporate perception of regulatory risk, which is believed to be more subjective than the former.

Both chapters also have unique emphases. Chapter 4 focuses on how information is released. Because public disclosure is motivated by multiple factors, the second research question aims to distinguish different groups with different motivations by scrutinising disclosed information. In the public disclosure group, companies with strong motivation to pre-empt external regulations are distinguished from those with legitimate purposes, through the conceptual framework of a WMS. Moreover, the second part complements and further clarifies the first. For instance, Chapter 4 determines that public disclosure is associated with strong external regulations, which at first glance confirms legitimacy theory and conflicts with self-regulation theory. This result is perhaps dominated by companies with a strong legitimacy threat. This can also be concluded when considering the negative signs of the integration variables. Chapter 5 sets apart the two groups by their WMS scores. OLS regression proves a negative association between self-regulation and external regulations. As can be seen from Chapter 5, companies with private disclosure show average self-regulation initiatives but are eager to communicate with powerful institutional investors. Although the contents of their responses are not available to the public, Chapter 5 predicts that they may aim to share water-related opportunities they have identified, as well as physical water risks. This information is hence believed to be of value for decision-making; therefore, companies decide to release this information to please institutional investors. Companies that did not respond probably have reduced physical water risks and fewer water opportunities.

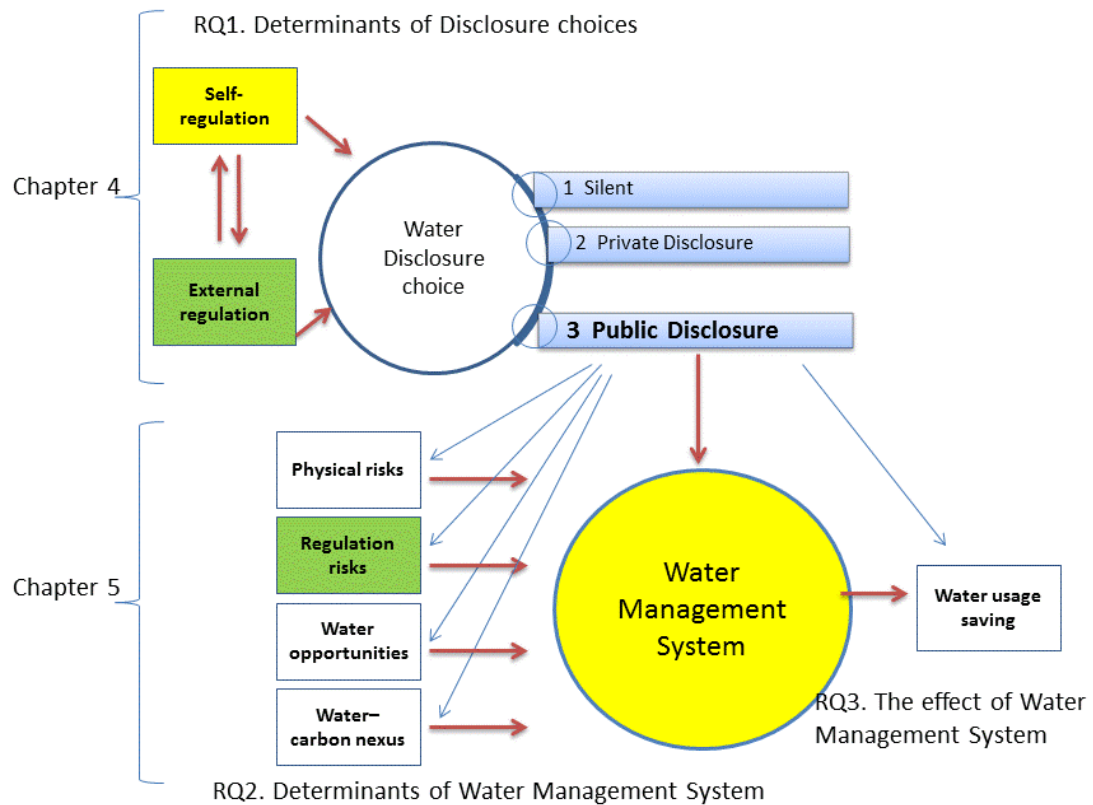


Figure 6.1 Thesis design overview

6.2 Theoretical contributions

A common problem in social and environmental studies is that they are inadequately theorised (Gray, 2002). The literature is mostly dominated by legitimacy theory, stakeholder theory, and others, which focus on the demand side of information. Companies are assumed to increase disclosure only as a compliance strategy for regulatory invention. This paper alternatively tries to show the existence of more incentives than merely those mentioned above. Because no single theory can explain diverse motives well, corporate disclosure may simultaneously be driven by interrelated incentives (Wilmshurst and Frost, 2000). This thesis complements extant theory by applying a self-regulation theory that focuses on the supply side of information. Previous theories, particularly legitimacy theory, simply assume unilateral effects of regulation on companies. Studies underpinned by this notion often assume that regulation is an exogenous factor. In fact, companies employ pre-emptive strategies to modify effects even before the formation of regulatory threats. In the case of the CDP water program, companies are taking the initiative to construct good self-regulation practices to make a sustainable and responsible impression for persuading

governmental authority to adopt less intervention. This theory enhances the understanding of the dynamics between society and business and adds a new facet of the character of self-interest maximisation among companies. This evidence has not been documented in previous studies.

Today, climate change, water crises, droughts, and floods threaten our living environment. Governments pay more attention to environmental issues and set more requirements for the industry. Even companies that are least suspect of impacting the environment are facing ever-increasing rules, standards, and even laws in regard to how to protect the environment in the business process. In this case, companies are motivated to mediate external regulations because they believe that stringent regulations will require them to be more transparent on environmental issues. Companies anticipate that if they can voluntarily adopt pro-environmental policies and proactively disclose related information, the chance of governmental interference will be reduced. The desired outcome is to have automation on this matter and forestall mandatory requirement. As stated in Chapter 2, this self-regulation notion is coherent and closely connected with other theories. Neither self-regulation theory nor the empirical results conflict with existing ideas; instead, this new theory extends them, at a new angle.

This thesis chooses the context of water management for the following reasons. Compared to carbon-emissions reduction, water issues are in general less regulated but more complex. Authorities generally do not possess as much expertise and experience as managers. Therefore, it is more likely that an autonomous approach will appear suitable for water management. As a result, self-regulation institutions play an important role in reducing information asymmetry before water reporting and disclosure becomes mandatory. The CDP water program is such an example, and its abundance of data facilitated the design of this study. Therefore, it is not incidental to apply this theory to the water scenario.

To sum up, this thesis critically examines existing theories in this field and demonstrates how legitimacy theory and self-regulation theory together reveal motives for proactive environmental activities. Empirical evidence proves the applicability of this in the context of water management and enriches the literature in this area.

6.3 Methodological contributions

A number of methodological contributions are identified, including the research setting, the source of data, the deployment of objectives, and the quantitative measures of key variables. Each of these are discussed in detail below.

First, the comprehensive, global approach of this study allows an overview of international reporting practices related to a broad set of aspects of water management. It is based on a large number of observations. Chapter 4 is based on more than 1,500 observations from about 40 countries over 4 years, and Chapter 5 includes all of the public responses in the first year of the CDP water program. Hence, this large sample increases the test power of the hypotheses in different institutional backgrounds. It also enhances the understanding of current developments in water management through intra-country comparisons and trend analysis.

Second, this thesis is facilitated by the CDP water program, which provides more structured and comparable data than conventional data sources, such as annual reports. Because water disclosure has thus far been voluntary, companies have great discretion on which and how water information is presented. Thus, this information is difficult to collect and is obscure in nature. To overcome this difficulty, the CDP water program sends standard questionnaires specifically about water management. Evidently, it is efficient to obtain information from the CDP rather than using other methods, such as interviews.

Another important contribution of this work is the classification among different types of disclosure. Private disclosure is often defined as partial disclosure, midway between public disclosure and no disclosure on the transparency spectrum. Although there have been normative discussions and case studies on the reasons for private disclosure, thus far no large empirical studies have addressed the private disclosure of environmental information, due to a lack of available data. This study fully utilises the unique design of the CDP, and includes private disclosure as a parallel status to public and no disclosure. Such a design is innovative and this issue is often neglected in research. To identify and compare the motivations for the three different types of disclosure, this study adopts three binary logistic regressions. For the robustness check, a multinomial regression is conducted, and the results are consistent.

To successfully apply self-regulation theory, innovative and rigorous designs are needed. Specifically, appropriate and representative proxies for explanatory variables are selected for both internal self-regulation and external regulation. Because internal self-regulation is difficult to observe, this thesis has created two methods to capture this motivation. First, a self-regulation index is constructed, by simply summing four individual aspects of water management. Because this index has been developed from corporate annual reports and websites, data are available from most large global companies. It thus allows the study to be conducted although some companies choose private disclosure or no disclosure for the CDP survey. Although the data are rough, they capture self-regulation to some degree, and later they proved to be consistent with the WMS. The WMS is arguably the largest contribution of this thesis. It is, to the best of my knowledge, the first WMS created for business. In nature, this WMS echoes the general concepts of an EMS or carbon-management system. As a more delicate measurement of water initiatives, the WMS, together with its scoring methodology, facilitates a comparison among companies in different industries or in different countries. The next section discusses practical implications for contemporary business management.

6.4 Practical implications

Water consumption and usage are daily operational issues faced by almost all companies worldwide. However, as one important dimension of sustainability, water management and disclosure are voluntary; they are far from sufficiently addressed on the corporate level. In the context of the current global economic crisis, this study has valuable implications for business practices, government policies, and mediator organisations like the CDP.

6.4.1 For managers

Water is a strategic resource for business sustainability, both financially and ecologically. From the corporate perspective, specialised staff, concrete targets for water-savings, and related incentives for improvement are good management practices that guide and bind a company for active information sharing with stakeholders on a broad scale. No matter what the motives may be, a WMS is designed to integrate water management into every facet of corporate management. The process of

implementation of this is not easy and takes time. The notion of self-regulation, at the very least, has proved helpful to stimulate the provision of information to external users.

6.4.2 For accountants

This paper demystifies water accounting. Today accountants have more responsibilities with regard to social, environmental, and ethical aspects than ever before. Water accounting expands the narrow view of conventional accounting and adds more value to support decision-making. Accountants are pursuing more proactive and advisory-type roles, which are outside the traditional realm of accounting. They are pursuing services that stretch across disciplines and functions. Future developments in water accounting will break the preconceived stereotype of accountants and grant them more power and accountability to help create a more sustainable future for humanity.

6.4.3 For governments

Water management is gaining more and more emphasis but practices and reporting still lack standard guidance. The government may wish to draft policies to mitigate the potential negative impact of the unsustainable use of environmental resources. This study shows that companies develop strategies to impede further mandatory regulations made by governments. Unfortunately, there is no evidence of improvement of environmental performance, which provides insights for public policy-makers on how to create effective schemes to encourage businesses to cooperate with rather than evade regulation. In particular, increasing the stringency of water regulations or a combined approach may trigger more incentives for companies to implement self-regulatory practices (Gunningham, 2007).

This study also shows the promise of normative and exercisable water accounting standards to account for the recognition of water assets, liabilities, costs, and expenses. To attest to the authenticity, compliance, and fairness of water information disclosures and to enhance the credibility of voluntary disclosure, regulators should formulate auditing and assurance standards for water and issue guidelines to strengthen the professionalism of environmental auditors (Huang and Chen, 2015).

6.4.4 For the CDP

CDP disclosure can be a possible guideline for future action. By asking companies what they have done in many aspects in relation to water, the CDP implicitly conveys the expectation of the adoption of WMS. It seems that companies have adopted a consistent strategy for CDP disclosures to maintain legitimacy created through previous reporting practices. Therefore, the CDP, a non-profit NGO actively mediating between corporations and institutional investors, may utilise this mechanism to galvanise and catalyse concrete actions.

The Holy Bible says “for by your words you will be justified, and by your words you will be condemned” (Matthew 12:37, English Standard Version). Although many companies disclosed information about water, it is still not assured how accurate the information is and what has actually taken place. The CDP by nature is still voluntary and not legally binding. Consistently, the results of the thesis reveal that companies with good self-claimed practices failed to improve their water use. Whether corporate disclosure through the CDP is just propaganda and whether the CDP, as a type of stakeholder, is held responsible need more future studies (Perez-Batres *et al.*, 2012b). Self-regulatory schemes, unavoidably, may experience free riding and opportunism in their early stages (King and Lenox, 2000). To overcome this limitation, the CDP may need to transform into a third-party verification provider to help differentiate and reward responsible firms and achieve its original promise.

6.5 Limitations

Quantitative methods are subject to many potential biases. Environmental management, disclosure, and environmental performance are closely connected (Al-Tuwaijri *et al.*, 2004, Clarkson *et al.*, 2008). Some studies have shown that they may be simultaneously determined by firm characteristics, such as underlying corporate strategy. Endogeneity is arguably the biggest issue in most studies in management. The correlation between disclosure, water management, and firm character may be due to causation, endogenous selection, or some other reason. There are alternative methods to address the selection issue such as structural equation modelling and instrumental variables, which may possibly increase the robustness and validity of the design. Due to the insufficiency of water-specific data, this thesis may not be able to

address this problem. There has been criticism of the discourse of corporate water reporting as a cynical attempt by businesses to extend control over resources; this is supported by the emergence of greenwashing to maintain a favourable brand image or a cosy arrangement of mutual benefit between the companies and non-profit NGOs involved (Hepworth, 2012). Although the CDP seems to stimulate more disclosure of specific environmental information, without further investigation it is still difficult to conclude whether the CDP provides credible information. In other words, it remains unresolved whether companies just talk the talk or actually walk the walk. Moreover, water risks are inherently a local issue, with company-, plant-, industry-, and area-specific issues and strategies. Hence, it is difficult to develop generalised approaches to solve water issues. The design of the CDP is incomplete in various ways; for instance, the content of water questionnaires has changed each year, until 2015. This hinders the comparison of observations between different years. This is the main reason why this thesis only uses the 2010 questionnaire for the content analysis and as the basis of the WMS: in that year, the question about perceived regulatory threat is replaced with more specific questions. Another limitation is that the CDP invites mainly large international corporations to participate. Thus results must be applied with caution to small and medium-sized enterprises.

One possible limitation of this study is that the research method may be subjective and may contain bias, including the construction of the self-regulation index and the scoring methodology of equal weight assigned to the 10 elements of WMS. In reality, some companies may discover a key issue and give more priority to one element over another. Under this scenario, applying the WMS developed herein to these companies may result in the same total scores but varying emphases. As mentioned before, the form and complexity of each WMS varies, but they should be kept as simple as possible. In this way, staff from the upper level of management to frontline workers can all understand and perform their duties well (Solomon, 2010).

Another limitation is that the division of perception and performance can be subjective and thus to some extent inaccurate. So far this limitation cannot be overcome, but this study does make an effort to dig deep into the purpose or the “soul” behind such unstructured questions. In doing so, this study suggests one way to interpret the content with critical thinking. Because of changes in the questionnaire from 2011 to 2013, the

quality of the WMS cannot be scored the same way as in 2010. As a result, observations have tremendously decreased. It could be promising to develop a more stable and applicable version of the WMS and compare changes in quality over many years. There still are some factors that have not been considered, such as institutional factors. For instance, organisational culture and atmosphere may potentially influence the adoption of an innovative approach to water management (Solomon, 2010). Such a WMS is not included, because this would be difficult to measure and implement.

In conclusion, this study is a preliminary attempt to solve challenging water issues using a unique approach. More scientifically designed studies are needed to increase validity and robustness. Self-regulation is an assumption that needs to be tested with more robust research and a large set of sample data. Because reality is abstract, little is known about this theory as ideology, particularly the origins and ideological functions (Bryer, 2012). Although this thesis has some limitations, it still sets a promising baseline for subsequent discussion and leaves room for future improvement.

6.6 Future studies

Sustainability strategies, reporting, and management are different, albeit related, concepts. Responsiveness does not necessarily guarantee responsible action. Still, it may help to some extent to gradually form a management philosophy and unique corporate culture, through continuous learning and systematic practice. Moreover, sustainability strategies are intended to allow firms to synergistically integrate long-term profitability with the protection of the ecosystem, and to achieve competitive advantage and market differentiation via environmental responsibility and leadership (Stead and Stead, 1995, Shrivastava, 1995). Given the complex nature of the political environment and the limited power of a pure cross-sectional analysis, more research is needed in the future to explore exactly how corporations integrate water-related strategies with normal business management. To articulate this process, the use of more in-depth case studies through content analysis of questionnaires would seem to be advantageous. With the acquisition of more detailed information, this thesis can go further in the direction of debatable normative issues. For example, a strong engagement with one particular audience is easy to perceive from the dialogic information in the CDP questionnaires. Does the gesture of answering a questionnaire convey a certain level of commitment or accountability to society? It is argued that

although stakeholder engagement has moral elements, it is primarily a morally neutral activity (Greenwood, 2007). Does the CDP reflect this notion? While this thesis will not be the last word on these subjects, it is a meaningful first step that opens up more discussion in the future.

Voluntary CSR reports vary in their levels of information quality, disclosure categories, and/or industry differences (Guidry and Patten, 2012, Wilmshurst and Frost, 2000). Corporations have discretion in selecting the proper means and content as to what and how environmental information should be disclosed, which implies that they may follow their own preference or priorities. In the sense that water presents an equally pressing challenge to the long-term sustainability of business as other challenges, the need for greater transparency in water management is just as vital as is transparency in other aspects of the environment. The identification of which aspects of disclosures are particularly of value to investors and to regulatory intervention would then become possible. It may be useful, in future research, to illustrate priorities, particularly among diverse aspects of social and environmental activities; for example, how do different institutional pressures lead to inconsistent strategies towards carbon and water disclosure? This will provide additional insight into disclosure strategies.

From a longitudinal view, companies that have participated in the CDP for more than one year may start analysing the effects of disclosure and peer performance by themselves. How the previous year's disclosure scheme helps companies' cumulative learning and leads to changes in the next year is a dynamic and interesting research question.

Meanwhile there is an escalating ecologic crisis with increasingly severe air pollution in China due to excessive coal consumption. Many people die due to air pollution-related respiratory illnesses. Water pollution is associated with food safety issues. The ecosystem is highly vulnerable and will not be compatible with high economic growth under a business-as-usual scenario. Fortunately, the government is trying to enforce some policies or mechanisms to mitigate this problem. This would allow some further contextualisation of water accounting to be designed in developing countries such as China.

To sum up, there is huge potential in this multidisciplinary area. New issues keep emerging and no satisfactory, conclusive answers can be easily found (Friedman, 2007). The question is no longer whether but how economics and ethics can be united.

This is a call for more research and increased knowledge sharing among experts presently working separately in universities, NGOs, industries, and government. Collaboration is critical for concrete benefits when applying abstract theories and concepts to the real world.

6.7 Conclusion

Water is a finite resource that each person and entity in society needs to sustain life and operation. The current ecological crisis is intensifying due to the population explosion and resource shortages. To resolve this issue, it must be framed in a wider context, including issues of material efficiency; the availability of safe, clean water, and sanitation; supply chain accountability; healthcare innovation; and infrastructure improvement. Recently, regulations and policies globally have emphasised the urgency of climate change, and thus many companies have placed priority on this over all other aspects of environmental management. However, as an important aspect of climate change, the importance of water should not be neglected or ignored.

Only what is measured can be managed. Water management for businesses is gaining in significance, while how to report or manage water is still in a very formative stage. Disclosures to date are just the tip of the iceberg of what is needed. Academics may be involved in educating organisations in the current issues that they face, advising and setting up new reporting structures and systems, as well as shaping the debate about the response to those issues. More specifically, they can advise managers to include environmental performance in the existing performance-measurement and reward systems: for instance, how to practice disciplined environmental cost control, reduce consumption, strengthen policies and procedures, and cultivate more probity and an ethical culture.

Thankfully, the paramount importance of water has been gradually recognised (Godfrey and Chalmers, 2012). There have recently been a growing number of studies on new aspects of environmental issues, leading to stiffer regulations governing water rights and responsibilities, and more attention is being paid to water management

(Mudd, 2008). One approach may be to internalise the externality by creating ownership of environmental problems. If that happens, corporate water users will have to bear an increasing share of the financial costs that will be incurred to ensure adequate provision (Money, 2014, Dobbs *et al.*, 2013). Therefore, it is rational for such corporations to take proactive actions to turn this future cost into opportunity by adopting self-regulation practices such as the CDP water program. Unfortunately, the signal sent by this pro-environmental gesture is vague to establish accountability for near-future performance. Nevertheless, corporations still need to engage with both governmental organisations and NGOs to work out desirable levels of regulations that not only effectively curb harmful business behaviour but also give sufficient incentives for concrete self-regulated practices (ACCA, 2009).

This study is far from perfect. However, this thesis provides improved specificity on certain views and thoughts that may enlighten debates and developments in the future. Hopefully, the knowledge we have been able to gain ourselves will help secure an environment with abundant clean water.

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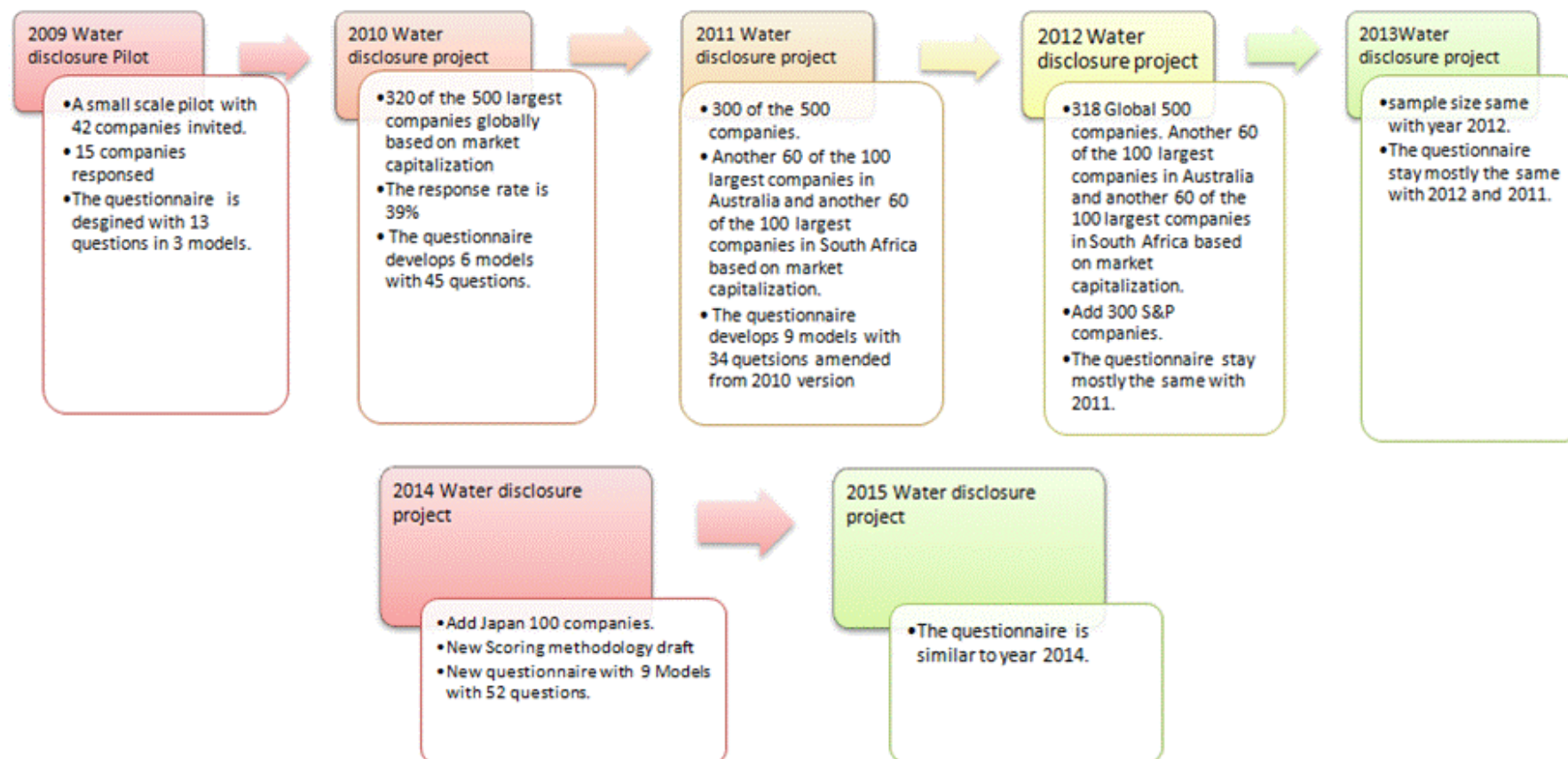
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Appendix A

1. CDP Water Disclosure Project Development



Appendix B

2010 Basf SE CDP Water Public Responses

Module1: Introduction

0.1 Introduction

Please give a general description and introduction to your organization.

BASF is the world's leading chemical company: The Chemical Company. Its portfolio ranges from chemicals, plastics and performance products to agricultural products, fine chemicals and oil and gas. As a reliable partner, BASF creates chemistry to help its customers in virtually all industries to be more successful. With its high-value products and intelligent solutions, BASF plays an important role in finding answers to global challenges such as climate protection, energy efficiency, nutrition, and mobility. BASF posted sales of more than €50 billion in 2009 and had approximately 105,000 employees as of the end of the year. BASF shares are traded on the stock exchanges in Frankfurt (Karimi et al.), London (BFA) and Zurich (AN). Further information on BASF is available on the Internet at www.basf.com.

Water protection is an integral part of BASF's global corporate strategy "We ensure sustainable development". The sustainable use of water and the conservation of water resources are an integral part of BASF's Values and Principles and important for our company's future success. Water availability and quality are global challenges of the future. We have identified water as an important issue for BASF through our issue management process.

Our action plan for sustainable water management is built on the following key elements:

- We have set global reduction targets for the emissions to water.
- All wastewater is treated appropriately and biologically purified in wastewater treatment plants.
- In 2009, we started a global project to review the water protection concepts at our major production sites by 2015.
- We currently analyze all BASF Verbund sites worldwide in terms of water stress.
- We use our Eco-Efficiency Analysis to evaluate products and processes with respect to their emissions to water. In 2009, we also started incorporating new criteria, such as local water scarcity, into this methodology.
- We have established an internal expert network, which meets regularly. Objectives of the network are to exchange information regarding best practices, Best Available Techniques (Perez-Batres et al.), and new market opportunities. The network further serves as a forum to coordinate positions regarding the issue of water.

0.2 Reporting Year

Please state the start and end date of the year for which you are reporting data.

Enter the period that will be disclosed.

Thu 01 Jan 2009 - Thu 31 Dec 2009

0.3a Reporting Boundary

Please indicate the category that describes the company, entities, or group for which you are reporting. Companies in which an equity share is held

0.3b Exclusions

Are there any geographies, activities, facilities or types of water inputs/outputs within this boundary which are not included in your disclosure?

Yes

0.3c List of Exclusions

Please describe any exclusion(s) in the following table.

Exclusion	Please explain why the geography, activity, facility or type of water input/output is excluded
Administrative sites (e.g. sales offices)	BASF only reports water inputs/outputs for its production sites. The water inputs/outputs from its various administrative sites are not collected

Exclusion	Please explain why the geography, activity, facility or type of water input/output is excluded
	since their contribution to BASF's total water inputs/outputs is not significant (< 0.1%).
Associated/affiliated companies over which BASF has significant influence but does not have financial control (so-called B-companies) or from subsidiaries that are considered to be immaterial from a BASF Group point of view (so-called C-companies)	The contribution of the water inputs/outputs from BASF's B- and C-companies to BASF's total water inputs/outputs is not significant (at least < 2%). Thus they are not collected and reported.

0.4 Country/Region Configuration

Please select the countries or regions for which you will be supplying data. This selection will be carried forward to assist you in completing your response.

Select country/region
Other: Europe
Other: Verbund site Ludwigshafen
Other: Verbund site Antwerp
Other: Verbund site Nanjing

Further Information

1.1 Does your company have a water policy, strategy or management plan?

Yes

1.2 Please describe your policy, strategy or plan here:

Water protection is an integral part of BASF's global corporate strategy "We ensure sustainable development". For us, sustainable development means combining economic success with environmental and social responsibility. We have anchored sustainability in our corporate strategy and organization.

The sustainable use of water and the conservation of water resources are an integral part of BASF's Values and Principles and important for our company's future success. Through our commitment, we aim to contribute to improving the quality of life of existing and future generations. Clean water is the most important requirement for public health, as well as for the preservation of ecosystems. Water availability and quality are global challenges of the future. We have identified water as an important issue for BASF through our issue management process.

Our water conservation activities involve our production and our products: We have decreased specific water usage in our production, reduced emissions to water, and are evaluating water protection and supply concepts at our sites. Our products contribute to water catchment and help our customers to save water and reduce emissions to water.

1.3 Where is the highest level of responsibility within your company for the policy, strategy or plan?

Board committee or other executive body

1.3a Please specify who is responsible.

Individual Board Member

1.4 Does the policy, strategy or plan specify water reduction, quality or efficiency targets or other water-related goals?

Type of target/goal	Target/goal	Comments
Absolute reduction	No global reduction target for the absolute volume of water consumed.	Water usage should be considered on a local level. Thus, in areas where water scarcity is not an issue, water usage does not necessarily lead to environmental damage. We have not set a global reduction goal for water use, as the sustainable use of water resources depends primarily on regional, local and temporal factors. As the availability and quality of water varies regionally and locally, we employ different methods for using water sustainably at our sites. To do so, we develop criteria to evaluate whether water at our production sites is sourced sustainably.

Type of target/goal	Target/goal	Comments
Quality of discharges	80% reduction of emissions of organic substances (Jones) to water. Base year: 2002; End year: 2020.	In 2009, we reduced emissions of organic substances to water by 80% compared with 2002. Emissions of organic substances amounted to approximately 18,600 metric tons (2008: 20,600 metric tons). In general, meeting discharge targets depends on various parameters, such as improvement measures, capacity utilization, changes in product portfolio, acquisitions or divestitures.
Quality of discharges	80% reduction of emissions of nitrogen to water. Base year: 2002; End year: 2020.	In 2009, emissions of nitrogen (N total) to water were 3,600 metric tons (2008: 4,400 metric tons). This amounts to a reduction of 84% compared with the baseline year 2002. In general, meeting discharge targets depends on various parameters, such as improvement measures, capacity utilization, changes in product portfolio, acquisitions or divestitures.
Quality of discharges	60% reduction of emissions of heavy metals to water. Base year: 2002; End year: 2020	In 2009, our wastewater contained 24 metric tons of heavy metals (2008: 27 metric tons). Heavy metal emissions were reduced by 61% compared with 2002. In general, meeting discharge targets depends on various parameters, such as improvement measures, capacity utilization, changes in product portfolio, acquisitions or divestitures.

1.5 What water-related actions has your company taken in respect of its own operations?

Action	Comments
Measured withdrawals and/or consumption of water	All sites use water measurement tools to track water withdrawals overall and by source (surface water, ground water, fresh water). In our corporate report we annually disclose our water balance by source according to the GRI EN8.
Reduced absolute withdrawals and/or consumption of water	BASF implements various technologies to ensure the sustainable use of water. For example, at our BASF Pakistan site, in order to address a potential water shortage, process water recycling was introduced in order to minimize ground water use from a well.
Reduced costs associated with water usage	Most of our large sites are located in close proximity to rivers. This provides a supply of surface water as a cost-effective source. We have decreased our specific water use in recent years. For instance, by intensively re-circulating water as much as possible. However, we do not want the recirculation of water to result in an increase in energy use, for instance when the water has to be re-cooled, or in other negative impacts on the environment (see also our answer to question 12).
Measured water discharge volumes and/or quality	All sites use water discharge measurement tools to track water withdrawal volumes and quality by type (cooling water, wastewater from production, gray water). In our corporate report we annually disclose our water balance by source according to the GRI EN8. In 2009, BASF discharged a combined total of approximately 185 million cubic meters of wastewater at all of our production sites.
Measured water recycling and reuse volumes	One tenth of the water used at BASF (total water use in 2009: 2,675 million cubic meters) comes into contact with products when used for washing or as a solvent or a reaction medium. All resulting wastewater is treated and biologically purified in wastewater treatment plants.
Improved quality of discharges	In 2009, BASF discharged a combined total of approximately 185 million cubic meters of wastewater at all of our production sites. Thus, our emissions were significantly reduced compared to our baseline year 2002.
Identified sustainability of water sources (including seasonal variations in availability)	In a pilot project with the European Water Partnership (EWP), we analyze all water sources at the Ludwigshafen site in terms of sustainability. The analysis includes considerations such as the sustainability of withdrawals and effluent quality (including seasonal variations), the impact of water withdrawal and discharges on ecosystems, compliance with legal laws, and other issues related to sustainable water management. Further, the insights gained from this pilot project with EWP project in Ludwigshafen will be shared with all BASF Group sites.

Action	Comments
Other: Strategic considerations relating to water in site selection	Water is an important aspect in chemical production. Therefore, the site selection process for new facilities incorporates water-related issues. In particular, the long-term availability of the resource water is an important criterion for the site decision.
Considered water-related issues in sourcing decisions	In 2009, we developed a new water supply concept at our Verbund site in Antwerp to address the issue of drinking water use in production. Starting in 2011, surface water in a tidal freshwater area in the southern part of the Netherlands will serve as a more sustainable source.
Invested in making products more water-efficient/developing more water-efficient products	In 2009, BASF expanded its portfolio of water treatment products through the acquisition of Ciba. With the integration of Ciba, we added water treatment chemicals as a new business sector. Our products contribute to water catchment and help our customers to save water and reduce emissions to water. As well as offering customers a range of individual products for handling water and wastewater, we also supply comprehensive solutions, from wastewater checks to preventive water pollution control. These tailor-made solutions meet individual customers' specific requirements and are part of our program SUCCESS – Sustainable Development for Added Value. SUCCESS combines BASF's accumulated sustainability expertise in the areas of energy, product responsibility, health, safety and environment.
Ensured employees have access to safe drinking water and sanitation	All our employees have access to safe drinking water and sanitation at the workplace.

1.6 What water-related actions has your company taken in respect of factors beyond its own operations?

Action	Comments
Engaged with local communities	A joint project with the United Nations Environment Program (UNEP) in Guatemala plans to teach people in mountain regions how to produce clean drinking water from rainwater.
Other: International Donation Project	In 2009, BASF Social Foundation's Christmas donation campaign contributed to improving the drinking water supply in the Umzimvubu region of South Africa. BASF SE made a donation of €100,000 to the project as starting capital. In addition, BASF employees in Germany and South Africa jointly donated more than €100,000. Our partner for this project is the United Nations Environment Program (UNEP).
Other: Aid project for natural catastrophe victims 2009 in Nepal, India and Philippines	In the area of long-term reconstruction aid, BASF Social Foundation also supports a UN-HABITAT project for flood victims in India and Nepal, as well as a disaster relief community project in the Philippines.
Engaged in initiatives to develop standardized water accounting methodology	BASF is currently running a pilot project with the European Water Partnership at the BASF site in Ludwigshafen. The goal of the pilot study is to test the applicability of a tool to define, monitor and assess water management at an operational level. This tool was developed in the EWP Water Stewardship project "Communication of Sustainable Water Management (SWM)" and embodies a set of principles, criteria and indicators on which an objective assessment of the water management of water users will be based. The outcome of the pilot study will directly contribute to the development of a voluntary system to assess, communicate and acknowledge SWM users in Europe.
Engaged in water management processes (e.g. consultations, user group discussions, conferences etc.)	We engage in a constant exchange and dialogue with expert groups and initiatives. For instance, we are a strategic partner of the EWP (European Water Partnership) and are a member of international initiatives such as the WBCSD (World Business Council for Sustainable Development), the UN Global Compact, and the ICPR (International Commission for the Protection of the Rhine).
Enhanced habitat or watershed management	BASF is developing concepts to protect surface water in conjunction with the European Crop Protection Association (ECPA). For example, grass alongside bodies of water and field edges has proven effective in catching the water flowing off fields following heavy rain and in filtering it. In a research project in France, measures of this kind have reduced the proportion of contaminated water samples in a river's catchment area by approximately 80 per cent.

Action	Comments
Enhanced habitat or watershed management	BASF support the pilot project “Schone Bronnen” in the Netherlands. This project involves water authorities cooperating with manufacturers to raise awareness of good agricultural practices for both crop protection advisers and farmers. Intensive, easy-to understand advice helps achieve a number of goals, such as restricting the use of crop protection products in critical areas or at critical times. This is also one of the central objectives of our product stewardship.
Increased access to safe drinking water	BASF supports a project of the Water Technology Center in Karlsruhe, Germany. This project is currently researching whether harmless substances can be transformed into toxins during drinking water treatment, for example, when metabolites of crop protection products are oxidized. The results of this project could affect water purification methods and the approval process for crop protection products, making them even safer to use. BASF produces Ultrason® a high performance plastic which is used in the portable Lifestraw® Family water purification system by Vestergaard Frandsen. This system simplifies on-site conversion of nonpotable water into potable water, reduces the risk of contracting gastrointestinal illnesses from nonpotable water and can purify at least 18,000 liters of water without the need for electricity, replacement parts or chemicals.
Engaged with local communities	Our Sao Bernardo do Campo site in Brazil is located next to a UNESCO biosphere reserve. In cooperation with the German Society for Technical Cooperation (GTZ), BASF opened the "Espaco Eco" foundation in this biosphere reserve in 2005 as the first competence center for eco-efficiency in South America. Our goal is to increase awareness for BASF’s Eco-Efficiency Analysis, which incorporates criteria such as local water scarcity. In addition, the foundation focuses on environmental education. Further, as part of the Mata Viva initiative, BASF has been engaged in sustainable agriculture projects in cooperation with farmers and local organizations for approximately 25 years.
Increased access to safe drinking water	Following the Asian Tsunami on December 26, 2004, which left hundreds of thousands of people displaced and homeless, BASF donated water purification units to process 6000 liters of drinking water per hour and a 100000 liter water tank. These were quickly sent to the affected region by the German organization THW.

1.7 What water-related actions are you considering taking?

The following action plan identifies key areas of activity for sustainable water management and applies to our own operations.

Action plan for sustainable water management:

- We have set global reduction targets for the emissions to water.
- All wastewater is treated appropriately and biologically purified in wastewater treatment plants.
- In 2009, we started a global project to review the water protection concepts at our major production sites by 2015.
- We currently analyze all BASF Verbund sites worldwide in terms of water stress.
- We use our Eco-Efficiency Analysis to evaluate products and processes with respect to their emissions to water. In 2009, we also started incorporating new criteria, such as local water scarcity, into this methodology.
- We have established an internal expert network, which meets regularly. Objectives of the network are to exchange information regarding best practices, Best Available Techniques (Perez-Batres et al.), and new market opportunities. The network further serves as a forum to coordinate positions regarding the issue of water.
- We contribute our know-how on sustainable water management to partnerships and international initiatives, for instance as a strategic partner of the European Water Partnership.
- As a research-based chemical company, we offer intelligent solutions with innovative ideas. For example, we are currently developing crops that are more resistant to drought than conventional varieties.
- We annually disclose our water balance and the current target achievement status in reducing emissions to water in our corporate report.
- BASF provides focused information regarding water issues on our Sustainability Center website: <http://www.basf.com/water>.

1.8 What water-related initiatives does your company participate in and what tools or resources does it use?

Identify water-related initiatives

Alliance for Water Stewardship
Global Reporting Initiative
WBCSD Global Water Tool
Other: European Water Partnership
Other: The chemical industry's voluntary initiative Responsible Care
Other: BASF's Eco-Efficiency Analysis tool
Other: BASF's SEEBALANCE (Socio-Eco-Efficiency Analysis) tool
Other: Water Stress Index

Further Information

Addendum to Q1.3: The highest level of responsibility for all environmental issues, including water, is attached to the board level. More precisely, Dr. Harald Schwager, who is a Board Member and Industrial Relations Director, is responsible for Environment, Health & Safety, and has the overall responsibility for all environmental issues. He chairs the globally responsible BASF Sustainability Council, which ensures that the BASF Group acts in accordance with the principles of sustainable development. The Sustainability Council advises the Board of Executive Directors on decisions concerning sustainability. It also issues globally valid Group directives and is the central decision-making body for all relevant sustainability topics. The Council comprises of nine heads of functional, operating and regional divisions, including the President of the Competence Center Environment, Health & Safety. The president of this Competence Center is Dr. Ulrich von Deessen, who reports directly to the Board of Executive Directors. The Sustainability Council is supported by regional steering committees in Europe, North and South America and Asia. They identify key regional topics, initiate the corresponding projects, and implement global decisions locally. The steering committees are assisted by task-specific project teams, which can be made up of employees from different units. Our Sustainability Center coordinates between the Sustainability Council, regional networks and operating units regarding the implementation of the strategy in day-to-day business. In addition, the Center serves as a point of contact for external stakeholders. The worldwide BASF Responsible Care network implements requirements in the areas of environment, health and safety.

Addendum to Q1.4: All reduction goals for emissions to water are Group-wide covering the company's own operations.

Addendum to Q1.8: Initiatives: a) Global Reporting Initiative (GRI) The GRI reporting guidelines are a valuable tool to assist companies in their sustainability reporting. Using the guidelines underpins the transparency and credibility of the reporting companies. BASF is an organizational stakeholder of GRI and involved in the development of new indicators sets. b) EWP (European Water Partnership) We contribute our expertise in the area of sustainable water management to partnerships and international initiatives, for example as a strategic partner of the European Water Partnership. EWP is a multi-stakeholder, non-profit organization which aims to promote water stewardship in Europe. Main activities are the definition of a European Water Vision, raising awareness for water use and protection (Aquawareness), networking, and water stewardship. BASF is currently running a pilot project with the European Water Partnership at the BASF site in Ludwigshafen. The goal of the pilot study is to test the applicability of a tool to define, monitor and assess water management at an operational level. This tool was developed in the EWP Water Stewardship project "Communication of Sustainable Water Management (SWM)" and embodies a set of principles, criteria and indicators on which an objective assessment of the water management of water users will be based. The outcome of the pilot study will directly contribute to the development of a voluntary system to assess, communicate and acknowledge SWM users in Europe. The overall goal is to establish an international water stewardship system which will identify and reward organizations that act as stewards of the world's freshwater resources. Benefits to BASF of the pilot study - Test applicability of the Water Stewardship Standard on an operational level - Incorporate the needs of the chemical industry into a European approach for water stewardship - Identify water-related risks at site level - Gain early experience in the implementation of the new Water Stewardship system c) Responsible Care We have embraced the goals of the chemical industry's voluntary "Responsible Care" initiative and apply them to the entire BASF Group. The Competence Center Responsible Care defines concrete goals for the key sectors of Responsible Care, ensures their implementation and monitors goal achievement. Tools: - Eco-Efficiency Analysis: BASF's Eco-Efficiency Analysis evaluates products and processes with respect to their emissions to water. In 2009, we also started incorporating new criteria such as local water scarcity into the methodology. - SEEBALANCE: The Socio-Eco-Efficiency Analysis SEEBALANCE® is an extension of the Eco-Efficiency Analysis to include social impact. This incorporates additional social criteria such as accidents at work, vocational training, and spending on research and development. (Report, Page 29) - Water stress index: We analyze all BASF Verbund sites worldwide regarding water stress. - Communication tools: Water Stewardship in Corporate Report, Homepage Water (www.basf.com/water), Corporate Campaign "Africa's water loves chemistry" Resources: - Sustainability Center - Environment, Health & Safety units - Global Responsible Care network - Expert network with the objective to exchange best practices, Best Available Techniques (Perez-Batres et al.) and information on market opportunities, as well as the coordination of positions regarding the issue of water.

2.1 Are you able to identify which of your operations are located in water-stressed regions?

Yes

2.2 Please state (or estimate) the percentage of your operations located in these regions.

Unit used for calculation	Percentage
Percentage of water withdrawals by volume	Less than or equal to 10%
Percentage of number of facilities	More than 20% but less than or equal to 30%

2.3 Please specify the method used to characterize water-stressed regions in questions 2.1 and 2.2.

Method	Please add any comments here:
Publicly available mapping tool (such as WBCSD Global Water Tool)	As for the quantification of the Water Stress Index at our sites, we followed the method as given in the paper by Pfister et al. (Pfister, Koehler and Hellweg, Assessing the Environmental Impacts of Freshwater Consumption in LCA, Environ. Sci. Technol, 2009, 43 (11), pp 4098–4104, DOI: 10.1021/es802423e). This so called WaterGap2 global model is a hydrological model on the global scale with a resolution of 0.5 degrees. It is provided by the Institute of Physical Geography, University of Frankfurt, Germany. A water-stressed region is defined as one with a Water Stress Index WSI > 0.9. This is characterized as a location in which more than approximately 60% of the hydrological available water is used by industry, households and agriculture. Some BASF sites in regions with water stress as classified above (WSI >0.9) are located in coastal regions. These sites mainly use seawater (approx. 95%) instead of fresh water for cooling purposes and thus are not significantly affected by water stress: Referring to BASF's total volume of water withdrawal in 2009, only about 7 million m3 of fresh water (approx. 0.3%) is withdrawn in water-stressed regions.

Module3: 2010-Water- Physical Risks**3.1 Is your company exposed to significant physical risks related to water in its own operations?**

Yes

3.2 What are the current and/or anticipated physical risks, and the associated locations and timescales?

Risk	Location	Timescale (years)	Further details
Flooding (due to changing local hydrological conditions) leading to disruption to operations	Other: Europe, Asia, North America, South America	21 - 50	Increased incidences of floods inland, scarcity of usable water, poor availability of water in rivers adequate for cooling purposes and transportation.
Increased water stress or scarcity leading to higher energy or commodity prices	Other: Europe, Asia, North America, South America	21 - 50	Increased water scarcity could result in a greater requirement to recycle cooling water, the largest type of water requirement for BASF. This would result in higher energy costs to cool this recycled water.
Flooding (due to rising sea levels) leading to disruption to operations	Other: Europe	> 50	Flooding of production sites (e.g. in Antwerp) due to sea-level rise.
Increased water stress or scarcity leading to higher energy or commodity prices	Other: Europe, Asia, North America, South America	21 - 50	Changes in precipitation patterns can lead to water scarcity and poor availability of water in rivers for cooling purposes.
Flooding (due to rising sea levels) leading to disruption to operations	Other: Tropical cyclone areas in North America and Asia	Current	Changes in frequency of extreme weather events leading to shut down of production due to hurricanes or flooding in coastal regions.

Risk	Location	Timescale (years)	Further details
Increased water stress or scarcity leading to disruption to operations	Other: Europe	> 50	Reduced usability of waterways for transportation, e.g. the Rhine River, at which our largest Verbund site Ludwigshafen is located.

3.3 Please describe the ways in which the identified risks affect or could affect your own operations.

BASF is aware of potential risks related to water and has related management systems and infrastructure in place in the occurrence of such events.

Nonetheless, extreme weather events such as hurricanes or flooding can rarely require a shut-down of our plants or hamper normal operation. This is associated with production losses, not only in terms of production being temporarily stopped, but also in terms of the transport of raw materials and products by ship. Only few examples have occurred so far: In August 2005, hurricane Katrina caused production facilities at the Geismar site to be temporarily shut down. In 2008, hurricane Ike caused facilities at the Texas Gulf Coast location to be shut down. Further, in September 2006 the Tarragona site and in February 2007 our site in Indonesia were flooded. Since the Tarragona site was flooded mainly due to special local conditions, appropriate measures were implemented by BASF together with the local authorities. However, as such occurrences are freak natural occurrences, it is difficult to take preventive measures against this risk.

Changes in precipitation patterns may result in reduced possibility of using water as a resource for process cooling and as a means of transportation. In 2009, we used 2.68 billion cubic meters of water worldwide, 91% for cooling purposes and 9% for production. 95% of the total water supply is taken from surface water. Changed availability of water therefore requires adaptation of the cooling equipment of our plants.

Also, in Europe, for example, 34% of goods (incoming and outgoing) are transported by ships on rivers to and from our production sites. Changes in the discharge of rivers therefore will require us to adapt our logistic concepts accordingly.

The transport of goods (both products and supplies) by water way is very important to BASF. In 2009, of the total 12.7 million tons of materials transported into and out of the BASF Ludwigshafen site, 5.5 million tons (or 43%) were transported by waterway (3.6 million tons of supplies and 1.9 million tons of products). Thus, rising and lowering water levels in waterways used to transport goods are a risk in our own production. During times of a too high water level (few times during the year on an hourly scale), the Rhine River may be blocked from docking at the site. During times of a too low water level (occasionally in the spring or fall), barges must reduce their load (e.g. 20-35% of their maximum load or 300-400 ton rather than 2000 tons) in order to enable transport without touching bottom. This was the case in 2003 when low water levels were experienced for the Rhine River from May to October. This has the effect of slightly increasing transport costs (since transport is shifted to more the costly alternatives train and truck), increasing personnel allotted for transport preparation and may potentially limit transport amounts through insufficient logistics infrastructure (e.g. loading stations). During this time of a low water level, sufficient cooling water to the Ludwigshafen was ensured through the use of addition pumps. One way of preparing for this risk is to increase the stock of supplies and products. However, this has a financial implication and must be carefully considered.

However, compared with some of our competitors we find ourselves in a favorable position regarding a decline in water levels as the vast majority of BASF's production sites are located at the sea or by major waterways.

3.4 Are there financial implications to the identified risks?

Yes

3.5 Please describe them.

Financial implications of the abovementioned physical risks are minimal. Forecasts on the amount of losses due to extreme weather events cannot be made, since exact forecasts on the future frequency of floods and hurricanes are not possible with the existing climate models. Based on our sales of €50.7 billion in 2009, shutdown of one of our major sites (5% of BASF's global production) for two days could result in a loss of sales of up to €14 million.

Financial losses due to destruction of our assets during extreme weather events is extremely unlikely, since we have taken preventive measures against this and constantly check whether they are still appropriate. In the same way our preventive measures prepare us well against financial losses from supply chain disruptions.

3.6 Please describe any actions the company has taken or plans to take to manage or adapt to the risks that have been identified, including their impact on operating costs (positive or negative) and CAPEX programs.

The evaluation of the physical risks from climate change is part of our extensive risk management in our global Competence Center Responsible Care, which is part of our global Competence Center Environment, Health and Safety.

BASF has put into practice an Environmental Protection Code to protect the environment by reducing emissions to air and water. This strategy requires the minimization of emissions generated by existing facilities as well as new ones to be planned and designed. BASF practices thorough hazard control. Technical measures such as closed systems are one of the main steps used in the prevention of exposures to chemical substances. Beyond this, there is an obligation to optimally prepare for and respond to involuntary chemical exposures.

Our international in-company BASF Climate Monitoring Expert Group is observing local climate changes at the fourteen most important production sites of the BASF Group in the four regions Europe, Asia, North and South America. Temperature changes, changes in precipitation quantities, and extreme weather events are observed and recorded. The results of published regional climate modeling studies are analyzed and compared with the trends identified internally. We cooperate with research institutes and internationally recognized institutions to interpret previous modeling studies and thus be able to better assess the extent to which we could be affected. On a yearly basis, recommendations for action are derived from identified physical risks for BASF locations.

Most of the identified risks will materialize within a timescale of more than 20 years. Also, the assessment of physical risks from climate change currently includes very high uncertainties, since accurate regional climate change models with high resolution are not available. For a clear assessment of how and to what extent climate change will affect our enterprise in the future we need even better models and studies, especially with higher regional resolution. BASF is supporting these efforts by taking part in a project of the German state of Rhineland-Palatinate with the Potsdam Institute for Climate Impact Research. The objective of the study is to analyze previous climate development and assess what is yet to come, to develop methods further and to identify further needs for research. No specific costs are associated with the described research projects or activities that focus on monitoring and evaluating climate change.

Overall, management of the identified risks in many cases rather implies deepening of the understanding of the exact extent and timeframe of the risk than physical action. The consequent monitoring of climate change enables us to adapt gradually, partly within the framework of regular investment cycles and thus reduce additional investment.

With regard to the risk of extreme weather events like hurricanes and flooding and the induced changes in the supply chain, we already see the consequences of climate change and have taken the appropriate actions:

- 1.) To avoid sites being flooded in the future, some smaller adaptations such as heightening of dams have been and will continuously be carried out at the relevant locations. These adaptation measures are mostly carried out as part of regular maintenance work and additional costs are therefore not being accounted for separately.
- 2.) Immediate action under such extreme weather events is described in our on-site Emergency Response Plans. The production sites are trained to activate our Emergency Response Management System, which covers our subsidiaries and joint ventures around the world and also extends to suppliers, customers, neighboring companies, as well as the cities, towns and the communities in which we operate.
- 3.) Sourcing: In our department Global Procurement & Logistics, the aim to reduce the number of single source products is a matter of principle. Thus, without causing additional costs the risk of disruption of the supply chain is greatly reduced.
- 4.) Adaptation to a reduced usability of rivers for transportation is possible and is already practiced nowadays in case of low water levels in the river Rhine. Since the alternative transportation by train or truck is more costly, depending on the level of adaptation required, logistics costs will increase.
- 5.) To minimize the risks resulting from induced changes in the supply chain and with our customers, BASF supports projects that increase the understanding of required adaptation measures in the overall business community. For example, BASF participates in a project of the German government with the UBA (Federal Environment Agency). This project analyzes the subject of plant security, including chemical plants, and environmentally affected sources of danger such as flooding, storm or subsidence caused by mining. No specific costs other than human resource costs are associated with this project for BASF.

Module4: 2010-Water- Regulatory Risks

4.1 Is your company exposed to significant regulatory risks related to water in its own operations?

Yes

4.2 What are the current and/or anticipated regulatory risks, and the associated locations and timescales?

Risk	Location	Timescale (years)	Further details
Regulation of discharge quality/volumes leading to higher compliance costs	Other: Europe	Uncertain	Implementation of the Industrial Emission Directive (IED) and following requirements (e.g. BREFS (BAT Reference Documents)) could lead to a revamping of BASF wastewater treatment plants.
Mandatory water efficiency, conservation, recycling or process standards leading to higher compliance costs	Other: China	Current	Regulatory requirements to recycle an increased amount of water at our Nanjing site.

4.3 Please describe the ways in which the identified risks affect or could affect your own operations.

The above identified risks are currently being evaluated.

4.4 Are there financial implications to the identified risks?

Yes

4.5 Please describe them.

There are possibly financial implications if the Industrial Emission Directive is implemented; however, it is too early to assess this. The requirement to recycle water at our Nanjing site has the financial implication that a new reverse osmosis plant is required, representing a significant investment.

4.6 Please describe any actions the company has taken or plans to take to manage or adapt to the risks that have been identified, including their impact on operating costs (positive or negative) and CAPEX programs.

We continuously monitor emerging legislation and advocate regarding water legislation. We actively engage with decision makers and governments on environmental issues either as an individual company or via a trade association such as Cefic (the European Chemical Industry Council) or other organizations. In the context of the European Transparency Initiative, BASF's estimated costs directly related to representing the company's interests to EU institutions in Brussels amount to €1,200,000 annually.

Module5: 2010-Water- Other Risks

5.1 Is your company exposed to other significant risks (such as product or reputational risks) related to water in its own operations?

Yes

5.2 What are the current and/or anticipated impacts or risks, and the associated locations and timescales?

Risk	Location	Timescale (years)	Further details
Reputational risk	Other: All regions	Current	Reputational risk due to transportation accident on waterway.
Other: Changes in the availability and costs of goods and services	Other: Europe	1 - 5	Increasing costs/prices for energy, water and raw materials.
Other: Changes in the availability and costs of goods and services	Other: All other regions	6 - 10	Increasing costs/prices for energy, water and raw materials.
Other: Geopolitical conditions	Other: All regions	21 - 50	Geopolitical instability due to climate change, such as migration, food wars, declining purchasing power etc.

5.3 Please describe the ways in which the identified risks affect or could affect your own operations.

The costs for water and other raw materials may increase due to climate change and water scarcity. The success of large, transnational companies such as BASF depends on the long-term availability of resources, economic stability, stable political conditions, good infrastructure and widespread purchasing power and economic wealth. Climate change influences these frameworks that affect our whole value chain including our suppliers, business partners and customers.

5.4 Are there financial implications to the identified risks?

Yes

5.5 Please describe them.

For the financial implication resulting from increased energy, water and raw material prices, exact data cannot be given for mid-term and long-term effects, since the impacts are steered by a multidimensional matrix of influencing factors that vary from business to business.

5.6 Please describe any actions the company has taken or plans to take to manage or adapt to the risks that have been identified, including their impact on operating costs (positive or negative) and CAPEX programs.

BASF regularly conducts wide-ranging analyses of climate change risks and opportunities as part of the corporate risk management and opportunity evaluation process. The identified risks and opportunities associated with changing consumption patterns and demand from different industry sectors are taken into account when developing long-term strategies for the business units that develop, produce, market and sell our products. BASF continuously invests in research and development of leading technologies and develops improved or new solutions that help protect the climate and hence water. In 2009, we spent about one third of our R&D expenditures (€1.4 billion) on product and process innovations where the R&D target is related to climate protection.

Transporting goods (also dangerous goods) via barge and ship occurs on a daily basis. BASF has established standardized group-wide safety standards for shipping. Information regarding ship safety evaluations by independent inspectors is documented in a database through the Chemical Distribution Institute (CDI). This information is available to all members of CDI and thus also to BASF employees.

In order to avert reputational risks, BASF holds an open dialogue with all stakeholders on climate change issues, including water and reports transparently through various media and initiatives (Corporate Report, CDP information request, website etc.) on its climate protection strategy and its ongoing efforts to reduce BASF's direct and indirect emissions to water. In addition, BASF informs customers and interested stakeholders on the water savings potentials when using BASF products such as BASF Color Fast Finish, Cyclanon® XC-W New or Cyclanon® ECO / Cyclanon® ECO Plus. To this end, BASF regularly reports on its total water use, water abstraction sources, water discharge volume and emissions to water. The results show that BASF continuously reduces emissions to water which could be harmful for water quality in general, biodiversity and ecosystems near its water sources in particular.

BASF collaborates with other companies and environmental organizations in the development of standard methods for good water stewardship. We thereby contribute our methodological expertise with the Eco-Efficiency Analysis (economic and ecological parameters), which BASF has used in more than 400 studies and which includes criteria related to water stress. In 2009, we started to participate in a pilot project of the European Water Partnership to develop a new standard for water stewardship in Europe. Furthermore, we are engaged in other water-related partnerships and initiatives, e.g. Alliance for Water Stewardship or the WBCSD Global Water Tool.

If not explicitly stated, no other specific costs or investments are linked to the described actions. Costs that are associated with these activities are covered by other BASF expenses such as administrative, personnel or general expenses.

Module6: Water Use**6.1 Are you able to identify which of your key water-intensive inputs come from water-stressed regions?**

Yes

6.2 Please state (or estimate) the percentage of your key water-intensive inputs that come from water-stressed regions.

Input	Percentage	Unit used for calculating percentage	Please add any comments here:
Exemplary key raw material Naphtha	Less than or equal to 5%	Percentage of total purchases of that input by volume	We have determined that <5% of naphtha, one of our most prominent raw materials and representing a significant portion of our total purchase volume, is supplied from water-stressed regions. Naphtha is purchased for our operations in Europe, Asia and North America, where the two latter regions have a 0% sourcing from water-stressed

Input	Percentage	Unit used for calculating percentage	Please add any comments here:
			locations. Further, a broad evaluation of all key raw materials (70) shows that approximately 1% is sourced from entirely water-stressed countries. As a general rule, BASF is committed to multiple-source purchasing. Thus, an evaluation of all sources for our portfolio of 19500 externally sourced raw materials is extremely complex. Of more than 6000 raw material suppliers, many are traders and may not disclose their sources. For example, as much as 100% of some specific raw materials (e.g. natural gas) are supplied by traders, affecting the feasibility of the study.

6.3 Please specify the method used to characterize water-stressed regions in questions 6.1 and 6.2.

Method	Please add any comments here:
Publicly available mapping tool (such as WBCSD Global Water Tool)	As for the quantification of the Water Stress Index at our sites, we followed the method as given in the paper by Pfister et al. (Pfister, Koehler and Hellweg, Assessing the Environmental Impacts of Freshwater Consumption in LCA, Environ. Sci. Technol, 2009, 43 (11), pp 4098–4104, DOI: 10.1021/es802423e). This so called WaterGap2 global model is a hydrological model on the global scale with a resolution of 0.5 degrees. It is provided by the Institute of Physical Geography, University of Frankfurt, Germany. A water-stressed region is defined as one with a Water Stress Index WSI > 0.9. This is characterized as a location in which more than approximately 60% of the hydrological available water is used by industry, households and agriculture.

6.4 Do you require your key suppliers to report on their water use, risks and management?

Yes

6.4a Please add any comments regarding supplier water reporting here:

When choosing suppliers, our decisions are not based solely on economic criteria. Both new and existing suppliers are also evaluated on the basis of environmental protection, occupational safety and social standards. These standards are incorporated in our procurement conditions. In 2009, BASF procured raw materials from more than 6000 suppliers worldwide. Risk matrices help us to identify potential high-risk suppliers. Our assessment is based on an evaluation of country, product and sector risks. Further, we conduct on-site visits to suppliers according to their risk potential. One part of these supplier visits includes questions related to water, such as the existence of permits, details of wastewater treatment, management concepts and operation procedures. In 2009, we paid on-site visits to approximately 140 raw materials suppliers to evaluate environmental, health and safety aspects, including aspects relating to water.

Module7: Physical Risks

7.1 Is your supply chain exposed to significant physical risks related to water?

No

7.7 Please explain why you do not consider your supply chain to be exposed to physical risks.

BASF is committed to multiple-source sourcing in order to circumvent various risks such as quality issues, availability and price volatility of raw materials and precursors or other unforeseen events. In our department Global Procurement & Logistics, the aim to reduce the number of single source products is a matter of principle. BASF sources its raw materials and precursors worldwide. Thus, as a general rule, the risk from supply chain or supply process disruption is very small.

Further Information

Module8: Regulatory Risks

8.1 Are the companies in your supply chain exposed to significant regulatory risks related to water?

No

8.7 Please explain why you do not consider your supply chain to be exposed to regulatory risks.

BASF is committed to multiple-source sourcing in order to circumvent various risks such as quality issues, availability and price volatility of raw materials and precursors or other unforeseen events. In our department Global Procurement & Logistics, the aim to reduce the number of single source products is a matter of principle. BASF sources its raw materials and precursors worldwide. Thus, as a general rule, the risk from supply chain or supply process disruption is very small.

Module9: Other Risks

9.1 Are the companies in your supply chain exposed to other significant risks (such as reputational risks) related to water?

No

9.7 Please explain why you do not consider your supply chain to be exposed to other risks.

BASF is committed to multiple-source sourcing in order to circumvent various risks such as quality issues, availability and price volatility of raw materials and precursors or other unforeseen events. In our department Global Procurement & Logistics, the aim to reduce the number of single source products is a matter of principle. BASF sources its raw materials and precursors worldwide. Thus, as a general rule, the risk from supply chain or supply process disruption is very small.

Module10: Detrimental Impacts

10.1 Please describe any detrimental impacts to business related to water your company has faced in the past five years, their financial impacts and whether they have resulted in any changes to company practices.

Extreme weather events such as hurricanes or flooding can require a shut-down of our plants or hamper normal operation. This is associated with production losses, not only in terms of production being temporarily stopped, but also in terms of the transport of raw materials and products by ship. For example, in August 2005, hurricane Katrina caused production facilities at the Geismar location to be shut down temporarily and in 2008, hurricane Ike caused facilities at the Texas Gulf Coast location to be shut down. In September 2006 the Tarragona site and in February 2007 our site in Indonesia were flooded. Since the Tarragona site was flooded mainly due to special local conditions, appropriate measures were implemented by BASF together with the local authorities.

The transport of goods (both products and supplies) by water way is very important to BASF. In 2009, of the total 12.7 million tons of materials transported into and out of the BASF Ludwigshafen site, 5.5 million tons (or 43%) were transported by waterway (3.6 million tons of supplies and 1.9 million tons of products). Thus, a further risk is the risk of closure of a major transport route. This may be due to an accident and cannot be anticipated. For example, on March 25, 2007, a poorly loaded barge (not linked to BASF) partially capsized in the Rhine River. This resulted in the river being closed to transport for more than one week. The river was again opened for transport once all barges could be removed from the river. This occurrence had the consequence of disrupting the transport of both incoming raw materials as well as outgoing products. By shifting the transport from boat to train and truck, we were able to manage this unforeseen occurrence, accepting slightly increased transportation costs.

Module11: Opportunities

11.1 Do water-related issues present significant opportunities for your company?

Yes

11.2 In what way(s) do water-related issues present significant opportunities for your company?

Increasing urbanization, as well as increasing global water and wastewater treatment standards are the major drivers for the increased use of water treatment chemicals (polyacrylamide based flocculants and acrylic coagulants).

Further, water shortage or climate change may present further opportunities for BASF. To meet these challenges, BASF provides:

- Products for water production and to improve water quality
- Products which help our customers save water and reduce emissions to water
- Products which improve the efficiency of water use in agriculture

Overall, BASF is an innovative partner to the water industry, adding value through our range of products.

11.3 Are there financial implications associated with the identified opportunities?

Yes

11.4 Please describe them.

The identified opportunities represent an opportunity for the profitable growth of BASF's products and services for water-related activities. For example, intensified water treatment leads automatically to an increased use of polyacrylamide based flocculants and coagulants which we produce and sell. These municipal and industrial effluent treatment and industrial water management products equate to 10% of our Performance Products sales of € 2.2 billion in 2009 and is expected to grow by 4 to 6% from 2010 to 2012 (see http://www.basf.com/group/corporate/de/function/conversions:/publish/content/investor-relations/calendar/images/100601/Presentation_PP_Investor_Day_Management.pdf).

11.5 Please describe any actions your company has taken or plans to take to exploit the opportunities identified, including the investment needed to take those actions.

We exploit the identified water-related opportunities through the following activities and measures:

- 1) We continuously invest in research and development of both new and existing products and technologies. In 2009, our expenditures on research and development amounted to €1,398 million.
- 2) We produce, market and sell products and technologies which can be used in water production and improve water quality, help our customers save water and reduce emissions to water, and improve the efficiency of water use in agriculture.
- 3) We offer all-round solutions for BASF customers: As well as offering customers a range of individual products for handling water and wastewater, BASF also supplies all-round solutions, from wastewater checks to preventive water pollution control, to BASF customers. These solutions developed specially to meet individual customers' requirements are part of the Sustainability Service's Success – Sustainable Development for Added Value program. Success combines BASF's accumulated sustainability expertise in the areas of energy, product responsibility, health, safety and environment (www.basf.com/success).

Some of BASF's water-relevant markets and products are summarized below.

1.) Products which are used in water production and improve water quality:

- Larvicide ABATE®: Disease-causing insects often contaminate water resources in at-risk areas. ABATE®, a larvicide developed by BASF, effectively kills mosquito larvae before they even reach maturity. This makes water safe for human consumption and unlike many other products, is approved for use in drinking water by the World Health Organization.
- BASF Water Treatment Chemicals: BASF has identified opportunities with respect to water and provides a range of products to meet current and future needs. These products are produced at sites worldwide and address a variety of water-related needs:
 - Water production: thermal desalination, membrane processes, conventional treatment
 - Water use: cooling water, boiler water, process water, agriculture, household water
 - Water purification: drinking water, wastewater and sludge treatment
 These products fall mainly in the following categories: biocides, cleaning agents, corrosion inhibitors, defoamers, deoilers/coagulants, dispersants, scale solvers, scale inhibitors and are used in the following applications: Thickening / dewatering of sludges (ZETAG® 9000 Series of cationic inverse emulsion flocculants), potable water treatment (coagulants / flocculants MAGNAFLOC® LT) and water conditioners for boiler feed water / cooling water (IRGATREAT®, Aseptrol® CW).

2.) Products, to help our customers save water and reduce emissions to water:

- Coloration system BASF Color Fast Finish: a one-step-process of dyeing and finishing. Total processing time is considerably shortened compared to the conventional process. It reduces the water consumption and subsequent wastewater load. Because it creates a faster and simpler process also leads to cost savings in energy, equipment and personnel. Using Color Fast Finish, one ton of fabric can have 13,000 liters in water savings. Thus, a mid-sized dye-house with an average production of 150 tons woven textiles per week can have 1,950,000 liters of water savings per week.
- Aftersoaping agent Cyclanon® XC-W New: Cyclanon® XC-W New is an aftersoaping agent for reactive-dyed cellulose fibers. It is the first after-soaping agent to prevent unfixed dye particles from re-depositing themselves on the textile fibers. Therefore, the number of rinsing baths during the dyeing process can be reduced, saving water, time and energy. One ton of fabric has then 18,000 liters of water savings, meaning that a mid-sized dye-house with an average production of 165 tons cotton knit goods per week can have 2,970,000 liters of water savings per week.
- Aftercleaning agent Cyclanon® ECO: Cyclanon® ECO reduces the after-cleaning process from 4 to 2 steps. It enables the reduction of process water by up to 40% and creates energy savings of up to 60%.
- Chelating Agent Trilon® M improves the cleaning effect of detergents and cleaning agents. A dishwashing tab based on Trilon® M produces 80% less wastewater load compared with phosphate-based formulations. Its market potential for BASF is €300 million.
- Lutensol® M has already been incorporated successfully into formulations of several detergents. Outstanding

emulsifying properties of the surfactant allow the production of laundry detergents with high detergent efficiency at low wash temperatures, thus, reducing energy requirements.

3.) Products that improve the efficiency of water use in agriculture:

-Drought resistant plants. In collaboration with Monsanto since 2007, BASF has helped create stress-tolerant plants. Stress-tolerant plants are more resistant to adverse environmental conditions such as drought.

Further Information

Addendum to Q11.5: Additional BASF products, which are used in water production and improve water quality, are summarized below: - Filter Membrane Ultrason® E 6020 P: Ultrason® filter membranes provide ultrafiltration and remove viruses as well as bacteria from dirty surface water. LifeStraw® simplifies on-site conversion of large quantities of dirty water into potable water in villages and by families, reducing the risk of contracting gastrointestinal illnesses from dirty water drastically. It can purify at least 18,000 liters of water reliably without the need for electricity, replacement parts, chemicals etc.

(<http://www.basf.com/group/pressrelease/P-09-305>). - Elastocoast®: a new and innovative coastal protection system. The term Elastocoast® means a bonding system that reinforces hydraulic gravel at their contact surfaces permanently by means of the 2-component plastic polyurethane (PU). The suitability of the use of Elastocoast® in coastal protection systems has been proven and the long-lasting stability under environmental influence has been demonstrated. Additional tests and dimensioning procedures (GOLFKLAP) for the use of Elastocoast® in accordance with international standards has been provided.

Module12: Linkage

12.1 Has your company identified any linkages between its use of water and energy, or considered any trade-offs between the two when taking action to manage water or carbon related risks or to exploit water or carbon related opportunities?

Yes

12.2

Please describe them.

Below, some examples are provided which demonstrate the linkages and trade-offs between water and energy/carbon for BASF.

Linkages:

Example 1. Energy Requirements for Pumping Water

Energy is needed to transport cooling water (our main use for water) at our BASF production sites. For example, at the BASF Ludwigshafen site, three water works provide cooling water for the site and have a significant energy requirement. This energy is consumed for operating the three water works (pumping cooling water) and operating four cooling towers, which lower the temperature of recycled cooling water during summer months. This energy consumption represents approximately 3% of the total energy use for the BASF Ludwigshafen site.

Example 2. Water Savings and their Relation to Energy

Over the last several years, a project has been initiated to investigate production plants at the BASF Ludwigshafen site one-by-one in order to identify optimization potential with respect to, for example, water use.

Re-use of condensate: At BASF, the steam supply is provided through the heating and evaporation of de-mineralized water in chemical production plants with exothermic process as well as in our (primarily gas-fed) power plants. Through the use of this steam as a heating medium, large amounts of condensate (water between ~80-100°C) result. This condensate is typically cooled by mixing with river water and either first treated or returned directly to the Rhine River. However, at BASF this condensate is re-used in the various ways. By reusing this water, the amount of de-mineralized water required is reduced. In Ludwigshafen approximately 8% of the fresh water is used to make de-mineralized water. This saves production costs for de-mineralized water, such as energy and chemicals. Further, through such measures, the capacity of the current demineralization plant is sufficient allowing new investment to be delayed. Secondly, in addition to the re-use of this water, its heat capacity is very often used. For example, during the winter, this condensate preheats river water to its required inlet temperature for production of de-mineralized-water, which saves steam use. Both of the above benefits also have benefits in terms of reduced energy use.

Recycling of cooling water: The requirement for river water used for cooling water in our production plants is reduced where technically feasible by identifying and implementing opportunities for the re-circulating of cooling water. This reduction in the amount of cooling water has the following advantages:

- The specific amount of cooling water (per product produced) is reduced in certain plants.
- The energy-efficiency of the cooling water pumps in the production plants is increased.
- Thus, this has both water usage and energy usage benefits.

Example 3. Emissions from Wastewater Plants

The emissions of BASF-operated wastewater plants are accounted for in our Scope 1 or Scope 2 emissions, respectively, and reported in our Carbon Disclosure Project response. The CO₂ emissions from non-BASF operated wastewater treatment plants were calculated as follows based on a TOC (Total Organic Carbon) material balance. It is assumed that 30% of the influent organic carbon load is insoluble and inert as well as the non-biodegradable TOC in the effluent. It is also assumed that the 25% of the remaining biotreatable TOC is converted into biosludge during biotreatment. The residual TOC, which is about 50% of the total influent TOC, was converted into CO₂. The CO₂ emissions were calculated from the residual TOC with a conversion factor of CO₂/TOC=3.67. They amount to about 13000 metric tons of CO₂ in 2009, which represents less than 0.05% of out total Scope 1 and Scope 2 emissions.

Trade-offs

Example 4. Cooling water, Energy and Carbon

We have decreased our specific water use in recent years, for instance, by intensively re-circulating water as much as possible. However, we do not want the re-circulation of water to result in an increase in energy use, for instance when the water has to be re-cooled, or in other negative impacts on the environment. Re-cooling re-circulated water, for example, has a greater energy demand and results in higher CO₂ emissions compared with the preparation of such water through the operation of water works. Therefore, increasing the amount of recycled water is in conflict with our energy goal 2020 (to increase energy efficiency by 25% relative to 2002). Typically, re-cooling re-circulated water is needed during the summer months. Nonetheless, the catchment, processing and transport of water also require energy. At our Ludwigshafen site, we have been able to reduce the specific energy use of our cooling water supply by 11% since 2005 thanks to technical measures and optimized operating methods such as improved pump networks.

Module13: Withdrawals

13.1 Are you able to provide data for the total water withdrawn in your own operations?

Yes

13.2a Please provide figures for total water withdrawal by source type (in cubic meters per year).

Area/business unit	Surface water (m3/yr)	Ground water (m3/yr)	Rainwater (m3/yr)	Waste water (m3/yr)	Municipal water (m3/yr)	Total (m3/yr)
Company total	1872850000	78908000	0	0	25450000	1977208000

13.2b If possible, please also provide data on your water withdrawals broken down by country, region, watershed, business unit, facility or any other area/unit appropriate to your business.

Area/business unit	Surface water (m3/yr)	Ground water (m3/yr)	Rainwater (m3/yr)	Waste water (m3/yr)	Municipal water (m3/yr)	Total (m3/yr)
Other: Verbund site Ludwigshafen						1344280000
Other: Verbund site Antwerp						294369000
Other: Verbund site Nanjing						6653000

13.2c Please add any comments here or use this space to report water withdrawals in a different format to that set out above:

BASF collects data on water supply, water use and water discharge at plant, site and business unit level. We publicly report this information for the entire company and for our Verbund sites in Ludwigshafen, Germany, in Antwerp, Belgium and in Nanjing, China.

In 2009, BASF withdrew 1,977 million cubic meters of water worldwide. The majority of the water, i.e. 91%, is used for cooling. The remaining 9 % is used for production. From the 1,977 million cubic meters of water supplied in 2009, about 97%, i.e. 1,922 million cubic meters of water were returned.

13.4 Are any water sources significantly affected by your withdrawal of water?

No

Addendum to Q13.4: None of our large production sites has a significant affect on water sources since we do not withdraw more than 5% or more than the annual average volume of a water body. In addition, most of our production sites continuously feed back non-contaminated water. Overall, water used for cooling purposes (not in contact with products) represents 91% of our water withdrawal (see BASF Report p. 96). The remaining 9%

of water withdrawn is used in production and treated. Both cooling water and treated production water are monitored and discharged.

Module14: Recycling

14.1 Do you know the total volume of water recycled and reused in your own operations?

Yes

14.2a Please report the total volume of water recycled and reused in your own operations (in cubic meters per year and as a percentage of the total water withdrawal reported in question 13.2a).

Area/business unit	Volume recycled (m3/yr)	Volume reused (m3/yr)	Total volume recycled/reused (m3/yr)	Total volume recycled/reused as a percentage of withdrawals (%)	Please add any comments here:
Company total	0	688300000	688300000	35%	

14.2b If possible, please also provide data on your water recycling and reuse broken down by country, region, watershed, business unit or facility, or any other area/unit appropriate to your business (in cubic meters per year and as a percentage of the total water withdrawal reported in question 13.2b).

Area/business unit	Volume recycled (m3/yr)	Volume reused (m3/yr)	Total volume recycled/reused (m3/yr)	Total volume recycled/reused as a percentage of withdrawals (%)	Please add any comments here:

Module15: Discharge

15.1 Are you able to identify your planned and unplanned discharges of water from your own operations by destination, by treatment method and by quality in terms of effluent using standard effluent parameters?

Yes

15.3 Has your company paid any significant penalties or fines in respect of breaches of regulations relating to discharges from your own operations during the reporting period?

No

15.5 Are any habitats significantly affected by discharges of water and runoff from your operations?

No

15.5a Please add any comments on your company's ability to identify affected habitats here:

We continuously monitor both cooling water and treated production water that are discharged from our production sites. For example at our largest Verbund site in Ludwigshafen we check the water quality of our main water body (supply and discharge), the Rhine River, on a regular basis. Our discharged water accounts for less than 5% of the Rhine's water discharge (cooling water < 2.8%, treated wastewater <0.3%). The results of the toxicological analysis show that the Rhine is not affected by discharges or runoffs from our operations, thus meeting the standard of the Waste Water Ordinance. The electro-fishing in the Rhine River conducted in 2006 showed diversity and good health among the fish in the river. A total of 17 species of fish were represented, including a sun fish and a perch, which had not been seen before. This number increased from 2002 and 2004, which showed 12 and 15 species, respectively. This year's catch proves the positive results of a biological control study which BASF and the "Struktur- und Genehmigungsdirektion" (SGD) South use to regularly test the quality of the water. Performed at least every two years since 1976, a commercial fishing business, on behalf of BASF and in cooperation with SGD South, has been using weak electric fields to stun the fish in a 10 kilometer stretch around BASF's Ludwigshafen site. The stunned fish are removed from the water with a net and are documented according to type, weight, size, health and nutrition, and then returned uninjured into the water.

At our Verbund site Antwerp, discharge of wastewater takes place in the river 'Schelde'. On the border of the Schelde - in the direct neighborhood of the BASF discharging point - an internationally proclaimed conservation area is located, named 'Groot Buitenschoor' (Habitat, Ramsar). In 2009 we finished an Environmental Assessment Report for the whole BASF site. This EAR was written by independent external environmental experts (SGS Belgium) and approved by the responsible authorities. For the topic 'water' the conclusion is that the discharge of BASF is not significant. The contribution of the BASF discharge to the river Schelde is only 0.27%.

Since 1990 we have been successful in improving the quality of our wastewater treatment plant effluents through various measures. For example between 1990 and 2008, the ammonia nitrogen load could be reduced by more than 98% and the TOC load by 78% at our Verbund site in Ludwigshafen. In addition the amount of effluent could be significantly reduced through implementation of water saving measures in our production plants.

One tenth of the water used at BASF comes into contact with products when used for rinsing or as a solvent or a reaction medium, for example. The resulting wastewater is treated appropriately and biologically purified in wastewater treatment plants. In 2009, BASF discharged a combined total of around 185 million cubic meters of wastewater at all its production sites. We reduced emissions of organic substances to water by 80% compared with 2002. Emissions of organic substances – calculated as chemical oxygen demand (Jones) – amounted to around 18,600 metric tons (2008: 20,600 metric tons). Emissions to water of nitrogen (N total) were 3,600 metric tons (2008: 4,400 metric tons). This amounts to a reduction of 84% compared with the baseline year 2002. Emissions of phosphorous were 355 metric tons (2008: 376 metric tons). Our wastewater contained 24 metric tons of heavy metals (2008: 27 metric tons). Heavy metal emissions were cut by 61% compared with 2002. Please see also our Corporate Report at <http://report.basf.com/2009/en/managementsanalysis/environmentandsafety/water.html?cat=m> or page 95ff. All of the discharged wastewater and cooling water is monitored mainly online for standard parameters like TOC or pH. Minimum Standard Parameters for wastewater treatment plant effluents of BASF sites, which are analyzed continuously or discontinuously on daily composite basis are: TOC (Total Organic Carbon) or COD (Chemical Oxygen Demand), BOD (Biological Oxygen Demand), NH₄-N (Ammonia nitrogen), NO₃-N (Nitrate nitrogen), NO₂-N (Nitrite nitrogen), total N (Inorganic and organic bounded nitrogen), P (Phosphorous) and the pH value.

Module16: Intensity

16.1 Please provide available financial intensity measurements for your water use (water unit / financial unit).

Area/business unit	Water use type	Volume of water	Water unit	Financial metric	Financial quantity	Currency unit	Please provide any contextual details that you consider relevant to understand the units or figures you have provided.
Other: Entire company	Water withdrawals	39	m3	Revenue	Thousand	EUR(€)	The financial metric 'revenue' is sales. 91% of our water withdrawal is for cooling purposes and not in contact with products, 9% is used in production and treated (see BASF Report page 96). Both cooling water and treated production water are monitored and discharged.

16.2 Please provide available activity-related intensity measurements for your water use (water unit / activity).

Area/business unit	Water use type	Water use volume	Water unit	Activity type	Please provide any contextual details that you consider relevant to understand the units or figures you have provided.
Other: Entire company	Water withdrawals	39	m3	Other: Per tonne of sales product	Please note that the denominator of this quotient refers to metric ton of sales product and not to metric ton of production. Any sales product can be the result of a multi-step production process; hence one ton of sales product is often the result of more

Area/business unit	Water use type	Water use volume	Water unit	Activity type	Please provide any contextual details that you consider relevant to understand the units or figures you have provided.
					than one ton of production. Comparing water use quotients is only reasonable if there are no major changes in the product portfolio (for example caused by acquisitions or divestitures). Sales product is defined as product sold to third parties. Goods for resale are not considered.

Module17: Intensity

17.1 Please indicate what percentage of your withdrawals and discharges have been verified or assured. Please include the relevant verification/assurance statements as attachments below.

Category	Percentage verified/assured	Comments
Withdrawals	More than 75%	The BASF Report 2009 is an integrated report and combines BASF's financial and sustainability reporting. This reporting is audited by a third party. KPMG AG Wirtschaftsprüfungsgesellschaft has audited the BASF Group Consolidated Financial Statements and the Management's Analysis and has approved them free of qualification. The audit covers financial and non-financial information -including information regarding water withdrawals- and was conducted in accordance with International Standard of Assurance Engagements 3000, a standard for sustainability accounting.
Discharges	More than 75%	The BASF Report 2009 is an integrated report and combines BASF's financial and sustainability reporting. This reporting is audited by a third party. KPMG AG Wirtschaftsprüfungsgesellschaft has audited the BASF Group Consolidated Financial Statements and the Management's Analysis and has approved them free of qualification. The audit covers financial and non-financial information -including information regarding water discharges- and was conducted in accordance with International Standard of Assurance Engagements 3000, a standard for sustainability accounting.