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CORPORATE WATER ACCOUNTING AND STAKEHOLDERS:
INVESTIGATING DETERMINANTS, EXPERIENCES, AND EXPECTATIONS

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INVESTIGATING DETERMINANTS, EXPERIENCES, AND EXPECTATIONS**

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Orientador: Prof. Hans Michael van Bellen, Dr.

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Este trabalho é dedicado à minha preciosa família.

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*“We are all time travellers, journeying together into the future. But let us work together to make that future a place we want to visit.
Be brave, be curious, be determined, overcome the odds. It can be done.”*

(Stephen Hawking, 2018)

RESUMO EXPANDIDO

A preocupação urgente em mitigar os riscos das empresas em relação aos recursos hídricos, gerenciá-los adequadamente e reportar sobre eles para atender às necessidades das partes interessadas tornou a contabilidade da água corporativa um tópico em evidência. Reconhecendo que as empresas são as maiores consumidoras de água doce no mundo, ações voltadas à preservação do recurso tornaram-se um campo transdisciplinar no ambiente corporativo. Os contadores, por sua vez, são profissionais com habilidades reconhecidas de mensuração, mitigação dos riscos, avaliação de incentivos, além de sua expertise em divulgações voluntárias e obrigatórias, e serviços de auditoria, ao mesmo tempo que consideram os interesses dos diferentes *stakeholders*. A partir disso, este estudo aborda questões hídricas no campo contábil sob quatro aspectos inter-relacionados que impulsionam a implementação da contabilidade corporativa da água: risco hídrico, gestão de recursos hídricos, reporte hídrico e auditoria hídrica. Ao discutir esses aspectos, o presente estudo reconhece que o engajamento dos *stakeholders* permeia seus avanços. Isso ocorre porque uma contabilidade da água eficaz, abrangendo desde o monitoramento da eficiência operacional hídrica na contabilidade gerencial até a mensuração monetária e os riscos financeiros associados na contabilidade financeira, revela impactos corporativos e socioambientais significativos, obrigando os *stakeholders* a exigirem maior transparência nos reportes sobre a água. Afinal, as partes interessadas podem influenciar decisões empresariais relacionadas a questões hídricas e enfrentar as consequências de suas ações (ou omissões). Assim, esta tese investiga as práticas de contabilidade da água corporativa explorando potenciais determinantes, explicando algumas experiências e abordando expectativas futuras em distintos contextos industriais e de mercado, ao mesmo tempo que reconhece os *stakeholders* inerentes. Dessa forma, três estudos foram conduzidos para tornar esta pesquisa viável. O primeiro explora as práticas de contabilidade e gestão da água de um fabricante multinacional de eletrodomésticos por meio de um estudo de caso único interpretativo. Portanto, o estudo investiga as motivações e os desafios nas práticas de contabilidade da água da empresa, suportado pelo método Gioia. O estudo também propõe uma tipologia que fundamenta temas e dimensões agregadas referentes às práticas de contabilidade e gestão da água corporativa reveladas no estudo de caso. Vários tópicos e práticas que emergiram dos dados também foram abordados. Esses *insights* de um caso prático visam estabelecer uma referência para gestores, ao mesmo tempo que promovem práticas de segurança hídrica que poderiam beneficiar diferentes *stakeholders*. O segundo estudo realiza uma análise de conteúdo para avaliar a medida em que as práticas de reporte hídrico estão em conformidade com os requisitos em andamento de divulgação de sustentabilidade nas indústrias de petróleo e gás. A conformidade das empresas com as recomendações do ISSB para divulgações relacionadas à água é avaliada examinando seu alinhamento com diferentes *frameworks* de reporte hídrico baseados nos requisitos do CDSB. Com base em uma avaliação tanto da quantidade quanto da qualidade das informações fornecidas em componentes textuais e visuais, este estudo revelou os *frameworks* priorizados pelas empresas e, consequentemente, seu público-alvo principal—investidores e reguladores. Elementos visuais, especialmente tabelas, foram altamente relevantes para a prática geral de divulgação. Ademais, a natureza inerente de cada requisito de divulgação interfere no formato e na qualidade da divulgação das informações. Adicionalmente, este artigo discute expectativas sobre potenciais passos em direção à padronização da divulgação sobre a água. Portanto, este estudo oferece *insights* significativos para todos os atores interessados em discutir a padronização das informações de sustentabilidade corporativa. Finalmente, o terceiro estudo primeiramente emprega um método baseado em Modelo de Linguagem de Grande Escala (LLM) para analisar as práticas

corporativas de divulgação sobre a água. Assim, introduz uma ferramenta analítica nova e precisa para medir um índice de reporte hídrico corporativo em empresas brasileiras listadas. Em seguida, este estudo investiga potenciais direcionadores que influenciam essas divulgações com base no ramo gerencial da Teoria dos *Stakeholders*. Os resultados indicam que auditoria externa, idade de listagem e setor impactaram positiva e significativamente o reporte hídrico. Os demais impulsionadores propostos, relacionados aos atributos de governança corporativa e ao desempenho financeiro, não influenciaram significativamente as práticas de divulgação hídrica. Esta pesquisa contribui com o conhecimento em relação à água ao propor métodos automatizados para avaliar a transparência corporativa, enquanto expande a discussão teórica sobre contabilidade da água. Com base nos achados destes três estudos e seu pluralismo epistemológico, esta tese oferece vários insights para avançar nas direções da contabilidade da água corporativa e da Teoria dos *Stakeholders*, ao mesmo tempo que incentiva uma maior responsabilidade hídrica corporativa.

Palavras-chave: Contabilidade da Água. Responsabilidade Hídrica Corporativa. Gestão de Recursos Hídricos. Reporte Hídrico. *Stakeholders*.

ABSTRACT

The urgent concern to mitigate businesses' risks to water resources, manage them appropriately, and report on them to address stakeholders' needs has made corporate water accounting a hot topic. Accordingly, this thesis investigates corporate water accounting practices by exploring potential determinants, explaining some experiences, and addressing future expectations across distinct industrial and market contexts while recognizing the inherent stakeholders. This multi-faceted investigation covers different aspects of corporate water accounting at various maturity levels against the backdrop of water risk, management, reporting, and auditing. Thus, three studies were conducted to make this research feasible. The first study explores the water management accounting practices of a multinational household appliance manufacturer through an interpretive single-case study. Therefore, the study investigates the motivations and challenges in the company's water management accounting practices, supported by the Gioia method. The study also proposes a typology that underlies themes and aggregate dimensions regarding corporate water management accounting practices uncovered in the case study. Several topics and practices that emerged from the data were also addressed. These insights from a real-world case aim to establish a benchmark for managers while promoting water security practices that could benefit different stakeholders. The second study pursues a content analysis to evaluate the extent to which water reporting practices comply with ongoing sustainability disclosure requirements in the oil and gas industries. Companies' compliance with the ISSB recommendations for water-related disclosures is assessed by examining their alignment with different water reporting frameworks based on the CDSB requirements. Based on an assessment of both the quantity and quality of the information provided in textual and visual components, this study revealed the companies' prioritized frameworks and consequently their key audience—investors and regulators. Visual elements, especially tables, were highly relevant to the overall disclosure practice. Furthermore, the inherent nature of each disclosure requirement interferes with the format and quality of the information disclosure. Additionally, this paper discussed expectations regarding potential steps toward water disclosure standardization. Therefore, this study offers significant insights to all the actors interested in discussing the standardization of corporate sustainability information. Finally, the third study first employs a Large Language Model (LLM)-based method to analyze corporate water disclosure practices. Thus, it introduces a novel and accurate analytical tool to measure a corporate water reporting index in Brazilian listed companies. Then, this study investigates potential drivers influencing these disclosures based on the managerial stakeholder theory branch. The findings indicate that external audit, listing age, and industry, positively and significantly impacted water reporting. This research contributes to the knowledge in relation to water by advancing automated methods for evaluating corporate transparency, while expanding the theoretical discussion on water accounting. Based on the findings of these three studies and their epistemological pluralism, this thesis offers several insights to advance the directions of corporate water accounting and stakeholder theory while encouraging greater corporate water responsibility.

Keywords: Water Accounting. Corporate Water Responsibility. Water Resources Management. Water Reporting. Stakeholders.

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ACRONYMS AND ABBREVIATIONS

AI	Artificial Intelligence
AWAS	Australian Water Accounting Standard
AWS	International Water Stewardship Standard
CBPS	Brazilian Committee for Sustainability Pronouncements
CDP	Carbon Disclosure Standards Project
CDSB	Climate Disclosure Standards Board
CFC	Federal Accounting Council (Brazil)
COP26	26 TH Conference of the Parties
CSR	Corporate Social Responsibility
CSRD	Corporate Sustainability Reporting Directive
CSSB	Canadian Sustainability Standards Board
CVM	Securities and Exchange Commission of Brazil
CWR	Corporate Water Reporting
CWRI	Corporate Water Reporting Index
ESG	Environmental, Social, and Governance
EU	European Union
GHG	Greenhouse Gas
GICS	Global Industry Classification Standard
GRI	Global Reporting Initiative
IFRS	International Financial Reporting Standards
IOSCO	International Organization of Securities Commissions
IPIECA	International Petroleum Industry Environmental Conservation Association
ISSB	International Sustainability Standards Board
KPI	Key Performance Indicator
LLM	Large Language Model
NBC TDS	Brazilian Technical Accounting Standards for Sustainability Information Disclosure
NFRD	Non-Financial Reporting Directive
NGO	Non-Governmental Organizations
OLS	Ordinary Least Squares
RAG	Retrieval-Augmented Generation

REQ	Requirement
ROA	Return on Assets
SASB	Sustainability Accounting Standards Board
SDG	Sustainable Development Goals
SEEA	System of Environmental-Economic Accounting
TCFD	Task Force on Climate-related Financial Disclosures
UK SDS	UK Sustainability Disclosure Standards
WASH	UK Sustainability Disclosure Standards
WBCSD	World Business Council for Sustainable Development
WCM	World Class Manufacturing

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1 THESIS INTRODUCTION

The escalating pressures on water resources, driven by factors such as increasing population, rising living standards, and climate change, underscore the interconnected nature of water resources, where activities by one user can negatively impact the activities of others (Christ & Burritt, 2017c; World Water Council, 2024). Despite the vital role water plays in supporting livelihoods, ecosystems, and development, it is managed and governed differently (Hazelton, 2013; Russell, 2017), leading to inequalities in global water access. Basic drinking water access is still lacking for 771 million people, while 30% of the global population (around 2.3 billion people) lacks basic water facilities for hygiene purposes, and global water conflict is continuously increasing (Statista, 2023b). It is crucial to note that even in areas where water access is not a major concern, unsustainable use can impact billions through water security issues. So, water resource issues involve many other global sustainability concerns, such as health, peace, zero hunger, and climate action (United Nations, 2024). Therefore, their impacts on various stakeholders, including businesses, have become more evident (Chapagain & Tickner, 2012).

Water is a critical resource for businesses to maintain operational continuity and sustainable competitive advantage (Zhu et al., 2023), being among the largest consumers of freshwater worldwide (Ortas et al., 2019). In Brazil, economic activities accounted for 98.3% of total water consumption in 2020 (IBGE & ANA, 2023). According to the Carbon Disclosure Project's (CDP) 2017 water report, 60% of the reporting companies face water-related risks, with 56% expecting these risks to materialize in the next six years (CDP, 2017). So, water concerns require management improvements to appropriately deal with water risks and scarcity (Burritt & Christ, 2018). This is particularly urgent among industries with strong impacts on water since they aim to satisfy stakeholders' expectations (Fialho et al., 2021; Wicaksono & Setiawan, 2023).

Acknowledging the urgent concern for mitigating businesses' risk on water resources, managing them appropriately, and reporting it to reach stakeholders' concerns, corporate water accounting has become a hot topic (Christ & Burritt, 2017b). Corporate water accounting rises in the 2000s to improve water management by businesses (Morrison & Schulte, 2010). It supports public and investor confidence by promoting transparency in water trading, consumption, and management for societal and environmental benefits (Water

Accounting Standards Board, 2014). At its most fundamental level, water accounting is the practice of measuring the physical units of water used and stored (Holyoak & Pisaniello, 2019). However, the monetarization of water-related impacts and effects gained recognition (R. L. Burritt & Christ, 2017).

Although it is a transdisciplinary field within corporations (Christ & Burritt, 2018), accountants play an important role. They understand how measurement affects incentives, the advantages and drawbacks of voluntary and mandatory disclosures, and provide standardized reporting and auditing services while promoting a stakeholders' perspective (Dechow, 2023; Holyoak & Pisaniello, 2019). Corporate water accounting then allows corporate water use to be not overlooked in a pathway to a water-secure future (R. L. Burritt & Christ, 2017). According to previous water accounting researchers (e.g., Chalmers, Godfrey, & Lynch, 2012; Gibassier, 2018; Hazelton, 2015), this study addresses water issues within the accounting field against the backdrop of four interrelated aspects that drive corporate water accounting implementation: water risk, water resources management, water reporting, and water auditing.

Water-related business risk is a growing concern worldwide, especially in sectors heavily relying on water, such as agriculture, energy production, mining, and materials (Burritt & Christ, 2018; OECD & World Water Council, 2023). According to the CDP (2013), corporate water risk arises from an organization's impact on water resources. Companies can be affected by corporate water risks from different sources like water-related disasters, such as floods and droughts, risks associated with water use, such as water scarcity, unsafe water supply, water supply change, substandard water quality, and the discharge of wastewater that leads to water pollution. These risks can also impact a company's reputation, investor expectations, and overall performance, putting them at risk of facing penalties and financial losses (Zhu et al., 2023). Financial losses include the disruption of the production process, the higher costs related to supply chain disruption, changes in production processes, capital expenditures to water concerns, regulatory compliance, and the increased price of consuming or discharging water (Levinson et al., 2008). So, identifying, classifying, and mitigating water risk is a condition for financial stability (OECD Environment Focus, 2023). Therefore, investors exposed to these growing risks increasingly demand companies to assess, manage, and disclose water-related risks (Adrio, 2012).

To assess and manage water resources properly, corporate water management accounting is proposed as a sub-discipline of environmental management accounting designed to support corporate management decisions and improve economic and environmental water-related business outcomes (Christ & Burritt, 2017c). So, access to appropriate forms of physical and monetary data is vital to operating water sustainably (Christ, 2014), although many water accounting initiatives still have no monetary indicators to apply (R. L. Burritt & Christ, 2017). It poses a concern about how to direct clever decision-making regarding water resources since poor water management can disrupt business, besides affecting human health and the ecosystem (Burritt et al., 2016). By addressing water management effectively, the critical importance of high-quality water-related information to inform decision-making gains recognition (Chalmers, Godfrey, & Potter, 2012). Thus, there's growing interest in organizational accounting of water management, spanning internal (management accounting) and external (reporting) interests (Russell, 2021).

Corporate water reporting is essential for enterprises to convey information about water management and risks to external interests (Z. Zhou, Liu, et al., 2018). It is an effective and credible signal for companies to demonstrate their commitment to responsible business practices. This commitment aligns with growing stakeholder demands for comprehensive, forward-looking information regarding corporate performance across multiple bottom-line dimensions, including governance, economic, ethical, social, and particularly environmental impacts (Brockett & Rezaee, 2012). The company issues water information disclosure internally and can be reviewed by investors through Corporate Social Responsibility (CSR), sustainability, and environmental-related reports. These reports can influence external observers' perceptions of the company's development prospects (Liu et al., 2021). Besides, water reporting strategies can help companies comprehend their water risks and related cost information and profit opportunities. This understanding provides a basis for implementing effective water resource management (Z. Zhou, Liu, et al., 2018). In summary, disclosing accounting for corporate water use and impacts is essential in helping companies improve their efforts to advance sustainable water management and meet external stakeholders' expectations (Morrison & Schulte, 2010).

Therefore, since corporate water accounting can enhance trust to meet stakeholders' expectations, a closing aspect of water accounting must be reinforced: water auditing. According to Lyu et al. (2023), water auditing ensures adherence to relevant laws, regulations,

standards, and norms governing water intake, use, conservation, and discharge. So, it is an important tool for water accounting since it identifies areas that require corrective action to direct water management and control, and ensures consistent implementation of water accounting systems. Moreover, Silveira and Van Bellen (2021) state that reporting water management practices and corporate impacts may have their relevance strengthened by the water information that is assured externally. Therefore, we reinforce the necessity to provide adequate and reliable information about an entity's water risks and management to improve water accounting relevance fairly. Finally, there are also reputational incentives, which involve accountants adapting corporate reporting for auditing and assurance standards to a water context (Chalmers, Godfrey, & Lynch, 2012).

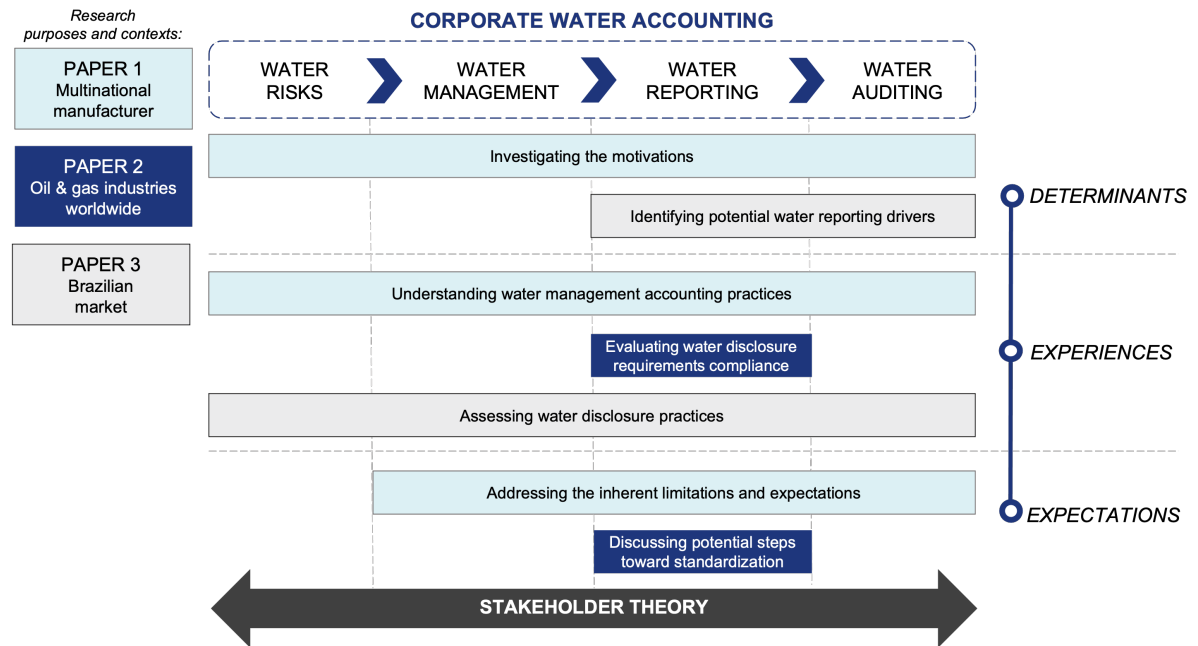
When discussing these water accounting aspects, stakeholder engagement is an inherent background that permeates their advancements. This is because effective water accounting, spanning from the tracking of water operational efficiency within management accounting to the monetary measurement and associated financial risks within financial accounting, reveals significant corporate and socio-environmental impacts, compelling stakeholders to demand greater transparency in water reporting. They may influence business decisions regarding water issues and face the consequences of their actions (or non-actions). This bilateral and interlinked way of understanding stakeholders' engagement incorporated the development of some branches of the stakeholder theory (e.g., Freeman, 1984; Rhenman, 1968). Although a single theory cannot summarize the diverse motives driving CSR practices (Wilmshurst & Frost, 2000; Zhang & Tang, 2019), the interaction between organizations and stakeholders can be a valuable tool to enhance the democratic process (O'Dwyer, 2005). Finally, we accountants "have a lot to offer if we embrace sustainability reporting and play a role in encouraging a stakeholders' perspective" (Dechow, 2023, p.492).

1.1 PURPOSE

This research investigates corporate water accounting practices by exploring potential determinants, explaining some experiences, and addressing future expectations across distinct industrial and market contexts while recognizing the inherent stakeholders. This multi-faceted investigation covers different aspects of corporate water accounting at different maturity levels against the backdrop of water risk, management, reporting, and auditing. Thus, three

studies were conducted to make this research feasible, summarized in the conceptual model as follows (Figure 1).

Figure 1 – Conceptual Model



Firstly, by broadly addressing all the corporate water accounting aspects mentioned above, we aim to conduct an interpretive single-case study to understand the water management accounting practices of a multinational household appliance manufacturer. This case was selected because the company's activities are considered to have a very high water impact (CDP, 2023b). Despite this, the chosen company has been nationally recognized for its management and sustainable use of water resources, positioning it as an exemplary benchmark for study. Therefore, the motivations and challenges in the company's water management accounting practices are investigated using Gioia method (Gioia et al., 2013). Based on the themes and concepts uncovered in the case study, we develop a novel typology structured around four aggregate dimensions regarding corporate water management accounting practices—operational management of water resources, development of sustainable products, global water strategies, and water reporting practices. Ultimately, this study contributes by offering an in-depth understanding of the determinants, experiences, and expectations shaping corporate water accounting in a high-impact industry.

Secondly, focusing specifically on the water reporting aspect of water accounting and in-depth into the oil and gas industries, this study aims to pursue a content analysis to evaluate the extent to which water reporting practices comply with ongoing sustainability disclosure requirements. Therefore, the study includes an assessment of both the quantity and quality of the information provided in textual and visual components. We then assess companies' compliance with the International Sustainability Standards Board (ISSB) recommendations for water-related disclosures while examining the alignment of these disclosures with different water reporting standards, frameworks, and guidelines based on the Climate Disclosure Standards Board (CDSB) requirements. The CDSB is a relevant framework to analyze since the inaugural requirements for disclosure of sustainability-related financial information, the International Financial Reporting Standards (IFRS) S1, recommends its application for water disclosure (IFRS, 2023b). We also relate each framework's key audience to its reporting practices, reflecting the most prioritized stakeholders. Finally, besides the reporting experiences from the companies, this paper also discusses expectations for the future sustainability disclosure standards for water.

Thirdly, the purpose of the last study is to employ a Large Language Model (LLM)-based method to analyze corporate water disclosure practices and investigate potential drivers influencing these disclosures. Therefore, an LLM-based Corporate Water Reporting Tool was proposed. This method can optimize the quantification of corporate sustainability information, enhancing both the efficiency and accuracy of data collection (Zou et al., 2025). Thus, while this research primarily focuses on water reporting practices, it utilizes a water reporting index encompassing a broader spectrum of corporate water accounting, ranging from water risk to auditing. After assessing this disclosure index for Brazilian listed companies, we aim to investigate its potential drivers based on the managerial stakeholder theory branch. Therefore, this paper addresses both the determinants and experiences of water accounting across various industries, allowing for a broader understanding of the water scenario.

Based on the above purposes, this thesis states that there are inherent stakeholders across distinct industrial and market contexts regarding the determinants, experiences, and future expectations of corporate water accounting, which comprises water risk, management, reporting, and auditing.

The following subchapter summarizes some relevant aspects of the stakeholder theory that will be used as a background in the thesis, besides summarizing its use in each paper.

1.2 STAKEHOLDER THEORY

Stakeholders are widely comprehended as groups or individuals affected by the corporation in order to achieve their personal goals and on whom the corporation depends for its existence. Its bilateral way of defining stakeholders (groups that not only affect the corporation's achievement but are also affected) is first found in Rhenman (1964, 1968; apud Vandekerckhove, 2009) and Freeman (1984) works. Therefore, stakeholder theory prescribes how an organization interacts with particular stakeholder groups to comply with stakeholder expectations and legitimize its operations (Deegan, 2006).

Nevertheless, recognizing which stakeholder groups a company should consider has been evolving over the theory development and its different perspectives. According to Freeman (1984), between the 1950s and the early 1970s, the use of the stakeholder concept of U.S. firms was limited in scope, and the concern with the external environment was generic and seen solely in economic terms. Although there was an emphasis on stockholders' focus, other stakeholders' benefits were already being recognized at that time. It enabled that in the 1970s and 1980s social and environmental concerns started to emerge, which made the CSR become viewed as an application of stakeholder theory to nontraditional stakeholder groups. It was particularly noticed after the pioneering work of Ullmann (1985) predicting corporate social activities based on the stakeholder theory of strategic management.

From a more ethical (or normative) branch of the stakeholder theory, the business can be recognized as a set of relationships among groups with a stake in the business activities, making the business about how to interact and create value (Freeman et al., 2007). According to Parmar et al. (2010), stakeholder theory proposes that value creation is a collaborative effort in relationships, ideally benefitting the focal business and all its stakeholders. Following this line of thought, Hörisch et al. (2014) argue that sustainability has to be one of the "important values" to include durability and environmental concerns in stakeholder theory comprehensively.

The corporate sustainability debate drew attention to additional ecological and social criteria and thus added further complexity, challenging companies to engage with stakeholders on many contemporary social and environmental topics (Hörisch et al., 2014). To better understand how corporate management sustainability and stakeholder theory belong together, Hörisch et al. (2014) highlighted some similarities between those aspects. In

addition to the sustainability-based value creation for stakeholders and the purpose of business beyond maximizing short-term shareholder value, as previously mentioned, the authors highlight the worry about business and ethics as fundamentally interlinked, the common understanding of morality and profit-making, and a long-term perspective with quality of life improvements. Moreover, the authors argue that to potent the theory of sustainability management, there is a necessity to develop sustainable solutions that are multistakeholder-oriented.

On the other hand, a managerial (or positive) perspective of the stakeholder theory recognizes that different stakeholder groups have different and sometimes conflicting expectations that organizations must meet (Fernando & Lawrence, 2014). Nevertheless, it is impossible for managers to meet all stakeholder demands, so they prioritize those with control over resources (Wicaksono & Setiawan, 2022). This means that they are more likely to respond to the concerns of powerful stakeholders, such as financial stakeholders and government regulators than to other stakeholders, such as environmentalists (Fernando & Lawrence, 2014). Therefore, previous studies using this managerial approach may consider, for instance, how companies identify their stakeholders, manage their relationships, and incorporate their expectations into their decisions (Gibson, 2000; Jones, 1995; Kaur & Lodhia, 2018).

This research did not apply stakeholder theory as an in-depth theoretical framework across all the proposed studies. Each study involves different levels of analysis. In the first paper, the approach allows stakeholder-related aspects to emerge or be indirectly captured during the case study. In the second paper, key audiences relevant to the frameworks analyzed are identified, and the findings reveal which stakeholder interests are more prominently addressed in each framework's compliance. In the third paper, the managerial branch of stakeholder theory is used to select variables considered potential drivers of corporate water reporting. Based on Fernando and Lawrence (2014), this paper adopts the view that powerful stakeholders include financial stakeholders and government regulators. Finally, the stakeholder theory insights from these studies are discussed in depth in the thesis conclusion.

1.3 JUSTIFICATION

This research is justified for several reasons. First, it fills some gaps in the incipient corporate water accounting literature, which has only recently increased after some dissemination works (e.g., Burritt et al., 2016; Christ & Burritt, 2017, 2018; Hazelton, 2013).

Regarding the first paper, deeply understanding water practices coming from a company that has high-water impact activities would already be of great value to understanding the experiences and practices on the subject. However, this paper adds even greater outcomes when we recognize that the studied company was nationally awarded for its effective management and sustainable use of water resources. To truly unpack how this benchmark performance is achieved amidst such challenges, an interpretive approach was necessary to explore the nuanced experiences and motivations of its managers. Therefore, this study employs the Gioia method (Gioia et al., 2013) to systematically analyze these managerial perspectives, creating a rigorous benchmark for water engagement activities that can be helpful for various actors interested in the field.

In the second paper, while also focusing on an industry with water-intensive activities, we advance the discussion on water reporting standardization by emphasizing the need to improve not only the reported content but also the way companies communicate this information. Our innovative approach to water studies addresses not only the quantity of water-related information disclosed but also assesses its quality. Furthermore, we examine the visual elements of these reports to understand and enhance their role in improving communication practices. In addition, drawing on a comprehensive understanding of the water-related frameworks analyzed and how companies report them, this study contributes to the sustainability reporting literature by exploring future directions for water-related disclosure standards.

Finally, the third paper addresses a rapidly growing gap in scientific research by proposing a novel approach that ensures greater efficiency and accuracy in the content analysis process through the combination of Large Language Models (LLMs) and Retrieval-Augmented Generation (RAG) technologies. The tool, unprecedented in the water accounting literature, is designed to perform semantic analysis that produces more reliable outputs than manual human analysis, especially when processing large datasets. Moreover, this paper uses an emerging tool in the water accounting literature to assess water disclosure practices – the

corporate water reporting index. The index is growing in its adoption around studies worldwide, but Brazil still has no application. Previous studies have mainly been in China (e.g., Liu et al., 2021; Zeng et al., 2020; Zhou et al., 2020; Zhou, Zhou, et al., 2018), Japan (e.g., Burritt et al., 2016), Indonesia (e.g., Adhariani, 2021; Wicaksono et al., 2024), and Peru (e.g., Bunclark & Scott, 2021). Recognizing these water disclosure practices in the leading country in renewable water resources is relevant for both academics and regulators.

Regarding the general thesis justification, we can justify its benefits to the development of corporate water accounting even further than individually. First, by applying a mixed methods approach and epistemological pluralism, the study brings results and discussions about the theme from different perspectives, encompassing the inherent complexity of corporate water accounting from different optics. Second, this study is justified by its broad concept of corporate water accounting. By segregating aspects of the theme that are used as background and addressed in distinct proportions in each study, the thesis provides a broad and, at the same time, deep discussion about all aspects inherent to corporate water accounting. Furthermore, this breadth and depth on the theme are strengthened by the different industries and markets that the thesis proposes to address (first study at a multinational home appliances manufacturer, therefore, with a broad market view; second study considering oil and gas industries in different markets; third study embracing different industries in a single market – Brazilian). Therefore, the thesis allows general characteristics and difficulties about the theme to be identified when they overlap even in different contexts, encouraging future measures for advancement in the area. Finally, we discuss water issues with a multiple bottom lines approach, whereas, besides the widely known environmental, social, and governance issues, our research provides relevant insights that encompass also financial and ethical concerns throughout the studies (Brockett & Rezaee, 2012).

Furthermore, this thesis is justified by its timeliness in offering relevant practical and policy implications. For practitioners, many previous studies highlighted firms' inadequate adoption (or not at all) of water accounting practices (e.g., Christ & Burritt, 2017; Ernst & Young, 2012; Talbot & Barbat, 2020). Through the concepts, practices, and findings provided, companies might use them as a benchmark and a guide for improving their water-related actions. Recognizing the inherent stakeholders is also a step toward guaranteeing that no stakeholder is left out of water decisions. Moreover, since we are facing impactful changes in sustainability-related disclosure, moving towards standardization and mandatory

application, this thesis proposes a base for change. Since the ISSB has not yet submitted a water-specific standard, this research contributes to practitioners' understanding of the changing regulatory scenario and moving smoothly to the best water actions. For regulators and standards setters, the drivers, experiences, and future expectations analyzed here are relevant insights to consider while guiding future actions.

Last but not least, this thesis brings accountants to the center front of water-related issues. Corporate water accounting has evolved rapidly and become significantly more complex since the Rio Summit in 1992 (Hazelton, 2015). We must highlight our main abilities as accountants (Dechow, 2023) and find our role in improving business performance and achieving global sustainability targets. 2030 is almost here, and there is still a lot of effort before achieving the Sustainable Development Goals (SDG). We all have a stake in the world's water accounting (Hazelton, 2015). This research then recognizes accountants as potential actors in the running of a water security world. After all, if the deeper green (or blue) perception is right, "the issues are considerably more important than trying to get a 1% market advantage over ones nearest competitor" (Gray, 1990, p. 134).

1.4 THESIS STRUCTURE

This thesis is composed of three main chapters besides this Introduction. It is organized as follows: in chapter two, we have the first study, "Water Management Accounting: A Case Study at a Multinational Appliance Manufacturer"; in chapter three, "Compliance with Sustainability Disclosure Requirements: A Content Analysis of Oil and Gas Water Reporting Practices"; and in chapter four, "Analyzing Corporate Water Disclosure through Large Language Models: Practices and Potential Drivers of Reporting". Finally, the thesis concludes with the Thesis Conclusion and the Thesis References.

2 WATER MANAGEMENT ACCOUNTING: A CASE STUDY AT A MULTINATIONAL APPLIANCE MANUFACTURER

ABSTRACT

The increasing attention given to the impact of companies' actions on water resources has led to stakeholders pressuring businesses and directing their water-related actions. It drew considerable attention to corporate water management accounting practices, advancing the concept of corporate water responsibility, especially in water-sensitive sectors. In this regard, this study aims to understand the water management accounting practices of a multinational household appliance manufacturer. The company is recognized for its high-water impact activities, yet it has also been awarded for its effective management and sustainable use of water resources. Therefore, we conducted an interpretive single-case study to identify the primary motivations and inherent challenges regarding water management accounting, along with stakeholder engagement. This inductive approach was supported by Gioia's three-step process throughout the study. Further, based on the themes and aggregate dimensions uncovered, we developed a typology of water management accounting practices comprising operational management of water resources, development of sustainable products, global water strategies, and water reporting practices. Finally, we discussed several topics that emerged from the data, such as the financial concerns in the sphere of natural resource preservation, including water's low-cost challenging financial returns and investment tension among different resources. We also addressed relevant environmental practices to consolidate water accounting within companies. These valuable insights from a real-world case aim to establish a benchmark for managers to guide their water-responsible actions. They may also support regulators and policymakers in addressing key water-related challenges while promoting water security practices that could benefit different stakeholders.

Keywords: Water Resources Management. Corporate Water Responsibility. Stakeholder Engagement. Sustainable Manufacturing.

2.1 INTRODUCTION

The Global Risk Report held by the World Economic Forum (2020) draws water crises as one of the top five global risks in terms of impact. Despite efforts to achieve SDG 6¹, current progress suggests that only 77% of the world's population will have access to safe and affordable drinking water by 2030. This leaves 2 billion people without safe, well-managed drinking water services (United Nations, 2023). Nevertheless, the current global water situation suggests an increasingly critical scenario. According to UNESCO (2023), water use has been increasing globally at approximately 1% per year over the last four decades, driven mainly by population growth, socio-economic development, and changing consumption patterns. This scenario poses concerns and opportunities for businesses to address, especially considering that effective water management is a challenge that both influences and is influenced by businesses (Hazelton, 2015). So, as water management and accounting challenges and impacts extend beyond the private sector, corporate water use attracts considerable attention (Muller, 2012).

The increasing attention given to the impact of companies' actions regarding water resources made community stakeholders pressure businesses and direct their water actions (Egan, 2018). After all, since water is a shared resource, one user's activities can harm others, and its usage in one location may have significant effects elsewhere (Chapagain & Tickner, 2012; Karimi et al., 2012). And, as businesses play a significant role in global water systems, often being “water-intensive” and increasing water shortages and quality problems, they must evolve those systems and respond to shocks and stresses (Chapagain et al., 2022; Martinez, 2015). Hence, corporate water management accounting practices emerge to mitigate the inherent conflicts that comprise water-related actors and concerns (Ostrom, 2010; Pretorius & Turton, 2012). It comprises assessing the water context, identifying the impact on water beyond the firm boundaries, recognizing risks and opportunities, guiding actions and setting targets, and reporting it to meet stakeholders' expectations (Christ & Burritt, 2017; WBCSD, 2012).

While meeting the stakeholders' expectations, companies can also explore several opportunities when addressing water-related concerns in their strategy. According to the UN

¹ The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015. In particular, SDG 6 – Clean Water and Sanitation, aims to ensure the availability and sustainable management of water and sanitation for all by 2030 (United Nations, 2024).

Global Compact (2022), investing in water management accounting practices can help companies save costs and reduce risks. Furthermore, manufacturing companies have identified water-related opportunities with potential benefits estimated at over US\$ 183 billion (CDP, 2023a). As a result, companies are incorporating water conservation into their strategies and establishing responsibility for meeting water targets while reporting it (CDP, 2021).

Within this context, the household appliance industry emerges as a particularly compelling field of study. Its water impact is uniquely twofold, extending far beyond direct operations. This impact is not confined to water consumption in manufacturing and the supply chain but extends to the product use phase. In fact, this extensive impact throughout the value chain is a key reason its activity is classified as having a “very high” water impact (CDP, 2023b). Consequently, as companies more exposed to water-related risks are expected to provide more detailed information about their mitigation actions (Ben-Amar & Chelli, 2018), this industry represents a critical arena for investigating advanced corporate water practices.

Therefore, the purpose of this paper is to understand the water management accounting practices of a multinational household appliance manufacturer. To address our research inquiry, we conducted an interpretive single-case study spanning 2023-2024. Besides identifying the main motivations and inherent challenges regarding water management accounting, the findings reveal a typology for these water practices based on the themes and concepts uncovered after the researcher's immersion in the case study. Hence, this study aims to provide valuable insights into the field of corporate sustainability and environmental management accounting, moving toward corporate water responsibility. After all, studies of corporate water responsibility could benefit significantly from considering the motivational antecedents and the possible tensions in water management accounting practices (Martinez, 2015).

This research aims to create valuable insights into the broader discourse on corporate water responsibility by examining a real-world case. It can then be helpful for managers to identify directions for implementing water management and accounting practices since the case study established a set of best practices, creating a benchmark for water engagement activities. This could be valuable for other companies seeking to enhance their water initiatives. Additionally, the motivations and challenges uncovered in the study can guide corporate policies within the industry and potentially address broader environmental

regulations. Finally, the paper aims to contribute to the sustainability of water resources and promote water security in local communities near water-sensitive industries while addressing the corporate role in managing water appropriately.

2.2 WATER MANAGEMENT ACCOUNTING: ADVANCING TOWARD CORPORATE WATER RESPONSIBILITY

Environmental accounting raises a fundamental question about the compatibility of the core values of advanced financial capitalism – e.g., growth, profit, expansion, consumption, and economic efficiency – with a genuine concern for the environment and whether these values can coexist with an active consideration of the natural world (Bebbington et al., 2021). So, since water is considered an essential part of “natural capital” (Hoekstra, 2009; NCC - Natural Capital Coalition, 2016), it poses an extension to environmental management accounting concerns. Therefore, corporate water management accounting is designed to support corporate management decisions and improve economic and environmental water-related business outcomes (Christ, 2014; Christ & Burritt, 2017c). And although still scattered and multiple (Gibassier, 2018), the importance of water for businesses has become a hot topic, increasingly matching the focus on managing greenhouse gas emissions (R. L. Burritt et al., 2016; Christ & Burritt, 2017b).

Despite increased scrutiny of corporate initiatives related to water management accounting, the academic community has not yet reached a consensus on its classification. More than a decade ago, Pretorius and Turton (2012) recognized water accounting as a system capable of avoiding or solving water-related conflicts. For that, the authors noted the necessity of identifying and understanding water-related risks. According to the CEO Water Mandate (2014, p. 50), water risk is identified as “the possibility of an entity experiencing a water-related challenge (e.g., water scarcity, water stress, flooding, infrastructure decay, drought)”, although different weightings of water risk information are available (Hewawithana et al., 2023).

Regarding water management, some authors recognized it into three classifications: water protection, participation, and innovation (Ji et al., 2023; Sarni & Pechet, 2013). Then, we can understand water protection as the activities related to protecting water resources and striving for water security. Water security might be understood as “the capacity of a

population to safeguard sustainable access to adequate quantities of acceptable quality water” (UN-Water, 2013, p.1). Water participation pertains to the water consumption activities conducted in the daily operations of a corporation, encompassing actions like water consumption and water supply. Finally, water innovation encompasses innovations related to water technologies, equipment, and strategies (Ji et al., 2023). Innovation concerns were also identified by Muller (2012) as a factor that underscores the necessity for corporate involvement in water accounting. The author states that corporations are key actors in water accounting beyond the pressure they face since they play a particular role in driving innovation to address water issues.

The WBCSD - World Business Council for Sustainable Development (2012) extends this approach when proposing five stages of water management to help managers use water management in practice. First, managers should assess the global and local water situations. Second, they might account for water use and understand its impacts on the local water context. Third, by doing so, they can identify water risks and opportunities. Later, actions and targets should be set. Finally, monitoring their performance and communicating it to their stakeholders is critical. Sengupta (2017) would define this last stage as “water profiling”, which involves water risk disclosure and water accounting report. Moreover, stakeholder engagement is also recommended at every stage, particularly at the watershed level (WBCSD, 2012).

This five-stage approach was recognized by Christ and Burritt (2017b) to propose a holistic water management accounting framework. It was based on the environmental management accounting concepts highlighted by Burritt et al. (2002). The framework links water accounting tools along four decision-making dimensions: type of information (physical or monetary), timeframe (past, current, or future-oriented), length of time frame (short or long term), and routineness of the information (routinely generated or ad hoc, based on specific needs) (Christ & Burritt, 2017c). Although one of the authors had already termed a similar approach as water management accounting in 2014 for an Australian wine supply chain (Christ, 2014), this proposed holistic framework brings valuable contributions. It assists managers in developing a more robust water system that improves decision-making, besides bringing water accounting aspects that go much beyond the emphasis on external reporting.

Moreover, Christ and Burritt (2017a) extend some of these dimensions, such as type of data and timeframe, and include key elements from water accounting literature: level of

analysis, categorization and evaluation of water risks, and transdisciplinarity. Previous studies and frameworks have already highlighted this level of analysis concern as being site-specific or if the boundaries are beyond corporate operations, such as considering the supply chain concerns (e.g. Barton, 2010; CDP, 2021). Besides, the authors bring a range of studies concerned with recognizing water risks in different types of organizations (WBCSD, 2012). The transdisciplinary in water accounting will be better discussed in the next subchapter, but it comprises the integrative collaboration required to address water accounting concerns (Christ & Burritt, 2018).

In the face of a range of different water management accounting concepts, tools, and applications among different companies, they all rely on a key concern – corporate water responsibility. While corporate water responsibility might be understood as a subfield of corporate social responsibility embracing the environmental responsibility of water resources (Gu et al., 2023; Zhang et al., 2021), many other sustainability concerns are embedded. In spite of water concerns sometimes generating conflict of interest in who to hold responsible (Ostrom, 2010), businesses have a responsibility to promote water efficiency while supporting the right to adequate clean water – this is the main direction to drive towards corporate water responsibility (Gu et al., 2023). Thus, water management accounting relies on a shift to a more sustainable usage of water resources, depending on the business's capacity to propose and implement corporate water responsibility solutions (Martinez, 2015).

2.3 BUT, FROM WHO FOR WHOM?

Concerning water management accounting within a company, a transdisciplinary approach should be taken to promote corporate water responsibility. Indeed, previous studies emphasize the multidisciplinary nature of water accounting as an imperative for its development (e.g. Chalmers et al., 2012; Christ & Burritt, 2018; United Nations, 2021). Since water accounting is capable of integrating professionals from fields such as environmental management specialists, meteorologists, hydrologists, engineers, accountants, and applied scientists, no single professional group would dominate its standards (Christ & Burritt, 2018; Tello et al., 2016). Egan's (2018) research, for instance, delves into managers' perceptions of the role of accountants in promoting water efficiency. The findings reveal that accountants have a limited role in monitoring, while decision-utility is attributed to non-accountants. At

the same time, Christ and Burritt (2018) state that the benefits from basic and discipline-based academic work in water accounting should not be underestimated. It poses a challenge for accountant professionals to work with interdisciplinary professionals to become deeply engaged in promoting corporate water responsibility. Hence, this research does not focus primarily on the involvement of accountants in water management accounting. We acknowledge its transdisciplinarity and aim to emphasize water accounting practices for corporate water responsibility.

Furthermore, pressure on companies to demonstrate better water responsibility comes from a wide range of stakeholders (Gu et al., 2023). Muller (2012) recognized public policy actors, corporate actors, and environmental advocacy actors as interested parties in water accounting. As water accounting studies often embrace a water reporting approach, they focus mostly on meeting investors' expectations, especially when regarding financial outcomes (e.g. Adhariani, 2021; Ji et al., 2023; Liu et al., 2021). Besides that, relevant stakeholders for water concerns might include, for example, suppliers/customers, trade organizations, employees, regulators, government, consumers, local communities, and non-government organizations (R. L. Burritt et al., 2016; Gilsbach et al., 2022a). According to Egan (2018), when this range of community stakeholders pressure managers, they tend to report more water information.

This awareness of different stakeholders regarding corporate action on water resources presents an opportunity for those who recognize it. For instance, the consumers' profile has brought the topic to the forefront. The household appliance manufacturer considered water and energy savings among its products because of consumers' consciousness while increasing its brand value (CDP, 2023a). This industry sector is the subject of analysis in the present research, as explained in the following section.

2.4 RESEARCH DESIGN

To address the research inquiry, semi-structured interviews were conducted in an interpretive single-case study (Creswell, 2013; Stake, 1995). The research is based on an inductive approach, allowing themes and patterns to emerge from the responses, creating new categories to complement the literature on the topic by touching unexplored topics. The following subchapters better detail the case study characteristics, its settings and analysis.

2.4.1 The Case Study

According to (Stake, 1995, p. xi), a “case study is the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances.” Thus, the case study is in a household appliances manufacturer mostly because it is considered a water-sensitive industry, being more exposed to water-related risks. Consequently, these companies are expected to provide more information about their exposure levels and their plans and actions to mitigate such risks than firms in industries with lower exposure to water-related challenges (Ben-Amar & Chelli, 2018). This company was selected because its activity is classified as “very high” water impact, according to the Water Watch - CDP Water Impact Index (2023b). The methodology considers the industries’ impact through three stages - direct operations, supply chain, and product use. Besides, the selected company has also been nationally awarded for its management and sustainable use of water resources. The accessibility and availability of the respondents were also decisive for the industry choice. Thus, the unit of analysis for this study is the set of water management accounting practices and the managerial perceptions surrounding them within this specific company.

2.4.2 An Interpretivist Approach

Experiences regarding water management accounting may differ or be nuanced according to the context of each firm's plants and the interviewee's role within the company. Thus, an interpretivist approach will enable a "conception of reality as a socially constructed space, nurturing a distinctly emic perspective that includes an interest in people’s subjective meanings and intentions" (Lukka & Modell, 2017, p. 39) while acquiring an understanding of the research issue. Therefore, in contrast to the post-positivist approach proposed by Yin (2018), which seeks to test existing theories using propositions/hypotheses, this research follows the case study tradition that prioritizes an in-depth understanding of the case's particularity, as advanced by Stake (1995). Consequently, by focusing on understanding the water management accounting experiences, our theoretical analysis was primarily inductive.

This inductive approach utilized the three-step Gioia method while supporting qualitative rigor in research (Gioia et al., 2013). The steps include first-order concepts,

second-order themes, and aggregate dimensions, which comprise distilling the emergent 2nd-order themes even further (Gioia et al., 2013). According to Gioia (2021), there is little effort to distill categories in the first-order analysis. However, through careful analysis, similarities and differences among the myriad categories begin to emerge. Consequently, due to the researcher's deep engagement with the case study, a "gestalt analysis" is called for, which enhances the understanding of organizational phenomena. These second-order themes may arise from new concepts not adequately addressed in the literature or existing concepts that gain significance in a new context. Ultimately, after identifying a set of themes and concepts, the researcher should aim to further distill the emergent second-order themes into aggregate dimensions (also called the third-order level) (Gioia, 2021).

2.4.3 Interview Settings

We conducted five individual interviews from October 2023 to July 2024. The interviews were conducted face-to-face and online and lasted fifty to sixty minutes each. The interviewees were individuals in managerial positions selected for their engagement in sustainability and/or water management practices, and they were based in different countries. Interviews were conducted until theoretical saturation was achieved. The interview preparation involved learning about the company, its previous water management accounting practices available online, and a general overview of the industry's impact on water resources.

Following the previous studies' approach (e.g. Venturelli et al., 2023), we divided the questions into introductory, core, and follow-up. All the interviews start with a brief presentation of the research and the concept of water management accounting, followed by a question concerning the engagement of the interviewee's position and experiences around the topic (introductory). The core questions that lead the interviews relate to the following aspects: the interviewee's perceptions of the company's engagement with water resources management, its drivers, practices, and limitations, while customizing the questions to each respondent's role. Then, follow-up questions are added to each case, increasing efficiency (Herriges & Shogren, 1996). This semi-structured approach allows researchers to add pertinent questions that emerge from the research process and are relevant to the subjects' problems (Hopper & Powell, 1985).

All interviews were conducted under strict ethical guidelines. Informed consent was obtained from all participants, who were assured of their anonymity and the confidentiality of their responses. All data was securely stored and anonymized during transcription.

2.4.4 Data Analysis

The interviews were recorded with the interviewers' permission and transcribed immediately after they occurred so the researcher could capture whether gaps could be filled in subsequent conversations. This confirms that the records are reasonable. Otherwise, fast-tracking notes must be made, although it was not necessary. Moreover, according to the interviewer's observations, notes were taken during the visits and online interviews.

The data analysis followed the systematic inductive process of the Gioia method, comprising a three-step coding process (Gioia et al., 2013). This approach is designed to bring qualitative rigor to the process of building theory from case study data. This paper also employs a triangulation method, enabling the researcher to build an analysis through different sources of evidence - the transcribed interviews, the notes made during the visits, documents available from the interviewee, and any other relevant data sources available during the process. These enhance the validity and reliability of the qualitative research on organizational and management accounting processes and understandings (Parker, 2012).

The coding process was conducted using ATLAS.ti software, which aided in organizing the data. The first step involved an open coding process to generate 1st-order concepts, using terms and phrases from the interviewees themselves to remain close to the data. Subsequently, we moved to a more theoretical level of coding (axial coding) to identify patterns and relationships among the 1st-order concepts, grouping them into 2nd-order themes. Finally, these themes were further distilled into aggregate dimensions, which form the basis of our resulting theoretical framework.

2.5 MOTIVATIONS AND CHALLENGES IN PROMOTING CORPORATE WATER RESPONSIBILITY

Among the main findings of the case study, two key questions were posed to all interviewees: their perceptions of the motivations and challenges in the company's water

management accounting practices. The findings on these aspects, along with observations of stakeholder engagement during the interviews, are presented in the following sections. Additionally, summarized concept quotes, second-order themes, and aggregate dimensions related to the identified drivers and challenges complement the analysis in Tables 1 and 2.

2.5.1 Motivation

The interviewees identified several factors that motivate corporate engagement in sustainability and water responsibility initiatives, indicating an evolution within the company over the years. In the 1970s, when the sustainability sector was first established, the focus was primarily on operational aspects. For example, the company concentrated on identifying suitable production materials, such as non-toxic substances, and fostering initial awareness of environmental issues at a time when only a few companies were discussing these topics. *"Our motivation back then, 60 years ago, when no one cared about water or energy, was very much about an awareness of the planet."* (I2). Over time, particularly after the 2000s, concerns began to include developing sustainable products. *"And after that, a discussion started like this: Man, our priority is no longer this, but the product. We are putting a lot of waste into the world. We need to start contributing in a way that has a more sustainable, more recycled, more durable product vision"* (I4). After all, the company's activity generates long-term products (from 10 to 20 years, according to I4), boosting motivation to reduce water consumption not only in the product's development but mainly in the consumers' houses. *"When we talk about water, we have mappings that show that 98% of (company's name)'s impact today is in the product. The biggest water impact concerning what we do comes from using the products at home. From the consumption of the washing machine, from the dishwasher..."* (I3). In discussing the evolution of motivational factors over the decades, the company's focus has increasingly shifted towards a stronger emphasis on recent ESG engagement. *"And today, added to that is the fact that there is an increasing appeal to ESG—on the stock market, consumers, [...], so I think now, beyond a genuine concern, it also becomes a matter of the business itself"* (I2).

The concern for business considerations is also evident in the motivations behind water-saving practices, particularly the associated financial benefits. As one interviewee noted, *"The financial conversion is important for getting projects approved because, typically*

[...] environmental projects compete with other projects. So, there is this financial appeal" (I3). Consequently, beyond the need for corporate projects to align with the company's culture, values, and strategy—an aspect also highlighted by interviewees—there is a fundamental need to leverage the business. *"So, I think this movement is obviously very focused on long-term cost reduction. Again, let's not be hypocritical—this is a capitalist company, period"* (I2).

However, for resources to be allocated effectively to water resource management projects, it is crucial for leaders to be actively engaged with the issue. One interviewee stated, *"I think that in the end... especially in a large company, right? It is the result of what the people inside it are doing. So, if you have engaged leaders, if you have leaders who care about the topic, it changes things."* (I3). This perspective highlights the importance of leadership engagement, drawing on the interviewee's past experiences with various types of leaders—some highly committed, while others were less so. This observation aligns with the findings of previous studies on the subject (e.g., Gibassier, 2018; Marie et al., 2024).

Additionally, respondents emphasized the awareness that managing these aspects contributes to the sustainability of the business itself. After all, *"If you are not evaluating climate risk, you are not evaluating the future risk of the business"* (I3). Furthermore, effective water management practices can enhance business sustainability by creating a competitive edge in the market. *"When we address the issue of increasing the water recycling rate and reducing water consumption per product produced, these numbers are really important for us to externally showcase the sustainability of our products and convert this into a commercial appeal, right, within the market."* (I1). These findings aligns with ideals that sustainable practices are capable of promoting corporate financial sustainability (Wong et al., 2025).

Investing in business sustainability through socially and environmentally responsible practices highlights another inherent motivator: reputation. Throughout the interviews, many participants addressed this topic in various ways. One interviewee stated, *"Today, we want to be seen, by people and other companies, as a bench [about 'benchmark'], to look at what we do well so they can implement it too, you know? That's our goal—to be a reference on the topic."* (I5). Reputation also came up when respondents discussed the criteria for evaluating the success of a water-related project. On this topic, one interviewee remarked, among other points: *"I think we are a socially responsible company, but capitalist. So, we also pay close*

attention to whether the project generated media coverage. We assess all of that.” (I2). Additionally, the project's impact on the community is evaluated. The interviewee explained, “In other words, [...] if it left a legacy for the community” (I2). Another aspect of the company's reputation is its relationship with the market through water reporting. Another interviewee noted, “I see that this type of external reporting is very important for us to consolidate our external vision in terms of ESG, in terms of a company committed to areas beyond just the financial market” (I1).

Concerns about the company's external image focus on a major motivator within the corporation: its relationship with stakeholders. After all, this growing focus on ESG discussions in the market, despite existing criticisms (Christensen et al., 2021; Edmans, 2023), is driving pressure from stakeholders to take meaningful action. However, consolidating the company's sustainable image goes far beyond what investors demand, it also entails a commitment to customers and, by extension, to society. As a result, the pressure they exert seems to drive water management and accounting practices. *“All our plants are in capitalist countries, (...) the company is a reflection; it will do what society asks. So, if you have consumers pressuring, if you have investors pressuring, that changes the prioritization the company gives to the subject” [I3].*

Another key stakeholder identified was the government. Corporate sustainable practices were mentioned as a valuable asset in negotiations with government entities. For instance, considerations such as the number of jobs the company creates, the extent of health coverage it provides that reduces the burden on public healthcare services, the amount of water and energy saved, and the taxes collected are all significant topics in governmental relations. *“Our role as a company is to equip these people with information, so I think we need to focus on a solid dialogue with the government. [...] So, this gives substance to the lobbying work” (I2). In this sense, both public and private data are used to enhance the discussion.*

Table 1 presents the listed concepts along with additional quotes. Through the analysis, these concepts were categorized by their themes and aggregate dimensions.

Table 1 – Data Structure of Corporate Water Accounting Drivers

First-order concepts	Second-order themes	Aggregate dimensions
• "[Company's name] prioritizes sustainability as a whole. When we look at what is related to water, both in operations and products, it always ranks among the top." [I4] • "I think our motivation back then, 60 years ago, when no one cared about water or energy, was very much about being conscious of the planet." [I2] • "We were at a point where we expanded operations to discover what materials are valid, what aren't, what is toxic, what isn't toxic, but ensuring that was the priority, I think probably until the 2000s." [I4] • "I think this is an important point for us to really show how much the brand has evolved, (...) how much we are truly concerned within our production process to deliver not only innovation and well-being to our customers but also sustainability." [I1] • "And after that, a discussion started like this: Man, our priority is no longer this, but the product. We are putting a lot of waste into the world. We need to start contributing in a way that has a more sustainable, more recycled, more durable product vision" [I4]	<i>Planet awareness</i> <i>Suitable materials</i> <i>Sustainable products</i>	Sustainability commitment
• "I see that this type of external reporting is very important for us to strengthen our external vision in terms of ESG, as a company committed to other fronts beyond just the financial market itself." [I1] • "And today, in addition to that, there is the fact that ESG is increasingly relevant in the stock market, for consumers [...], so I think that now, beyond a genuine concern, it also becomes a business matter." [I2] • "Obviously, there is a point: if those in leadership are smart, they understand that this is also about the sustainability of the business." [I3] • "So, we develop technologies and address the topics so we can internally truly achieve good results and be a reference in sustainability." [I5] • "So, I think this movement is obviously very focused on long-term cost reduction. Again, let's not be hypocritical—this is a capitalist company, period" [I2] • "Obviously, the environmental aspect is important, right? But we want to do something that always has a technical and financial basis, you know?" [I5] • "There is this financial appeal, and the cost-benefit analysis is crucial when determining whether a project will be approved or not." [I3]	<i>ESG engagement</i> <i>Business sustainability</i> <i>Cost reduction</i> <i>Financial return</i>	Financial concerns
• "If you have engaged leaders, if you have leaders who care about the topic, it completely changes things. [...] Because, you see, leaders are the ones who decide where to invest and where not to invest." [I3] • "So, the connection of the project with our organizational culture and the values of [company's name]" [I2]	<i>Engaged leaders</i> <i>Corporate culture</i>	Institutional structure
• "But when we address the issue of increasing the water recycling rate and reducing water consumption per product produced, these numbers are really important for [company's name] to externally showcase the sustainability of our products and convert this into a commercial appeal, right, within the market." [I1] • "And I think it's something the market demands, right, for you to start aligning with sustainability, governance, and social standards. I see that this type of external reporting is very important for us to consolidate our external vision in terms of ESG, as a company committed to other fronts beyond just the financial market itself." [I1] • "I think we are a socially responsible company, but capitalist. So, we also look at whether the project generated media coverage; we assess all of that." [I2]	<i>Competitive edge</i> <i>Reputation</i>	Market reputation

• “Today, we want to be seen, by people and other companies, as a bench [about ‘benchmark’], to look at what we do well so they can implement it too, you know? That's our goal—to be a reference on the topic.” [I5]

• “Our role as a company is to equip these people with information, so I think we need to focus on a solid dialogue with the government. [...] So, this gives substance to the lobbying work” [I2]	<i>Government relations</i>	Stakeholders’ engagement
• “Today, what we see is that companies are very engaged (...) because it’s a societal demand. So where do we see this? We see it in the purchase of products, in customer demand, in the way ratings, the scores we have in environmental assessments. So for me, this completely changes things, like, at the highest level of the company, the actions.” [I3]	<i>Society's demand</i>	

Source: Research findings.

2.5.2 Challenges in Promoting Corporate Water Responsibility Practices

In spite of the drivers involving the government relationship, many challenges highlighted in the case study seem to stem from government and regulatory agencies. First, the lack of a restrictive structure discourages companies from implementing voluntary initiatives that promote water conservation. *“I would like the environmental agencies, the ratings, the investors, to demand this in a more structured manner [...]. If there were a structured framework that companies must adhere to, under greater pressure, I think that would [...] compel the companies to take action.”* (I3). At the company's plants based in Brazil, the lack of a national requirement seems to force the company to look for structures outside the country – *“So, we seek international standards because we don't have any standards here, you know? So, maybe that ends up delaying some things, right?”* (I5). When the regulatory challenges in Brazil are addressed at the state level, they reveal even greater discrepancies that hinder the effective management of water resources. For example, one interviewee pointed out that the State of Santa Catarina lacks stringent regulations in this area. In contrast, the State of São Paulo requires the collection of water indicators for regulatory agencies.

“And today, like, I see in Santa Catarina, right? As a whole, we don't have legislation that is so active regarding water control, [...] so, like, we have concessions, we have licenses, but these reports—we have all the data here, and we monitor everything. Anyway, we have all the information, but the agency responsible doesn't have that information or that data, you know? And I know that, like, in other states, like São Paulo, you have to report that information, at least, to the environmental agency or the agency responsible for water resources. Like, and today, no—we have that data for internal monitoring and control, but we don't have any reporting, like, you know?” (I5).

Furthermore, given the vast number of environmental issues that require public and governmental attention, some interviewees emphasized the challenge of distinguishing water

resources from others, such as energy. Some comments compared the lack of water-related restrictions with the bunch of energy and climate change-related restrictions that somehow stressed the importance of the subject around different companies and stakeholders - *"So, how can the government further promote that companies do this? So, when you think about energy efficiency today, you already see many calls for proposals emerging with that purpose, right? [...] We see few of those for water yet, very few."* (I2).

Beyond huge public investments and projects to mitigate energy waste, some more common measures for energy purposes could improve water efficiency if we had more stringent regulations, such as efficiency labeling. However, concerning product efficiency, one interviewee stated, *"There are still few consumers who look at energy efficiency labels. We don't have water efficiency labels, and I think we are far from having them."* (I2), while another asserted that *"One of the few places where energy labeling, or product efficiency labeling, includes and regulates a maximum water usage is in Brazil, okay? [referring to washing machines and dishwashers]"* (I4). The latter view is borne out by the Inmetro (National Institute of Metrology, Quality, and Technology) label on these appliances, which not only addresses energy consumption performance but also specifies water consumption performance, among other product indicators. However, if professionals fail to acknowledge this performance evaluation, how can we expect Brazilian consumers to recognize it? This stalemate in the consumer goods industry may stem from the issue raised by one interviewee: water regulations allow too much leeway, as outlined below:

"The Inmetro label is, like, regulating that we have to use a maximum amount of water per load of laundry, per cycle, okay? And that actually is a regulation, if we can call it that, a weak one, okay? Because our products—by the way, not just ours, but products in the market in general—use less than what the regulation allows, okay? It's very different from the energy regulation, where there is a huge effort for us to get products within the maximum limit, and many times we have products that are label B, and many times they are label C; this is happening in refrigeration now, there's a big energy shift, but for water, it isn't like that, okay? For a long time now, we haven't had difficulty in the market with a product that isn't labeled A because of water, okay? It will always be because of energy." (I4).

We must also address the nuances of the country's regulations, particularly when dealing with a multinational company. When comparing the stringent regulations for energy and water resources in certain plants—such as those in Europe—the legislative weaknesses of other regions, notably Brazil, became evident. Throughout the interviews, it became clear that the lack of water-related incentives from regulatory agencies makes companies struggle to

direct efforts toward expanding the market penetration of products efficient in water-related aspects. An interviewee highlighted Brazil's absence of incentives for industries and consumers compared to the more supportive environment found in the European market. *"Very different from what Europe did 20 or 30 years ago when it simply banned top load washers, switched to front-load, ensured subsidies, and today we have, obviously much later, front loads operating at the prices that top loads used to cost."* (I4). The interviewee mentions these products as an example of how front-load washers can save significantly more water than top-load models, as also highlighted in the company's annual report.

The evidence presented above lends support to critics of why some countries, especially those in water-stressed areas, still have no incentives to make water-efficient products more affordable to consumers. After all, *"Our consumer still has a short-term and price-focused mindset."* (I2). Therefore, while consumer disinterest in water-efficient products presents a barrier for many of the interviewed managers, there is also an understanding of the complexity of demanding environmental education in a critically challenged environmental context, especially when adequate human conditions are not guaranteed – *"How are we going to talk about conscious water use if this person doesn't even have basic sanitation, right?!"* (I2). Thus, again, there is an urgent need for political engagement and incentives to make water-efficient products more accessible. *"It's still a very specific niche of consumers who value this, and what's missing is communication, right? And I don't believe it's solely the responsibility of companies. We must hold the government accountable because they play a crucial role."* (I2).

The need for public and regulatory incentives mentioned above aligns with another water-related challenge raised by four interviewees: the low cost of water resources. One interviewee pointed out a contradiction in India regarding the lack of consumer engagement in purchasing products with a lower water impact. Despite some regions having access to water for fewer than four hours a day, water is provided free of charge to the population.

"So, like, the water is free, they have little water, and at the same time, there's no benefit if they save a little. If they improve consumption by 10% month over month, there's no benefit at all. So, it's a very complex issue. I see that if it doesn't come from a regulatory or political initiative, the industry will keep providing a range of options, and the consumer will have plenty of choices, but there's no incentive to choose a better option. And if there's no benefit, there will be no engagement." (I4)

Another major issue posed by the interviewees concerning the low cost of water is the constant struggle to approve water-related projects internally since these projects usually do not have the best benefit-cost compared to more expensive resources – such as energy. *"Because the cost of water is still a major challenge for making projects viable in business terms."* (I1). And apparently, this is a major issue worldwide. *"With water, we can't achieve a good cost reduction. This is true everywhere. I found the same situation in the United States, and the same in Mexico"* (I3). Thus, while consumers may not initially see a financial saving from reusing or saving water, the same appears to happen with companies. *"There comes a point when the real challenge is being able to transform the topic [water] into a business case to justify multi-million changes"* (I1).

Ultimately, we arrive at the last two interrelated main challenges the interviewees posed: annual water consumption reduction targets and a lack of long-term vision for water. Two managers mentioned the company's struggle with having a yearly water consumption target as it relies on past performance and must account for their already highly optimized water-saving scenario after years of improvements. *"We have a reduction target. Before, we worked with 5% per year; now, we've moved to 3% because it's getting harder every year to achieve disruptive projects regarding water consumption reduction."* (I1). So now we return to the previously mentioned challenge: opportunities for new water reduction projects to address the minimal consumption still present in the process face significant financial barriers. Another manager also expressed dissatisfaction with the exclusive use of annual water consumption reduction targets, suggesting the need for a more long-term strategic vision for water, similar to the approach taken with climate-related actions.

"I think all companies should have—like, net zero was an example—you can't think about performance only year by year. To me, performance only matters if you think long-term. [...] When it comes to water, I see that companies are just now starting to develop long-term strategies, and we are pushing internally to do the same. You need to define a strategy for several years ahead and then break it down into annual targets." (I3).

Summarizing the most frequently identified challenges from the interviews, the data structure is presented as follows.

Table 2 – Data Structure of Corporate Water Accounting Challenges

First-order concepts	Second-order themes	Aggregate dimensions
• "So, but today, without any attached legislation, in a role simply of sustainability, I'm not going to say that it's impossible because I've already seen disruptive projects happen simply through improvement, but I think it's tough for it to happen." [I1] • "In Brazil we don't have any kind of applicable legislation, for example, regarding the contamination of rainwater, right?" [I1] • "Within the consumer goods sector, water is a business that is very scarcely regulated, okay?" [I4] • "Today we know that not everyone has control of what they're consuming, of what they're spending, of what they're generating in the affluent, anyway. So, I think that it would be interesting, you know, to have that more firmly, like, you know, to monitor and control." [I5] • "So, we seek international standards because we don't have any standards here, you know? So, maybe that ends up delaying some things, right?" [I5] • "I think that the lack, right, I would say that it's the lack of investment and public promotion for that. So, when we think about the data that I shared with you on water recyclability and rainwater reuse, when we think about it we are unburdening the public water system. So how can the government further promote that companies do this." [I2] • "The government is not concerned with giving any benefit, neither for the consumer nor for the industry, to, let's say, prioritize the appliance that is better in water usage, ok?" [I4]	<i>Deficient regulation</i> <i>Lack of national standards</i> <i>Absence of governmental incentives</i>	Weak regulatory and governmental commitment
• "So, we are still very far from the consumer valuing that [water savings], you know? It's still a very specific niche of consumers that values that, and what is missing is communication, right?" [I2] • "So, like, the same thing, the communication about the dishwasher, okay? We try to convince the consumer that this is the best solution, both in terms of performance, time, time-saving, reduction of domestic chores, huge water savings, etc. Man, if the consumer understands that for him, that thing doesn't work because he lives alone and doesn't want to accumulate water, or he doesn't believe that the dishwasher works due to past beliefs. Anyway, he won't buy it to save water, okay?" [I4] • "Today, you already see that younger people, new couples, no longer talk about not having a dishwasher at home; people already understand that washing dishes is time lost in life. But still, older people—our population is a somewhat older new population—carry this stigma that dishwashers consume energy and water, anyway, and they don't see value in the product." [I2] • "It is a solution that helps the consumer save water and reduce water consumption; it is available, has a series of models, and a wide variety of prices, as long as the consumer wants to use it, okay? So, it's much more a matter of the company providing a solution and trying to convince the consumer to get on board with that solution." [I4]	<i>Poor environmental communication</i> <i>Consumer apathy</i>	Lack of consumer engagement
• "It will continue and, again, you know, water is often cheap in those places. I mean, I don't know if you know, water in India is free, and they have water for less than 4 hours per day in the vast majority of regions, okay?" [I4] • "Water is still a very cheap resource when you compare it with other resources, with energy, for example." [I3] • "So, like, in these small details, we see that the company is engaged [...] because the cost of water is very low, we can't achieve a considerable saving to prioritize a project of this type." [I1]	<i>Low cost of water</i>	Undervalued resource

• "So, the projects you have for reducing water consumption normally don't have a... they call it BC, right? They don't have a good cost-benefit. And then it becomes tough for you to get them approved." [I3] • "We will have to base things a lot on the cost to verify which processes we need to add to be able to use this water again. So, these are things that are mapped, but we are monetizing all of this to verify the cost/benefit issue." [I5] • "There are indeed financial discussions, okay? So, I'm going to replace a system that today discharges water with one that reuses water. Man, how much benefit will I generate—financial benefit, sustainability benefit, alignment with our targets? [...] We have capital, a limited budget, obviously." [I4] • "We always try to develop projects that have some financial return for the company, not just an outlay, you know? So, it is a huge challenge in many ways." [I5] • "Honestly, what I see the most, like, is this issue of us being able to make the project viable in terms of savings—I think that's what matters the most, [...] because if we were to look at this solely in financial terms, in terms of saving with a project like this, it almost doesn't exist." [I1]	<i>Unfavorable cost-benefit in water projects</i>	
• "Obviously, it is based on the previous performance. So, we have a reduction target of, I think, 3% each year, which is our current target. So, you have to reduce 3% year after year. Then, factories that—and what brings up another problem—have already reduced a lot and continue with a target that perhaps no longer makes sense for them because they are already performing much better than other factories. So, this is a point that is not yet customized." [I3] • "And maybe shortly it might happen, but like, for us to be able to move optimizations, okay, each year it's more difficult in terms of processes, you know, I consider [...] we are already very well placed in terms of optimizing water consumption." [I1] • "One of the things that we are doing now is, that I'm seeing, not only for us, but I see that for most companies water, they talk about reduction and such, but I see few companies with long-term, long-term targets for water." [I3]	<i>Limited financial return</i>	
	<i>Ongoing water consumption decrease</i>	<i>Strategic challenges</i>
	<i>Lack of long-term vision</i>	

Source: Research findings.

2.6 TYPOLOGY OF WATER MANAGEMENT ACCOUNTING PRACTICES

Beyond the motivations and challenges in water management and accounting, several other themes were uncovered after the researcher's immersion in the case study. A typology of four themes—operational management of water resources, development of sustainable products, global water strategies, and water reporting practices—illustrates the underlying themes and aggregate dimensions regarding corporate water management accounting practices that emerged from the interviews. The following figure summarizes the main categories identified within each theme, based on insights gathered from the interviews.

Figure 2 – Research Themes and Categories



Source: Research findings.

2.6.1 Operational Water Management

Among the key topics related to water sustainability in the company's operations, indicators are frequently discussed for data collection and decision-making. According to Interviewee 5, the company reports water-related indicators monthly while monitoring them weekly. However, the team recognizes that daily tracking would be more beneficial for improving results. This approach allows faster detection of leaks and process deviations, ensuring better control and a quicker response to necessary actions. In addition, the water-related indicators are reviewed annually.

"So, for example, sometimes there's a problem in a process, a quality issue, where people have to repaint or rewash parts, for instance. I end up consuming more water, and I can see the impact on the total water volume, but figuring out exactly where it came from... So, I can map the specific area, the specific water meter, you know, and direct my actions and measures to monitor the solutions as well." (I5).

Aiming to integrate and improve water-related decisions in the management processes, monetary water indicators must be on the fore, as Burritt and Christ (2017) indicated.

Nevertheless, many companies still focus exclusively on physical water data (R. L. Burritt & Christ, 2017). But, surprisingly, Interviewee 1 spontaneously pointed out that their software tracks water KPIs in both physical and cost-based terms. *"We have a valuation process, where we assess the specific resource in terms of environmental impact valuation, which is then converted into monetary values, reflecting the costs associated with each resource."* (I1). This emphasizes the need for efficient water use since it is directly related to costs (Chandra et al., 2024). The interviewee also mentioned that the software compiles historical data on various water resource indicators, including different sources of water consumption (such as groundwater, rainwater, publicly supplied water, and industrial water), the total volume treated and recirculated, supporting the indicator of water volume consumed in production.

Although still tied to using indicators and aiming to achieve operational excellence, a noteworthy theme emerged in three interviews—the World Class Manufacturing (WCM) methodology. *"WCM is a tool for reducing losses within the manufacturing process, from start to finish. It is divided into 10 different pillars, each worked on by specific teams. Specifically, in the Environmental Pillar, water becomes one of the key aspects."* (I1). The interviews made it clear how the WCM methodology guides operations and drives a significant portion of water-related projects: *"This methodology is heavily based on prioritization. [...] So, we always direct our projects according to the losses mapped by the system, you know?"* (I5). We also quickly noticed how deeply engaged and proud the managers—and the company as a whole—are of their recent achievement in earning a prestigious award for their work using this methodology. This sense of pride was not only expressed by several interviewees but also prominently displayed in the visitors' waiting area upon entering the company.

In line with the commitment to operational excellence, the company has prioritized mapping various water sources and maintaining a high-water recycling rate. For instance, at one plant we visited, 98.5% of total water usage is successfully recycled (I1). Besides, according to interviewee 5, *"We are also currently developing some technologies, seeking information so that we can achieve our ideal dream, which is to reuse 100% of the effluent we generate, right? That is our goal."*

Beyond water recycling efforts, the company also utilizes the water footprint as a key tool for water accounting. Interviewee 4 explained:

"We have mapped out how much [company's name] contributes to water use worldwide. What does that mean? How much water do our operations consume, so, across all our manufacturing sites globally, okay?! How much water do our products consume throughout their lifecycle, okay?! [...] Additionally, we have a somewhat more estimated, less precise mapping of how much water our suppliers use to produce the parts that go into our products, okay?! [...] Thus, okay, with this footprint overview, we can identify our biggest challenges, okay?! Or, what is our Pareto, what are our priorities, okay?! [...] From there, we develop, let's put it that way, action plans or improvement strategies to implement over time." (I4).

Known as an essential step toward adequate water management (Zhang & Tang, 2019), the water footprint of a product is an indicator of freshwater use, representing the total volume of water consumed both directly and indirectly throughout its production process (Hoekstra et al., 2011). Therefore, the evidence presented above lends support to the knowledge that a detailed accounting of water footprint should adopt supply-chain thinking (Christ & Burritt, 2017a; Islam & Murakami, 2020). This is particularly important because, in many cases, the supply-chain impact is much bigger than the direct water impact to create a product (Islam & Murakami, 2020).

Based on our observations, most interviewees stressed the engagement and worry about water on the company's value chain. While the worry about water consumption in the company's operations and the customers' houses throughout the years was largely mentioned, only one interviewee mentioned the suppliers' impact on water resources. *"Most water use is in products in the field, ok? So, operations and suppliers. Operations are the smallest use, followed by suppliers, and the biggest use is the products in the field."* (I4). However, considering the company's activity group's "very high" score on the CDP Water Watch (2023b), which posed the supply chain as the biggest water impact, followed by the product use and direct operation with a smaller effect, we expected a deeper and more often mention of their supply chain during the interviews. Finally, Interviewee 2 also mentioned the company's actions and difficulties regarding the reverse logistics. The company has developed its own reverse logistics program, which collects any product over 30 kg—whether from its own brand or a competitor—directly from the consumer's home. However, challenges arise, such as road access issues occasionally leading to closures, further increasing costs that most consumers are unwilling to cover.

2.6.2 Sustainable Products

Concerning the sustainable products category, beyond the themes already mentioned in these results – such as the need for governmental subsidy to drive the development of more water-sustainable products and the company's engagement in understanding the products' life cycle to monitor the company's water footprint, some other aspects define this theme within the company.

Many interviewees expressed concerns about water efficiency in the consumers' houses, as this relates to the company's impact on water resources, especially since the products are designed to last for years. However, while the developed products require water consumption at the consumer's home, they ultimately reduce water usage when their function is compared to the consumer performing the task manually. Therefore, as emphasized by many respondents, *"our products reduce water consumption at home, right?"* (I3). To ensure this efficiency, a team is dedicated to it—*"There is a design for sustainability team that is linked to the product development team to devise strategies for reducing water consumption in the product."* (I3).

Effective water sustainable product development also requires investments in innovation and technology (Christ & Burritt, 2017b). In the company, it was observed that while some product technologies do not significantly impact the final price, others seem to add a cost that the end consumer does not always absorb. On this behalf, research and internal assessments are conducted to determine whether introducing a product to the market is feasible. This was the case with a low-cost technology—water reuse: *"All our washing machines launched since 2020 have water reuse functions, right?"* (I4). Before adding a feature that reduces water consumption, the company conducts consumer research to assess whether the associated costs will be positively received in the market. *"So, the technology we make available, we offer, it's up to the consumer to understand whether they want to pay for it or not."* (I4). Therefore, according to the interviewee 2 perception, the lack of engagement from Brazilian consumers, or their price-focused mindset, ends up limiting the entry of technologies into the market, as exposed below.

"We have a lot of technology that doesn't reach the Brazilian market, right? Our development platforms are global today, so we have people in Brazil developing products for the whole world, product technology for the whole world, and there are many that are not launched in the Brazilian market, right? And I think it's still very much because our consumer still has a short-term, price-focused mindset." (I2).

2.6.3 Global Water Strategies

Water strategies were the third aggregate dimension we identified while understanding the company's water management accounting practices. Given the company's global dimension and position and the international initiatives focused on corporate water responsibility, it makes sense to consider this category as global water strategies. Consequently, as a multinational company, there is a theme that permeates the company's water strategy – evaluating each water stress context. The CEO Water Mandate (2014) defines water stress as a lack of ability to meet human and ecological demand for freshwater regarding water quantity, quality, and accessibility. Hence, Interviewee 4 states the necessity of mapping the water context a company is working on, for aligning the best strategy for each scenario while identifying and mitigating water-related risks.

"The index we use is an index called the Country Water Stress Indicator, okay, which comes from water risk. This index is public, and it categorizes countries into extremely high, high, medium-high, medium-low, and low water risk, okay? So, in 2023, we have a view of what percentage of our water-using products was sent to each of the countries listed in each risk category, okay? So, I have a chart where I can see, man, what percentage of my products went to countries that are at extremely high risk, how much went to countries that are at high risk." (I4).

During some interviews, two other water-engagement themes raised our attention: the number of collaborative water projects the company has and how many global water initiatives they have committed to. The partnerships' actions were in different locations and involved different actors from different social classes, and some were specially directed to women. However, the main point of those projects was to understand how these partnerships with public and private companies, as well as nonprofit organizations, can all yield results that directly or indirectly influence the population's relationship with water. And, of course, the strong engagement from top management in major global initiatives reflects the company's commitment to its stakeholders, demonstrating its dedication to upholding corporate water responsibility. This is quite relevant, especially when considering the water-related goals and strategies that comprise a significant part of the initiatives. Furthermore, among the global water initiatives mentioned by the interviewees are the United Nations Global Compact, the CEO Water Mandate, and the Water Resilience Coalition.

Regarding the company's departmental structure on water issues, while different areas are involved and different areas were interviewed, here we emphasize the organizational structure of the sustainability departments since they are the major division involved in water accounting concepts. *"So, sustainability at [company's name] is addressed globally; it is not a regional department but a global one. And the global sustainability team is built on three main pillars."* (I4). So, based on the three pillars of the global sustainability department expressed by Interviewee 4 and our perspective throughout the interviews, the following Figure illustrates the organization and assignments of the global sustainability team within the company.

Figure 3 – Sustainability Departments Structure



Source: Research findings.

2.6.4 Water Reporting

When dealing with corporate water accounting and other sustainability-related issues, reporting information to a range of stakeholders requires a comprehensive approach. This involves ensuring transparency, aligning with recognized frameworks and standards, addressing ESG indexes, consolidating data effectively, evaluating materiality, and incorporating assurance practices. Therefore, since effective reporting not only fosters trust but also demonstrates an organization's commitment to corporate water responsibility, it was a topic constantly discussed during the interviews.

The interviewees highlighted the increasing influence of ESG indexes in sustainability reporting, emphasizing both internal processes and external perceptions. Interviewee 1 pointed out the role of a global team in consolidating information to respond to market inquiries and to develop a more mature understanding of issues like water stress: *"The global*

team that takes care of our indexes [...] needs to have this consolidated view in order to answer the questions that come from the market." (I1). Furthermore, the interviewee emphasized how external reporting supports the company's commitment to ESG practices, stating, *"This type of external reporting is very important for us to consolidate our external view in terms of ESG."* (I1). Integrating sustainability into production processes, community partnerships, and social and environmental projects demonstrates the organization's broader commitment beyond financial markets. Similarly, Interviewee 2 reinforced the business necessity of addressing ESG concerns, citing the rising influence of consumer preferences and stock market expectations: *"We have a niche of consumers who make decisions by looking at the ESG aspects of companies."* (I2). This growing access to information and market demand underscores the dual role of ESG reporting as both a genuine concern and a strategic necessity for modern businesses.

Consolidating water information to externally report it through sustainability reports, ESG reports, or other sources requires several steps, based on our interviews' perceptions, from collecting data according to internally established standards to consolidating this data in specialized areas, studying the materiality, and aligning with international reporting standards and frameworks. First of all, interviewee 1 established how the water data arrives to the team responsibly for consolidating and reporting it. So, interviewee 1 explained that the entire manufacturing process has water consumption meters well distributed across the different water sources. Therefore, monthly, all the branches input their water consumption data into a software. *"And then this software, the whole global team has access to it, and there they consolidate information on water from sustainable sources, water from non-sustainable sources. They can then check how much water we have from recirculation and easily generate these external reports, right, monthly, annually, whatever is necessary."* (I1). Then, according to interviewee 3, there is a team inside the ESG team that is responsible for all the reporting processes, investor relations, and sustainability reporting.

When asked about how the company decides what to report in the sustainability report, two key aspects were highlighted: the company's materiality assessment and global frameworks. Aligned with the company's strategy, Interviewee 3 explained that a materiality study is conducted to determine which ESG topics are most relevant to the company, considering factors such as industry sector and geographic location. *"We do this study every year, with the help of an external company, and define, look, what is material for [company's*

name] *are these topics here. [...] This defines why we focus more.*" (I3). In this interview was emphasized that materiality plays a crucial role in defining both the scope and depth of the information reported. Regarding the specifics of reporting, *"They are very related to the frameworks, to the ratings, that we are subject to, or that we voluntarily decide to follow."* (I3). By the way, the interviewee mentioned that frameworks and ratings have significantly influenced how the company measures its internal water-related indicators. This approach allows the company to avoid collecting internal water data and recalculating it to fit external metrics. *"So I looked at how they were asking, and we updated the way we report our indicators to match what GRI is asking, what CDP is asking, what Dow Jones is asking."* (I3).

Lastly, water auditing refers to the engagement of a third party to examine the organization's water information for accuracy (Zhang & Tang, 2019). So, when relevant, we questioned Interviewee 3 about the existence of external audits for water-related data. It was stated that, at present, there is no third-party assurance for water data, only for energy data. Although external assurance is not currently mandatory for water or waste data, the interviewee mentioned that they are considering expanding it to these areas in the coming years. To support this expansion, they are enhancing their internal processes: *"We have a structured reporting system, we are starting to use it, structuring the process better to ensure the highest quality in the data we report."* (I3). Additionally, the interviewee stated that the performance of ESG indexes declines when data is not certified by third parties. However, regarding third-party assurance beyond external reporting, another interviewee referred to an external audit conducted on the WCM methodology, previously mentioned: *"We go through an external audit of WCM. [...] We have the creator of the methodology, he comes to audit us every year and check how the application is going, how the projects are going."* (I5).

2.7 DISCUSSION AND IMPLICATIONS

This paper sets out to understand the water management accounting practices of a multinational household appliance manufacturer. Based on the coding and categorization framework, the key aspects emerging from the interviews become clearer regarding the ambition to achieve corporate water sustainability. So this chapter aims to discuss and emphasize some of these key points while raising possible related opportunities for developing the topic.

Considering the company's niche, size, and market visibility, along with other inherent aspects of the business, this case contributes to the discussion on financial concerns in the sphere of natural resource preservation. The research made evident that financial aspects drive company practices on water issues, as well as may challenge it when there is no engagement from key stakeholders involved, such as regulators, governments, and consumers. However, this topic remains a subject of debate in the scientific literature. Some would argue that sustainable practices bear significant favorable corporate financial implications (Wong et al., 2025) and that even if corporate water management practices alone are not sufficient conditions for high corporate financial performance, it is definitely necessary (Ji et al., 2023). Others are more skeptical, arguing that sustainable corporate practices rarely make a substantial contribution to sustainability, particularly in a capitalist economy (Gray, 2010). But our point here is that when a financial impetus for responsible corporate behavior exists, we could easily reorganize the debate to consider not only the inherent moral philosophy and business ethics concern but also root these actions on the spectrum of modern economic principles (Brooks & Oikonomou, 2018).

However, while this case study to some extent highlights the challenges and effort to justify financial returns on water-related projects, considering water's low cost, previous events have shown that when we take a long-term perspective for water risk management, it is in fact the cheapest option from an environmental, social, and economic perspective (R. L. Burritt & Christ, 2018). But the ongoing discussion about the challenges of setting long-term water goals highlights an institutional weakness that seems to underestimate the urgency of the issue on both global and corporate agendas. While a few initiatives mention the need for long-term water strategies, such as the CDP (2024), it seems insufficient to overcome these challenges. It poses opportunities for agencies and tools to support businesses in evaluating long-term water strategies and exposure to water risk while providing more opportunities for water investments. After all, sustainable water management is vital for the long-term performance of companies (CDP, 2011).

Still on this financial regard, the case study has shown that there seems to be tension between the financial investment decisions among different resources. This is often a concern when we discuss listed companies' ESG engagement since the environmental spectrum is often used as a synonym for climate change. Furthermore, the EU environmental commissioner Jessika Roswall indicated that energy fixation has left the water crisis

unaddressed, and water shortages affecting business should be addressed urgently (Hancock & Bounds, 2025). It is definitely not a race to determine the importance of resources. After all, *"environment everything impacts everything, right?"* (I3). In fact, Interviewee 3 mentions that the company's main climate-related risk is water stress. Therefore, the case study outcomes have raised a relevant, nebulous area: how can we interlink water with other sustainability-related issues? When we focus on understanding the interconnectivity of resources (Zhang & Tang, 2019), we may find it easier to approve projects while considering both their urgency and the complexity of environmental systems. This presents an opportunity and challenge for various management and reporting initiatives to reframe their perspective on natural resources. By adopting a more integrated approach, they can extend these opportunities to companies.

From this perspective, we can consider which widely adopted practices for other environmental issues could help establish a more consolidated water accounting within companies. In this regard, there is a concept already well-established in the context of climate change, as mentioned in the case study, which has gradually started to incorporate water initiatives — the idea of achieving net positive impact. Being a step further than net zero, the United Nations (2024) defines net positive as businesses that have a good impact, going beyond ‘doing less harm’. For doing so, Delpey and Lee (2016) identify three steps companies can take: reducing water consumption, recycling as much water as possible, and capturing and recapturing. More recently, the concept of net positive water impact has emerged, and water quality and accessibility have been considered through a long-term water resilience vision to mitigate water stress (Brill et al., 2024). Some interviewees already raised this desire to account for water beyond “water consumption per product”, by integrating the idea of net positive water within the company.

While being net positive serves as an example of a voluntary initiative, it leads us to another issue discussed in this paper—the debate between mandatory and voluntary water actions. Although the findings suggest a deep conviction in the role of regulators and agencies in enhancing water practices and reporting regulations, literature narratives are used in both scenarios. Some state that water management without regulations is insufficient for reducing water usage (Zhang & Tang, 2019) and that voluntary water reporting is never better than mandatory ones (Leong et al., 2014). Others argue that mandatory practices might hinder innovation by focusing solely on formal compliance (Overell et al., 2008). However, based on

the case study findings, we may even acknowledge some benefits of voluntary water management, but we should primarily consider the potential advantages of a mandatory corporate approach to drive engagement and enhance the quality of water management and accounting practices (OECD Environment Focus, 2023).

Ultimately, many management and accounting concerns with water resources were pointed out in this research, as well as many intrinsic stakeholders that are directly or indirectly involved with water resources. Based on Ostrom's (1990) seminal work, we can easily understand water resources as a so-called common-pool resource, especially since water entails shared risks (Chapagain & Tickner, 2012). Therefore, the "tragedy of the commons" can be avoided through the construction of norms that are enforced through mutual monitoring and alignment with local conditions (Ostrom, 1990). This raises the question of whether a top-down approach would be effective if we don't have the empowerment of local stakeholders to strengthen water conservation governance. That is why we have sought in this paper the inherent challenges within the company in improving water conservation. It has become evident that without a shared awareness of water issues among different actors achieving effective water preservation will be far more difficult than it should be. And, in the end, *"the ones who lose are the population, the ones who lose are the consumers"* (I4).

2.8 CONCLUSION

We have sought in this paper to understand the water management accounting practices of a multinational manufacturer. Hence, this inductive interview approach identified core aggregate dimensions and themes that perpetuate its practices, which were classified into the following aggregate dimensions: operational management of water resources, development of sustainable products, global water strategies, and water reporting practices. This so-called typology of water management accounting practices aids in understanding organizational operations by guiding actions toward corporate water responsibility.

Although the proposed typology was based on the case of a multinational manufacturer, its primary contribution lies in its adaptability as a strategic tool for other water-intensive industries. Sectors such as food and beverage, automotive, and textiles, which face similar challenges of complex manufacturing and global supply chains, can customize the framework to their realities. For instance, the Sustainable Products quadrant could be

adapted in the food and beverage industry to target water efficiency in the agricultural supply chain, while the Operational Water Management framework can guide the textile industry in addressing high water usage in dyeing processes. Therefore, the typology serves not as a rigid model but as a practical diagnostic tool to enhance corporate water stewardship across different sectors.

Beyond this framework, the research raised relevant challenges the experts face when implementing actions for water-saving initiatives and highlighted the key drivers of water management accounting practices according to the interviewees' perception. Specifically, stakeholder pressure and engagement on water issues emerged as relevant motivations.

While providing benchmarking on water management and accounting initiatives across companies, the study also highlights key barriers that hamper the topic's development. These insights open up avenues for future research, offering a foundation for further investigation. Moreover, the findings urge legislators, particularly in Brazil, to critically address the regulatory gaps in water resource management, which currently hinder the advancement of numerous corporate initiatives.

Despite the research's limitations, such as a small number of interviewees and inherent methodological challenges, including the potential for restricted responses due to confidentiality, this study aims to contribute valuable insights to the broader discourse on corporate water responsibility by examining a real-world case. We hope our findings will advance water accounting and management practices, fostering greater corporate responsibility in water stewardship.

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3 COMPLIANCE WITH SUSTAINABILITY DISCLOSURE REQUIREMENTS: A CONTENT ANALYSIS OF OIL AND GAS WATER REPORTING PRACTICES

ABSTRACT

This study evaluates the extent to which water reporting practices in the oil and gas industry comply with ongoing sustainability disclosure requirements, focusing on the quantity and quality in both textual and visual formats. How a company manages water is of interest to diverse stakeholder groups, especially in this water-sensitive sector. However, the diversity of available frameworks challenges achieving comprehensive water disclosure. Amidst the growing momentum for sustainability reporting standardization, improvements are being encouraged in both the reported content and how companies communicate this information. Recognizing that sustainability reports convey complex information through both textual explanations and visual data representations, this research uses narrative and visual content analysis to assess compliance with ISSB recommendations for water-related disclosures and their alignment with various water reporting standards and frameworks based on the CDSB requirements. The analysis encompassed the sustainability reports of fifteen leading oil and gas companies worldwide, focusing on both the quantity and quality of water-related disclosures. The findings indicate a prioritized adoption of climate-related disclosure through the TCFD framework and sector-specifics like SASB Oil & Gas and IPIECA, reflecting a focus on a particular group of key stakeholders - investors and regulators. Tables were the most frequently used visual format, while graphs were underrepresented despite their communicative potential. Their considerable representativeness and readability underscored the importance of incorporating visuals into disclosure practices. Over the sustainability disclosure requirements addressed, we noticed that the inherent nature of each requirement interferes with the format and quality of the information disclosure. Finally, the paper contributes to the development of future standards by proposing a more visually-driven and democratic disclosure model, designed to enhance transparency and engage a broader spectrum of stakeholders beyond just investors and regulators.

Keywords: Water Accounting. Sustainability Disclosure. Visual Content Analysis. Reporting Standards.

3.1 INTRODUCTION

Global concerns regarding the socio-environmental and economic impacts of the oil and gas industries are widely known (Cardoni et al., 2019; CDP, 2023b; Cho et al., 2015). The current vulnerability scenario resulting from geopolitical conflicts and trade disputes disrupting global energy markets, besides the countless GHG emissions, is a reminder of the growing run toward a clean energy transition. However, the demand for fossil fuels remains around 80% of the global energy supply for decades. Although there is a tendency to reach 73% by 2030, there is still a long way to go to reach global climate goals (Gaudencio et al., 2020; IEA, 2023). Moreover, this highly environmentally, economically, and socially sensitive profile brings issues far beyond that – as it does for water.

Water-intense activities, wastewater discharge containing hazardous substances, and oil spills are only a few examples of how the oil and gas industry can severely harm the availability and quality of water resources (GRI, 2023). Besides these direct impacts, the sector still indirectly harms water security through other socio-environmental issues, such as climate change, causing floods and droughts in many regions. It reminds us, as Hazelton (2013) stated, that access to water is a fundamental human right, just like access to water-related information. Thus, increasing transparency and comparability in managing water resources amidst growing water-related risks is a pressing need, especially in high water-dependent companies (Brock et al., 2022). It raises pressure from various stakeholders for oil and gas companies to disclose water information (Cardoni et al., 2019; Z. Zhou, Zhou, et al., 2018).

How a company manages water might, in turn, be of interest to diverse stakeholder groups – concerned citizens, external planning authorities, households, community groups, managers, and concerned global citizens, among others (Egan & Agyemang, 2022). These stakeholders can potentially influence a change in the industry code and the reporting behavior (Deegan & Blomquist, 2006). Furthermore, although this paper acknowledges the significant criticism of corporate sustainability-related reporting practices, including the misleading nature of stand-alone sustainability reports (Cho et al., 2018) and the inverse relation between them and their environmental performance (Lu & Wang, 2021; Patten, 2002), we focus on their potential to improve transparency, communication, and reputation. Therefore, stakeholders can better understand the company's social and environmental

impacts (Bebbington et al., 2014; Z. Zhou, Zhou, et al., 2018). Moreover, previous studies have recognized that water reporting can reduce a company's systematic risk (Zeng et al., 2020), improve financial performance (Ji et al., 2023), and impact the cost of capital (Z. Zhou, Zhou, et al., 2018).

However, reporting water information is complex, mainly due to its critical geographical dimension. Unlike CO₂ emissions, using a liter of water does not have the same environmental impact in different locations, requiring careful consideration of geographical factors (Signori & Bodino, 2013b). Besides, when reporting on water-related information, companies may struggle to identify a single set of stakeholder expectations from a wide range of potentially conflicting views (Rinaldi et al., 2014; Thomson & Bebbington, 2005).

Several water accounting standards, frameworks, and guidelines have been developed to address these different water reporting concerns from various actors and contexts (Gibassier, 2018; Russell & Lewis, 2014). These may relate to corporate perspectives (e.g., The CEO Water Mandate - Corporate Water Disclosure Guidelines), or they may encompass watersheds, governments, and regions (e.g., SEEA-Water) or adapt both concerns (e.g., AWAS - Australian Water Accounting Standards). Some standards are designed for general corporate adequacy (e.g., GRI 303 - Water and Effluents), while others comprise sector-specific concerns (e.g., the IPIECA Sustainability reporting guidance for the oil and gas industry and the SASB Standards Application Guidance). Finally, some standards focus on addressing a wide range of stakeholders concerned with the company's impact materiality (e.g., EU CSRD - Corporate Sustainability Reporting Directive). In contrast, others aim to ensure that material water-related information is disclosed for effective capital allocation while meeting the needs of investors, lenders, and other creditors (e.g., the CDP Water Security Questionnaire and the CDSB Water Guidance).

Efforts are underway to integrate these different water information frameworks to generate helpful information for decision-making. Over a decade ago, the inherent limitations of water accounting guidelines were discussed by Morrison and Schulte (2010), and it was noted by Larrinaga-González and Pérez-Chamorro (2008) that its voluntary reporting basis made it challenging to provide comprehensive water-related information. As these water accounting initiatives evolved, there were several common characteristics between them (Russell & Lewis, 2014), causing confusion over competing frameworks and overlapping tools (Egan & Agyemang, 2022). To facilitate the implementation of water accounting, a

hierarchy of institutions is needed to consolidate and combine this range of reporting frameworks (Andreu et al., 2012; Egan & Agyemang, 2022), as we can see in the recent International Sustainability Standards Board (ISSB) efforts in creating a new era of sustainability-related disclosures in capital markets worldwide.

The ISSB has recently launched its inaugural requirements for disclosure of sustainability-related financial information (IFRS S1 and S2), aiming to enhance trust and confidence in corporate sustainability reporting to inform investment decisions. Although there is no specific standard for water-related concerns yet, the IFRS S1 states that an organization may refer to and apply the CDSB Framework Application Guidance for Water-related Disclosures (IFRS, 2023b). This guidance helps companies report material water-related information, ensuring investors receive the information needed to drive a sustainable, resilient, and water-secure economy (CDSB, 2021).

The standardization of sustainability reporting practices through emerging standards and established frameworks has improved not only the reported content but also the way companies communicate this information. According to Serafini and Reid (2023), given the myriad ways texts are defined, produced, disseminated, and experienced, researchers need to consider the affordances of various modes of representation and communication. IFRS S1 (2023b, p. 42) addresses this concern for sustainability-related disclosure by stating that “the clearest form a disclosure can take will depend on the nature of the information and might include tables, graphs or diagrams in addition to narrative text”. So, when evaluating reporting practices, researchers should not omit the visuals from analyses since this can lead to an incomplete quantification of disclosure (Pesci & Costa, 2014; Unerman, 2000). Moreover, to increase informativeness and transparency in sustainability-related reporting practices, the informational quality of disclosure should also be enhanced (Chauvey et al., 2015).

In this regard, and to understand the direction companies might walk through to guarantee efforts in global trends of water-disclosure standards and how many steps are left to get there, this study was developed. Therefore, this study seeks to evaluate the extent to which water reporting practices in the oil and gas industry comply with ongoing sustainability disclosure requirements, considering the quantity and quality of information provided in both textual and visual components. Hence, this study employs narrative and visual content analysis to assess compliance with the ISSB recommendations for water-related disclosures

while examining the alignment of these disclosures with different water reporting standards, frameworks, and guidelines based on the CDSB requirements. The analysis concerns both the quantity and quality of water-related information disclosed in the sustainability reports of the fifteen leading oil and gas companies worldwide. Finally, based on the findings, the paper discusses expectations for the future sustainability disclosure standards for water.

Thus, the methodological approach of this research, which involves analyzing not only the presence of indicators but also their presentation format (visual vs. narrative), addresses a gap that has received limited attention concerning sustainability reporting requirements and practices (Pesci & Costa, 2014; Unerman, 2000), particularly regarding water reporting practices. Moreover, this approach enables the inference of the extent to which companies align with internationally recognized best practices in communication transparency. By quantifying text units by type and qualifying the level of disclosure, this research contributes to a more sophisticated evaluation of the conformity and maturity of water reporting practices within one of the industries with the most significant impact on global water resources.

This paper analyzes solely the oil and gas industry, which is supported by previous studies identifying a higher level of sustainability-related disclosure among companies operating in highly impactful sectors (e.g., Cho et al., 2020). According to the Water Impact Watch (CDP, 2023b), the oil and gas industry has the highest overall water impact, encompassing its direct operations, supply chain, and product use. Additionally, since different frameworks may not apply to all sectors (IPIECA, 2014), focusing on a single industry group can provide a better understanding of the sustainability reporting guidelines and stakeholder demands without bigger concerns about the industry's effect on the reporting practices.

We hope our paper contributes to water reporting literature in several ways. First, it encompasses a recent and challenging discussion on sustainability-related disclosure standardization for a resource that is still left out – water. Since an initial focus from the ISSB is carbon disclosure-based, besides general sustainability requirements, water-sensitive companies can refer to existing methodologies to transition smoothly into standardized water requirements. Second, this study provides a stakeholder reflection on the available framework and guidelines regarding different pressures. Third, we hope to contribute to academics, practitioners, and standards-setters with discussions over the future pathways of water reporting standards. Based on an investigation into the emerging developments that led

accounting to direct sustainability reporting standards through different sources of information, in addition to the narrative and visual content analysis on quantity and quality proposed here, we hope our insights will provide a valuable outlook on the future pathway of corporate water reporting standardization.

3.2 THE EMERGING REGULATORY REGIMES FOR SUSTAINABILITY REPORTING

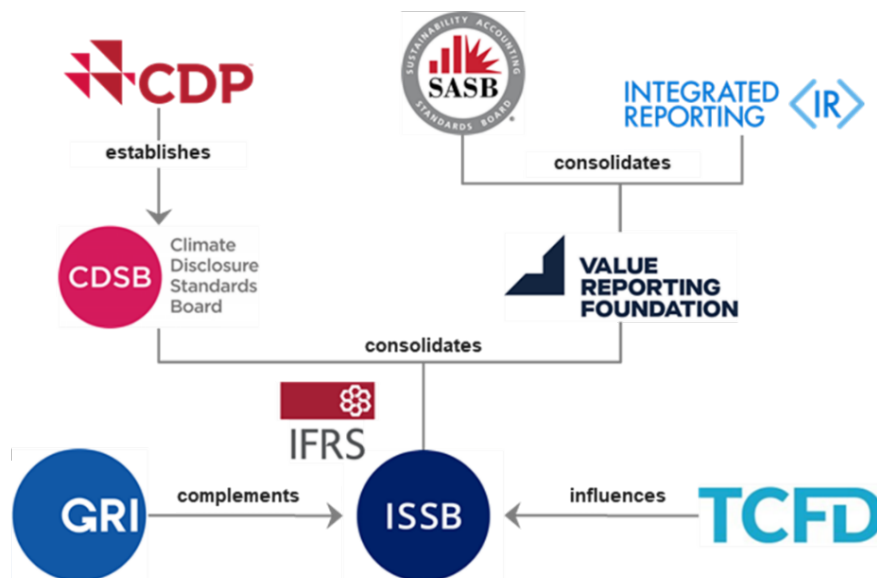
Significant global milestones in the standardization of corporate sustainability reporting have marked the past few years. In the European Union, the Non-Financial Reporting Directive (NFRD) was introduced in 2014, a legal requirement affecting all EU member states, mandating the disclosure of environmental, social, employee-related matters, respect for human rights, and anti-corruption and bribery issues (European Union, 2014; Korca et al., 2021). However, it was replaced in 2022 by the Corporate Sustainability Reporting Directive (CSRD), substantially expanding the scope and depth of required disclosures. A central element of the CSRD is the explicit adoption of the double materiality concept: companies are required to report on both financial (outside-in) materiality and impact (inside-out) materiality (European Union, 2022; Fasan, 2024).

Beyond the European Union, during COP26 in 2021, the IFRS Foundation announced the creation of the International Sustainability Standards Board (ISSB), aiming to provide a comprehensive global baseline for sustainability-related disclosure standards. These standards offer investors and other capital market participants information about companies' sustainability-related risks and opportunities to facilitate informed decisions (Dechow, 2023; IFRS, 2023a). Although stakeholder opinions diverge regarding the new ISSB (Bohn et al., 2025; de Villiers et al., 2024), the standards launched by the ISSB aim to establish a "common language" to communicate ESG risks' effects on companies to investors. These standards serve as a consistent global baseline that can be adopted by various countries (Faber, 2023). As a result, multiple jurisdictions are utilizing ISSB standards as a basis for publishing their sustainability disclosure standards tailored to their specific contexts. Examples include Brazil (Brazilian Committee for Sustainability Pronouncements - CBPS) (CBPS, 2024), the United Kingdom (UK Sustainability Disclosure Standards - UK SDS) (Department for Business and Trade, 2024), and Canada (Canadian Sustainability Standards Board - CSSB) (FRAS Sustainability, 2025). Additionally, international regulatory bodies are

expected to support the adoption of ISSB standards, as exemplified by IOSCO, broadening their mandatory reach in the coming years (IFRS, 2024).

ISSB standards build on or incorporate commonly used standards and frameworks, such as the Task Force on Climate-related Financial Disclosures (TCFD), Sustainability Accounting Standards Board (SASB), Global Reporting Initiative (GRI), and Climate Disclosure Standards Board (CDSB). Figure 4 summarizes the frameworks converging toward the ISSB development. In June 2023, the initial standards IFRS S1 and S2 were released, defining general requirements for disclosing sustainability risks and opportunities affecting companies' future prospects (S1), and specifically climate-related risks and opportunities (S2) (IFRS, 2023b). Additionally, ISSB has already signaled an expansion of its future scope to include standards on biodiversity, ecosystems and ecosystem services, and human capital, addressing demands for information beyond climate change (IFRS, 2025a, 2025b). Thus, the ISSB envisions a future agenda covering environmental and other topics, consolidating its position as a global benchmark for financially relevant sustainability reporting.

Figure 4 – Convergence of Voluntary Sustainability Disclosure Standards



Source: Farmer et al. (2022)

Although ISSB's IFRS S1 and S2 do not yet provide specific requirements for water-related disclosures, IFRS S1 advises companies to refer to internationally consolidated materials for relevant topics that are not yet standardized. Within this context, the ISSB recognizes the CDSB Application Guidance for Water-Related Disclosures as a valid methodological reference (CDSB, 2021). This framework was developed by the Climate Disclosure Standards Board (CDSB), and despite CDSB concluding its activities in 2021, its guidelines formed the basis for ISSB standards development, as noted in Figure 4. This CDSB water framework encompasses water-related information for inclusion in various reporting channels, such as sustainability reports, outlining specific water reporting requirements, including (1) water governance; (2) water policies, strategies, targets, and management practices; (3) water-related risks and opportunities; (4) sources of water-related environmental impact; (5) water performance and comparative analysis; and (6) water outlook (CDSB, 2021). To map these requirements, the guidance recommends integrating various frameworks, voluntarily adopted but widely recognized as best practices in water reporting. Notably, these include the TCFD, CDP Water Security Questionnaire, GRI 303 – water and effluents, CEO Water Mandate, AWS Standard, Natural Capital Protocol, and for the specific oil and gas sector, the IPIECA Sustainability Reporting Guidance and SASB Oil & Gas standards. Together, these constitute an integrated approach matrix that can support companies across sectors in reporting water-related risks, impacts, and strategies (CDSB, 2021). Appendix B presents this matrix.

3.3 WATER REPORTING STANDARDS, FRAMEWORKS, AND GUIDELINES: WHICH STAKEHOLDERS ARE WE LOOKING?

The present research aims to evaluate companies' compliance with the ISSB recommendations for water-related disclosures while examining the alignment of these disclosures with the CDSB requirements. Therefore, the CDSB Water Guidance assists organizations in identifying and assessing water-related financial information for mainstream reporting, including risks and opportunities, and preparing high-quality disclosures that enable users of mainstream reports to assess material information. The Guidance proposes an alignment with the main water-related reporting standards and frameworks, such as the TCFD, CDP, GRI, and SASB. Thus, it helps organizations integrate water-related financial

information in mainstream reports, minimize the reporting burden by avoiding additional data collection, and communicate an enhanced understanding and awareness of water-related issues and their links to natural capital (CDSB, 2021).

This section provides an overview of the related initiatives based on this alignment of different water reporting standards, frameworks, and guidelines. Table 3 summarizes each corporate water-related framework's purposes, start date, scope, and key stakeholders or audience. The scope and target audience, here considered as the main stakeholder, are determined through the author's analysis of information sourced from the standard-setting bodies. Besides, general stakeholders, such as communities, suppliers, employees, regulators, government, consumers, and NGOs, might be considered rather than a particular focus.

It is worth emphasizing that the water-related tools expressed here are the ones the CDSB Guidance proposes alignment. Other water accounting frameworks are available for corporate and broader applications (e.g., The Water Footprint Assessment Manual, WRI Aqueduct Water Risk Atlas, and the Ceres Sustainability Disclosure Tool). In the same way, different water accounting frameworks are available beyond the corporate scope, such as the System of Environmental-Economic Accounting for Water (SEEA-Water).

Table 3 – Corporate Water Reporting Standards, Frameworks, and Guidelines

Water Reporting Initiative	Start Date	Purpose	Scope	Key audience
Australian Water Accounting Standard 1	2010	To explain how to prepare and present a general-purpose water accounting report by setting out requirements for the recognition, quantification, presentation, and disclosure (Chalmers, Godfrey, & Potter, 2012; Signori & Bodino, 2013a; WASB, 2012)	Geographical, Corporate	General Stakeholders
CDP Water Security Questionnaire	2010	To provide insight on current and future water-related risks and opportunities, drive water management improvements, and enable benchmarking against leading practices (CDP, 2024)	Corporate	Investors
CDSB Framework: Application guidance for water-related disclosures	2021	To guide reporting water-related material information in mainstream reports to investors (CDSB, 2021)	Corporate	Investors
GRI 303 – Water and Effluents	2002	To help organizations reporting information about their water-related impacts and how they manage these impacts (GRI, 2018)	Corporate	General Stakeholders
International Water Stewardship Standard	2014	To provide a common, credible, globally applicable framework for major water users to understand their water use and impacts and to work collaboratively and transparently with others (AWS, 2019, 2020)	Corporate	General Stakeholders
IPIECA – Sustainability reporting guidance for the oil and gas industry	2014	To provide good practice guidance for water management in upstream onshore oil and gas facilities while meeting an oil or gas operation's water requirements (IPIECA, 2014)	Corporate (oil & gas)	Regulators
Natural Capital Protocol	2016	To support better decisions by including how we interact with nature, or more specifically natural capital, in decision-making (NCC, 2016)	Corporate	Internal Decision-Makers
SASB	2011	To provide industry-based disclosures about sustainability-related risks and opportunities that could reasonably be expected to affect the entity's cash flows, access to finance, or cost of capital over the short, medium, or long-term (SASB, 2024)	Corporate (industry-based)	Investors
TCFD	2017	To improve and increase reporting of climate-related financial information (TCFD, 2017)	Corporate	Investors
The CEO Water Mandate - Corporate Water Disclosure Guidelines	2014	To advance a common approach to corporate water disclosure that addresses the complexity and local nature of water resources (The CEO Water Mandate, 2012)	Corporate	General Stakeholders

3.4 RESEARCH METHOD

This study proposes to evaluate the extent to which water reporting practices in the oil and gas industry comply with ongoing sustainability disclosure requirements, considering the quantity and quality of information provided in both narrative and visual components. In order to allow this inquiry, this paper employs narrative and visual content analysis to assess compliance with the ISSB recommendations for water-related disclosures while examining the alignment of these disclosures with different water reporting standards, frameworks, and guidelines based on the CDSB requirements. Further details on the sector and the content analysis settings can be found in the following sections.

3.4.1 Oil and Gas Companies

This research evaluated the water-related reporting practices of the fifteen leading oil and gas producers worldwide. According to the Statista database (2023), they are the leading companies based on revenue in 2023. Thus, the sample consists of the following companies, listed in their revenue order: Sinopec, PetroChina, ExxonMobil, Shell PLC, Total Energies, BP, Chevron, Marathon Petroleum, Valero, Phillips 66, Equinor, Eni SpA, Petrobras, Indian Oil Corporation Ltd, and Lukoil. Thus, regarding the analysis of water reporting practices, this study encompasses a content analysis of the 2023 sustainability-related reports and the attached files from each company's sustainability webpage.

Based on the 2023 Water Impact Watch, which ranks over 200 industrial activities by their potential water resource impact in quantity and quality (CDP, 2023b), the oil and gas industry emerged with the highest overall water impact. It assesses the relative impact of companies' direct operations, supply chain, and product use on water resources. Thus, this study focuses on the oil and gas sector for several reasons. Firstly, its significant water impact requires further attention. Secondly, the application of sustainability reporting frameworks can vary considerably across industries. For instance, the IPIECA - Sustainability Reporting Guidance for the oil and gas industry (2014) and the SASB Oil & Gas - Exploration & Production (2023) provide sector-specific recommendations. So, concentrating on a single industry group like oil and gas allows for a more in-depth analysis of sustainability reporting

practices without the complexities of overlapping or conflicting requirements from diverse sectors.

3.4.2 Content Analysis

Content analysis, recognized as one of the most essential research techniques in the social sciences, is succinctly described as a research method employing a systematic set of procedures to derive valid inferences from text (Krippendorff, 2018). Most studies applying content analysis to sustainability reports, while predominantly focusing on a quantitative evaluation, tend to assume that the volume of disclosures reflects their relative importance (Beck et al., 2010; Costa & Agostini, 2016; Gray et al., 1995). However, conducting content analysis solely based on textual and numerical information, while ignoring non-narrative disclosures such as graphs, tables, and pictures, would result in an incomplete representation of the quantum, omitting relevant information (Unerman, 2000). This limitation is especially true in sustainability reporting research, given the massive use of visual elements in corporate social and environmental reports noted in previous studies (Pesci & Costa, 2014; Unerman, 2000), with nearly one visual per page observed on average (Pesci & Costa, 2014). Thus, visual content analysis, in addition to traditional narrative analysis, significantly influences research outcomes (Pesci & Costa, 2014) and should not be disregarded.

This approach, which extends beyond traditional content analysis by encompassing alternative forms of information communication (Serafini & Reid, 2023), has predominantly been quantified in media research (Bell, 2011) but has increasingly captured the attention of social science studies (e.g., Ali et al., 2021; Fenk, 2025). Additionally, presenting information in formats other than traditional narrative text can enhance readability and improve users' retention of visual content while being more user-friendly (Beattie & Jones, 1997; Leivian, 1980). Therefore, this research broadens its scope of content analysis beyond narrative texts to also incorporate graphs, tables, infographics, and process visuals (e.g. flowcharts and logic diagrams).

According to Campbell (2017), content analysis methods produce findings that facilitate understanding the quality and quantity of particular reports or narratives. To quantify CSR disclosures, Unerman (2000) identified a variety of measures from prior studies, including the number of documents mentioning a particular disclosure category, counting

characters, words, sentences, pages, or the proportion of pages dedicated to specific categories, as well as calculating the proportion of CSR disclosure volume relative to the total disclosures. In this research, we follow previous studies employing a text units approach (e.g., Costa & Agostini, 2016; Pesci & Costa, 2014). According to Beattie and Thomson (2007, p. 142), when applying text units as the unit of analysis, "each piece of information in a sentence is coded based on the context of that sentence." Furthermore, by analyzing context rather than sentences or paragraphs alone, this method can also be more easily extended to non-narrative disclosures. Considering the scope of this research, which evaluates various formats of information (narrative and visual) alongside a broad spectrum of water-related disclosures, each addressing particular water concerns, the use of text units enables researchers to take full advantage of each piece of data, aligning them precisely with corresponding water-related codes.

Beyond the quantitative dimension, although accounting studies have thoroughly explored the reporting quantity or extension (e.g., Peng et al., 2023; Zhang et al., 2021), research that also measures reporting quality can provide even richer insights (Chauvey et al., 2015; Korca et al., 2021). Accordingly, this study analyses both the quantity and quality of the narrative and visual reported information. In terms of quality measurement, the research adopts a completeness analysis, which assesses whether the information is absent, briefly mentioned, described in detail, or evaluated (Al-Tuwaijri et al., 2004; Korca et al., 2021). Therefore, to evaluate the extent to which water reporting practices in the oil and gas industry comply with ongoing sustainability disclosure requirements, this paper incorporates multiple assessment approaches—evaluating both the quantity and quality of information disclosed in narrative and visual formats.

Several procedures were established in this research concerning the reliability of this evaluation. Based on Krippendorff's (2018, p. 24) definition of content analysis, recognizing it as "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use", the main coder established and documented strict rules and step-by-step procedures while recording all analysis in a codebook to ensure the reliability of the analysis (Appendix A). Whenever the initial rules proved insufficient or failed to address a particular format of the content unit, they were revisited and refined to maintain consistent application across all analyses. When the coding analysis is finished, the main coder shares the coding rules with a different coder who analyses a sample of the

analytical elements. Inconsistencies between the two analyses were then discussed, and, if any doubts persist, a third party may be reached (Li et al., 2018). After all, “as content analysis researchers, we must do our best to explicate what we are doing and describe how we derive our judgments so that others—especially our critics—can replicate our results or build on them” (Krippendorff, 2018).

Finally, since content analysis involves counting and coding the information based on themes (Davison & Warren, 2017), the thematic structure adopted in this study relies on the six requirements proposed by the CDSB guidance to ensure the disclosure of material and decision-useful water-related information (CDSB, 2021), as described in Table 4. Given that the CDSB guidance recommends integrating various frameworks to map these requirements effectively, this research evaluates corporate compliance by cross-referencing the CDSB requirements with 242 analytical elements derived from multiple water reporting standards, frameworks, and guidelines: Task Force on Climate-related Financial Disclosures (TCFD), CDP Water Security Questionnaire, GRI 303 Water and Effluents, SASB Oil & Gas Standards, IPIECA Sustainability Reporting Guidance for the Oil and Gas Industry, Alliance for Water Stewardship (AWS) Standard, Australian Water Accounting Standard 1 (AWAS 1), and CEO Water Mandate. Together, these constitute an integrated approach matrix that supports water disclosure practices by incorporating elements from established water-related reporting frameworks while facilitating alignment with ISSB recommendations (CDSB, 2021; IFRS, 2023b). Appendix B presents the integrated matrix proposed by the CDSB, whose indicators constitute this study's core analysis elements. Although recommended by the CDSB, the Natural Capital Protocol disclosure adequacy was not analyzed since it is focused on internal decision-making (as exposed in Table 3), which could obscure its reporting level.

Moreover, to avoid double-counting elements in the content analysis, analytical elements that overlapped between frameworks were consolidated. This occurred when different approaches included a common indicator, and these were integrated into a single analysis category: overlapped elements (presented in Appendix C). For instance, three similar indicators were identified: one in the CEO Water Mandate (“Total and percentage of withdrawals located in water-stressed or water-scarce areas”), one in the IPIECA framework (“Report the percentage of freshwater you withdraw or consume in waterstressed or water-scarce areas, detailing how you reached that percentage”), and one on the CDP Water Security Questionnaire (“Indicate whether water is withdrawn from areas with water stress

and provide the proportion”). Given their similarity, these were analyzed and counted only once under the unified indicator “Percentage of withdrawals in water-stressed areas.”

Table 4 – CDSB Water Application Guidance

CDSB Requirement	Description
REQ 01 - Governance	Disclosures shall describe the governance of environmental policies, strategy and information
REQ 02 - Management’s environmental policies, strategy and targets	Disclosures shall report management’s environmental policies, strategy and targets, including the indicators, plans and timelines used to assess performance
REQ 03 – Risks and opportunities	Disclosures shall explain the material current and anticipated environmental risks and opportunities affecting the organization
REQ 04 – Sources of environmental impact	Quantitative and qualitative results, together with the methodologies used to prepare them, shall be reported to reflect material sources of environmental impact
REQ 05 – Performance and comparative analysis	Disclosures shall include an analysis of the information disclosed in REQ-04 compared with any performance targets set and with results reported in previous periods
REQ 06 - Outlook	Management shall summarize their conclusions about the effect of environmental impacts, risks and opportunities on the organization’s future performance and position

Source: CDSB (2021).

3.5 FINDINGS AND DISCUSSION

These research findings are structured into four stages. First, it defines the scope of the analysis. Second, it evaluates how water frameworks were addressed. Third, it examines the extent to which CDSB requirements were covered. Finally, a discussion over the expectations for the future standardization of water reporting is set. Throughout our analysis, we explore how information is disclosed, considering the format (narrative versus visual) and its qualitative and quantitative aspects.

Before exploring the content analysis findings, we first outline whether the companies under study explicitly reference adherence to any frameworks, standards, and methods guiding this research. Table 5 represents any such mentions identified within the analyzed sustainability-related reports.

Table 5 – Companies and referred frameworks on their sustainability-related reports

Company	Head- quarters Country	Referred reporting frameworks								
		CDSB	TCFD	CDP Water Security Questionnaire	GRI	SASB - Oil & Gas	IPIECA	AWS Standard	AWAS 1	The CEO Water Mandate
BP	UK		✓		✓	✓	✓			
Chevron	US		✓			✓	✓			
Eni SpA.	Italy		✓	✓	✓	✓	✓	✓		✓
Equinor	Norway		✓		✓		✓			
ExxonMobil	US		✓		✓	✓	✓			
Indian Oil Corporation Ltd	India		✓		✓	✓	✓			
Lukoil	Russia		✓		✓	✓	✓			
Marathon Petroleum	US		✓	✓	✓	✓	✓			
Petrobras	Brazil				✓	✓	✓			
PetroChina	China		✓		✓		✓			
Phillips 66	US		✓	✓	✓	✓	✓			
Shell PLC	UK		✓		✓	✓	✓			
Sinopec	China		✓		✓					
Total Energies	France		✓	✓	✓	✓	✓			✓
Valero	US		✓			✓				

Source: Research data.

As can be seen, the most frequently referenced frameworks, in order of prevalence, are TCFD, GRI, IPIECA, and SASB. There is no mention of using the CDSB framework, although a few companies mentioned the ISSB standards, referring to the TCFD (BP, ExxonMobil, Lukoil, and Total Energies). Although four companies mentioned responding to the CDP Water Security Questionnaire, only three made it available for the public – Eni SpA, Marathon Petroleum, and Total Energies. Thus, Phillips 66's response did not encompass the analysis.

While seeking to evaluate the extent to which water reporting practices in the oil and gas industry comply with ongoing sustainability disclosure requirements, considering the quantity and quality of information provided in both narrative and visual components, Tables 6 and 7 present our findings.

In terms of companies' adherence to water-related frameworks, they strongly align with the TCFD disclosure indicators. This indicates that companies prioritize climate-related disclosures, not only in terms of narrative content but also through a significant volume of visuals integrated into these reports. Beyond the quantitative analysis, it is notable that the TCFD elements disclosed by companies exhibit superior quality compared to other frameworks. Specifically, 80% of the analytical elements are thoroughly described and evaluated, reflecting a high level of detail and rigor in their disclosure practices. This supports previous researchers' suggestions that water access and management can be as urgent to businesses as climate change issues, even when companies do not appear to prioritize them (R. Burritt & Christ, 2015; Gibassier, 2018). However, it is crucial to emphasize that both resources are precious, and scientific evidence clearly shows that climate change simultaneously causes water scarcity and global warming (Zhang & Tang, 2019). Therefore, climate-related concerns should not be overlooked when managing water resources, especially when assessing corporate water-related risks.

Besides the TCFD, the companies' strong coverage with the SASB Oil & Gas and IPIECA frameworks reflects a trend of prioritizing reporting for a specific group of stakeholders—investors and regulators. As highlighted in Table 6, and considering the nature of the SASB and IPIECA frameworks, which reflect the particularities and specific demands of the oil and gas sector, the results suggest a stronger effort to address the needs of these key stakeholders. These findings align with the managerial branch of stakeholder theory, which posits that corporate disclosure is a strategy focused on a select group of stakeholders critical for achieving organizational goals (Gray et al., 1996; Ullmann, 1985). Specifically, in this case, the findings align with Fernando and Lawrence (2014), who identified financial stakeholders and government regulators as powerful stakeholders. Future research could further explore this relationship with prioritized stakeholders in oil and gas companies, as investigated in other sectors (e.g., Pesci & Costa, 2014; Wicaksono & Setiawan, 2022).

Table 6 – Quantitative and qualitative coverage of water-related reporting frameworks

	Quantity												Quality ¹			
	Narrative/ Non-visuals		Visuals								Total		Absent	Mentioned	Described	Evaluated
			Graphs		Infographs		Process Visuals		Tables							
			Text unit	Covered elem.	Text unit	Covered elem.	Text unit	Covered elem.	Text unit	Covered elem.						
Overlapped Elements	280	85,71%	8	21,43%	10	35,71%	5	21,43%	218	85,71%	521	100,00%				
TCFD	676	100,00%	80	77,78%	85	77,78%	55	66,67%	556	100,00%	1453	100,00%	3,70%	15,56%	51,85%	28,89%
CDP Water Sec. Quest.	753	82,35%	11	3,92%	4	3,92%	4	5,88%	722	47,06%	1494	92,16%	76,99%	6,41%	12,81%	3,79%
GRI 303	210	76,92%	1	7,69%	11	23,08%	2	15,38%	67	61,54%	291	92,31%	48,72%	6,15%	36,41%	8,72%
SASB - Oil & Gas	182	90,91%	0	0,00%	4	27,27%	4	18,18%	36	90,91%	226	100,00%	50,30%	2,42%	33,33%	13,94%
IPIECA	437	81,25%	4	9,38%	22	25,00%	15	21,88%	113	50,00%	591	87,50%	57,08%	4,58%	18,54%	19,79%
AWS Standard	395	61,19%	2	1,49%	23	16,42%	13	11,94%	52	28,36%	483	68,66%	79,90%	5,77%	12,14%	2,19%
AWAS 1	40	23,08%	0	0,00%	0	0,00%	0	0,00%	6	7,69%	46	23,08%	92,31%	2,56%	2,05%	3,08%
CEO Water Mandate	333	87,50%	10	9,38%	34	28,13%	16	15,63%	65	21,88%	458	87,50%	63,96%	7,08%	25,42%	3,54%
Total	3306		116		193		114		1835		5563					
	59,43%		2,09%		3,47%		2,05%		32,99%		100,00%					

Covered elem. = percentage of the analytical elements covered by the companies, despite the quantity of text units.

¹ Quality is measured by the percentage of the analytical elements that are absent, mentioned, described, or evaluated for each framework.

Table 7 – Quantitative and qualitative coverage of CDSB requirements

	Quantity						Quality ²			
	Narrative/ Non-visuals	Visuals				Total	Absent	Mentioned	Described	Evaluated
		Graphs	Infograph	Process Visuals	Tables					
	Covered elem.	Covered elem.	Covered elem.	Covered elem.	Covered elem.	Covered elem.				
REQ 01	95,12%	7,32%	34,15%	21,95%	39,02%	95,12%	87,80%	68,29%	87,80%	31,71%
REQ 02	73,11%	8,40%	23,53%	16,81%	37,82%	80,67%	93,28%	43,70%	68,91%	34,45%
REQ 03	68,89%	5,56%	20,00%	15,56%	33,33%	71,11%	91,11%	42,22%	58,89%	31,11%
REQ 04	65,31%	9,18%	16,33%	11,22%	54,08%	76,53%	97,96%	33,67%	42,86%	53,06%
REQ 05	66,10%	10,17%	16,95%	11,86%	37,29%	72,88%	96,61%	37,29%	45,76%	40,68%
REQ 06	66,67%	7,58%	24,24%	22,73%	34,85%	71,21%	93,94%	50,00%	59,09%	28,79%

REQ 01 – Governance; REQ 02 – Management’s environmental policies, strategy, and targets; REQ 03 – Risks and opportunities; REQ 04 – Sources of environmental impact; REQ 05 – Performance and comparative analysis; REQ 06 – Outlook.

Covered elem. = percentage of the analytical elements covering the CDSB requirement by the companies.

² Quality is measured by the percentage of the analytical elements associated with each CDSB requirement that are absent, mentioned, described, or evaluated.

Note: Each of the 175 analytical elements typically addresses more than one CDSB requirement (see Appendix B).

Nevertheless, there is a water-related framework also aligned with investors' expectations that was not prioritized by the companies, resulting in low-quality adequacy (77% absent elements). This is the case with the CDP Water Security Questionnaire, probably due to the costly investment required to establish a self-regulatory system needed for this framework (Zhang et al., 2021). It occurs mainly due to the highly detailed nature of the questionnaire, with quite specific requirements demanding data that may not be assessed internally by the companies. Furthermore, given that the questionnaire returns a score for the company based on the responses, this may lead to a fear of damaging their image before the market. However, this low engagement ultimately harms the informativeness and comparability of the water data reported. This is mainly because the CDP water survey is considered more comprehensive and consistent than data from other sources, as every company faces the same question set, thus reducing greenwashing-type disclosure (Luo et al., 2012; Zhang & Tang, 2019). The consistent structure provided by the questionnaire justifies the low number of visuals from sources other than tables, as it encompasses a predefined structure that includes only tables and narratives.

Still on the frameworks, the low level of adherence to the AWAS 1 framework is notable, as only 23% of the analytical elements are covered. It is not surprising, as the structure of the methodology is oriented toward the development of General Purpose Water Accounting Reports, such as the Statement of Water Assets and Water Liabilities, the Statement of Changes in Water Assets and Water Liabilities, and the Statement of Water Flows (WASB, 2012). Consequently, the analytical elements of this framework define very specific aspects of the Water Statements that are not commonly found in general sustainability reports, such as water assets and water liabilities. Furthermore, some scholars consider the framework an instrument for macro-level water accounting (national and global), such as the SEEA-Water (Christ & Burritt, 2018). Although companies can utilize it, there is limited research in this area, as challenges exist regarding data availability and translating financial accounting into water (Tello & Hazelton, 2018). Although the framework is more widely applied to water entities, watersheds, and geographic locations, AWAS 1 remains a challenging goal for water-engaged companies that view water as a valuable asset and are willing to treat it similarly to how they manage financial assets. Future water standards should embrace the challenges and opportunities for companies engaging with Water Accounting Reports.

Visual coverage in our analysis represents a particularly significant portion of the extracted text units, accounting for 40% of them. These visuals are predominantly tables, comprising 33% of the total text units. In this study, we observed a clear tendency for tables to convey quantitative assessments, including temporal evaluations, thereby enhancing the comparability of information and facilitating reader analysis and decision-making. The high quality identified in many of these tables may further highlight their role as indicators that encourage companies to monitor and improve performance continuously, since stakeholders would negatively perceive any decline. Although previous studies considered graphs to be more user-friendly than tables, by synthesizing key performance indicators in a readily accessible form (Beattie & Jones, 1997), we noticed a substantial imbalance, with graphs accounting for only 2% of the text units. Thus, future water reporting standards could reinforce the particularity of each visual type, rescuing its strengths to enhance the informativeness of water-related disclosures.

Regarding the CDSB requirements covered, asymmetries in scope are also observed, reflecting the inherent nature of each requirement. For instance, while Requirement 1 focuses on the governance of environmental policies, strategy, and information disclosure, there is extensive coverage through descriptive narratives, with 95% of elements addressed via narrative and 88% fully described. On the other hand, the quality of disclosure is enhanced by the more analytical requirements—specifically, Requirements 4 and 5. By defining sources of impact and performance, as well as enabling comparative analysis, these requirements stood out in terms of quality due to their strong engagement with the evaluated elements (53% and 41%, respectively). This high quality is also associated with a greater use of tables (54% and 37%, respectively), as many of them tend to present comparative quantitative data. Finally, Requirement 6 drew attention due to its use of visuals, particularly graphs, infographics, and process diagrams, compared to the other requirements. Given that the CDSB recommends a summary of environmental impacts, risks, and opportunities, visual formats appear to be an appropriate way to provide an overview of the data. We should emphasize that, given that each of the 242 analytical elements typically corresponds to more than one CDSB requirement, as exposed in Appendix B, analyzing by text units is not appropriate in this context, as it would lead to overlapping counts.

Collectively, the theoretical discussion, research findings, and insights gathered during the content analysis made it possible to construct a landscape of expectations that may be

addressed in the future standardization of water reporting. Initially, this research emphasizes a clear expectation for the encouragement of visual elements in reporting, due to their vast and fast informational capacity, and since companies seem to be used to addressing them. Just as the IFRS S1 guidance advocates for the inclusion of tables, charts, and diagrams alongside narrative texts, we observed that the high engagement with visual elements within the TCFD framework may be associated, among other factors, with what is explicitly stated in its methodology: “Disclosures should show an appropriate balance between qualitative and quantitative information and use text, numbers, and graphical presentations as appropriate.” (TCFD, 2017, p.52). Furthermore, the TCFD’s approach to targeting not only sophisticated users but a broader range of stakeholders, including those who are less specialized (TCFD, 2017), points toward a more inclusive and accessible model of water reporting. This broader communicative strategy, potentially more democratic in format and narrative, is essential for the effective governance of water, a shared resource and a universal human right (Hazelton, 2013).

Future standards should also emphasize the importance of visually presenting longitudinal assessments of water performance targets to enhance comparability and, consequently, the quality of reported information. Based on our observations of current oil & gas reports, we believe that incorporating such performance indicators into visual formats could serve as a catalyst for deeper corporate engagement in continuously improving water performance and internal water management practices.

In addition to expectations regarding format and user orientation, we identified some water management practices that are not addressed in the analytical elements of existing standards but are found in some of the oil and gas companies’ reports. These include using water footprint indices, water balance sheets, goals such as becoming net water positive, and integrating nature-based solutions for water-related issues. While these practices may not be feasible for all organizations, we discourage a mandatory approach. Instead, we advocate for providing incentives to encourage companies to consider such practices and goals. Encouraging water-related targets, such as becoming water net positive, could broaden the spectrum of stakeholders engaged by the organization, extending beyond investors and regulators.

Despite the recommendations presented above, we expect standard-setting bodies to consider the implications for companies when mandating the disclosure of certain

information, such as costs and divergences between stakeholders. For instance, while some frameworks, such as AWAS 1 and CDP, require more costly and complex adaptations in internal environmental management systems, mandatory water reporting standards should set forth more feasible requirements that still encourage continuous improvement. In this sense, we recommend maintaining approaches similar to those adopted by the ISSB and GRI, distinguishing between mandatory disclosures and those merely suggested. This differentiated guidance allows for greater flexibility on water reporting, while better aligning water disclosure to the stakeholders interest (Gilsbach et al., 2022a) and supporting progressive corporate alignment with best practices, without imposing disproportionate burdens on organizations.

3.6 CONCLUSION

Driven by the persistent lack of standardization among a myriad of reporting frameworks and the inherent difficulties in communicating complex, geographically sensitive water data to a diverse range of stakeholders, this study aimed to evaluate the extent to which water reporting practices in the oil and gas industry comply with ongoing sustainability disclosure requirements. Specifically, it considered the quantity and quality of information provided in both narrative and visual components. The research employed narrative and visual content analysis to assess compliance with the ISSB recommendations for water-related disclosures by examining the alignment of these disclosures with different water reporting standards, frameworks, and guidelines based on the CDSB requirements.

By evaluating the water-related disclosures in the sustainability-related reports from the fifteen leading oil and gas companies worldwide, meaningful findings were revealed. First, considering the frameworks covered, we noticed a prioritized adoption of climate-related disclosure through the TCFD framework, as well as from other sector-specific frameworks, the SASB Oil & Gas and IPIECA. Since those frameworks have investors or regulators as key audiences, it was consistent with the managerial branch of stakeholder theory, which posits that corporate disclosure is a strategy focused on a select group of stakeholders critical for achieving organizational goals (Gray et al., 1996; Ullmann, 1985). We also addressed the limited adherence to the CDP Water Security Questionnaire and AWAS 1, which reflects, among other factors, its detailed nature and limited scope,

respectively. In our visual analysis, tables emerged as the dominant visual format, while the potential of graphs was underutilized, highlighting an opportunity for future water reporting standards to better leverage the strengths of each visual type to enhance stakeholder communication and accountability.

Second, insights into the format and extent of each CDSB requirement were addressed. Requirement 1 relied heavily on descriptive narratives, while Requirements 4 and 5 demonstrated higher quality through comparative and analytical content, often presented in tables. Requirement 6 stood out for its greater use of visuals, such as graphs and infographics, aligning well with CDSB's emphasis on summarizing environmental impacts.

Moreover, this paper contributes to the discussion on the future standardization of corporate water reporting by highlighting the need for a more visually oriented disclosure model. We suggest a growing consensus on the value of integrating visual elements, not only to enhance the clarity and comparability of information but also to make disclosures more inclusive for a broader range of stakeholders. Additionally, we emphasize the importance of longitudinal visual representations of performance targets to foster corporate continuous improvement in water management. The study also uncovers relevant practices in the oil and gas sector for water responsibility, such as water footprinting, water balance sheets, and nature-based solutions for water issues, which suggest the potential benefits of encouraging their consideration. Finally, the paper emphasizes the importance of establishing future standards that clearly differentiate between mandatory and voluntary disclosures. This approach aims to enhance transparency while avoiding excessive burdens on organizations.

Additionally, this study contributes to academia in several ways. Initially, we contribute to the discussion on the standardization of corporate sustainability information, encompassing a resource not yet explored by the ISSB but which should be addressed in the future – water. By considering the number of visual elements in corporate sustainability reports, we also emphasized the necessity for content analysis studies to consider those visual elements in their analysis to account for the extent of the information reported appropriately. This paper also comprises a brief discussion on the key audiences for sustainability-related frameworks and how companies might, directly or indirectly, be addressing the interests of priority stakeholders. It also prompts oil and gas companies to reflect on their real intentions with the public when reporting certain water information. Companies can also benefit from a deep analysis of the interconnection between the ISSB recommendations on using the CDSB

water guidance and the frameworks related to each of its requirements. Hence, water-sensitive companies can refer to existing methodologies to transition smoothly into standardized water requirements. Finally, for standard-setting bodies, we contribute to the pathway towards water reporting standardization by bringing significant insights from the format and extent companies are engaging.

In spite of the contributions offered by this paper, we also acknowledge limitations. Regarding the methodological choices, since we selected specific frameworks for analysis, the compliance assessment might generate different results if more frameworks were integrated. Besides, although well-defined rules were established for content analysis, and all analysis is recorded and easily retrieved in a codebook for possible alignment, the method involves an element of subjectivity. Moreover, this study did not extend its critical analysis to the potential strategic use of disclosures as a form of impression management, which opens a venue for future investigations. Finally, the rapidly evolving landscape of sustainability reporting means these findings reflect practices within the specific timeframe and context of the analyzed reports. Despite that, we hope the insights coming from our analysis will provide a valuable outlook on the future pathway of corporate water reporting standardization.

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APPENDIX A – Excerpt from the research codebook

FRAME- WORK		DISCL_INDICATOR	BP							Chevron						
	#		TOTAL	NARRATIVE QUANTITY	GRAPH	TABLE	PROCESS	INFOGRAPH	QUALITY	TOTAL	NARRATIVE QUANTITY	GRAPH	TABLE	PROCESS	INFOGRAPH	QUALITY
OVERLAP	1	Percentage of withdrawals in water-stressed areas	5	4	0	1	0	0	(3) Evaluated	3	0	1	2	0	0	(3) Evaluated
OVERLAP	2	Total water withdrawal from water-stressed areas	2	1	0	1	0	0	(3) Evaluated	1	1	0	0	0	0	(1) Mentioned
OVERLAP	3	Average water intensity in waterstressed or water-scarce areas	1	0	0	1	0	0	(3) Evaluated	0	0	0	0	0	0	(0) Absent
OVERLAP	4	Total water withdrawal by source type (e.g., surface water, groundwa	0	0	0	0	0	0	(0) Absent	0	0	0	0	0	0	(0) Absent
OVERLAP	5	Water discharge in water stress areas	0	0	0	0	0	0	(0) Absent	0	0	0	0	0	0	(0) Absent
OVERLAP	6	Total water discharge by destination type	0	0	0	0	0	0	(0) Absent	2	0	0	2	0	0	(3) Evaluated
OVERLAP	7	Total water (or freshwater) consumption	2	0	0	2	0	0	(3) Evaluated	2	0	0	2	0	0	(3) Evaluated
OVERLAP	8	Report the amount of hydrocarbon spills to the environment	2	0	0	2	0	0	(3) Evaluated	1	0	0	1	0	0	(3) Evaluated
OVERLAP	9	Compliance with water quality standards and regulations	1	1	0	0	0	0	(1) Mentioned	0	0	0	0	0	0	(0) Absent
OVERLAP	10	Describe the governance and management of climate-related risks a	4	4	0	0	0	0	(2) Described	5	5	0	0	0	0	(2) Described
OVERLAP	12	Assessment of water-related business opportunities	1	1	0	0	0	0	(2) Described	2	2	0	0	0	0	(2) Described
OVERLAP	13	Report the volume of produced water during its activities	2	1	0	1	0	0	(3) Evaluated	0	0	0	0	0	0	(0) Absent
OVERLAP	14	Water risk and impact assessment overview	10	10	0	0	0	0	(2) Described	5	5	0	0	0	0	(2) Described
CEO Water	44	Improvements (or plans) in direct operations (by management and techno	2	2	0	0	0	0	(2) Described	5	5	0	0	0	0	(3) Evaluated
CEO Water	45	Product innovation with respect to water	0	0	0	0	0	0	(0) Absent	0	0	0	0	0	0	(0) Absent
CEO Water	46	Value chain prioritization, engagement, and improvements to encourage s	0	0	0	0	0	0	(0) Absent	0	0	0	0	0	0	(0) Absent
CEO Water	47	Participation in water-related global initiatives	0	0	0	0	0	0	(0) Absent	1	1	0	0	0	0	(2) Described
CEO Water	48	Consumer/public engagement and awareness building with respect to wa	0	0	0	0	0	0	(0) Absent	0	0	0	0	0	0	(0) Absent
TCFD	60	a. Describe the climate-related risks and opportunities the organization ha	8	8	0	0	0	0	(2) Described	4	4	0	0	0	0	(2) Described
TCFD	61	b. Describe the impact of climate-related risks and opportunities on the or	4	4	0	0	0	0	(2) Described	5	5	0	0	0	0	(2) Described
TCFD	62	c. Describe the resilience of the organization's strategy, taking into consid	3	3	0	0	0	0	(2) Described	19	18	1	0	0	0	(3) Evaluated
TCFD	63	a. Describe the organization's processes for identifying and assessing clim	1	1	0	0	0	0	(1) Mentioned	4	4	0	0	0	0	(2) Described
TCFD	64	b. Describe the organization's processes for managing climate-related risk	3	3	0	0	0	0	(2) Described	4	4	0	0	0	0	(2) Described
TCFD	65	c. Describe how processes for identifying, assessing, and managing clima	4	4	0	0	0	0	(2) Described	5	5	0	0	0	0	(2) Described

Source: Research codebook

APPENDIX B – Mapping the CDSB and water reporting standards

	CDSB Framework					
	REQ 01	REQ 02	REQ 03	REQ 04	REQ 05	REQ 06
TCFD	- Governance (a, b) - Risk Management (a, b, c)	- Governance (b) - Strategy (b) - Risk Management (a, b, c) - Metrics and Targets (a, c)	- Governance (b) - Strategy (a, b, c) - Risk Management (a, b, c)	- Metrics and Targets (a, b)	- Metrics and Targets (a, b)	- Strategy (a, b, c) - Risk Management (c) - Metrics and Targets (a)
CDP Water Security Questionnaire	-W1.4; -W3.3a; W3.3c; -W6.2; W6.2a; W6.2b; W6.2c; W6.3; W6.4; W6.4a; W6.5; W6.5a;	- W1.1; W1.2; W1.2b; W1.4a; W1.4c; W1.4d; - module W.2; - W3.3b; W3.3c; W3.3d; - W4.2; W4.2a; W4.2b; W4.2c; W4.3a; - W5.1a; - W6.1; W6.1a; - W7.1; W7.4; - W8.1; W8.1a; W8.1b; W8.1c; - module W9	- W1.2d; - module W.2; - W3.3a; W3.3b; W3.3c; W3.3d; W3.3e; - W4.1; W4.1a; W4.1b; W4.1c; W4.2; W4.2a; W4.3; W4.3a; W4.3b; - W7.2;	- W1.2b; W1.2d; W1.2h; W1.2i; - W5.1	- W5.1; -W8.1a; W8.1b	- W.4.3a; -W7.3; W7.3a; W7.3b
GRI 303 - Water and Effluents	- REQ. 303-1 (c, d)	- REQ. 303-1 (a, b, c, d) - REQ. 303-2	REQ. 303-1 (a)	- REQ. 303-1 (a, b) - REQ. 303-3 - REQ. 303-4 - REQ. 303-5	REQ. 303-1 (a)	REQ. 303-1 (b)
SASB - EM: Oil & Gas	- Standard Application Guidance - 5.0 (a, c)	- Standard Application Guidance - 5.0 (b, d) - Note to EM-EP-140a.4 - EM-EP-160a.1	Standard Application Guidance - 5.0 (b, d)	- EM-EP-140a.2 - EM-EP-140a.3 - EM-EP-140a.4		
IPIECA	- 4.5 ENV-6: C4 - 3.6 CCE-1	- 4.5 ENV-1: A6, A7, A10, A11; - 4.5 ENV-2: A2, A3; - 4.5 ENV-6: C1, C3, C4	- 4.5 ENV-1: C3	- 4.5 ENV-1: C1, C2, C4, A1, A2, A3, A4, A5, A8, A9; - 4.5 ENV-2: C1, C2, A1, A5, A6, A7; - 4.5 ENV-6: C2, A1, A2, A3, A4, A5, A6, A7, A8	- 4.5 ENV-1: C5; - 4.5 ENV-2: A4	

AWS - International Water Stewardship Standard	Step 2	Step 1, Step 2 and Step 3	Step 1 and Step 2	Step 1 and Step 5	Step 3, Step 4 and Step 5	Step 1, Step 2, Step 4 and Step 5
Australian Water Accounting Standard 1	- Contextual statement	- Contextual statement	- Contextual statement -Statement of Water Assets & Water Liabilities; -Note Disclosures	- Contextual statement -Note Disclosures	- Stat. of water assets & water liabilities; - Stat. of changes in water assets & water liabilities; - Stat. of water flows	- Note Disclosures
The CEO Water Mandate - Corporate Water Disclosure Guidelines	- Response: Policies, governance, and targets	- Company water profile - Interactions with water; commitment & response - Response: Policies, governance, and targets; Internal actions; External engagement	- Company water profile - Challenges and opportunities; Hotspot basins; - Defining what to report - Business risks, opportunities, and impacts - Current state - Context - Implications	- Company water profile - Profile metrics - Current state - Performance; Compliance - Implications - External impacts	- Company water profile - Metrics on water performance - Current state - Performance	- Defining what to report

APPENDIX C – Overlapped analytical elements

Frameworks	CDSB Requirements	Analytical Elements
CDP Water, IPIECA, CEO Water Mandate	3, 4, 5	Percentage of withdrawals in water-stressed areas
GRI 303, CEO Water Mandate	4, 5	Total water withdrawal from water-stressed areas
CEO Water Mandate	4, 5	Average water intensity in waterstressed or water-scarce areas
GRI 303, CDP Water, CEO Water Mandate	4, 5	Total water withdrawal by source type (e.g., surface water, groundwater, seawater, produced water, third-party water)
GRI 303, IPIECA	4	Water discharge in water stress areas
GRI 303, CDP Water, IPIECA, CEO Water Mandate	4, 5	Total water discharge by destination type
GRI 303, IPIECA, CEO Water Mandate	4, 5	Total water (or freshwater) consumption
SASB, IPIECA	4	Report the amount of hydrocarbon spills to the environment
CEO Water Mandate, GRI 303	4, 5	Compliance with water quality standards and regulations
TCFD, IPIECA	1, 2, 3	Describe the governance and management of climate-related risks and opportunities
AWS, CEO Water Mandate	2, 4, 5	Provision of adequate WASH services for all workers
CEO Water Mandate, CDP Water	3	Assessment of water-related business opportunities
SASB, IPIECA	4	Report the volume of produced water during its activities
CEO Water Mandate, GRI 303	2, 3, 4, 6	Water risk and impact assessment overview

Source: Research codebook.

4 ANALYZING CORPORATE WATER DISCLOSURE THROUGH LARGE LANGUAGE MODELS: PRACTICES AND POTENTIAL DRIVERS OF REPORTING

ABSTRACT

Corporate governance for strategic decision-making and water-related information availability underpins corporate water management, and water-related transparency is fundamental to this. Therefore, corporate water reporting allows companies to publicly present their water management practices to stakeholders. However, the extensive nature of these reports can pose challenges for both managers making decisions and researchers analyzing the data. To address this challenge, this study employs a Large Language Model (LLM)-based method to analyze corporate water disclosure practices and investigate potential drivers influencing these disclosures. This approach proves to be a consistent and accurate tool for evaluating water disclosure practices. It enables us to identify which water-related indicators are widely used to assess water concerns and which require deeper adoption, highlighting the main challenges in the development of water accounting. Regarding the potential drivers, our proposed hypotheses are based on the managerial branch of the stakeholder theory, divided into two main categories – corporate governance attributes and financial performance. Our findings indicate that corporate water reporting among Brazilian-listed companies is primarily influenced by external pressures, such as external audit, listing age, and industry. This suggests that in a voluntary reporting context, disclosure practices are more aligned with seeking legitimacy and adhering to institutional norms than with directly addressing specific stakeholder demands, challenging the sufficiency of the managerial stakeholder theory branch in fully explaining water-related disclosures. Ultimately, this study contributes by introducing an innovative method utilizing LLMs and Retrieval-Augmented Generation (RAG) techniques to advance the automated analysis of corporate water transparency with a verification output. Then, this research supports more effective water governance and accountability, while guiding regulators, standard-setters, and managers in the discussion on water accounting practices, especially in a transition scenario toward mandatory sustainability reporting.

Keywords: Corporate Water Accounting. Sustainability Disclosure. Stakeholder Theory. Large Language Model (LLM).

4.1 INTRODUCTION

Water is a proxy for life itself (The Economist, 2019). It plays a key role in providing security, sustainability, development, and human well-being (UN-Water, 2013). However, high water stress is experienced by over 2 billion people, while 4 billion suffer from severe water scarcity during at least one month of the year (UNESCO, 2019). Meanwhile, Brazil is leading the world in renewable water resources, with almost double the amount of cubic meters than the second leading country (Statista, 2023b). This has put Brazil at the center of international discussions regarding its actions (e.g., Ordóñez & IWMI, 2023; World Water Forum, 2018). It reflects the acknowledgment that water core issues are not related to water resources themselves or technicalities - they are managerial (The Economist, 2019). So weak governance can lead to several negative impacts on water availability and quality (Bunclark & Scott, 2021). However, its management does not involve only public governance. Businesses are at the forefront of water strategic concerns (Morrison & Schulte, 2010). After all, water is an irreplaceable resource that many companies rely upon (Latiff & Marimuthu, 2021). Therefore, corporate governance for strategic decision-making and water-related information availability underpins corporate water management (Karimi et al., 2012; Peng et al., 2023; Rao & Tilt, 2016) and water-related transparency is fundamental to this (Hazelton, 2013; Lamb et al., 2023).

When a company is not transparent about addressing water security issues, stakeholders can never be sure about a company's true performance (Lamb et al., 2023). And companies cannot run their business without the support of stakeholders (Rudyanto & Siregar, 2018). Thus, they can influence and be influenced by the use and governance of water resources (Chapagain et al., 2022). The unfavorable impact of an enterprise due to water resources initially raises concerns among investors or creditors and quickly leads to a loss of trust in the business (Z. Zhou, Zhou, et al., 2018). Because of that, investors seek more than financial information in annual reports to ensure profitable investments (Latiff & Marimuthu, 2021). Consequently, by reporting mature sustainability information, companies can survive the scrutiny of the markets (Cho et al., 2020).

Corporate water reporting (CWR) allows companies to publicly present their water management practices to stakeholders, enabling them to better understand the company's water management practices (Peng et al., 2022) and mitigate water-related risks in their

portfolios (Zeng et al., 2020). Therefore, corporate water disclosure enhances business awareness and understanding, provides relevant information for investors and other key stakeholders, raises public awareness, and improves regulatory compliance (Sengupta, 2017). And, for disclosing water-related information, the corporate social responsibility report, sustainability report, and annual report can all become the main channels (Z. Zhou, Zhou, et al., 2018).

Nonetheless, the primary challenge in quantitative research on water reporting lies in the extensive length of reports containing water-related information. The vast number of water reporting frameworks and standards (Gibassier, 2018), coupled with increasingly detailed sustainability reports (van Oorschot et al., 2024), results in a significant manual workload for researchers (Wang et al., 2024), which can jeopardize the validity of the data produced. While this issue is gradually gaining attention in sustainability research, such as studies on carbon footprint accounting (Wang et al., 2024) and ESG or sustainability reports (Bronzini et al., 2024; Zou et al., 2025), it still remains unaddressed in the field of water accounting research.

Moreover, prior research on corporate water reporting identified a lack of quality in the disclosure practices (Russell, 2021). Many organizations base their water-related business decisions on ad hoc and incomplete data or sometimes even guesswork (Christ & Burritt, 2017; Ernst & Young, 2012). According to Talbot and Barbat (2020), most corporate water reporting practices has incomplete water information, and companies seem to minimize the importance of certain elements to idealize their image with stakeholders. Here, this paper acknowledges the difficulty of accessing reliable information about water resources since there is an inherent complexity. Lack of data availability and hydrologic complexities of water use, storage, and water reuse (Karimi et al., 2012) might challenge its development. This poses managers with an increasing need to thoroughly examine water-related risks and opportunities, take corrective actions, and offer transparency to stakeholders.

The field of corporate water accounting faces numerous methodological challenges as the disclosure of water information remains in its early stages and lacks a unified and robust framework with established guidelines (Gibassier, 2018; Z. Zhou, Zhou, et al., 2018). In this context, traditional disclosure assessments often fail to capture the nuances and complexity inherent in corporate reporting practices. Thus, there is an opportunity to employ innovative methodologies, such as Large Language Models (LLM), to more effectively analyze

sustainability-related corporate disclosures (Zou et al., 2025). Additionally, understanding the possible factors associated with disclosure practices might help direct actions that improve water reporting quality. Therefore, this study seeks to address these issues by addressing two research questions: (i) What is the extent of water disclosure practices through an LLM-based analysis?; And (ii) What are the potential drivers associated with corporate water reporting?

Recent advancements in artificial intelligence models, especially LLM and Retrieval-Augmented Generation (RAG) techniques, can optimize the quantification of corporate sustainability information, enhancing both the efficiency and accuracy of data collection (Zou et al., 2025). Consequently, this paper introduces a novel approach that integrates these techniques to measure corporate water reporting practices. This integration of LLMs and RAG aims to enhance reliability, transparency, standardization, and efficiency, not only in water-related data but across a broader spectrum of corporate sustainability information, providing researchers, regulators, and investors with a more accurate analytical tool.

Moreover, understanding that sustainable water usage requires meaningful information that allows stakeholders to build opinions, make sustainability-oriented decisions on procurement, permitting, or investment, and hold companies accountable for their water-related activities (Gilsbach et al., 2022b), this paper is based on the managerial branch of the stakeholder theory. Thus, regarding the second research question, this paper proposes five potential drivers of corporate water disclosure, divided into two main categories – corporate governance attributes and financial performance. The hypothesized impacts include: board characteristics, ownership structure, external audit, profitability, and leverage. This theory is the most used to explain corporate sustainability and water reporting (e.g., Talbot & Barbat, 2020; Wicaksono & Setiawan, 2022, 2023; Yu, 2022; Yu et al., 2020). The stakeholder concept is helpful for managers to understand better the strategic challenges they face (Tello et al., 2016). Based on a range of stakeholders' demands regarding sustainability reporting, the managerial perspective of the theory states that companies prioritize which related interests they will meet (Wicaksono & Setiawan, 2022). Preston and Sapienza (1990) defend the proposition that corporations should look for the benefit of shareholders only. In examining prior research on social accounting, O'Dwyer (2005) recommends emphasizing the perspectives of economic stakeholders. Then, this study aligns with Fernando and Lawrence (2014) by understanding powerful stakeholders being financial stakeholders and government regulators.

This paper uses Brazilian-listed companies to investigate water disclosure practices and impacts for many reasons. First, despite having the highest water availability worldwide (Statista, 2023b), there are still significant inequalities in access to water and sanitation across Brazil's geographical regions, rural and urban communities, and households. The country also relies heavily on water for hydropower and food security, and both droughts and floods threaten water security for Brazilians (Water.org, 2024). After all, water security covers from water-related disasters and water-borne diseases to governance challenges, biodiversity, and groundwater quality (Neo & Jha, 2023). Therefore, identifying and guiding corporate actions regarding water in the world's biggest stock of renewable water resources sounds relevant.

Second, Brazil is moving to mandatory sustainability reporting starting in 2026, and water-related information is included. In 2022, the Federal Council of Accounting approved the creation of the Brazilian Committee for Sustainability Pronouncements (CBPS), which aims to adjust and implement the International Sustainability Standards Board (ISSB) standards to the Brazilian reality. Brazilian listed companies might apply the Brazilian Accounting Standards for Disclosure of Sustainability Information (NBC TDS) voluntarily in 2024 and mandatorily from the 2026 report (CFC Resolution No. 1,710, 2023). The same pathway to mandatory sustainability-related disclosure is happening in the European Union. Since 2024, large and listed companies must report following the European Sustainability Reporting Standards (ESRS). The standards list water and marine resources as a critical topic, alongside climate change, pollution, biodiversity, ecosystems, resource use, and circular economy. Nevertheless, understanding the drivers of sustainability-related disclosure in a mandatory context cannot be seen as a signal of ethical behavior or long-term orientation (Fasan, 2024) or attendance to key stakeholders' expectations. Therefore, the underlying Brazilian context before the reports become mandatory will bring relevant outcomes to understand the preceding context of the standardization, basing a future comparison of water disclosure before and after the regulation while guiding standardization bodies.

The remainder of the paper is arranged as follows: Section 4.2 introduces artificial intelligence and LLM concepts within the related literature, while Section 4.3 provides the theoretical background of stakeholder theory and a literature review used to draw hypotheses based on the managerial branch. Then, Section 4.4 discusses the research design. Section 4.5 presents this study's results and discusses the findings. Finally, Section 4.6 concludes the paper.

4.2 ARTIFICIAL INTELLIGENCE AND LARGE LANGUAGE MODELS

Artificial Intelligence (AI), particularly through LLMs, represents a sophisticated class of computational systems capable of comprehending, producing, and engaging meaningfully with natural human language, performing diverse functions ranging from answering queries, translating text, and summarizing extensive content to supporting creative processes (W. Gao & Ju, 2024). These powerful AI models, exemplified by OpenAI's GPT series, Google's Gemini, and the Chinese DeepSeek, have also evolved into robust analytical tools, significantly enhancing data processing and knowledge extraction capabilities. Given these advanced analytical and large-scale data processing capabilities, LLMs have increasingly attracted the attention of researchers across various fields, including early studies in financial reporting studies. After all, integrating LLMs in accounting and finance areas can significantly improve efficiency and effectiveness, enabling users assisted by LLMs to achieve higher productivity than those working without such assistance (Dong et al., 2024).

Recent and relatively scarce advancements in the field using the LLMs approach primarily rely on OpenAI's GPT models, such as ChatGPT 4.0. For instance, Gao and Ju (2024) tested ChatGPT's effectiveness in assisting the public with ESG-related inquiries. Eggart et al. (2025) deployed a structure analysis using LLM to interpret financial reports and streamline competitive analysis in the chemical industry. Wood et al. (2025) expanded the scope beyond OpenAI technologies by incorporating a broader selection of LLMs to analyze mutual funds' ESG commitments. While the mentioned studies primarily relied on the chatbot interface of LLMs, other researchers have advanced this approach by integrating RAG technology through ChatGPT's API version.

RAG technology addresses critical limitations of LLMs, particularly their tendency to generate inaccurate outputs ("hallucinations") in knowledge-intensive tasks. It improves the accuracy and reliability of generated content by retrieving relevant document segments from external knowledge bases through semantic similarity calculation (Y. Gao et al., 2024). According to Wang et al. (2024), combining LLM and RAG methods can outperform traditional methods and other standalone LLMs approaches, achieving higher information retrieval rates and significantly lower information deviations while applying them to carbon footprint accounting. Therefore, recent studies combining LLM and RAG technologies have demonstrated more robust and reliable results, especially when handling extensive volumes of

unstructured data. This is the case with studies involving corporate sustainability reports. For instance, Bronzini et al. (2024) employed a generative LLM combined with RAG technology and In-Context Learning to extract structured ESG insights from companies' sustainability reports. Building on the same LLM and RAG technologies, Zou et al. (2025) introduced ESGReveal, a comprehensive framework designed to systematically extract structured ESG data from the unstructured disclosures of 166 companies listed on the Hong Kong Stock Exchange. The model achieved high accuracy in both disclosure identification and specific data extraction from ESG reports. For this reason, this study combines LLM and RAG approaches to optimize and enhance the reliability of data collection for the variable of interest, the CWRI, as detailed in Section 4.4.

4.3 THEORY AND HYPOTHESES DEVELOPMENT

4.3.1 Theoretical Underpinning: Stakeholder Theory

Acknowledging corporations' impact and influence on water resources, the topic is no longer about whether companies should adopt responsible practices, such as water security, but on determining the most strategic and effective ways for them to do so (Bunclark & Scott, 2021; Wang et al., 2016). The diverse set of stakeholders (e.g., employees, customers, suppliers, creditors, advocate groups, and public authorities) pursuing different economic, environmental, and social interests might determine the success of an organization (Hahn & Kühnen, 2013). Therefore, companies must determine which interest groups to provide information to and participate in the accountability process (Cunha & Moneva, 2018).

A stakeholder is defined as “any group or individual who can affect or is affected by the achievement of the organization's objectives” (Freeman, 1984, p.46). Engaging with stakeholders' concerns is likely to support the activities and strategy of the corporation, positively impacting its sustainability and evolution (Freeman, 2017). However, since businesses are built around specific purposes, it can be crucial to determine if stakeholders want to cooperate or refuse to do so (Freeman, 2010; Freudenreich et al., 2020). So, when considering corporate engagement with water concerns, stakeholders often consider a firm's water-related disclosure as a factor in assessing its reliability and legitimacy (Yu et al., 2020).

Stakeholder theory has been largely used by scholars to explain how stakeholders affect disclosure practices (Wicaksono & Setiawan, 2022). To address those reporting drivers, two branches of the stakeholder theory have been widely used - normative (or ethical) and managerial (or positive). While both approaches emphasize sufficient and transparent disclosure, the difference is in the focus of the content (Yu et al., 2020).

Under the normative approach, management has an ethical responsibility to treat all stakeholders equally for the optimal benefit of both the firm and its stakeholders (Freeman, 1984). It means that, through the normative or ethical branch, volunteer water information disclosure should be made to all interest groups without exception.

On the other hand, the managerial approach believes that due to limited resources and time, it's impossible for managers to meet the needs of an unlimited list of stakeholders. Therefore, managers should focus on a select group of stakeholders who are critical for achieving organizational goals (Ullmann, 1985). That is, corporate disclosure is a strategy for managing the demands of particular groups (Gray et al., 1996).

This study adopts the managerial lens of stakeholder theory. As Ullmann (1985, p. 2) stated, “our position is that organisations survive to the extent that they are effective. Their effectiveness derives from the management of demands, particularly the demands of interest groups upon which the organisation depends.”

Previous studies on the drivers of corporate water reporting had focused on both branches of the theory – the normative (e.g. Burritt et al., 2016; Wicaksono & Setiawan, 2022) and managerial approaches (e.g. Wicaksono & Setiawan, 2023; Yu et al., 2020). However, in practice, we argue that Brazilian market characteristics encourage attention given to strategic stakeholders to achieve company goals. Therefore, considering Brazil's weak enforcement profile, limited general credit offers, high ownership concentration, and high international demand for pro-environmental practices, we hypothesize based on governance attributes and financial concerns related to the Brazilian profile and previous literature. This paper's hypotheses are developed in the following chapter.

4.3.2 Hypotheses Development

This study considered five key factors as potential drivers of water reporting practices among Brazilian companies. They are based on corporate governance attributes (board of

directors' characteristics, ownership and external audit) and financial performance (profitability and leverage). These factors were considered due to their potential to influence corporate water disclosure, as argued in the previous literature (Liu et al., 2022). The possible role of these factors is discussed in turn.

4.3.2.1 Corporate Governance Attributes

Corporate governance is defined by Daily et al. (2003) as determining the broad uses to which organizational resources will be deployed and resolving conflicts between stakeholders. So, governance practices must be implemented to report sustainability-related information while considering the interests of shareholders and stakeholders (Ong & Djajadikerta, 2018). After all, according to Rudyanto and Siregar (2018), demands for sustainability reports come from outside (stakeholders) and inside the company (corporate governance). When the pressure is from the inside, companies will generate more high-quality reports.

Extensive literature researches various governance attributes as drivers of sustainability disclosure practices (e.g. Alodat et al., 2023; Lu & Wang, 2021). Regarding water-specific disclosure practices, examples of governance attributes significantly impacting those reporting practices include board characteristics (e.g. Hamad et al., 2020; Peng et al., 2023), executive compensation (e.g. Lu & Wang, 2021), and ownership structure (e.g. Wicaksono et al., 2024; Wicaksono & Setiawan, 2022). This study considers three key corporate governance attributes that are likely to influence water reporting practices (board characteristics, ownership and external audit). Those attributes have already been used as proxies of corporate governance in previous literature regarding emerging countries (e.g. Fakhfakh & Jarboui, 2022). The possible role of these factors in improving corporate water disclosure is discussed below.

Board characteristics

Concerning the board characteristics, we based our analyses on two main proxies that match the water-related literature and the Brazilian context – female board participation and board independence. According to the Brazilian Institute of Corporate Governance, the diversity of the board of directors is crucial as it enables better decision-making through a

range of plurality of arguments. Therefore, the Code of Best Practices of Corporate Governance clearly states that the board's composition should consider the diversity of knowledge, experience, age, gender, color or race, ethnicity, and sexual orientation, among other aspects (IBGC, 2023).

In keeping with the previous literature, stakeholder theory emphasizes the importance of having directors on boards to facilitate financial and non-financial decision-making processes while strengthening the relationship between firms and their stakeholders (Pucheta-Martínez et al., 2018). About their impact on water-related decisions, female directors can promote not only water disclosure but also positive corporate water performance (Liu et al., 2022).

Board independence is another aspect emphasized in the Brazilian Code of Best Practices of Corporate Governance. The code states that the board's independent performance ensures the integrity of the governance system and protects the organization's value. Therefore, board members must act technically, honestly, and autonomously (IBGC, 2023). Previous literature usually hypothesizes a positive and significant relationship between board independence and sustainability-related disclosure, Brazil included (Fuente et al., 2017; Miras-Rodríguez et al., 2018). However, Fuente et al. (2017) found positive but no significant relation among Brazilian listed firms.

Consistently with stakeholder theory, Liao et al. (2015) suggest that a diversified and independent board moderates the possible conflicting expectations of stakeholders on sustainability volunteer disclosure. Hence, based on the above discussion and on previous studies that found a positive and significant relation between female board directors and board independence in increasing water reporting (e.g. Liu et al., 2022; Peng et al., 2023), the following hypotheses are proposed:

H1a. Female board members positively influence water-related disclosure.

H1b. Board independence positively influences water-related disclosure.

Ownership

Previous research endeavoring to address several ownership variables, such as a company's listing on the stock market, government ownership, concentrated or dispersed ownership, and foreign ownership, are limited. Given the background of water-related

literature and the market profile of Brazil, we have identified two main aspects of ownership structure that require attention - ownership concentration and foreign ownership.

Concentrated ownership might be assumed differently depending on each context, although usually negatively related to a better CSR rating (Reverte, 2009). It is often assumed that an investor owns more than 5% of the outstanding voting shares (Yu et al., 2020), but a 20% assumption is also found. Considering Brazilian high ownership concentration, some studies use a 20% to 40% measure (Martins et al., 2017). This concentration can be considered to impede sustainability reporting since dominant shareholders are supposed to have access to relevant information already (Hahn & Kühnen, 2013). Aiming to avoid bias from potential country-specific characteristics, many studies use the percentage of total shares owned by the top five shareholders (R. L. Burritt et al., 2016; Wicaksono et al., 2024; Yu et al., 2020).

Studies investigating the relationship between ownership concentration and water disclosure have typically found an inverse association. Hence, companies tend to disclose less water information if the firms' shares are concentrated in a few shareholders (Wicaksono et al., 2024). Burritt et al. (2016) and Ben Lahouel et al. (2014) observed that companies with dispersed ownership have the highest levels of water-related disclosure and will be less likely to respond to stakeholder inquiries for information. Aligned with previous studies, we expect that a higher ownership concentration will negatively relate to water disclosure.

Regarding foreign ownership, empirical evidence on its relationship with water reporting generally follows an agreement. As happens with environmental disclosure, higher ownership of foreign investors usually drives a higher level of water disclosure practices (de Oliveira et al., 2022; Ismail et al., 2018; Wicaksono et al., 2024; Wicaksono & Setiawan, 2022). Therefore, companies operating internationally face pressure from stakeholders to be responsible for water as it is an international resource necessary for human life, ecosystems, and economics (Wicaksono & Setiawan, 2022). This approach is adopted, especially considering Brazil's international pressure regarding its reputation as a holder of extensive environmental assets and its inequitable availability of water resources. According to the WWF (2024), it poses Brazil with a scale of very high reputational water risk. This risk represents stakeholders' perceptions on whether companies conduct business sustainably or responsibly concerning water. In this sense, the following hypotheses are presented.

H2a. Ownership concentration negatively influences water-related disclosure.

H2b. Foreign ownership positively influences water-related disclosure.

External Audit

Independent audit is another attribute implied on corporate governance concerns. The Brazilian Institute of Corporate Governance (IBGC, 2023) recommends that integrated reports, including financial and non-financial information, should be assured by an independent auditor as a best practice for corporate governance. Previous studies have also considered audit quality as an attribute of corporate governance that might influence sustainability reporting practices (Fakhfakh & Jarboui, 2022).

Regarding water information, water auditing identifies areas requiring corrective action for effective water management and control, ensuring consistent implementation of water accounting systems (Lyu et al., 2023). However, Silveira and Van Bellen (2021) noted that Brazilian companies' adherence to the assurance of their sustainability/integrated reports externally rarely includes the assurance of water content. Therefore, this research follows a broader scope by considering the third-party assurance mechanisms (external verification) of the sustainability-related report, without specifying water-related information. The existence of external assurance for sustainability reports has already been the subject of previous studies evaluating its relationship with environmental performance, although with varied results (Braam & Peeters, 2018; Datt et al., 2018; Talbot & Barbat, 2020).

Given that external sustainability assurance provides stakeholders with a credible and objective evaluation of an organization's sustainability performance and reporting (Baboukardos et al., 2021; Issa & Hanaysha, 2023), it is hypothesized that more water-engaged companies tend to invest in the assurance process for their reports to guarantee the validity of their environmental information and meet stakeholders' demands.

H3. There is a positive association between sustainability-related reports audited by a third-party company and water-related disclosure.

4.3.2.2 Financial Performance

Extensive literature research on various financial variables as related drivers of water disclosure. Based on the managerial branch of stakeholder theory, this study uses two proxies of financial performance that are deeply used for key stakeholders' decision-making, such as investors/rating agencies, creditors, and the government – profitability and leverage. Thus, in line with Gray et al. (1996), since corporate disclosure is a strategy for managing the demands of particular groups, water-related disclosure is expected to be associated with these indicators. After all, both CSR disclosure and financial performance are attributes that improve corporate reputation among its stakeholders (Vishwanathan et al., 2020).

Profitability

A number of studies on water resources management and accounting empirical investigation have used profitability as a driver of water information disclosure (R. L. Burritt et al., 2016; Ji et al., 2023; Liu et al., 2022; Wicaksono & Setiawan, 2023; Yu et al., 2020). Organizations that are profitable often face increased scrutiny from stakeholders to ensure that they are operating in a manner that aligns with society's expectations (Gamerschlag et al., 2011). As a result, they are more likely to disclose more information (Alnabsha et al., 2018), including water resources information (Yu, 2022). However, Burritt et al. (2016) failed to detect a significant association between profitability and water disclosure in Japanese companies. Despite the controversial results, this paper hypothesizes that more profitable companies can lead to higher transparency of water-related information, as follows.

H4. There is a positive association between profitability and water-related disclosure.

Leverage

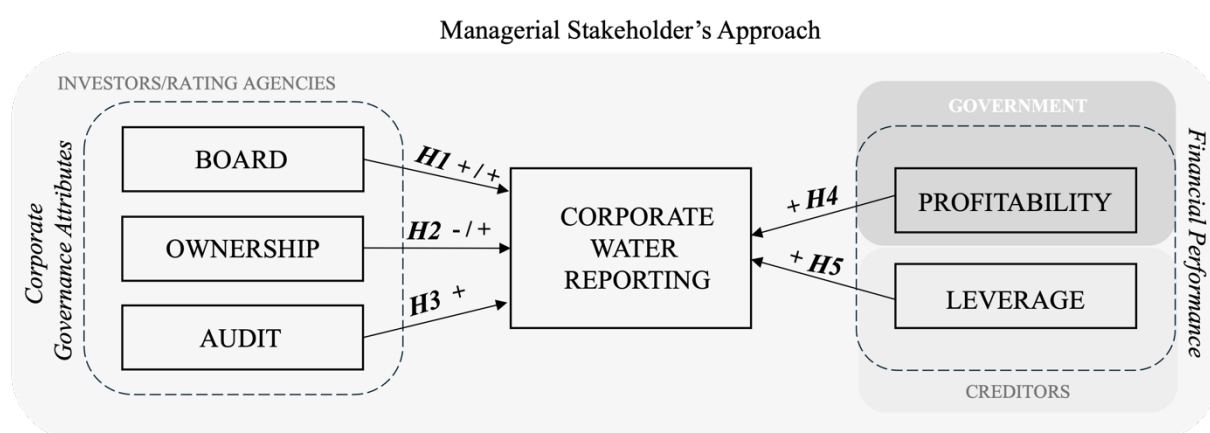
The literature regarding leverage ratios on water disclosure practices is scarce, although with an increasing profile (Liu et al., 2022; Zeng et al., 2020; Z. Zhou et al., 2020). In spite of the fact that some researchers understand that higher leverage may reduce the financial resources of managers to provide environmental disclosures (Brammer & Pavelin, 2006), posing a negative association, this study adopts a contrasting perspective. Based on the managerial approach of the stakeholder theory, it is assumed that companies with higher

leverage ratios would potentially consider the concerns of key stakeholders, such as creditors. To gain credibility, these companies would disclose more environmental and social information. Additionally, since leverage requires careful risk management, companies with higher leverage ratios would better express their mitigating risk strategies by disclosing more water-related information. This would help investors to better understand the associated risks. Hence, in line with the perspective of Zeng et al. (2020), the following hypothesis is proposed.

H5. There is a positive association between the leverage ratio and water-related disclosure.

Finally, a conceptual model that summarizes the proposed hypotheses is provided. It includes some potential stakeholders concerning reporting practices in line with the managerial approach (investors, rating agencies, government, and creditors), as exposed in Figure 5. Nevertheless, this study acknowledges the complexity of questioning who are key users of sustainability reporting (Cooper & Michelon, 2022). The intention here is not necessarily to identify key users but to advance upon analyzing key drivers related to potential information users in the context examined. Therefore, interested parties go far beyond these stakeholders - including local communities, employees, suppliers, consumers, and NGOs, among others.

Figure 5 – Conceptual Model with Hypotheses



4.4 RESEARCH DESIGN

4.4.1 Sample and Data

This study final sample consists of 203 listed companies on Brazil's Stock Exchange (B3). In addition to the Refinitiv database and the CVM website (the Brazilian equivalent of the SEC), data were collected via sustainability-related reports from 2023. The reports upon which the analysis was conducted were downloaded from the companies' websites. The use of sustainability reports as sources of data is well documented in previous research on water disclosure (R. L. Burritt et al., 2016; Z. Zhou, Zhou, et al., 2018). Thus, firms with unavailable 2023 sustainability-related reports by October 2024, or with missing data for the variables under study, were excluded from the final sample.

4.4.2 Corporate Water Reporting Index

This study uses the Corporate Water Reporting Index (CWRI) as the dependent variable. The index was initially proposed by Burritt et al. (2016) based on Morikawa et al. (2007). After some adjustments, inclusions, and information splitting (Cantele et al., 2018; Z. Zhou, Liu, et al., 2018), the index is widely applied in water accounting literature (Liu et al., 2022; Zeng et al., 2020; Z. Zhou et al., 2020). Hence, since this measure was already applied in other jurisdictions (e.g., Peng et al., 2023), the index is considered appropriate for the present sample and aligned with the Brazilian context as well. Then, 35 water-related indicators are used to measure the dependent variable. Each indicator is scored (1) for the indicator disclosure and (0) otherwise. According to Liu et al. (2021), this index refers to the Global Reporting Initiative, the CDP's Water Safety Questionnaires, and adds the supply chain water footprint proposed by Hoekstra et al. (2011). Therefore, each company received a score from 0 to 35 based on their sustainability-related report. Table 8 summarizes the water-related disclosure indicators and the eight categories of the CWRI. These water-related indicators were collected by integrating RAG technology with LLM, as exposed in the following sub-chapter.

Table 8 – Corporate Water Reporting Index

Categories	Water Indicators	Disclosed?
<i>Water Demand</i>	Water sources (surface water, underground water, rainwater)	Yes (1); No (0)
	Environmental damage from drawing water	Yes (1); No (0)
	Water resource conditions (in area where enterprise operates)	Yes (1); No (0)
	Water demand	Yes (1); No (0)
	Water price, water resource cost	Yes (1); No (0)
	Water sources quality and standards	Yes (1); No (0)
<i>Water Recycling/ Reuse and Discharge</i>	Type of discharged wastewater	Yes (1); No (0)
	Rainwater collection and reuse	Yes (1); No (0)
	Wastewater quality and standards	Yes (1); No (0)
	Environmental damage from wastewater discharge	Yes (1); No (0)
	Water recycling, water recycling efficiency	Yes (1); No (0)
	Wastewater discharge (relative/absolute)	Yes (1); No (0)
	Sewage charges and sewage limitation	Yes (1); No (0)
<i>Water Use</i>	Use of water	Yes (1); No (0)
	Water consumption (relative/absolute)	Yes (1); No (0)
<i>Saving Water</i>	Clean, efficient products/services	Yes (1); No (0)
	Efficient water use	Yes (1); No (0)
	Investment in water saving and wastewater treatment	Yes (1); No (0)
	Saving water/ reducing water use (relative/absolute)	Yes (1); No (0)
<i>Water Management</i>	Water management plans, objectives, or strategies	Yes (1); No (0)
	Special environmental department/ responsibility system	Yes (1); No (0)
	Describe the current situation and existing problems of water resource management	Yes (1); No (0)
	Provide all employees with fully functional and safe water, hygiene, and sanitation (WASH) services	Yes (1); No (0)
	Strategic cooperation with others in water management	Yes (1); No (0)
	Supply chain water footprint	Yes (1); No (0)
	Communication with stakeholders on water issues	Yes (1); No (0)
<i>Water Policy</i>	Using the GRI Sustainability Reporting Guidelines	Yes (1); No (0)
	Declaration of compliance with international, domestic, or local environmental laws/regulations	Yes (1); No (0)
	Access to environmental subsidies, special financial incentives	Yes (1); No (0)
<i>Water Risks/ Opportunities</i>	Water risks (physical risk, reputation, regulatory)	Yes (1); No (0)
	Water-related penalties, remedies	Yes (1); No (0)
	No major water pollution accidents during the reporting period	Yes (1); No (0)
	Water-related opportunities	Yes (1); No (0)
<i>Water Data Reliability</i>	Water data audited by third parties	Yes (1); No (0)
	Method of measuring quantitative indicators	Yes (1); No (0)
CORPORATE WATER REPORTING INDEX		0 - 35

4.4.3 An LLM-based Corporate Water Reporting Tool

Operationalizing the corporate water reporting variable by hand-collecting the 35 indicators for each of the 203 companies would require a massive, exhausting, and, consequently, possibly ineffective workload. Traditional content analysis methods usually rely on manually reading reports of around 150 pages each or by simple keyword searches, which are prone to missing key insights due to variations in terminology. Estimating that reviewing a single disclosure indicator in a document would take around 10 minutes, manually processing all reports would require thousands of hours, making automation essential. Therefore, this study proposes a systematic and automated method for corporate water reporting analysis.

This method automates and accelerates the process using AI-powered systems like LLM combined with RAG. LLM, such as OpenAI's GPT models and their successors, are AI models trained on vast datasets using advanced neural network architectures, being useful for a wide range of applications (Wang et al., 2024). However, LLM has inherent limitations when it comes to knowledge-intensive tasks, often leading to "hallucinations" when handling questions outside of their training data (Y. Gao et al., 2024). In this scenario, hallucinations would be answers bringing information that is not fully supported (e.g., extrapolation or partial support) by the report (Ni et al., 2023). Thus, these issues can be mitigated by applying RAG since it improves LLM performance by referencing external knowledge through semantic similarity calculations (Y. Gao et al., 2024). By leveraging RAG, the model can extract and analyze relevant information, making large-scale document reviews feasible and more accurate. Among the tasks an LLM associated with RAG can perform is the analysis of unstructured documents and semantic understanding, which have recently attracted researchers' attention to ESG concerns (Bronzini et al., 2024; Zou et al., 2025).

In this research, RAG is applied by processing both the CWRI disclosure indicators and sustainability-related reports (in PDF format), then segmenting them into chunks and transforming them into embeddings². These embedding vectors, which are the essence of LLMs, are numerical representations of text segments that capture their semantic meaning.

² According to Dong et al. (2024, p.3), "the parameters of an LLM consist of weights, biases, and word embeddings. Analogous to the coefficient of a linear function, weights determine the strength of connections between neurons in different layers of the neural network. Biases allow activation functions to be shifted to the left or right and are similar to the constant of a linear function. (...) Word embeddings learned by an LLM during the training process are context-dependent, wherein the final representation of each token is informed by the entire input sequence. This allows the model to capture complexities and subtleties of natural language."

Rather than retaining raw text, RAG systems transform textual data into embeddings, facilitating efficient semantic comparisons instead of relying on exact word matches. Therefore, the RAG framework operates by computing the similarity between the embeddings of the query and document segments, where the semantic representation capability of embedding models plays a crucial role (Y. Gao et al., 2024). According to Rodriguez and Spirling (2022), pre-trained embeddings can perform as well as, or even better than, human coders, which increases the reliability of this research.

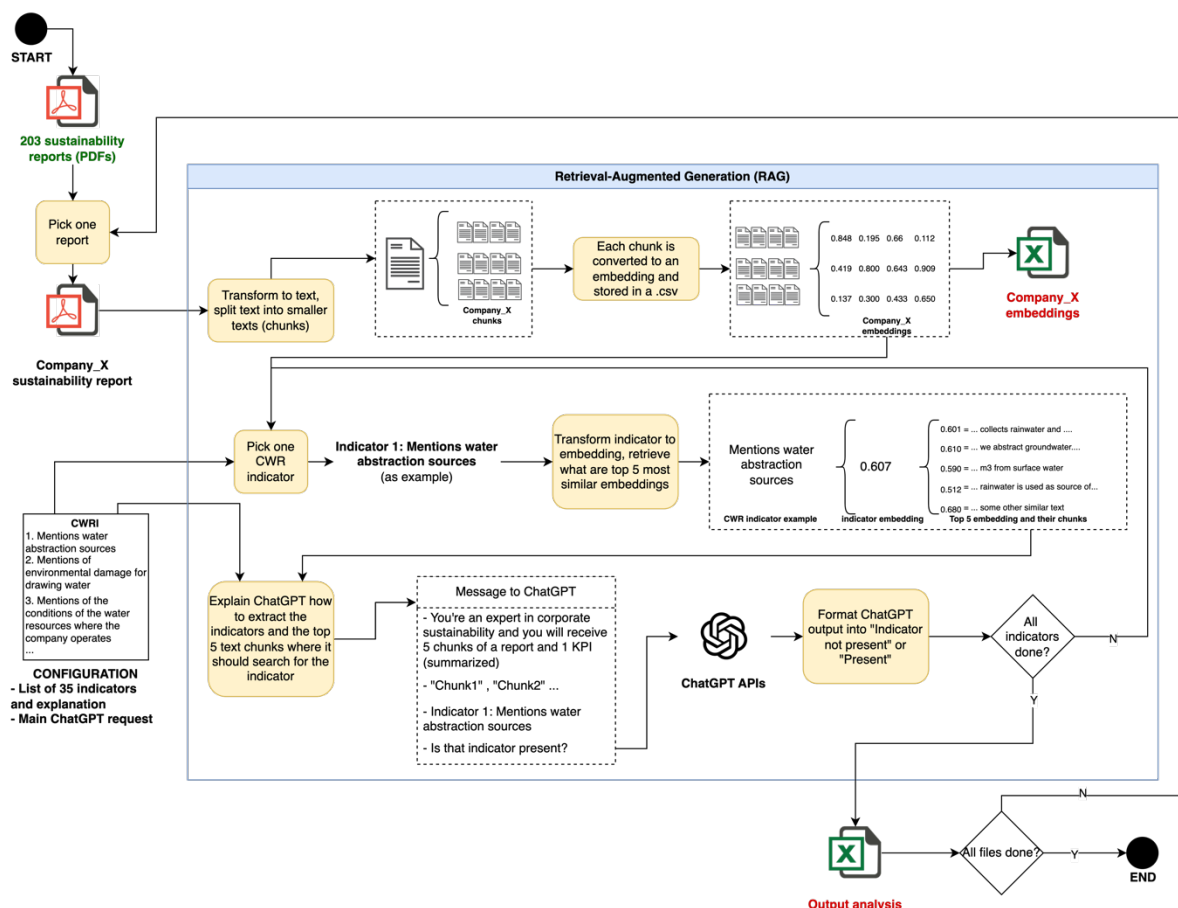
In summary, the corporate water reporting framework proposed here (Figure 6) is based on an RAG system that provides a clear output for the researcher comprising a few steps. First, the system receives the 203 sustainability reports in PDF format. Second, it extracts text chunks from each PDF and converts them into vector embeddings. The same happens for each of the 35 water-related indicators from the proposed CWRI. Third, for each indicator, the system searches for the five most relevant text sections (embeddings) in each company's documents. Finally, the system has a relevance validation process to check whether the indicator is present or not. Instead of directly assuming relevance, the system creates a structured query to the LLM (ChatGPT 4.0), asking whether the water-related indicator is mentioned in the retrieved information. Then, the system captures and outputs the specific text sections that were considered most relevant to the indicator in a .csv format.

Therefore, the tool generates as an output a .csv file that contains a summary of the analysis, showing for each company if each indicator is present or not and a complete list of the top 5 sections that match each indicator for each company (see Appendix D). Since this allows human reviewing to verify and validate the AI's assessment, many tests to validate the system were performed before actually running it. So, first, there was an evaluation of the most efficient OpenAI's ChatGPT, which turned out to be ChatGPT-4.0, aligned with previous studies (Eggart et al., 2025). Then, the clearest description of each indicator from the proposed CWRI and the most accurate prompts to our model was tested, by running the model dozens of times until finding the description that best matches the proposed one. During this evaluating phase, the text sections outputted were crossed with the original sustainability reports of an aleatory sample, ensuring that the final results were accurate and reliable.

This approach allows for efficient analysis of large document collections while maintaining accuracy in disclosure indicator identification. By leveraging LLM combined

with RAG, it becomes possible to confidently make sense of extensive company reports and extract meaningful insights.

Figure 6 – RAG-based Corporate Water Reporting Framework Proposed



Source: Research method.

4.4.4 Independent and Control Variables

Regarding the independent variables, this research adheres to previous studies to define their measurement. First, on the corporate governance attributes, the following variables were used: the proportion of females on the board (Hamad et al., 2020; Liu et al., 2022; Peng et al., 2023), of independent non-executive directors (Hamad et al., 2020; Prado-Lorenzo et al., 2009; Z. Zhou et al., 2020), of shares owned by foreigners (Ben-Amar & Chelli, 2018; Wicaksono & Setiawan, 2022), a dummy variable if 40% or more of the total shares are owned by three or fewer shareholders (Gonzalez-Gonzalez & Zamora Ramírez, 2016), and another dummy if the sustainability-related report was assured by a third party (Talbot & Barbat, 2020).

Second, over the financial performance variables, there are divergences in the literature concerning its measurement. Hence, this research follows previous studies on water disclosure and uses the return on assets (ROA), the earnings before interest and tax divided by the total assets, as the profitability measure (Ben-Amar & Chelli, 2018; R. L. Burritt et al., 2016; Wicaksono & Setiawan, 2023; Yu, 2022; Yu et al., 2020). For the leverage ratio, the total liabilities by the total assets (Liu et al., 2022; Zeng et al., 2020; Q. Zhou et al., 2021; Z. Zhou et al., 2020).

Finally, to eliminate the likely confounding effect, some control variables are included based on some previous studies on corporate water reporting – firm size, age, and water-sensitivity industry. The firms' size is measured by their total assets, in accordance with, for example, Liu et al. (2022), Zeng et al. (2020), and Zhou et al. (2020). This study follows Zhou et al. (2021) to measure the firm's age using the firm-listed age, although Wicaksono and Setiawan (2022) used the age since the firm's inception.

Lastly, in assessing water-sensitive industries, this study uses the sectors outlined in the Global Industry Classification Standard (GICS) available in the Refinitiv database. To evaluate if a company belongs to a water-sensitive industry or not, this research is based on the Barton (2010), CEO Water Mandate (2014), Levinson et al. (2008), and Morikawa et al. (2007) classification of sensitivity. The definition and measurement methods of the variables are presented in Table 9.

4.4.5 Model and Estimation

The Ordinary Least Squares (OLS) regression model is estimated to analyze the potential drivers associated with corporate water reporting practices in Brazilian-listed companies, as the following equation shows. Although the CWRI is a count variable, diagnostic tests indicate that OLS assumptions are reasonably met. However, given the count nature of the dependent variable, Negative Binomial regression is also applied as a complementary regression model since it is a standard model used for counting data, especially when tests indicate the presence of overdispersion (Hilbe, 2011). Thus, both OLS and Negative Binomial regressions are used as complementary strategies, providing robustness and additional insights into the determinants of water disclosure practices. Besides, all data processing and estimations were performed via RStudio 1.3.959.

$$CWRI_i = \beta_0 + \beta_1 FEMALE_i + \beta_2 INDE_B_i + \beta_3 OW_CON_i + \beta_4 FOR_OW_i + \beta_5 AUDIT + \beta_6 ROA_i + \beta_7 LEV_i + \beta_8 \ln(SIZE_i) + \beta_9 \ln(AGE_i) + \beta_{10} IND_i + \varepsilon_i$$

Table 9 – Variable definition and measurement

Variable	Variable name	Definition and measurement	Data source
Dependent Variable			
CWRI	Water reporting	Corporate Water Reporting Index (Cantele et al., 2018; Liu et al., 2021)	Sustainability report
Independent Variable			
<i>Corporate Governance Attributes</i>			
FEMALE	Female on the board	The percentage of female directors on the board	CVM
INDE_B	Board independence	The percentage of nonexecutive directors on the board	CVM
OW_CON	Ownership concentration	Dummy variable takes (1) if 40% or more of the total shares are owned by 3 or fewer shareholders and (0) otherwise (Gonzalez-Gonzalez & Zamora Ramírez, 2016)	CVM
FOR_OW	Foreign ownership	The percentage of total shares owned by foreigners	CVM
AUDIT	External audit	Dummy variable takes (1) if the sustainability-related report was assured by a third party, and (0) otherwise	Sustainability report
<i>Financial Performance</i>			
ROA	Profitability	The ratio of earnings before interest and tax to total assets	Refinitiv
LEV	Leverage	The ratio of firms' total liabilities to total assets	Refinitiv
Control Variables			
<i>Firm Characteristics</i>			
LN_SIZE	Firm size	The natural logarithm of the total assets	Refinitiv
LN_AGE	Firm age	The natural logarithm of the firm's listed age	CVM
IND	Water-sensitivity industry	A dummy variable takes (1) if a firm belongs to a water-sensitive industry and (0) otherwise	Refinitiv

Source: Research method.

4.5 RESULTS AND DISCUSSIONS

This section addresses the findings of both research questions: (i) What is the extent of water disclosure practices through an LLM-based analysis? and (ii) What are the potential drivers associated with corporate water reporting? Thus, the first subchapter discusses the outcomes of the LLM-based Corporate Water Reporting–CWR Tool, while the second presents the regression results.

4.5.1 LLM-based Corporate Water Reporting Tool Outcome

The LLM-based CWR Tool produced a .csv spreadsheet containing data on all 35 indicators of the CWRI for all the analyzed companies. This spreadsheet includes the specific excerpt from the sustainability report identified by the model as evidence related to each indicator. To enhance understanding, a portion of this spreadsheet is provided in Appendix D. This output serves as a verification dashboard for researchers. It supports the evaluation of the tool's output, streamlines the data collection process, and ensures greater adherence to each indicator through the model's embedded semantic analysis.

Consistent with prior disclosure index studies (Orlitzky et al., 2017; Wicaksono & Setiawan, 2022), a Cronbach's alpha test was conducted to assess the internal consistency of the CWR Tool. According to Field (2009), an alpha coefficient of 0.80 or higher, or even 0.7 in certain cases, indicates the coding results are considered reliable. This paper yielded a Cronbach's alpha of 0.84, indicating a high level of internal consistency and reliability, confirming that the selected indicators jointly capture a coherent underlying construct.

Additionally, the disclosure level of the 35 indicators from the CWRI, generated using the LLM-based Corporate Water Reporting Tool, is presented as a heatmap in Figure 7. The disclosure level was segmented according to the companies' industry sectors, following the Global Industry Classification Standard (GICS). While the disclosure levels are relatively consistent across sectors (min 0.418; max 0.558), more prominent variation is observed in the disclosure of individual indicators.

When assessing the disclosure level of each indicator for the 203 companies, the most reported are efficient water use (0.951 disclosure rate), adoption of the GRI Guidelines (0.941), and provision of clean and efficient products or services (0.927). These results are

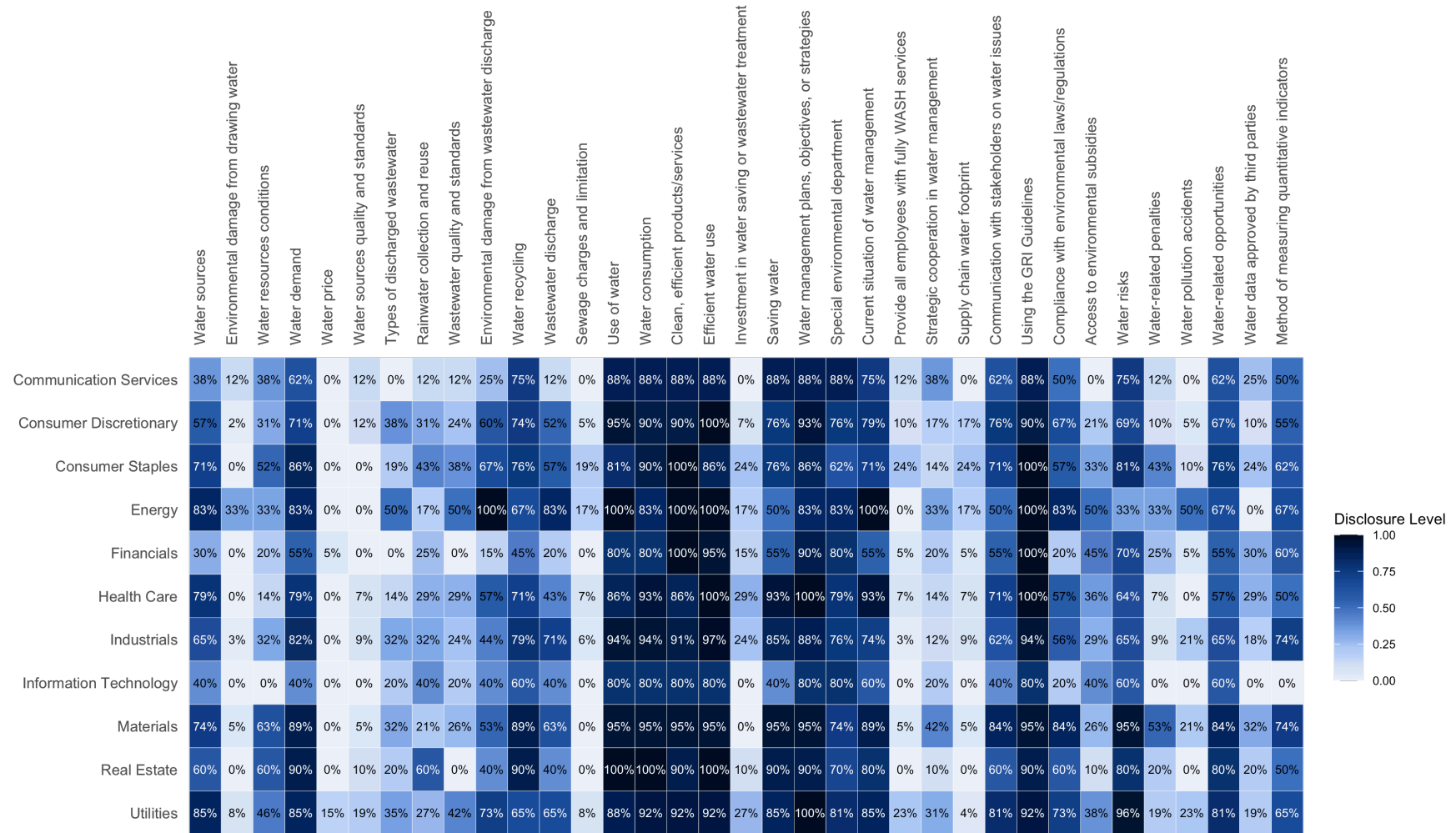
expected, given the widespread acceptance of GRI guidelines globally (Adhariani, 2021), and the broad thematic scope of indicators related to efficient water practices and environmentally sustainable offerings. In particular, the third indicator extends beyond water-specific concerns, encompassing broader sustainability commitments.

On the other hand, the lowest disclosure rate is water pricing (0.024). This reflects a broader issue in water accounting, where low water costs discourage investment in water-related initiatives (Hazelton, 2014), leading businesses to overlook the importance of monetary information (R. L. Burritt & Christ, 2017). In the context of Brazil's lower water pricing, this issue might be even more pronounced. It is reasonable to infer that, considering the low cost of water, it undermines companies' motivation to disclose water-related financial outcomes, since it might not represent a significant expense in their operations, thereby failing to become a compelling or material topic for corporate reporting.

Following this, we have environmental damage from drawing water (0.039). One plausible explanation is companies' tendency to withhold negative information in their sustainability reports in an effort to maintain an environmentally responsible image (Cho et al., 2015). This possible effort to maintain an image should serve as a warning, as it may even lead to impression management and greenwashing practices, thereby diminishing the credibility of the reported information. Alternatively, and more optimistically, this may suggest that technological improvements and regulatory frameworks have led to more responsible and standardized water withdrawal practices, thereby reducing the incidence—or at least the perception—of environmental harm.

Lastly, there was also a low disclosure of sewerage charges and limitations indicator (0.058). Once again, the lack of monetary data on water-related issues becomes clearer (R. L. Burritt & Christ, 2017). The mean disclosure level across all CWRI indicators is 17,123 out of 35 (representing 49%), as presented in the descriptive statistics of the following subchapter.

Figure 7 – Adherence to the Corporate Water Reporting Index by GICS sectors



Source: Research findings.

4.5.2 Descriptive Statistics and Regression Analysis

Table 10 shows the descriptive statistics for the variables used in the analysis. In this regard, the mean level of water disclosure in the Brazilian sample is 17.123, representing 49% of the total CWRI. This implies a higher overall level of reporting when compared to previous studies analyzing corporate water disclosure. For instance, based on 24 indicators for water-related disclosure, Burritt et al. (2016) found a mean of 2.395 (representing 9,98%) in Japanese firms. In China, Liu et al. (2021) found a mean of 1.360 using a 37 items corporate water disclosure index (representing 3,68%). This places Brazil in a prominent position regarding the disclosure of water-related information. However, we must consider that the Brazilian context, which is moving toward voluntary ISSB implementation in 2024, might be leading firms to enhance their water reporting efforts, justifying the high disclosure rate. Yet, our sample consists of more recent reports (2023) than the other studies. Besides, when manually collecting indicator data, researchers often use structured keywords to search for information in extensive reports, such as sustainability reports. Although this is a viable approach, semantic analysis through similarity calculations provided by the RAG system on the proposed CWR tool offers a more detailed examination of the semantic context in which the indicator is embedded. Therefore, using the proposed tool yields more accurate results regarding information disclosure, identifying units of information that might otherwise go unnoticed through manual collection alone.

Some additional highlights from the descriptive statistics include the low representation of women as board members. The average proportion of females on the board was only 16.9%, indicating low gender diversity on the board, with a zero minimum participation. We can also observe the high ownership concentration among Brazilian listed companies (72.9%), indicating that major shareholders hold significant control. Foreign investors are also not prominent among the shareholders of Brazilian companies, accounting for only 9.8%. Regarding the external audit, almost half of the sample had third-party assurance mechanisms (47.8%).

Table 10 – Descriptive Statistics

Variables	Sample	Mean	Median	SD	Min.	Max.
CWRI	203	17,123	18,000	5,358	4,000	29,000
FEMALE	203	0,169	0,154	0,119	0,000	0,500
INDE_B	203	0,456	0,444	0,232	0,000	1,000
OW_CON	203	0,729	1,000	0,446	0,000	1,000
FOR_OW	203	0,098	0,000	0,193	0,000	0,944
AUDIT	203	0,478	0,000	0,501	0,000	1,000
ROA	203	0,045	0,037	0,071	-0,227	0,266
LEV	203	0,647	0,653	0,262	0,174	2,037
LN_SIZE	203	23,224	23,128	1,680	18,954	28,564
LN_AGE	203	2,683	2,833	1,016	0,000	4,454
IND	203	0,433	0,000	0,497	0,000	1,000

Notes: CWRI = Corporate Water Reporting Index; FEMALE = Female on Board; INDE_B = Board Independence; OW_CON = Ownership Concentration; FOR_OW = Foreign Ownership; AUDIT = External Audit; ROA = Profitability; LEV = Leverage; LN_SIZE = Firm Size; LN_AGE = Firm Age; IND = Water-Sensitivity Industry.

Table 11 presents the results of the Spearman correlation analysis to assess potential multicollinearity issues among the independent variables. The results show that audit (H3), firm size, listed age, and operating in a water-sensitive industry are significantly and positively correlated with the CWRI. Additionally, profitability (ROA) is positively associated with the water disclosure index, supporting H4 at this initial point in the analysis. These findings suggest that larger, older, and more profitable companies, as well as those operating in water-sensitive sectors and with external assurance mechanisms, tend to disclose more water-related information. The correlation coefficients among all other variables remain well below the conventional multicollinearity threshold of 0.6, suggesting that multicollinearity is not a concern in the subsequent regression analysis. Moreover, no VIF exceeded 1.396 (Mean VIF = 1.186), indicating that multicollinearity is unlikely to bias the regression estimates.

Table 11 – Correlation Matrix

	CWRI	FEMALE	INDE_B	OW_CON	FOR_OW	AUDIT	ROA	LEV	LN_SIZE	LN_AGE	IND
CWRI	1										
FEMALE	0,014	1									
INDE_B	0,003	0,044	1								
OW_CON	0,047	0,005	-0,321***	1							
FOR_OW	0,006	0,070	0,020	-0,065	1						
AUDIT	0,305***	0,063	-0,073	0,006	0,252***	1					
ROA	0,145*	0,037	-0,004	-0,083	-0,036	-0,050	1				
LEV	-0,076	-0,019	-0,018	0,112	-0,061	0,109	-0,483***	1			
LN_SIZE	0,198**	0,104	0,092	-0,141*	0,265***	0,433***	-0,184**	0,356***	1		
LN_AGE	0,222**	0,032	-0,104	-0,102	-0,055	0,145*	0,185**	-0,017	0,151*	1	
IND	0,304***	-0,033	-0,059	-0,004	-0,023	0,019	0,111	-0,066	0,046	0,146*	1

Notes: CWRI = Corporate Water Reporting Index; FEMALE = Female on Board; INDE_B = Board Independence; OW_CON = Ownership Concentration; FOR_OW = Foreign Ownership; AUDIT = External Audit; ROA = Profitability; LEV = Leverage; LN_SIZE = Firm Size; LN_AGE = Firm Age; IND = Water-Sensitivity Industry.

***, **, and * denote significance at 0.1, 1 and 5% levels, respectively.

Regarding the regression results, an OLS and a Negative Binomial regression were estimated and are summarized in Table 12. The OLS model explained 22% (R^2) of the water disclosure practices in our sample (adjusted R^2 of 17.5%), suggesting a moderate/limited explanatory capacity, similar to other water reporting analyses (Wicaksono & Setiawan, 2022; Yu, 2022; Z. Zhou, Liu, et al., 2018). This is probably due to the complexity of predicting water disclosure practices, which can be influenced by a range of other factors that are not easily observable through a single econometric model. Despite this, the models meet the basic assumptions of homogeneity and normality of residuals, reinforcing the validity of the results.

Table 12 – Regression Results

Variables	(1) OLS	(2) Negative Binomial
FEMALE	-0.837 (2.944)	-0.050 (0.172)
INDE_B	0.515 (1.603)	0.021 (0.094)
OW_CON	0.978 (0.828)	0.054 (0.049)
FOR_OW	-0.861 (1.888)	-0.047 (0.112)
AUDIT	2.610 (0.771)***	0.152 (0.045)***
ROA	0.027 (5.351)	0.004 (0.315)
LEV	-1.404 (1.453)	-0.082 (0.088)
LN_SIZE	0.348 (0.241)	0.020 (0.014)
LN_AGE	0.842 (0.364)*	0.051 (0.022)*
IND	2.717 (0.703)***	0.156 (0.041)***
CONSTANT	4.533 (5.414)	2.106 (0.314)***
N	203	203
R^2 / Adjusted R^2	0.216 / 0.175	—
AIC	—	1254.5

Notes: CWRI = Corporate Water Reporting Index; FEMALE = Female on Board; INDE_B = Board Independence; OW_CON = Ownership Concentration; FOR_OW = Foreign Ownership; AUDIT = External Audit; ROA = Profitability; LEV = Leverage; LN_SIZE = Firm Size; LN_AGE = Firm Age; IND = Water-Sensitivity Industry.

Standard errors are reported in parentheses. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The results indicate that external audit and some firm-level characteristics (listing age, and industry) positively influence corporate water reporting practices among Brazilian-listed companies. Consequently, the findings support hypothesis H3, demonstrating that boards that decide to externally assure their sustainability-related reports tend to exhibit higher water disclosure levels. Previous studies already demonstrated that the board may direct firms' decisions to purchase external assurance or to demand high audit quality (Alfraih, 2017; García-Sánchez et al., 2022). This aligns with the hypothesized idea that, although the

demand for sustainability information comes from different sources (internal and external), companies will generate higher-quality reports when the pressure is from the inside (Rudyanto and Siregar, 2018). However, the lack of significance of the remaining hypothesized corporate governance attributes weakens this argument. Notably, when a company is proactive in improving the credibility of its sustainability-related reports, it seems to make a greater effort to provide higher disclosure levels of water data. Conversely, companies without the external auditing pressure may fail to achieve better water transparency levels.

Firm-listed age was also significantly and positively related to the extent of water disclosure, aligning with studies conducted in different countries (e.g., Wicaksono et al., 2024; Wicaksono & Setiawan, 2022). This suggests that longer-listed companies may have more structured reporting processes and greater experience managing regulations and attending to stakeholder demands, reflecting a gradual adaptation to evolving market expectations.

Concerning the company's industry, its sensitivity to water resource issues was strongly associated with water reporting practices. This is no surprise since many previous studies have emphasized that firms operating in water-sensitive industries tend to disclose significantly more water-related information. For instance, Burritt et al. (2016) found a significant and positive association between industry water sensitivity and water reporting practices in Japanese firms using a similar Water Reporting Index. Similarly, despite analyzing disclosure levels from responses to the CDP Water Security Questionnaire, Ben-Amar and Chelli (2018) and Yu et al. (2020) also captured this association in different jurisdictions. The same finding emerged in the study of Wicaksono et al. (2024), who investigated the impact of ownership structure on water disclosure using a disclosure index based on the Global Reporting Initiative's (GRI) Water Guidelines (GRI-303). Ultimately, most water-sensitive industries are exposed to higher water risks and face increased stakeholder pressure to disclose comprehensive water-related data (Yu et al., 2020).

Contrary to our expectations, the board characteristics, ownership concentration, profitability, and leverage hypotheses showed no significance in explaining companies' water reporting practices in any model. Instead, it appears that the main drivers of water disclosure practices in this context lie more in broad external pressures (external audit and being in a water-sensitive industry) than in the other internal characteristics initially hypothesized.

However, given the inherent complexity in determining water and other sustainability-related drivers, many previous studies faced the same non-significant findings in different contexts.

Regarding the presence of female board members and water disclosure practices, Liu et al. (2021) did not find a significant relationship in their study of Chinese listed companies as well. Although previous studies highlighting the importance of board diversity, such as Liao et al. (2015), this association does not appear to align with the Brazilian context—at least not yet. Considering Brazil's low rate of female board representation (16.9%) and other specific characteristics of the Brazilian market, it is possible that these factors limit their direct influence on corporate water disclosure.

In a similar vein, we can assume that specific characteristics of the Brazilian market—such as the high ownership concentration by major shareholders (mean of 72.9%) and the low engagement of foreign investors (mean of 9.8%)—may have limited the significance of board-related characteristics in explaining water disclosure practices. We can suppose that, in contexts where control is often centralized and external stakeholder pressure is limited, internal governance mechanisms may have a reduced impact on driving water transparency initiatives. Previous studies, such as Wicaksono and Setiawan (2022), also found no significant effect of foreign ownership on Chinese companies in the agricultural sector. However, they observed a positive and significant relationship in other countries.

Moreover, the lack of financial indicators significance, such as ROA and leverage, suggests that these factors may be less relevant in explaining water disclosure in the context studied. These findings are consistent with previous research, such as Wicaksono et al. (2024) and Yu et al. (2020), which also reported no significant relationship between these variables and water disclosure in the Indonesian and Chinese contexts, respectively. Burritt et al. (2016) did not find significance in ROA in Japanese companies either. These results do not support the hypotheses that companies with better financial performance are more responsive to the needs of key stakeholders. As a result, these firms are not necessarily more inclined to adopt water disclosure practices as a strategy to reduce their environmental and reputational risks. One possible explanation is that water-related transparency in emerging markets like Brazil may not yet be perceived as a financially material issue (Bebbington et al., 2023; OECD & World Water Council, 2023), limiting the extent to which firms, regardless of their financial performance, incorporate it into their disclosure strategies.

These findings challenge our initial assumption that attributes related to the managerial branch of Stakeholder Theory significantly influence corporate actions through voluntary water disclosure. While we initially predicted that managers would primarily focus on key organizational stakeholders due to limited resources (Ullmann, 1985), our results only captured the interest more related to investors and rating agencies through the disclosure of an external audit mechanism. Our results suggest there is room for further investigation involving a broader range of stakeholders, while highlighting the need to expand the theoretical foundations considered in this research.

Considering that our results showed no significance regarding most corporate governance attributes and financial performance, with the sole exception being the external audit hypothesis, the drivers for water disclosure appear not to originate purely from internal strategic decisions. Instead, we can assume that companies frequently act not due to internal strategic choices but rather as a response to institutional pressures and societal expectations, aiming to achieve legitimacy. This might be particularly true especially considering Brazil's position as the world's biggest stock of renewable water resources (Statista, 2023b). Thus, Brazilian companies may face an inherent range of external pressures from diverse stakeholders in their pursuit of legitimacy, extending far beyond their internal governance structures or solely financially related stakeholders. These elements align with the foundations of Legitimacy Theory and Institutional Theory, especially the neo-institutional sociological perspective (DiMaggio & Powell, 1983).

Additionally, the findings highlighting the industry's significant impact on water disclosure align with the concept of mimetic isomorphism within Institutional Theory. Under this mimetic perspective, voluntary environmental disclosure tends to spread across industry sectors as companies imitate peers perceived as leaders in best practices (DiMaggio & Powell, 1983). Thus, it can be understood that when pioneering companies disclose extensive water information, gaining legitimacy and subsequently reaping rewards in terms of improved reputation or investor preference, their competitors are inclined to imitate these practices. This phenomenon is supported by previous studies, such as those by Pozzoli et al. (2023), which utilized the mimetic isomorphism approach to identify higher disclosure among companies within environmentally impactful sectors, following sector-specific patterns. Similarly, Zeng et al. (2020) emphasize this mimetic approach regarding water disclosure, asserting that the extent of disclosed water information is driven primarily by imitation behaviors and

adherence to institutional normative pressures for legitimacy. Furthermore, coercive and normative pressures may also influence water reporting practices among corporations (Egan, 2014), although these influences were not explicitly captured by our model.

4.6 CONCLUSION

This research emerged within an incipient regulatory scenario regarding sustainability reporting in Brazil, characterized by a broad array of available frameworks and models for water-related disclosures. As a result, water reporting appears in varying formats within extensive corporate sustainability reports. Therefore, this study sought to address two research questions: (i) What is the extent of water disclosure practices through an LLM-based analysis? And (ii) What are the potential drivers associated with corporate water reporting? To address these research questions, several steps were undertaken.

First, we developed an AI-based model to ensure accuracy and reliability to identify water disclosure practices. The combined use of LLM and RAG technologies enabled the development of an efficient model to extract water-related information from the sustainability reports of numerous listed Brazilian companies. The RAG approach facilitated content analysis through semantic similarity calculation by providing the model with a limited data source base (the sustainability reports). This approach improved efficiency in collecting extensive data compared to manual analysis by researchers, also preventing hallucinations in data generation by the LLM. Ultimately, the LLM-based CWR Tool produced a spreadsheet containing all captured data for each investigated indicator. This output equips the researcher with a document to verify the model-generated results, enabling accurate analysis of the extent of water disclosure practices while developing the dependent variable of interest—the CWRI.

Second, through the CWR Tool output, we were able to analyze the extent of water disclosure practices, addressing our first research question. Here, we examined Brazilian companies' disclosure level to each of the 35 water reporting indicators, the CWRI. We evaluated the adoption by different sectors and the most and least disclosed indicators, which reflected the advances and difficulties inherent to water accounting, as mentioned in the literature.

Finally, drawing on the managerial branch of stakeholder theory, we explored the potential drivers associated with corporate water reporting, answering the second research question. Our findings reveal that external audit, listing age, and industry positively influence corporate water reporting practices among Brazilian-listed companies. So, the findings reveal that the main drivers of water disclosure practices in this context lie more in broad external pressures than in the internal characteristics initially hypothesized. Therefore, since our results challenged our assumption that organizations focus on key stakeholders due to limited resources, it expanded our theoretical discussion, including aspects from legitimacy theory and institutional theory to underpin our findings. These subject merits further future studies.

Our study has several implications. First, for researchers and professionals who work with extensive analyses of corporate reports, we offer a novel approach that ensures greater efficiency and accuracy in the evaluation process. So, the CWR Tool can easily be replicable in other contexts as long as the indicators are well-defined and validated. Moreover, as it proved to be a tool of consistency and reliability, the combined application of LLM and RAG technologies can be extended to other contexts in which document length may hinder or even prevent effective assessments. Specifically, regarding the tool we proposed, the generated spreadsheet also provides a systematized output that enables precise verification in a significantly shorter timeframe. It is worth noting that the semantic analysis performed by the tool tends to produce more reliable outputs than manual human analysis, especially when processing large datasets.

The findings also offer practical implications for policymakers and corporate managers. Regulators should consider creating incentives for less water-sensitive industries to enhance their disclosure practices. Additionally, support programs aimed at building the capacity of younger firms could help raise corporate transparency. Recognizing the factors that do not show a significant association with water disclosure also provides insights that can better guide the allocation of resources and the design of policies aimed at improving corporate transparency. This research provides valuable insights for sustainability standard-setters working toward mandatory adoption and for managers seeking to improve their corporate water reporting. By capturing the voluntary disclosure landscape, this study establishes a crucial baseline of the pre-mandatory context. This foundation for future comparisons helps guide standardization bodies by revealing that current reporting is driven more by external pressures for legitimacy than by a widespread proactive stance. By

identifying key gaps in water disclosure, efforts can be made to implement systems that support the generation of water-related indicators, along with frameworks that facilitate, encourage, and standardize water reporting across companies. These aspects would contribute to developing a more robust and widely recognized water accounting system, not only in the water reporting sphere but also in the previous steps for better water risk mitigation and water resources management. Consequently, an optimistic outlook for enhanced disclosure levels and improving water accounting is anticipated as ISSB standards gain broader acceptance.

In spite of the contributions offered by this study, the limitations are also acknowledged. First, while the CWRI was constructed through a rigorous and automated methodology using LLMs and RAG, the accuracy of the metric depends on the model's ability to capture context-specific disclosures via semantic similarity calculation, which may occasionally lead to omission or misinterpretation of nuanced information. Second, the analysis is based on Brazilian-listed companies with available sustainability reports, which limits statistical generalizability beyond this population. Third, the CWRI reflects disclosure levels rather than actual water management performance and should therefore be interpreted as a measure of transparency rather than sustainability outcomes. Finally, the hypotheses were based on a theoretical framing restricted to the managerial branch of stakeholder theory. So, future studies could implement alternative theory perspectives to explain water disclosure. Besides, since the cross-sectional nature of the data prevents dynamic inferences, longitudinal studies are encouraged for future research.

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APPENDIX D – Section of the LLM-based Corporate Water Reporting Tool Outcome

File Name	1. Cita fontes de captação de água (água superficial, água)	2. Menção sobre danos ambientais decorrentes da captação de	3. Menção sobre as condições dos recursos hídricos onde	4. Apresenta dados sobre o volume de captação ou demanda de	5. Cita o preço cobrado ou pago pela água	6. Apresenta dados sobre parâmetros de qualidade das fontes de água	7. Menção sobre o tipo de efluentes lançados pela empresa (por	8. Cita práticas de coleta ou reutilização da água da chuva (seus	9. Apresenta dados sobre parâmetros de qualidade dos efluentes	10. Menção sobre danos ambientais decorrentes da descarga de	11. Menção sobre práticas de reuso ou reciclagem da água	12. Apresenta dados sobre o volume da efluentes descartados
3R Petroleum Oleo e Gas SA_embeddings	"Captação total de água por fonte de captação em	NO	NO	"Captação total de água por fonte de captação em	NO	NO	"Efluente sanitário - é tratada e recebe destinação	NO	"Para as operações industriais, por exemplo, a	"Não foram detectadas na água de descarte substâncias que	NO	"Total de descarte de água 1,2,3,4 (ML) GRI 303-4
Aeris Industria e Comercio de Equipamentos para Geracao de Energia SA_embeddings	"A água captada vem do conjunto de obras hídricas chamado Eixão	NO	NO	"Ao todo, foram 119,4 mil m3, dos quais 101.856 m3	NO	NO	NO	"Para reduzir a captação de água dos mananciais, a	NO	"A Companhia trata todo o efluente gerado nas operações,	"Para reduzir a captação de água dos mananciais, a	NO
AES Brasil Energia SA_embeddings	"Captação de água doce de superfície 2.340 1.313 2.987	NO	"Por conta das variações hidrologicas, o enquadramento	"Consumo de água (m³) 2023 2022 2021 Captação de	NO	NO	"Efluentes De acordo com o nosso plano de monitoramento	NO	"De acordo com o nosso plano de monitoramento e medição,	"De acordo com o nosso plano de monitoramento e medição,	"Na sede do Centro de Controle Operacional de	"Descarga de água (m³) 2023 2022 2021 [...] Total captado
AgroGalaxy Participacoes SA_embeddings	NO	NO	NO	"Captação de água 22,88 37,92" e "Em 2023, o uso	NO	NO	NO	NO	NO	"O portfólio da Companhia, contudo, pode apresentar um	"Da água captada ou cedida pela concessionária,	"Descarte de água 18,30 30,34"
Allos SA_embeddings	"ÁGUA DE REÚSO A água coletada do sistema de	NO	"1) 100% dos shoppings fazem a sua própria gestão de	"TOTAL DE ÁGUA CAPTADA* (ML) (SASB IF-RE-140A.3)	NO	NO	NO	"Outra estratégia relacionada ao consumo de água é a	NO	NO	"A implantação de estações de produção de água de reúso	"Em 2023, 593,61ML de água foram descartados em
Allpark Empreendimentos Participacoes e Servicos SA_embeddings	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Alpargatas SA_embeddings	"Captação total de água por fonte (megalitro) 2021 2022 2023	NO	NO	"Captação total de água por fonte (megalitro) 2021 2022 2023	NO	NO	"Os efluentes gerados nos restaurantes e nos banheiros,	NO	NO	"Adicionalmente, não fazemos o descarte de água em fontes	"Além disso, são promovidas campanhas internas sobre o	"Em 2023, a Alpargatas descartou 40 megalitros de
Alphaville SA_embeddings	"Nossas fontes de água incluem o fornecimento por	NO	NO	"CAPTAÇÃO TOTAL DE ÁGUA, EM MEGALITROS CAPTAÇÃO DE	NO	NO	"DESCARTE TOTAL DE ÁGUA EM MEGALITROS,	NO	NO	"18.2 GESTÃO DE IMPACTOS RELACIONADOS AO DESCARTE DE	"Desta forma, mantemos nosso propósito de promoção de	"DESCARTE TOTAL DE ÁGUA EM MEGALITROS,
Alupar Investimento SA_embeddings	"CAPTAÇÃO DE ÁGUA POR FONTE (MEGALITROS)	NO	NO	"CAPTAÇÃO DE ÁGUA POR FONTE (MEGALITROS)	NO	NO	NO	"A Alupar, em parceria com a SDW, e por meio do Projeto Social	NO	NO	NO	NO
Ambev SA_embeddings	"A água utilizada em nossas operações é retirada de três	NO	"Acompanhamos a qualidade da água dos rios onde lançamos	"Gestão Hídrica (1) Total de água retirada, (2) porcentagem	NO	NO	NO	NO	NO	"A Ambev respeita os volumes outorgados e as	"Em 2023, conseguimos economizar cerca de 35 mil	NO
Ambipar Participacoes e Empreendimentos SA_embeddings	"Captação total de água (m³) 2021 2022 2023 2022 x 2023	NO	NO	"Captação total de água (m³) 2021 2022 2023 2022 x 2023	NO	NO	NO	"Esse sistema de captação de água da chuva e reuso, coloca o	NO	"Ainda temos, na Ambipar Environment Peru, a gestão e	"Captação total de água (m³) 2021 2022 2023 2022 x 2023	"Destinação dos Efluentes m³ % Mar 1.019,10 1,11% Estação
Atacadao SA_embeddings	NO	NO	NO	"Captação total de água 4.601,5"	NO	NO	NO	NO	NO	NO	NO	"Descarte total de água 3.680,8"

5 THESIS CONCLUSION

The present thesis investigated corporate water accounting practices by exploring potential determinants, explaining some experiences, and addressing future expectations across distinct industrial and market contexts while recognizing the inherent stakeholders. This multi-faceted investigation covered different aspects of corporate water accounting at different maturity levels against the backdrop of water risk, management, reporting, and auditing.

To begin with, the first study comprehensively addressed all the above-mentioned aspects of water accounting by conducting an interpretive single-case study to understand the water management accounting practices of a multinational household appliance manufacturer. Based on interviews with individuals in managerial positions and other data sources, we identified the primary motivations and inherent challenges regarding water management accounting, along with stakeholder engagement. Furthermore, based on the themes and aggregate dimensions uncovered, we developed a typology of best practices that encompasses operational management of water resources, development of sustainable products, global water strategies, and water reporting practices. We also discussed financial concerns and addressed relevant environmental practices to improve corporate water sustainability. Therefore, this study provided an in-depth analysis of water management accounting determinants (motivations), experiences (typology and discussed practices), and expectations (challenges and discussions on how to overcome them).

In addition, the second study was more closely aligned with the water reporting aspect, focusing on the oil and gas industries to evaluate how water reporting practices comply with ongoing sustainability disclosure requirements. Hence, the findings revealed several considerations regarding the quantitative and qualitative aspects of water disclosure experiences. While we observed a prioritized adoption of climate-related and sector-specific frameworks over a more water-specific approach, investors and regulators are the primary audiences for these reports. The visual representation of the analyzed analytical elements was also found to be highly relevant to the overall disclosure practice while enhancing stakeholder communication and accountability and highlighting the frequent use of tables. Over the sustainability disclosure requirements addressed, we noticed that the inherent nature of each requirement interferes with the format and quality of the information disclosure. Additionally,

this paper discussed expectations regarding potential steps toward water disclosure standardization.

Furthermore, the third study employed a Large Language Model (LLM)-based method to analyze corporate water disclosure practices and investigate potential drivers influencing these disclosures. By integrating LLM and Retrieval-Augmented Generation (RAG) techniques, we introduced a novel and reliable analytical tool to measure the corporate water reporting index in Brazilian listed companies. Additionally, we rely on the managerial stakeholder theory branch to propose that corporate governance attributes and financial performance are potential drivers of water disclosure. External audit was the proposed stakeholder-related driver related to corporate governance attributes that positively and significantly influenced water disclosure practices. Moreover, firm characteristics, such as listed age and operating in a water-sensitive industry, also had a positive and significant impact on water reporting. Thus, this study contributes to the understanding of motivators and water reporting experiences in a single market that comprises distinct industries.

Integrating the findings from these studies, it is evident that several common insights emerge even when employing distinct methodological approaches to address corporate water accounting. Regarding the experiences and expectations of the companies analyzed, a shared commitment to water management measures and goals is evident, including reducing the water footprint and achieving a net water-positive status. The desire for robust regulatory standards concerning the topic was also a recurring theme. Furthermore, there appears to be greater corporate and regulatory incentives and engagement with climate-related issues compared to water, despite their direct connection. Finally, financial aspects proved significant in the discussion, as the low price of water hinders its effective management and subsequent monetary data reporting. This is compounded by the high costs associated with complying with frameworks that necessitate complex water data collection.

Regarding the inherent stakeholders as determinants in corporate water accounting, the diverse scenarios analyzed led stakeholder theory in alternative directions. While our first study highlighted a broader stakeholder relationship as a determinant of water management accounting, in line with the ethical stakeholder theory branch, the second one, although more closely related to water reporting itself, demonstrated a reporting strategy focused on a selected group of stakeholders, aligning with the managerial stakeholder theory branch. On the other hand, the managerial branch did not fully support the third study to test potential

drivers for water reporting. Since each of these findings is based on different aspects of corporate water accounting, from a broader concept to the specificities of reporting, in distinct industries and markets, this presents opportunities and challenges for future studies that can delve into the complexity of the corporate world to understand better how stakeholder theory can be updated in a corporate sustainability context.

These findings generate significant theoretical implications. Initially, the thesis advances the accounting literature on water resources by dissecting different conceptual aspects of corporate water accounting and understanding it in different contexts. The use of distinct methodological approaches in the research also encourages epistemological pluralism for understanding a topic, recognizing that different epistemologies have value and that combining them can generate a richer understanding of the research problem. Moreover, this thesis assists academics by introducing emerging and alternative methodologies in the field of corporate sustainability, aiming to improve the way we conduct research, such as using LLM models and visual content analysis. The thesis also explores the standardization of corporate sustainability reporting, which is still very incipient, bringing water to the center of this mandatory discussion in accounting. Finally, it also promotes a discussion on whether current approaches to stakeholder theory are sufficient to understand the inherent complexities of corporate sustainability decisions, highlighting the need to consider theoretical pluralism in this discussion.

This thesis also provides practical implications. Initially, both studies provide relevant contributions for standard-setters and regulators on water issues. The issues discussed regarding gaps in water-related legislation and potential water incentives for companies are relevant for these agents. Understanding how the reporting of water-related actions occurs can also assist them in considering different disclosure formats and scopes when developing reporting standards. For companies, the thesis provides a benchmark across different industries and markets capable of assisting them in improving their water responsibility practices, encompassing aspects from water risk to auditing. Furthermore, based on the recognition of prioritized stakeholders, other stakeholders are expected to recognize the need to exert greater pressure for their interests regarding water resources to be adopted by companies, leading towards more environmentally and socially responsible practices.

Despite the contributions offered by this thesis, some limitations are also acknowledged. To begin with, the Stakeholder Theory presents complexities and

demonstrated variable applicability depending on the specific context under study, highlighting its limitations in providing a unified explanation for the diverse facets of corporate water accounting. There are also specific methodological limitations associated with each study. For example, the qualitative research faced challenges due to a limited number of interviewees, while the content analysis involved a degree of subjectivity. Moreover, the accuracy of the proposed LLMs tool relies on its ability to correctly interpret complex contextual information. Furthermore, a limitation that relies on different studies is our limited information sources, specifically the sustainability-related reports. Other potential sources, such as news articles, web pages, or social media content, were not covered in the scope of this analysis.

The present thesis provides insights that could guide future research on corporate water accounting. Future studies could qualitatively underly the complexities of determining why some stakeholder pressures succeed and others fail in influencing corporate actions. Despite interlinked, studies can also explore the rationales behind the prevalent prioritization of climate-related issues over water management inside companies. Further research could also improve and validate our LLM-based tool proposed to analyze corporate water disclosures, thereby enhancing their reliability, accuracy, and applicability across various reporting contexts. Finally, after the development of the so-expected ISSB water reporting standards, researchers should assess its subsequent impact of potential mandatory reporting framework on the disclosure quality.

Finally, this thesis provided a comprehensive view of corporate water accounting across diverse industrial and market contexts using epistemological pluralism. Hopefully, it will contribute to the development of corporate water strategies and reporting standards while advancing the discussion on natural resources within the accounting field. Therefore, this research not only advances the understanding of corporate water accounting and its inherent stakeholders but also fundamentally seeks to encourage greater corporate water responsibility.

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