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# Using Formal Concept Analysis to Examine Water Disclosure in Corporate Social Responsibility Reports

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## ABSTRACT

Corporate social responsibility (CSR) water disclosures vary in content, leading to concern about the quality and extent of such disclosures. This paper employs formal concept analysis (FCA) to examine water reporting of selected companies in the US food and beverage industry that have followed the water guidelines set forth by the Global Reporting Initiative (GRI) and in the disclosure guidelines of the CEO Water Mandate. Assessments of water consumption and water withdrawal were cited more often in our sample firms' CSR reports. FCA results also identify the major focus of our sample firms as setting sustainable water management goals and water quality strategy. Other important issues included leadership, partnership, and employee involvement. While the FCA text mining tool is demonstrated using water-related behaviors here, it can be used to identify continuous improvement opportunities and examine many other issues of interest to corporate stakeholders in other industries and communities worldwide. Copyright © 2017 John Wiley & Sons, Ltd and ERP Environment

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**Keywords:** water disclosure; corporate social responsibility reports; formal concept analysis; CEO Water Mandate; sustainability; Global Reporting Initiative

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## Introduction

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**A**LTHOUGH CLIMATE CHANGE IS WIDELY DISCUSSED IN THE PRESS, VERY LITTLE RESEARCH HAS DISCUSSED WATER PERFORMANCE IN business and how it is related to business operation. Few case studies have been developed regarding the social responsibility of water use. Given the importance of managing water resources well, since doing so, as the Global Water Partnership (2014, p. 2) states, 'maximize(s) economic and social welfare without compromising the sustainability of ecosystems and the environment', it is time steps were taken to foster transparency in water disclosures, transparency that might in itself result in better business practices thereto.

The main purpose of this research is to use a formal concept analysis (FCA) to apply the water guideline of Global Reporting Initiative (GRI) and disclosure guidelines of the CEO Water Mandate to enhance our understanding of water disclosure in the corporate social responsibility (CSR) report. Understanding corporate efforts, or lack of

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same, with respect to maintenance of water resources, has become extremely important, given the impact of global warming on the distribution and quality of water resources across the globe (Misra, 2014). The World Economic Forum (2015) also considers water crises as likely to have one of the highest impacts on humanity, with a very high likelihood of such water crises happening. This exploratory research studies water reporting of select companies in the food and beverage industry in the United States by using an innovative information technology that helps lay bare the use of water resources in an industry vitally impacted by potential changes in the availability of those resources (World Economic Forum, 2016). The importance of this topic has led to the relatively recent call by the Climate Disclosure Standard Board (CDSB, 2015) for public comment on the expansion of its global corporate reporting framework beyond climate change to include natural capital information, namely water and forest commodities. Therefore, water disclosure should receive greater emphasis than at present. Further, in 2014, the Corporate Water Disclosure Guidelines were published by the CEO Water Mandate. The CEO Water Mandate sought to lay out a disclosure framework capable of addressing the nature and complexity of water resources. In the United States, in 2010, the Securities Exchange Commission (SEC) required disclosure of significant global-warming-related information, something that would also fall – if applicable – under the required enumeration inside corporate annual reports (a.k.a., SEC Form 10-Ks) of risks facing US-based, publicly held entities. Corporations that sell stock on any US stock exchange are required to file annual reports with the SEC, reporting both corporate financial and much non-financial information. While the SEC's enforcement efforts with respect to this have been meager, the potential exists for them to be stepped up. Such efforts by regulatory agencies point to the necessity for a new approach to evaluating corporate disclosure of sustainability performance. We provide such a new approach here, with respect to the food and beverage industry. The need for a new approach to studying water use is also evident in various recent publications (Ahmetovic *et al.*, 2015; Hori, 2016). Ahmetovic *et al.* (2015, p. 1) note the 'importance of simultaneous optimising processes, water and energy integration for achieving profitability and sustainability within process industries.' They continue with the statement that 'only brief overviews of this important field have so far been provided within the literature.' Water is a limiting factor with respect to economic growth and human survival. It is therefore vital that the way it is used, and either restored to usefulness or discarded as ultimately too damaged to reuse, become an important focus of financial reporting. To the extent that the markets come to focus on sustainability practices of corporations, new, meaningful tools for such disclosure need to be developed. There is much written about carbon pollution generation and control (Lu & Abeysekera, 2014; Meng *et al.*, 2014; Rahman *et al.*, 2014; Doda *et al.*, 2016; Muller-Eie & Bjorno, 2016; Qiu *et al.*, 2016), but nothing about water. Carbon emissions impact the warming of the atmosphere and the hydrological cycle, shifting rainfall and related weather patterns from one area of the globe to the other, impacting crop yields through the creation of historically severe droughts sometimes and extraordinarily heavy rainfalls at other times. Rising seas and water tables, as in Miami, FL, USA, and Bangladesh, threaten the existence of nations and well-established local industries. More particularly, as the population grows, the need for greater crop production grows with it. Crop production and processing of crops into processed foods are heavy consumers of water with, it has been written, it taking up to 7 liters of water to generate one liter of bottled water (Gustafson, 2013). With changing weather patterns, melting ice, rising seas, heavier storms, and historic droughts, a need arises for corporations to disclose their own sustainability-related practices regarding water use. How much pristine water, for example, is drawn into their production processes and returned as pristine water to the ecosystem that provided the water in the first place? Or instead has it been degraded? Bagatin *et al.* (2014) describe finding ways to use water more efficiently and effectively as a global challenge. Bagatin *et al.*'s (2014) paper is geared toward discussing technical topics and approaches to water management; it does not provide tools to allow better conceptual understanding of the impact of the corporation's sustainability choices on corporate financial disclosure. Our paper does.

These issues motivate our study of whether, and how much, and in what ways, corporations disclose their water use.

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## Research Background

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### Climate Disclosures and Practices

Since 2010, the US SEC has required reporting of carbon and other risks to accelerated filers in the United States (see Securities and Exchange Commission Guidance Regarding Disclosure Related to Climate Change, 2010). That release required US accelerated filers to report significant risks to themselves from events related to climate change in their annual filings with the US SEC. Requirements relating to climate disclosures required by the SEC go back to the 1970s. In the 1970s' requirements, firms were required to report the financial impact of environmental laws upon themselves (SEC, 2010). Through the 1970s and beyond, the SEC adopted additional requirements regarding such disclosures. Only Hershey, among the companies in our sample, had made a water disclosure in its Form 10-K by 2014. The trigger for the disclosure may have been a fine in Eastern Europe. The need to push such disclosures thus becomes evident. Item 101(c)(1)(xii) of Regulation S-K requires:

*Appropriate disclosure also shall be made as to the material effects that compliance with Federal, State and local provisions which have been enacted or adopted regulating the discharge of materials into the environment, or otherwise relating to the protection of the environment, may have upon the capital expenditures, earnings and competitive position of the registrant and its subsidiaries. The registrant shall disclose any material estimated capital expenditures for environmental control facilities for the remainder of its current fiscal year and its succeeding fiscal year and for such further periods as the registrant may deem material.*

Ahmad and Mohamad (2014) studied environmental disclosures by Malaysian construction companies, based on the companies' 2009 annual reports. They categorized the companies' disclosures by qualitative and quantitative characteristics, and whether they revealed non-monetary or monetary environmental information. The authors stated that the 'disclosures are neither complete nor comprehensive enough and are largely confined to general, narrative statements which cannot be verified' (p. 240). The authors argue that their approach is consistent with the emphasis of Parker (2005) in helping 'understand disclosure practices from a more normative, accountability perspective' (p. 240). While Ahmad and Mohamad (2014) address carbon disclosure issues in Malaysia from the said 'normative, accountability perspective,' our study looks at water disclosures by firms in the US food industry from the same perspective. Unlike Ahmad and Mohamad (2014), ours is an exploratory study that generates insight into the potential usefulness of FCA in fostering greater understanding of such water-related disclosures as exist. It also provides a tool to allow greater insight into the comparative nature of disclosures by firms in the food industry. This single sector focus allows, as Ahmad and Mohamad (2014) claim for their study of construction firms, deeper in-depth insights into the ways, and extent, to which denizens of an industry whose functioning vitally depends upon plentiful, potable water supplies, disclose the tools, techniques, and quantities of water they use in each of four types of water transactions.

The importance of sustainability-related disclosures is shown in the literature (Jenkins, 2004; Stanny & Ely, 2008; Kolk & Pinkse, 2010). Matsumura *et al.* (2014) find that firm value decreased by over \$200,000 for every thousand metric tons of carbon firms in their sample released into the environment. Further, the authors found that *disclosing* carbon emissions data led to higher firm valuations, by some \$2.3 billion dollars compared to non-disclosing firms. Interestingly, DiSalvio and Dorata (2014) find that there was a significantly positive reaction by the market to the 2010 SEC reporting guidance release concerning disclosure of the impact of climate change. Firms in industries with greater exposure to climate risks experienced more positive returns apparently due to the SEC disclosure guidance than firms not as subject to climate change risk. These results, taken together suggest the interest of the markets in such disclosures. Previous studies of water management used more primitive approaches. In Linneman *et al.*'s (2015) case, for example, the authors use a checklist populated by an analysis of published information on the corporations in their sample. Their results demonstrated that water management transparency differences were great between industry sectors, and within industry sectors.

### Disclosure Guidelines and Frameworks for Action

Global Reporting Initiative (2015) provides four specific water indicators: (i) EN8 Total water withdrawal by source, (ii) EN9 Water sources significantly affected by withdrawal of water, (iii) EN10 Percentage and total volume of water recycled and reused, and (iv) EN22 Total water discharge by quality and destination (also Chapter 7 of Herriott, 2016). Water withdrawal, consumption, discharge, and recycling disclosures are important as part of the wider

package of signaling that a firm achieves through its disclosure practices. The CEO Water Mandate (2014) White Paper entitled *Corporate Water Disclosure Guidelines: Toward a Common Approach to Reporting Water Issues* also notes that many disclosure practices are possible, but that the relevance of each may differ between corporate disclosers.

Further, different companies may have different optimal disclosure needs, with additional disclosures rendered impossible due to lack of capacity to implement such disclosure choices. Advantages said to accrue to water disclosers include improving the firm's own understanding of challenges it may face because of issues related to water sourcing, use, and repair. In addition, given the increasing water-related risks stemming from global warming, publishing the firm's activities related to water use and conservation may bolster confidence in the firm's foresight, improve the firm's reputation, and raise investor confidence in the firms. Also, such disclosure aids the firm's credibility. Our choice of water issues here (water withdrawal, consumption, recycling, and discharge) derived from the water guidelines of the GRI captures the fundamentals of each firm's relationship to the water resource.

Corporate governance is important because the decision to use water more efficiently or effectively is not made in a vacuum. Such decisions may have tie-ins to the decision-making processes of the firm choosing more efficient and effective processes *and, importantly*, making the decision to disclose their behaviors. De Souza *et al.* (2015) tie corporate governance, as measured by the GRI, to the Carbon Disclosure Project (CDP) reports. Such a tie-in, De Souza *et al.* (2015) argue, allows organizations to achieve economy in their reporting behaviors because they can use the same data points in responding to inquiries of both venues. The further integration of GRI, CDP, and CEO Water Mandate disclosure guidelines will significantly enhance the usefulness of such disclosures. Frequent common discussions in the political sphere are replete with invocations of cost-and-benefit calculations regarding disclosure. Given that corporations often have multiple stakeholders, calculating a cost–benefit number is extremely difficult. Individuals or firms in various counter-roles will have different weights as to the cost of different inputs and the value of different outputs (in a different context, refer to Naustdalslid, 2015). Choosing an optimal disclosure narrative, then, becomes difficult due to disagreements among stakeholders occupying diverse counter-positions with respect to the focal, disclosing, firm. That said, finding a tool useful in laying bare the nature and quantity of disclosures between firms in the same industry, especially using highly vetted data such as that that appears in the CDP, CEO Water Mandate disclosures, and related databases, is highly desirable. Egan (2015) notes that, for his sample of five Australian food and beverage producing firms, motivations to improve water handling varied significantly between firms, with some moving forward just to comply with some mandate, and others driven by community pressures. Egan (2015) further notes, that management level staff who were extremely interested in water efficiency were also important in 'driving change.' Finally, Egan (2015, p.87) reported that 'cultural changes were apparent in a new focus on maximizing water efficiencies, and a broadening of meta-rules to give more consideration to longer-term reputational benefits.' Egan's work speaks to the diverse drivers of change in water efficiency practices in Australia. The study neatly highlights how different populations facing the focal firm(s), from both within and without, can affect decisions the organization makes. To the extent that groups of investors, for example, wish to divert their investable funds to firms with greater, and more meaningful, disclosures, a tool that can render transparency to such disclosures is very desirable.

### Sample Firms

For the purpose of this study, we focus here on water-related disclosures by seven large United States-based food as well beverage producing firms (i.e., Cola-Cola and Pepsico, Inc.) because food provision is likely to be severely impacted by global warming due to the latter's impact on the hydrological and other cycles. Upon careful perusal of the Carbon Disclosure Project report (2015) and considering the data needs for the analysis (Morikawa *et al.*, 2009; Palaniappan & Gleick, 2009), we identify our firms as those that have the following characteristics:

- The firm in question reports its current status as to sustainable water management via CDP platforms with a particular focus on (i) assessment of water conditions and water risks, (ii) stakeholder engagement, and (iii) quantitative data of water consumption or withdrawal.
- The firm in question reports its vision of sustainable water management such as water policy and supply chain engagement via CDP platforms.

- The firm in question reports its action plans and workable solutions in five areas via CDP platforms: technology, partnership, performance measurement, continuous improvement initiatives, and qualitative analyses.

Seven firms in the food and beverage industry in the United States show greater openness to such standards: Kellogg, Hershey, J.M. Smucker, General Mill, Pepsico, Inc., Brown Forman, and Coca-Cola. The use of a sample of such a size is consistent with Egan (2015). Egan (2015) focused on water management practices of five large food and beverage producing organizations operating in Sydney, Australia.

It is also observed that food producers' disclosures become a handy bellwether of how water-related disclosures are handled by firms most at risk due to failing water resources. As such, then, it can be argued that hard cases make bad law, that disclosure practices of firms in an industry most subject to the risk of failing water resources are unlikely to be terribly useful to firms with less exposure to water bankruptcy. We argue, however, that the risk position of the seven major food producers forces them to tease out their legal, moral, and social obligations earlier than other industries will need to. In the process of this teasing out, these seven firms provide a possible reporting template for firms in less risky positions.

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## Research Methods

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FCA is a tool for conceptual clustering (Diaz-Agudo & Gonzalez-Calero, 2001; Schnabel, 2002; Cimiano *et al.*, 2004; Ganter *et al.*, 2005; Formica, 2006; Lai & Zhang, 2009; Lin *et al.*, 2013). It allows researchers to derive conceptual hierarchies from a cross table containing Objects (O), Attributes (A), and relations (R) between Objects and Attributes. It can generate line diagrams through lattice construction algorithms and/or computer software for showing concepts. It is based on a mathematical theory of concepts and concept hierarchies. It usefully promotes better communication with interested parties.

The usefulness of formal concept analysis in generating greater insight into complex underlying structures has been pointed out by Annoni and Brüggemann (2009), for example. Annoni and Brüggemann (2009, p. 471) argue that aggregation of data led to difficulties in disentangling what was needed from the whole, causing interpretation difficulties. They point to the use of formal concept analysis as a possible tool to disaggregate data, allowing for more meaningful information. The result of their efforts, they claim, was to '... pinpoint [the] role and relevance of different attributes characterizing EU countries which are used to define the partial order.' Sarmah *et al.* (2015) argue that learning is aided by formally presenting human thoughts. Sarmah *et al.* (2015) go on to note that FCA is one means of formalizing human thought, with such formalization being of assistance in considering the interrelationship between a context's intent and extent. Given the murkiness of many concepts in the sustainability arena, it is useful to have a tool such as FCA that can formalize thought and provide a framework for understanding the interrelationship between the possessor of an attribute (i.e., the object) and the attribute of the object. Using FCA, therefore, we seek to pinpoint both the similarities and difference in water disclosure between firms in the food industry. In addition, we seek to tie the seven focal firms' water disclosures to GRI characteristics and the CEO Water Mandate disclosure guidelines, and in this way to provide to researchers, investors, and corporate managements a tool that will enable them to understand where a firm is with respect to other firms within that industry. Their study, in addition, of the combination of governance and water management enables stakeholders to see where the focal firm is on a complicated metric. That is, how do governance practices impact water-related behaviors and disclosures? These are issues rarely before addressed in the literature, issues which – given the disturbances of water distribution and intensity in recent years – will become increasingly important as the years go on.

FCA has been explored in other contexts. Lai and Zhang (2009) examined the usefulness of FCA and rough set theory. They found that FCA generated greater value than the value of concept lattices that were, as they said, based on rough set theory. Further, Lin *et al.* (2013) use FCA and other tools to examine the content of supply chain quality management. Lin *et al.* (2013) describe content analysis techniques such as FCA as useful in assisting researchers with handling great amounts of qualitative data, and in doing so help them uncover 'important mutually exclusive categories in a systemic manner' (p. 353). The researchers go on to say that FCA 'allows researchers to derive conceptual hierarchies from a cross-table containing Objects (O), Attributes (A), and the relations between them'

Objects	Attributes			
	Water Withdrawal	Water Consumption	Water Recycle	Water Discharge
<b>Kellogg</b>		X		
<b>Hershey</b>	X	X		X
<b>J. M. Smucker</b>	X			
<b>General Mill</b>	X	X		
<b>Brown Forman</b>		X		
<b>Pepsico, Inc.</b>	X	X	X	
<b>Coca-Cola</b>	X	X	X	X

**Table 1.** Cross table – specific GRI Items of water disclosure in the food and beverage industry

(p. 353). The result of the four-step process Lin *et al.* (2013) define is the development of new knowledge, knowledge attained via review of the FCA-generated line diagrams showing concepts (attributes) and their connections to individual objects. The connections are the relationships between Objects and Attributes. The potential usefulness of FCA is described by Lin *et al.* (2013) regarding their findings, that the technique lays bare the content (what to do?), the structure (how to link things, and in what order?), and governance (who bears responsibility for carrying out required activities?). Our use of FCA in this context will show the transliterability of these supply chain analytic results to water management.

## Empirical Assessment

To implement FCA on water disclosure, we performed an FCA analysis by following guidelines suggested by Ganter *et al.* (2005) and Lin *et al.* (2013). We shall focus on two cases in point, namely, the water guidelines of the Global Reporting Initiative and disclosure guidelines of the CEO Water Mandate. They are introduced briefly as follows.

### Formal Concept Analysis for GRI's Four Water Disclosure Indicators

#### Studying CSR Reports

First, we studied the CSR reports of seven firms, with these seven firms becoming our objects in FCA. The sources of this and other relevant data are reported in Appendix 1.

#### Using GRI Water Indicators

We identified relevant attributes by using GRI environmental performance indicators discussed in the section *Disclosure Guidelines and Frameworks for Action*. We identified those four GRI indicators as FCA attributes and used the following variable names for them: water withdrawals, water consumption, water recycle, and water discharge.<sup>1</sup>

#### Preparing Cross Tables

We prepared a cross table in Table 1 based on the CSR reports of these firms. As noted, Appendix 1 provides the sources of the corporate social responsibility reports. Table 1 consists of objects by companies and attributes by water disclosure attributes. Each company is associated with several attributes.

<sup>1</sup>The operational definition of water withdrawals, water consumption and water discharge are also available via <http://ceowatermandate.org/disclosure/resources/glossary/>. Withdrawals are defined as the volume of freshwater abstraction from surface or groundwater. Water consumption is defined as the volume of freshwater used and then evaporated or incorporated into a product. It also includes water abstracted from surface or groundwater in a catchment and returned to another catchment or the sea. Water discharge was defined as wastewater removed from the organization via truck. Discharge of collected rainwater and domestic sewage is not regarded as water discharge.

## Employing Concept Explorer Software and Presenting Line Diagrams

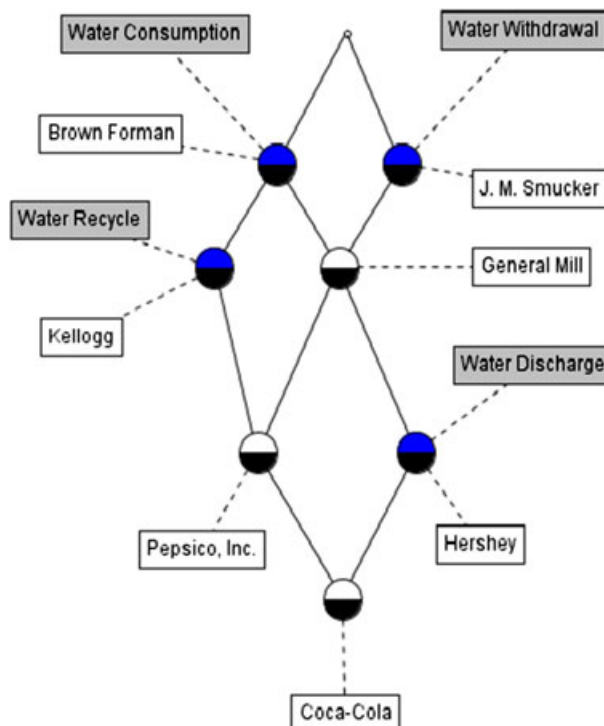
After we format the cross table dubbed Table 1, we used Concept Explorer (<http://conexp.sourceforge.net/index.html>) to produce Figure 1. Figure 1 presents a line diagram with concept lattices. The circles in the line diagram represent the concepts. For example, water consumption and water withdrawal are the more common disclosure data provided in firms' CSR. As shown in Figure 1, the line diagram developed in this work classified concepts (represented as circles) and explored their mutual relationships.

## Interpreting the Results

In the context of water guidelines of GRI, there are many indicators or terms that must be combined to form a functional model of sustainable water management. For the purpose of this study, four such indicators are used (Appendix 2): water withdrawal, water consumption, water recycle, and water discharge. Although water guidelines of GRI has undoubtedly gained momentum across the business communities during the past few years, few case studies were developed to find corporations' experiences of sustainability management centering on water withdrawal, water consumption, water recycle, and water discharge in their CSR reports. To fill this gap, we mine publicly available information provided by our sample firms. Details of results, including the quantity of water as well as the range of metrics, are presented in Appendix 2. They are used subsequently to create Table 1.

Brüggemann and Patil (2011, p.124) note that 'the filled upper semicircle indicates that there is a property [attribute] attached to the corresponding concept, whereas the filled lower semicircle indicates an object attached to the corresponding concept.' To read this line diagram and find the related concepts, one needs to follow the following guidelines (Wolff, 1993; Brüggemann & Patil, 2011; Lin *et al.*, 2013).

- If a node contains a blue-filled upper semicircle, there is an attribute (or attributes) attached to this concept (i.e., four water disclosure indicators).
- If a node contains a black-filled lower semicircle, there is an object (or objects) attached to this concept (i.e., seven companies).
- Following an upwards leading path from the node in question (e.g. 'Brown Forman' and 'J. M. Smucker'), one can find the attribute concepts (i.e., 'Water Consumption' and 'Water Withdrawal'), and



**Figure 1.** Formal concept analysis for GRI's four water disclosure indicators. [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



- Every object below an object (or objects) (e.g. 'General Mill') shares attributes (i.e., 'Water Consumption' and 'Water Withdrawal') with the object(s) above it (i.e., 'Brown Forman' and 'J. M. Smucker,' respectively). Following this rationale, one can easily tell: (i) Pepsico, Inc. discloses Water Consumption, Water Withdrawal, and Water Recycle; and (ii) Hershey discloses Water Consumption, Water Withdrawal, and Water Discharge in their CSR reports. Only Coca-Cola discloses information on all four water attributes.

Appendix 2 provides a breakdown of reportage on each of these attributes by sample companies.

#### Deriving More Information from Association Rules

We use the association rules to summarize our findings. Annoni and Brüggemann (2009) note that the mutual relations observed can be very symmetric. This way the FCA output can be evaluated using the association rules originally proposed by Ganter and Wille (1999). The deliverables of 'association rule or implication' generation functions in Concept Explorer are main conclusions with or without premise(s) (or antecedent(s)) associated with any lattices of concern. Both premise and conclusion are attribute names. The association rules or implications yield the proportion of objects (e.g. 100% or less than 100%) 'with the specified antecedents for which the consequent is also true' (Annoni & Brüggemann, 2009, p.484).

In other words, there are two types of association rules in Concept Explorer: strict rule (i.e., all objects or the majority of objects fully (or 100%) support the conclusion of interest) and approximate rule (i.e., less than 100%, if the specified antecedents hold, conclusion (s) don't necessarily hold for all objects). Its form can be shown as follows:

$$\text{Premise(s)} \Rightarrow \text{Conclusion(s)} \quad (1)$$

In this work, we employ Concept Explorer software to produce two strict rules as the following

$$\langle 3 \text{ firms} \rangle \text{ Water Recycle} = [100\%] \Rightarrow \langle 3 \text{ firms} \rangle \text{ Water Consumption} \quad (2)$$

$$\begin{aligned} \langle 2 \text{ firm} \rangle \text{ Water Discharge} = [100\%] \Rightarrow \langle 2 \text{ firm} \\ \rangle \text{ Water Withdrawal Water Consumption Water Recycle} \end{aligned} \quad (3)$$

The outcomes of the strict rule are now summarized.

*Strict Rule 1: If firms under evaluation report water recycle, then they also report water withdrawal and water consumption. There are three firms that satisfy this rule. They are Kellogg, Pepsico, Inc. and Coca-Cola.*

*Strict Rule 2: If firms under evaluation report water discharge, then they also report water withdrawal, water consumption, and water recycle. Both Hershey and Coca-Cola satisfy this rule.*

These two rules can be verified by inspecting the first cross table (Table 1).

In the same fashion, we employ Concept Explorer software to produce two approximate rules as the following

$$\langle 5 \text{ firms} \rangle \text{ Water Withdrawal} = [80\%] \Rightarrow \langle 4 \text{ firms} \rangle \text{ Water Consumption} \quad (4)$$

$$\langle 7 \text{ firms} \rangle \{ \} = [86\%] \Rightarrow \langle 6 \text{ firms} \rangle \text{ Water Consumption} \quad (5)$$

Note that both rules display ‘less than 100% of objects’ covered by the premise of rule. For example, referring to the first approximate rule, we note that four out of five firms (i.e., 80%) displaying a specific pattern, i.e., Water Withdrawal = = > Water Consumption.

Searching for associations thus complements the initial line diagram analyses by offering specific implications or conclusions.

### Formal Concept Analysis for CEO Water Mandate Five Water Disclosure Indicators

Corporate Water Disclosure Guidelines developed by the CEO Water Mandate organization provides more water disclosure attributes (CEO Water Mandate, 2014). We present three main research findings and interpretations in a way that reflects the essence of the section *Formal Concept Analysis for GRI’s Four Water Disclosure Indicators*.

#### Preparing the Cross Table in Question

Using the same rationale as described in analyzing the four GRI water indicators presented in the section *Formal Concept Analysis for GRI’s Four Water Disclosure Indicators*, we perform another FCA analysis and create a cross table in Table 2, which presents the water disclosure quality of seven firms’ CSR reports based on Corporate Water Disclosure Guidelines. Appendix 3 presents some of the seven firms’ indications of the qualities they state that they demonstrate by their water-related practices and disclosures.

#### Producing and Presenting the Corresponding Line Diagram

Based on Table 2, we use the Concept Explorer again to produce Figure 2. Similar to development of Figure 1, Figure 2 presents a line diagram with concept lattices. Figure 2 shows that ‘Goal Setting’ and ‘Water Quality Strategy’ are dominant concepts. Further, Kellogg and Hershey are the only two firms in the group not listing ‘Leadership’ in their CSR reports. Smucker is the only firm in the group not listing ‘Employee Involvement’ in its CSR report. Brown Forman has addressed ‘Goal Setting’, ‘Water Quality Strategy’, ‘Employee Involvement’, and ‘Leadership’ in its CRS report. General Mills Inc., Pepsico, Inc. and Coca-Cola have all five water attributes including Partnership in their CSR report.

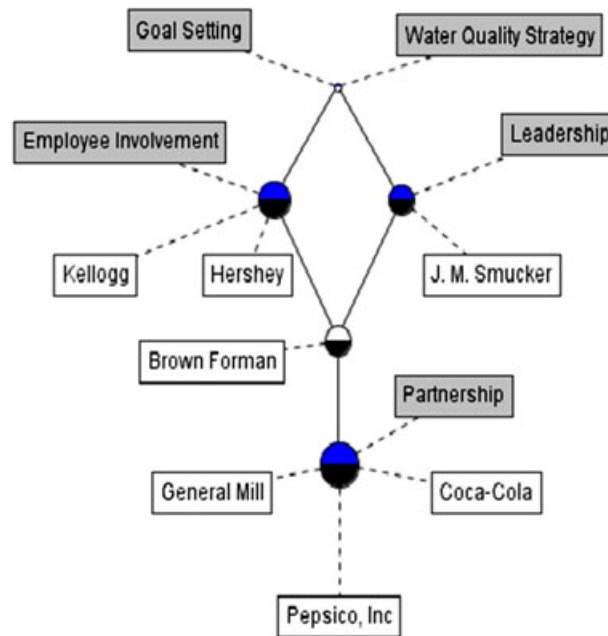
#### Reviewing Association Rules

Association rules were also generated by formal concept analysis based on Table 2. Two strict rules are shown as the following:

$$\langle 7 \text{ firms} \rangle \{ \} = [100\%] \Rightarrow \langle 7 \text{ firms} \rangle \text{Water Quality Strategy Goal Setting} \quad (6)$$

Objects	Attributes				
	Water Quality Strategy	Leadership	Employee Involvement	Goal Setting	Partnership
<b>Kellogg</b>	X		X	X	
<b>Hershey</b>	X		X	X	
<b>J. M. Smucker</b>	X	X		X	
<b>General Mill</b>	X	X	X	X	X
<b>Brown Forman</b>	X	X	X	X	
<b>Pepsico, Inc.</b>	X	X	X	X	X
<b>Coca-Cola</b>	X	X	X	X	X

**Table 2.** Cross table – qualities firms state are illustrated via CSR water disclosure in the food and beverage industry based on the CEO Water Mandate disclosure guidelines



**Figure 2.** Formal concept analysis for CEO Water Mandate’s five water disclosure indicators. [Colour figure can be viewed at wileyonlinelibrary.com]

$$\langle 3 \text{ firms} \rangle \text{ Water Quality Strategy Goal Setting Partnership} = [100\%] \Rightarrow \langle 3 \text{ firms} \rangle \text{ Leadership Employee Involvement} \tag{7}$$

The outcomes of the strict rule are now summarized.

*Rule 1: ‘Goal Setting’ and ‘Water Quality Strategy’ are the first group of relevant conclusions. All objects (i.e., all seven firms) from context are found to support this particular claim. There is no premise for deriving this rule. It is a simple fact, based on the context under evaluation.*

*Rule 2: If firm(s) under evaluation report ‘Goal Setting’, ‘Partnership’, and ‘Water Quality Strategy’, then they also report ‘Leadership’ and ‘Employee Involvement.’ Three firms satisfy this rule: General Mill, PepsiCo, Inc., and Coca-Cola.*

These main association rules can be verified by inspecting the cross table in question (Table 2). Further, two approximate rules are also shown as the following

$$\langle 7 \text{ firms} \rangle \text{ Water Quality Strategy Goal Setting} = [86\%] \Rightarrow \langle 6 \text{ firms} \rangle \text{ Employee Involvement} \tag{8}$$

$$\langle 5 \text{ firms} \rangle \text{ Water Quality Strategy Leadership Goal Setting} = [80\%] \Rightarrow \langle 4 \text{ firms} \rangle \text{ Employee Involvement} \tag{9}$$

It appears that FCA provides a useful tool that can help policy/decision makers both visualize relations among Objects and Attributes, and help them understand relevant implications or associations among attributes. Although this case is applied to institutions in the consumer staples sector, the FCA approach can be applied to understand disclosures in any industry.

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## Implications

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The following lessons can be drawn from the scientific inquiry proposed in this study:

In contrast to earlier studies, our study uses FCA to derive conceptual hierarchies from a cross table containing key components in the business corporate social responsibility reports. This helps the public understand the disclosure quality and communication of CSR (Dobers & Springett, 2010). Our study follows the GRI and the CEO Water Mandate disclosure guidelines applied in a firm's CSR report and uses FCA to summarize those focal elements. Our paper contributes to the discussion by enhancing the readability and communication of water disclosure in CSR report.

The SEC's requirements, along with those of major US and other stock exchanges and investor interests (e.g. United Nations Sustainable Stock Exchanges Initiatives, 2014; Ceres, 3/2014) point to the importance of developing sustainability reporting standards and disclosures. Such reports, though, may consist of quantitative and qualitative information. Qualitative information bears the burden of shared understanding. Also, it lacks the ability, *per se*, to be quantified, and therefore becomes less subject to comparison across reporting objects. Nevertheless, it is important to have tools available that provide the means of grouping and discriminating between objects with attributes that are either similar or dissimilar. FCA provides such a tool, and in doing so can assist in the understanding of corporate sustainability disclosures, here focused on use, abuse, and reclamation of water resources by firms in the food and beverage industry. One can, of course, peruse the individual disclosures of the seven firms featured in this study. Doing so reveals that the separate, standalone GRI report of Coca-Cola Company provides a great deal of information, even in contrast to that of Pepsico, Inc., which provides a GRI report that includes many other items than those pertinent to the topic of this study. Further, the Coca-Cola report provides forms of display other than flat text, i.e., it includes video and interactive charting as well as text. These features provide saliency to the information, rendering it at once more available and more of a cynosure. The other reports surveyed fell even further from the mark than did that of Pepsico, Inc. That said, though, industrial-level comparisons demand abstractions from mere display. Such comparisons demand organization of data for systematic analysis. We believe that the FCA routine provides such a tool of organization and presentation, enabling the interested observer to gain greater insight into the flows of comparative information that would not otherwise be visible. This tool allows interested parties to see the hidden orders and structures in the form of graphical models.

The disclosures also analyzed in this study present a full picture, for the best disclosers at least, of the firm's awareness (and willingness to describe) its relationship to necessary water resources. Water withdrawal, in combination with recycling and discharge, presents the firm's connection to its environment with the juxtaposition of the firm's recycling and discharge on the one hand with water withdrawal on the other, presenting the firm's awareness of its dependence on the environment for future livelihood. For example, Pepsico, Inc.'s 2014 GRI report indicated that in 2013, total withdrawal from municipal water supplies (or from other water utilities) of non-brackish and non-salt-laden water supplies was 37.6 million cubic meters and total withdrawal from all other sources was 15.9 million cubic meters. The elements depicted here, in combination, provide in themselves what the CEO Water Mandate (2014, p.18) White Paper describes in a different context as a 'quantitative snapshot' of its water-related performance. While potential reporting issues, according to the CEOWaterMandate.org White Paper, are legion (e.g. water quality, scarcity, flooding), and while different reports may have different needs based on their contextual issues, these four elements are relevant to all. All companies must use water for some purpose; therefore, quantity of water withdrawal is a knowable and valid metric. While water withdrawal in a parched area of the Earth is more of a public issue than in a lesser stressed *pied à terre*, still, all areas are now subject to drought, given changing weather patterns and ongoing greenhouse gas issues. Focusing on water withdrawal is vital in linking the firm to its environment and, in the process, providing would be investors with a signal as to the focal firm's forethought. Revelation of the quantities of water recycled versus discharged, signals to the investor the climate consciousness of the firm. Water consumption, of course, is another signal as to the sustainability of the firm's business practices, given, again, the ongoing concerns about sustainability. Therefore, we focus on these water reporting foci.

This is not to say that there are no other tools available, other than the one we propose – FCA. Other tools for understanding water use, for example, include Ahmetovic *et al.*'s (2015) process system engineering-related approach. The prior work that these authors describe includes 'pinch analysis, mathematical programming, and their combination.' A great deal of sustainability research focuses on carbon emissions, looking at its impact on rising seas, strength of storms, and the like. Annoni and Brüggemann (2009) argue that there is too much aggregation of data and that there is virtue to be found in disaggregating such in order to retrieve information that

might not otherwise be available for analysis. The authors argue that it is important to understand the dimensions underlying broad problems, rather than just to see the broad problems themselves. Such an approach is popularly found in the description of people seeing the forest and not the trees. Although that aphorism can be reversed to 'do not miss the forest for the trees.' Either way, Annoni and Brüggemann (2009) raise an important point, which is that it is important to be able to go back and forth between the particular and the more general. This way, a problem can be analyzed by particular dimensions or facets while also be looked at as a collectivity. Such a granular understanding allows greater knowledge of how water issues relate to other global warming related issues, making possible perhaps a better sense of what are the most efficient tradeoffs between protecting water resources or protecting some other common good. Given that resources are scarce, one must begin in the framework of tradeoffs; or, doing the least damage possible to attain the highest good. We use formal concept analysis here to understand the different dimensions of food producer water disclosure behaviors.

Although the qualitative water data used here were derived from sample firms in the food and beverage industry in the United States, we expect the same to be applicable to the institutions operating in other sectors worldwide. They share the same sustainable water management problems as sample firms presented in this study and have also faced increased concerns due to climate change and water supply chain system dynamics. The productive inquiry approach proposed in this work would lead to effective continuous improvement programs by employing the text documents that express an institution's main sustainable water management concerns and targeting issues of concern to benefit every stakeholder in its supply networks.

Beyond water, this research has more general implications as well. Since the advent of disclosure guidelines of the GRI and the CEO Water Mandate, it is of paramount importance for business enterprises to identify the compliance gaps, refer to benchmarking, match their approaches to dimensions of sustainable water management, and/or imitate peer institutions' sustainable water management practices. As shown in Figure 1, only two firms, i.e., Hershey and Coca-Cola, take into account the need to report water discharge efforts and activities. As suggested by the GRI water guidelines, however, there should be a high commitment placed on such a dimension of sustainable water management in the food and beverage industry. Referring to water discharge reports prepared by Hershey and Coca-Cola and the GRI water guidelines, we contend that other five firms in this study should investigate this matter from functional, product, process, organizational, and supply chain perspectives. Figure 2 reveals the compliance gaps according to disclosure guidelines of the CEO Water Mandate. After reviewing Figure 2, top managers and policymakers can select candidates for rapid responses and systematic implementation. Referring to Figure 2, we, for example, note that all seven CSR reports we studied speak of their efforts on water quality and goal setting. As evident from Figure 2, however, it is not the case for other three dimensions of sustainable water management as outlined by the CEO Water Mandate. We thus postulate that there should be a high priority placed on 'Partnership', 'Leadership', and 'Employee Involvement' in the food and beverage industry in the USA. Our approach enables policymakers and the critical mass in the same industry to understand different dimensions of sustainable water management, and peer institutions' behaviors, strategic concerns, and business policy deployment. We expect that our proposed approach can be adopted in dealing with environmental pressures, understanding the current states of practical engagements, and formulating environmentally conscious business strategies in other business settings or case studies.

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## Conclusion

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In line with the growing concerns of climate change and the importance of sustainable development, stakeholder engagement, and environmental policy, modern enterprises tend to describe their experiences of sustainability management in their CSR reports. Water use and reclamation, for example, is an important issue facing the world in this time of climate change. Much has been written about the challenges facing corporations and other entities given the potential for climate change to result in large shifts in precipitation patterns across the globe. Accordingly, understanding corporate plans from large quantities of text shown in CSR reports for addressing climate change issues regarding water use and reclamation is important. At the present time, however, identifying the hidden orders and practical engagements from peer institutions' CSR reports is often overlooked. To overcome this

drawback, we focus this work on providing a practical example of seven corporate approaches to sustainable water management in the food and beverage sector. Specifically, in this study, we demonstrate the use of a valuable text data visualization/analysis tool, FCA, for understanding corporate behavior and the linkages between different behaviors. The tool also provides a way of categorizing firms based on their adherence to different formal concepts. Having such a tool enables interested parties to mine publicly available information to discern relative adherence to policies and behaviors that best promote sustainable water management practices and enhance the advancement of sustainability management. While this tool is demonstrated using water-related behaviors here, it can be used to model other environmental issues, visualize the linkages between frameworks/guideline for actions and current corporate practices, shake up the formula for sustainability management, provide an improved sustainable development analytics and knowledge base for better decision-making, and examine many other issues of interest regarding corporate and other actors' behaviors to stakeholders, for example issues involving energy, food, and forests production and exploitation, for years to come.

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## Appendix 1. Sources of Corporate Social Responsibility Information and Use of the GRI Initiative

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1 Kellogg provided a CSR report and a separate GRI index file.

[http://www.kelloggcompany.com/content/dam/kelloggcompanyus/corporate\\_responsibility/pdf/2015/Kelloggs\\_CRR\\_2014\\_FINAL.pdf](http://www.kelloggcompany.com/content/dam/kelloggcompanyus/corporate_responsibility/pdf/2015/Kelloggs_CRR_2014_FINAL.pdf)

[https://www.kelloggcompany.com/content/dam/kelloggcompanyus/corporate\\_responsibility/pdf/2015/Kelloggs\\_CRR\\_2014\\_GRI\\_Index.pdf](https://www.kelloggcompany.com/content/dam/kelloggcompanyus/corporate_responsibility/pdf/2015/Kelloggs_CRR_2014_GRI_Index.pdf)

1 Hershey included a GRI index at the end of its CSR report

<https://www.thehersheycompany.com/content/dam/corporate-us/documents/csr-reports/2014-hershey-csr-report.pdf>

1 J. M. Smucker provided a CSR report.

<http://bit.ly/2fh8TV4>

1 Brown-Forman provided a CSR report.

[http://www.brown-forman.com/wp-content/uploads/2014/08/BF\\_scorecard\\_2013-14.pdf](http://www.brown-forman.com/wp-content/uploads/2014/08/BF_scorecard_2013-14.pdf)

1 General Mills included a GRI index at the end of its CSR report

[https://www.generalmills.com/~media/Files/GRR/2014\\_global\\_respon\\_report.pdf?la=en](https://www.generalmills.com/~media/Files/GRR/2014_global_respon_report.pdf?la=en)

1 Pepsico, Inc. provided sustainability reports and separate GRI reports.

<http://www.pepsico.com/Purpose/sustainability-reporting>

1 Coca-Cola provided a sustainability report.

<http://www.coca-colacompany.com/content/dam/journey/us/en/private/fileassets/pdf/2015/09/2014-2015-sustainability-report.pdf>

1 Coca-Cola also provided 2011/2012 GRI report

<http://www.coca-colacompany.com/content/dam/journey/us/en/private/fileassets/pdf/2015/09/2012-sustainability-report.pdf>

Company	Water Withdrawal	Water Consumption	Water Recycle	Water Discharge
Kellogg	No	Gallons/per metric ton of food produced Y2010: 1363.13 Y2011: 1355.20 Y2012: 1344.64 Y2013: 1423.89 Y2014: 1408.04 Y2015(GOAL): 1275.95–1355.20	No	No
Hershey	Percentage from ground Y2014: 57.2% Y2013: 60.0% Y2012: 70.8%	Gallons/pounds of product produced--- Gallons/Metric ton of product Y2014: 700---0.3175 Y2013: 660---0.2994 Y2012: 980---0.4445	No	Gallons Y2014: 431,176,000 Y2013: 504,342,000 Y2012: 405,923,000
J. M. Smucker	Cubic Meters Y2014: 3,666,719 Y2009: 5,051,945	No	No	No
General Mill	Cubic Meters Y2011: 10300 Y2012: 10000 Y2013: 10000 Y2013: 16200	Gallons/Metric ton of product Y2011: 686.8472 Y2012: 660.43 Y2013: 1056.688	No	No

<sup>2</sup>Illustrative disclosures included in table.



Company	Water Withdrawal	Water Consumption	Water Recycle	Water Discharge
Brown-Forman	Y2014: 9800 Y2014: 15600 No	Y2014: 1003.8536 Million Gallons Y2011: 866 Y2012: 866 Y2013: 884 Y2014: 815	No	No
Pepsico, Inc.	Water withdrawal performance by percentage since Y2006 is provided.	Millions of cubic meters Y2010: 101.5 Y2011: 101.1 Y2012: 99.0 Y2013: 96.9 Y2014: 95.9 Y2015: 92.7	Maximize water reuse in high-water-risk areas and ensure that 100 percent of wastewater from our operations meets PepsiCo's high standards for protection of the environment.	No
Coca-Cola	Details provided in its 2011/2012 GRI report to meet the water withdrawal (EN8) disclosure.	Details provided in its 2011/2012 GRI report to meet the water consumption (EN9) disclosure.	Details provided in its 2011/2012 GRI report to meet the water recycle (EN10) disclosure.	Details provided in its 2011/2012 GRI report to meet the water discharge (EN21) disclosure.

1 Coca-Cola further provided Water Stewardship and Replenish Reports  
<http://www.coca-colacompany.com/packages/water-stewardship-replenish-report.html>

**Appendix 2. Each Firm’s Water Withdrawal, Water Consumption, Water Recycle and Water Discharge Disclosures from their Corporate Social Responsibility Reports<sup>2</sup>**

**Appendix 3. Some Qualities Claimed to be Illustrated by Water Disclosure Behavior**

**HERSHEY (2014 CSR): Employee Involvement:**

‘Steps: work with individual facilities to understand their water demand-----query water suppliers and regulatory agencies to monitor conditions and regulations-----track a variety of water assessments’ (p. 34).

**BROWN FORMAN (2013–2014 CSR): LEADERSHIP, SUSTAINABILITY ROADMAP:** In May 2011, BF became the first beverage alcohol company to join the Ceres Company network. Joining the organization has enabled The firm to tap into a diverse group of environmental sustainability experts...(p. 43).

**JM SMUCKER: 2014 CSR:** Responsible sourcing: leadership: membership in The Sustainability Consortium (TSC); conduct a water risk analysis in seven key company supply chains (p. 30).

**GENERAL MILLS: 2014 GRR: Economic Performance:** Strategy: Fostering and engaging in watershed stewardship plans-----General Mills follows a four-step sustainable sourcing model – assessment, strategy formation, transformation and monitoring/evaluation (p. 52, 66, 67).