EXPLORING THE DEVELOPMENT OF A CONTEXT-BASED COMPOSITE ENVIRONMENTAL SUSTAINABILITY INDICATOR FOR THE BREWING INDUSTRY

by

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Abstract

Exploring the Development of a Context-based Composite Environmental Sustainability Indicator for the Brewing Industry

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This research explores environmental reporting in the brewing industry through collecting the indicators breweries are reporting on and determining the extent of science-based environmental targets in reports. A content analysis of brewery websites and public reports was conducted to collect the environmental indicators and targets of breweries. This information was used to inform the development of a brewery-specific environmental composite-indicator framework and to answer the following: Are the indicators breweries report enough to measure environmental sustainability in relation to global limits? The composite-indicator framework draws from the Planetary Boundaries (i.e., global limits) and subsequently developed Planetary Quotas as the basis for setting its indicator targets. It was found that some breweries are reporting on many industry-relevant areas of environmental importance and using science-based emissions targets. However, supply chain contributions (e.g., agriculture) are not fully considered when reporting, which leads to a lack of necessary information when calculating global environmental impacts.

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Table of Contents

Author's Declaration ii

Abstract iii

Acknowledgements iv

List of Tables viii

List of Figures ix

List of Equations x

List of Appendices xi

1.0 Introduction 1

1.1 The Brewing Industry and Context-based Sustainability 3

1.2 Motivations and Research Questions 5

1.3 Overview of the Thesis 7

2.0 Literature Review 8

2.1 Context-based Sustainability and the Planetary Boundaries 8

2.2 Corporate Social Responsibility 12

2.3 Isomorphism, Legitimacy Theory, and Organizational Façades 13

2.4 Initiatives for Sustainability Reporting 16

2.5 Sustainability in the Brewing Industry 21

2.6 Using the Planetary Boundaries to Assess Sustainability Reporting 23

2.7 Using Composite-Indicators to Measure Sustainability 25

2.8 Translating the PBs to the Corporate Scale Through Composite-Indicators 28

3.0 Methods 34

3.1 Content Analysis 34

3.1.1 Company Selection 36

3.1.2 Report and Website Collection 37
3.1.3 Sample Content Analysis and Intra-Rater Reliability Test 38
3.1.4 Collecting Indicators and Targets 38
3.1.5 Indicator Categorizing 41
3.1.6 Target Categorizing 41
3.1.7 Assigning Associated PBs to Indicators and Targets 42
3.1.8 Finding Unique Indicators and Targets 44
3.2 Composite-Indicator Development 45
3.2.1 Definition of Activity 47
3.2.2 Quantification of Environmental Pressure 49
3.2.3 Comparison of Pressure to Carrying Capacity 52
3.2.4 Presentation of Results 55
4.0 Results 56
4.1 Content Analysis 56
4.1.1 Indicators 56
4.1.2 Representation of the PBs in brewery indicator reporting 61
4.1.3 Targets 62
4.1.4 Range and degree of context in target-setting 65
4.1.5 Representation of the PBs in brewery target reporting 67
4.2 Composite-Indicator 68
4.2.1 Climate Change 69
4.2.2 Biosphere Integrity 71
4.2.3 Land System Change 72
4.2.4 Freshwater Use 76

4.2.5 Biogeochemical Flows 78
4.2.6 Ocean Acidification 83
4.2.7 Atmospheric Aerosol Loading 83
4.2.8 Stratospheric Ozone Depletion 87
4.2.9 Novel Entities 87
4.2.10 Bringing Together the Composite Indicator 89
5.0 Discussion 91
5.1 Content Analysis 91
5.2 Composite-Indicator 91
5.3 CSR Reporting and Institutionalized Practices 93
5.4 Environmental Indicators and Targets 94
5.5 Considering Planetary Boundaries 95
5.5.1 Positive Aspects of Report Trends 95
5.5.2 Negative Aspects of Report Trends 96
5.6 Gaps in Reported Information 97
5.7 Contributions 98
6.0 Conclusions 101
6.1 Addressing the Research Questions 101
6.2 Limitations 102
6.3 Future Work 103
Appendices 105
References 180

List of Tables

Table 1: The Planetary Boundaries and their associated indicators, adapted from Steffen et al. (2015b). 10
Table 2: Environmental initiatives relevant to the brewing industry. 16
Table 3: Summary of previous brewery sustainability models. 26
Table 4: Literature review research summary. 29
Table 5: Steps for conducting a content analysis, adapted from Krippendorf (2004). 35
Table 6: Examples on assigning PBs to indicators and targets. 43
Table 7: Most frequently reported environmental sustainability indicators noted by the content analysis (n≥5). 56
Table 8: Most common reported environmental sustainability targets among analyzed breweries. 62
Table 9: Frequency of target categories among breweries. 64
Table 10: Average distribution of target types among breweries who reported at least one environmental target. 66
Table 11: Variables and values used in PQ composite-indicator calculations. 68
Table 12: Indicators collected with impacts on land use. 73
Table 13: Nitrogen released to the environment using a range of values for yield, nitrogen application, and crop nitrogen retention/seepage. 79
Table 14: Spring barley data for phosphorus losses compared to field application, A and B (Tidaker et al., 2016) and the high and low loss values for fallow barley and grass ley C and D (Yläranta et al., 1996). 82
Table 15: Sources and reported indicators for aerosol emissions. 84
Table 16: Summary of the sub-indicator calculations 89

List of Figures

Figure 1: Outline of research methods, developed from Bjørn et al. (2019), Meyer and Newman (2018), Burgass et al. (2017), OECD (2008b), and Krippendorf, (2004)....................................... 34
Figure 2: Content analysis indicator collection decision chart. 40
Figure 3: Outline for developing a context-based environmental sustainability composite-indicator, adapted from (Bjørn et al., 2019).. 47
Figure 4: Unique indicators in each environmental category. 57
Figure 5: Frequency of category appearance among unique targets. 64
Figure 6: Portion of breweries reporting environmental targets with a given combination of target types representing environmental context. 66
Figure 7: The number of companies reporting targets that affect a given PB. 67
Figure 8: Count of targets focusing on each PB... 68

List of Equations

Equation 1: Using contribution to value-added to determine percent allocation of the PQs for the brewing industry using 2017 data. 50

Equation 2: Allocation of planetary quotas to the brewing industry. 50

Equation 3: Brewing company production relative to global beer production to assess brewing-company-specific value added using 2017 data for Carlsberg. 51

Equation 4: Applying brewing company value-added to the PQs. 51

Equation 5: Distance to a reference calculation for each normalized variable (OECD, 2008b). .. 52

Equation 6: Composite indicator aggregation using equal weighting. 89

List of Appendices

Appendix A: Content Analysis Documents and Webpages Analyzed 105

Table 1: Summary of brewing company reports and webpages, used for the content analysis completed Spring 2019. 105

Table 2: The categories and degree of PB referencing found during content analysis for brewing company environmental targets. 107

Appendix B: Industry Interviews 109

Table 3: Steps for the industry interview phase. 109

Appendix C: Brewery Data Collected 123

Table 4: Environmental targets collected during the content analysis (duplicates within companies have been merged). 123

Table 5: Environmental indicators collected during the content analysis (duplicates within companies have been merged). 131

Appendix D: Composite-Indicator Options 170

Equation 7: Calculating the value for the minimum variable value. 170

Equation 8: Minimum-maximum calculation for each normalized variable (OECD, 2008b). . 170

Appendix E: Composite-Indicator Calculations and Reference Values 174

Table 6: Input values for PQ normalization calculations. 174

Equation 9: Barley required to be harvested per year for a given beer production 176

Equation 10: Calculating leached active nitrogen from Tidaker et al. (2016) data 177

Equation 11: Calculating leached active nitrogen using literature values for yield, nitrogen application and nitrogen retention 177

Equation 12: Calculating phosphorous to the environment using literature values for yield and phosphorous leaching rates 178

1.0 Introduction

The maintenance of modern society as we know it is owed to the predictable climate of the Holocene which has allowed for human expansion through the increase of habitable regions (Steffen et al., 2015b; Steffen et al., 2005). However, the resilience of our environment is under threat by human-driven climate change and anthropogenic environmental damage that are pushing the limits of the ecological systems that have allowed humans to thrive, i.e., the Earth system (Steffen et al., 2015a).

This disruption of the Earth system is pushing beyond the stability and limitations of the Holocene epoch (Rockström et al., 2009). Global-scale limits have been developed to measure these changes: The Planetary Boundaries (PBs) (Rockström et al., 2009). These boundaries and their limits have since been updated and include climate change, biosphere integrity, land-system change, freshwater use, biogeochemical flows, ocean acidification, atmospheric aerosol loading, stratospheric ozone depletion, and novel entities (Steffen et al., 2015b).

Corporations are focusing more than ever on their environmental impact and the principle of ecological resilience has been making its way into models for corporate sustainability (Davidson, 2011; Whiteman et al., 2004). Ecological resilience is a term used to help represent the non-linear dynamics of ecosystems. It is defined as “the amount of disruption an ecosystem could withstand”, beyond which the processes of that ecosystem are changed and cannot recuperate, thus existing in a new pseudo-steady state (Gunderson, 2000, p.425). This potential for non-reversible impacts to the Earth system and the eco-services it provides has caught the attention of many. While these environmental disruptions and their impact on the Earth system are a growing threat, an opportunity has been created for organizations to take the lead and rise to the challenge (Woodward, 2019).

Consumer awareness regarding the environment and social inequities are driving corporate greening and companies have turned towards green design, production, and marketing strategies (Cherian & Jacob, 2012). These efforts can be made internally, such as reducing pollution or energy consumption, or externally such as monitoring supply chain activities (Kleindorfer et al., 2005; Cronin et al., 2011). Bansal and Roth (2000) explained the key reasons why companies undertake green activities: competitiveness, legitimation, and ecological responsibility. Isomorphism explains the powerful drive of companies to become more similar in their institutionalized practices, influenced by factors such as stakeholder values and industry competition (DiMaggio & Powell, 1983). These practices can take the form of activities such as environmental reporting and green marketing. The current understanding of corporate behaviour shows that through isomorphism, large-scale shifts in business practices can evolve including promotion of CSR[1] reporting (Bondy, 2009; DiMaggio & Powell, 1983; Meyer & Rowan, 1977). But what is the supposed goal of these practices?

Sustainability – its definition varies from source to source and tends to develop according to a given institution's objectives (Mebratu, 1998). Overall, these definitions tend to embody a mindset of keeping use of a resource (be it environmental, financial, or social) below a level beyond which would eventually exhaust it or diminish its quality.

Mebratu (1998) argues that sustainability is defined by its roots in resource scarcity and the theory of environmental limits; that a holistic or systems approach should be the lens through which sustainability is defined. Strong sustainability allocates a unique value to natural capital such that it cannot be fully substituted with economic capital (Ekins et al., 2003; Mavrommati et al., 2016). Ekins et al. (2003) goes on to state that "without the 'functions of' natural capital, no other category of functions would be able to exist on a sustained and systemic basis" (p.170). This further reinforces the need to emphasize the importance of natural capital and its limits when discussing sustainability. The idea of strong sustainability, which is focused on natural capital being of utmost importance and essential to the function of both social and economic capital, will be the focus of this research (Pelenc et al., 2015).

[1] As terms have become blurred and used interchangeably over recent years, Corporate Social Responsibility (CSR) is often used synonymously with Environmental, Social and Governance, Corporate Sustainability (CS), and Corporate Ethics and tends to refer to the triple bottom line (environmental, social and economic aspects) (Bansal & Song, 2017; Boerner & Coppola, 2017). However, CSR was founded in a need for markets to serve society and through a normative approach while CS was founded in environmental management through a systems approach (Bansal & Song, 2017). While CSR and CS have different backgrounds, modern uses tend to have the same goals in mind (Montiel, 2008).

Most relevant to this research is the idea of Corporate Sustainability. Corporate Sustainability (CS) can been defined as the contributions, actions, goals, and strategies an organization employs to contribute to sustainable development (Meuer et al., 2019). CS has historically focused on social and environmental issues and is a key factor when discussing the reporting habits of corporations (Montiel, 2008). Those who research CS have found two main perspectives: environmental sustainability and the triple bottom line (Montiel, 2008). However, these two approaches should not be confused. CS may find its roots in a systems approach with focus given to the environmental impacts of industry and society, but its use has increasingly overlapped with CSR in recent years (Bansal & Song, 2017). The two terms have converged and their definitions have blurred over time; they are now both used to discuss impacts on society, the economy, and the environment (Bansal & Song, 2017). However, Milne and Gray (2013) have argued that the TBL, currently associated with both CSR and CS, may do more harm than good when it comes to the pursuit of sustainability. In theory, its application should result in more sustainable business practices, however in practice can result in limited environmental action and can miss the sustainability mark. As definitions for CSR and CS have merged, so has the idea that the TBL approach represents sustainability (Milne & Gray, 2013). Context-based sustainability is a way to counter simply accounting for social, environmental, and economic impact and instead pursues thresholds external to the company, such as science-based limits, and places them within the context of broader social responsibilities (McElroy & van Engelen, 2012). This research aims to apply the context-based sustainability approach.

1.1 The Brewing Industry and Context-based Sustainability

Beermann (2011) argues that mitigating global environmental challenges cannot be solely the responsibility of government but that corporations must also contribute. The brewing industry provides an interesting case to study this challenge. The brewing industry is global, is dominated by a relatively small number of large companies, and some of its key environmental impacts have clear linkages to the PBs. The activities of breweries can impact several of the PBs through their reliance on fresh water, agricultural land, and energy sources, as well as the waste generated by packaging (Cordella et al., 2008). The global reach of the brewing industry as well as that of individual brewing companies lends itself to applying the PBs to environmental sustainability measurement. Moreover, as explained by Jones et al. (2013), members of the brewing industry, specifically large breweries, are increasingly incorporating CSR into their businesses and mention environmental concerns in their public reporting. This can take the form of sustainability reports[2] or webpages.

When it comes to the content of these reports, corporations may choose to report their environmental performance in terms of metrics or indicators[3]. These metrics may be absolute or relative. For example, an absolute metric for water is overall water use, while the associated relative metric could be water use per unit of product. Context-based metrics go a step further by relating a relative metric to what the norms, standards, or thresholds are to ensure sustainability (McElroy & van Engelen, 2012). These norms, standards, or thresholds are reference points that can be used to relate progress to and may be based on science (e.g., Paris Agreement), socially accepted norms, or obligations (e.g., maintaining standards for a certification). As explained by McElroy (2015), science-based metrics are those founded in scientific knowledge and may relate to a threshold but do not necessarily account for equitable division of a resource. Context-based metrics are then developed through the equitable division of a science-based metric.

Both science- and context-based goal setting can be open to considerable debate, but well-established scientific reference points, such as the PBs, provide a strong basis for exploring setting overall thresholds to be used in metrics. In the case of the PBs, they have the power to contribute the thresholds and therefore the scientific foundation of a context-based metric. In turn, these metrics can go on to form the variables of composite-indicators that address the concerns of the depletion of the Earth system by incorporating targets derived from the PBs. Composite-indicators can be used to compare entities, such as countries or companies, on issues that are multifaceted by combining the contributing factors into a single comparable

[2] A report published by a company or organization containing quantitative and qualitative information on the economic, environmental and social efficiency and improvement for the given reporting period and relevant impacts caused by its activities (GRI, 2019; Daub, 2007).

[3] Metrics and indicators are qualitative or quantitative measurements used to understand and track company performance. Some of these measurements are given high status and are said to be representative of performance in a given area: key performance indicators.

value (OECD, 2008b). This allows for an overview on issues that are much more complex, such is the case with environmental sustainability.

1.2 Motivations and Research Questions

There exists disconnect between corporate reporting and the natural sciences (Whiteman et al., 2013; Bansal & Hoffman, 2012). It has been argued that "Business management literature remains focused on understanding the social, organizational, or institutional implications of corporate sustainability, in isolation from quantitative indicators of ecosystem functioning" (Whiteman, et al., 2013, p.308). Whiteman et al. (2013) argues that the social, economical, and institutional theories are incomplete without incorporating ecological knowledge as it continues to evolve. This research aims to quantify this disconnect through studying brewing companies, specifically those most likely to be reporting environmental indicators and targets: large companies with the resources to publish reports and brewing companies that have committed to environmental sustainability management (i.e., B Corporation[4] breweries and brewery members of the Beverage Industry Environmental Roundtable). The purpose of this study is to observe the reporting habits of brewing companies in relation to their environmental impact and compare the reported data to global ecological limits. This study aims to fill a research gap that exists for both the environmental reporting habits of brewing companies and the intersection of sustainable development and addressing the degradation of the natural environment (Whiteman et al., 2013; Reid et al., 2010).

Despite the increasing research on science-based targets and the general approval of recognized reporting guidelines, little is known about the extent to which these are influencing company reporting. Is there any consistency among the environmental indicators and targets reported by brewing companies? As science-based targets become more common, are brewing companies adopting them in their reporting?

Based on the above, research question 1 is proposed:

[4] B Corporations "are legally required to consider the impact of their decisions on their workers, customers, suppliers, community, and the environment" (B Corporation, 2019).

RQ1. What context-based environmental information is publicly disclosed by brewing companies?

Reporting on company environmental impact is becoming institutionalized through corporate social responsibility reporting (de Villiers & Alexander, 2014). As this trend continues, some have argued that simply reporting on the triple bottom line (economic, social, and environmental issues) is not representative of true sustainability (Milne and Gray, 2013).

Composite-indicators for assessing brewing company sustainability have been developed but have included a combination of social, environmental, and economic variables and tend to rely on comparing company performance between companies rather than to science-based limits. While composite-indicators can be used to give a good summary of complex systems, as environmental sustainability is, they are open to critiques of transparency (OECD, 2008b). It may be therefore be argued that environmental impact deserves separate consideration when discussing sustainability. Additionally, as these previous models have been based on ranking companies by internal efficiency or industry benchmarks, environmental context has been lacking.

The Planetary Boundaries provide a way to quantify contributions to environmental degradation and represent a scientific component for context-based environmental sustainability. They hold the potential to be used as a basis of comparison and to represent the holistic and systems approach advocated for when considering corporate environmental impact (e.g., Whiteman et al., 2013). The subsequently developed Planetary Quotas[5] (PQs) allow for the responsibility of managing the Planetary Boundaries to be divided and quantified (e.g., individual, country, or corporate basis) and can be used to assign quantitative limits that can be compared to reported brewing company data. But are companies reporting on enough information to determine their sustainability?

[5] "The Planetary Quotas are limits for human activity, derived from the Planetary Boundaries" (Meyer & Newman, 2018, p.1). They have been developed to allow for dividing the responsibility for managing global ecological limits. Some examples include forestland with deforestation as the control variable, water with net water consumption as the control variable, and carbon dioxide with net CO_2 emissions as the control variable (Meyer & Newman, 2018).

Based on the above, research question 2 is proposed:

RQ2. Are the public disclosures of brewing companies sufficient to develop a context-based composite environmental indicator?

1.3 Overview of the Thesis

Chapter 2 of this thesis discusses background literature, relevant studies, and organizations related to this research. Chapter 3 then discusses the methods used. Chapter 4 displays the results of this research. Chapter 5 compares results to the literature and discusses main findings. Chapter 6 summarizes the main conclusions of this research and discuss future work.

2.0 Literature Review

This literature review consists of background information on climate change and environmental impacts, the Planetary Boundaries, corporate theory, and current corporate environmental sustainability reporting guidelines. Also discussed is previous research on environmental sustainability in the brewing industry, context-based sustainability in corporate reporting, and using the Planetary Boundaries to assess corporate environmental sustainability.

The current geological era that the Earth is in is the Holocene epoch, defined by the end of the last ice age within the last 11,700 years (Steffen et al., 2015b). Human-driven effects on the Earth system have been documented: a "Great Acceleration" of human influence on the environment has been noted through the relatively recent rapid increase of several Earth system indicators (Steffen et al., 2015a; Steffen et al., 2011). The ability to track Earth system indicators has been used to demonstrate the effectiveness of environmental policies (e.g., the Montreal Protocol) (Steffen et al., 2011). This kind of big-picture thinking is essential to add meaning to the way companies track their environmental performance.

2.1 Context-based Sustainability and the Planetary Boundaries

According to McElroy and van Engelen (2012), the sustainability of a given entity cannot be assessed without reference to the broader context in which an organization operates. McElroy and van Engelen (2012) define this "context-based sustainability" as a three-step process: 1. identifying vital capitals and their carrying capacities related to maintaining and seeking stakeholder well-being. In the case of environmental sustainability, vital capitals are the natural capitals on which society depends, and whose functions are not interchangeable with human-made capitals (Mavrommati et al., 2016). Carrying capacity is "the maximum 'load' than can safely be imposed on the environment by people" (Rees, 1996, p.197); 2. determining the appropriate population to task with managing the carrying capacities. Most often, natural resource management takes place at the regional scale, thus carrying capacity management makes sense to be tasked here as well (Dearing et al., 2014); 3. allocating appropriate shares of these capitals as well as burdens for maintenance[6]. The three allocation methods adopted with strong sustainability in mind are Gross Value Added (GVA), grandfathering, and societal cost minimization (Bjørn & Røpke, 2018). GVA determines the "fair" amount of carrying capacity to be allocated to a company, from that company's share of the gross world product. Grandfathering allocates carrying capacity based on the company's share of total environmental pressures over the past year. Societal cost minimization states that "the 'burden' of any reduction in resource use or pollution needed to respect carrying capacity is inversely proportional to the economic cost of reduction at the margin" (Bjørn & Røpke, 2018, p.212). Krabbe et al. (2015) developed the societal cost minimization method (Sectoral Decarbonization Approach) to be used for GHG emissions and sets decarbonization targets based on global targets, sector, and current performance.

In summary, the "context" comes from the combination of a science-based limit for resource use (carrying capacity) and "fair" allocation of the resource among users.

One of the challenges of context-based sustainability is determining which reference point to use when determining carrying capacity. Fortunately, credible reference points are beginning to emerge, the most prominent of which is arguably the PBs. Both Steffen et al. (2015b) and Rockström et al. (2009) draw attention to the importance of understanding environmental sustainability from a global perspective and defining thresholds, such as those focused on ocean acidification, land use, and global freshwater use. This concept has a goal of directing societal development to keep anthropogenic activities within the "Planetary Boundaries" which, in the case of Steffen et al. (2015b), are defined as a line "below which the risk of destabilization of the Earth system is likely to remain low – 'a safe operating space'" (p.736). Although the PBs were originally designed for application at the global level, there is a growing recognition they can provide a reference point for corporate sustainability as well (Butz et al., 2018; Meyer & Newman, 2018; Whiteman et al., 2013). The Planetary Boundaries and their associated indicators are shown below in Table 1.

[6] In this case, the responsibility to manage impact such that environmental capitals are not depleted.

Table 1: The Planetary Boundaries and their associated indicators, adapted from Steffen et al. (2015b).

Planetary Boundary	**Indicators**
Climate change	Atmospheric CO_2 concentration, ppm Energy imbalance at top-of-atmosphere, W/m^2
Biosphere integrity	Genetic diversity – Extinction rate, E/MSY Functional diversity – Biodiversity Intactness Index, %
Land-system change	Global – Area of forested land as % of original forest cover Biome – Area of forested land as % of potential forest
Freshwater use	Global – Maximum amount of consumptive blue water use, km^3/year Basin – Blue water withdrawal as % of mean monthly river flow
Biogeochemical flows	Phosphorus Global – P flow from freshwater systems into the oceans, Tg P/year Phosphorus Regional – P flow from fertilizers to erodible soils, Tg P/year Nitrogen Global – Industrial and intentional biological fixation of N, Tg N/year
Ocean acidification	Carbonate ion concentration, average global surface ocean saturation state with respect to aragonite, Ω_{arag}
Atmospheric aerosol loading	Global – Aerosol Optical Depth (AOD) Regional – AOD as seasonal average over a region
Stratospheric ozone depletion	Stratospheric O_3 concentration, DU
Novel entities	No control variable currently defined

As the Earth system is being deteriorated beyond its resilience, Whiteman et al. (2013) discusses the need to frame corporate impact in terms of the PBs. Despite the multitude of corporate "greening" efforts, the Earth system remains in peril. Researchers have taken note and the "translation" of these PBs from global boundaries to corporate usability is already underway (e.g., Butz et al., 2018; Meyer & Newman, 2018). Albeit with some assumptions, values for corporate contribution to the PB indicator thresholds have been determined which also take into account the idea of "fair" distribution (Butz et al., 2018). The work of Butz et al. (2018) showed that using the PBs to guide environmental sustainability action at the corporate level is possible and has begun to address the concerns brought to light that express need for research that measures the impact of corporations on PBs (Whiteman et al., 2013). Additionally, Meyer and Newman (2018) have argued for a multi-scalar approach when it comes to environmental management and have developed the Planetary Quotas (PQs), based on the PBs, which are global allowances designed to be allocated among users when considering environmental sustainability.

The PBs are boundaries developed by Rockström et al. (2009) and updated by Steffen at al. (2015b). They were generally intended to measure the "state" of the Earth system through estimating suitable ranges for the indicators mentioned in Table 1. They are based on the idea that the Earth system is resilient and that Holocene-like conditions are maintainable as long as these indicators remain within a given range. These limits have the potential to drive change; however, the PBs only represent a snapshot of the current conditions relative to their "safe range", and do not set a target directly relatable to human actions.

As a way to "translate" these global limits in such a way that can be used to influence change at various scales (e.g., national, corporate, community) the PQs have been developed by Meyer and Newman (2018). They have related the "state" based PBs into "pressure" based global limits. For example, the PB indicator for climate change, atmospheric CO_2 concentration, has been translated to CO_2 emissions/year. This PQ target is set such that if it is met, the atmospheric CO_2 concentration PB will be met by the end of this century. These PQs are also meant to be divisible such that responsibility for maintaining human impact below these global ecological limits can be divided at various scales.

In this research, the brewing industry will be examined. It has direct ties to several PBs, is an industry with global reach, and research on its impacts has generally been limited to triple bottom line composite-indicators, life cycle assessments, and qualitative accounts of environmental initiatives (e.g., Kasem et al., 2015; Olajire, 2012; Tokos et al., 2012; Zhou et al., 2012; Cordella et al., 2008). As current research is starting to look at the extent to which companies are accounting for ecological limits within their sustainability activities (Bjørn et al., 2017), this research provides a case of applying environmental sustainability models theorized by Meyer and Newman (2018) and Bjørn et al. (2019).

Models, such as that suggested by Meyer and Newman (2018), if adapted for breweries, could provide a basis for moving science-based reporting beyond current initiatives, which focus on GHG emissions goals (i.e., Science Based Targets, 2018).

2.2 Corporate Social Responsibility

Companies have been increasing their participation in corporate social responsibility (CSR) by reporting on social and environmental issues, but it was still often not a top priority for those in a position to change company policy (Rangan et al., 2012). The global trend towards reporting can be attributed to the associated added value for the company, as well as the mimicking behaviours of companies, but does not guarantee quality (de Villiers & Alexander, 2014). As of 2013, 93% of the largest 250 corporations in the world carried out CSR reporting; however, quality and consistency are still lacking (Cao et al., 2016; Danish Business Authority, 2013; Danwatch, 2011).

There are four main carriers for transmitting CSR: symbolic systems, relational systems, routines, and artifacts (Scott, 2001). Symbolic systems are expressed as standards including a company's policies and code of ethics. Relational systems refer to expectations of social positions, e.g., hiring CSR specialists. Routines, or habits based on unarticulated knowledge, refers to activities including automatic annual charitable donations or using recycled paper products in the office. Artifacts are easy to identify and are defined as material culture from human ingenuity, for example, pollution prevention systems or sustainable agriculture techniques (Bondy, 2009; Scott, 2001).

When a company produces a CSR report, they tend to detail their impact on the environment and society, and strategies for improvement in the future. However, the forces influencing the decisions made by companies when publishing reports may not indicate a strong foundation in sustainability. “The pursuit of ‘eco-efficiency’ is often driven mainly by financial concerns but presented as an environmental endeavor for marketing and corporate social responsibility (CSR) reasons” (McKinnon & Pieck, 2012, p.629).

Some of the goals of sustainability reporting include legitimizing corporate activities related to environmental and social impact, increasing reputation, using sustainability reporting to show superior performance, comparing against competition, showing transparency, and attracting and motivating employees (Herzig & Schaltegger, 2016; Searcy & Buslovich, 2014). These motivators may reference environmental impact, but instead of focusing on ecological wellbeing, are rooted in legitimization, a corporate- or industry-centric approach. The overarching goals seem to be showcasing and then justifying the current ways in which they are trying to improve their impact in relation to the competition.

Several countries also have sustainability reporting guidelines or regulations, typically meant for large companies. In 2016, Global Reporting (2016) found 383 sustainability reporting instruments globally. These instruments were either mandatory, or guidelines-based and were implemented by government, a financial market regulator, or stock exchange. They required formats for reporting such as sustainability reports, integrated reports, or annual reports and either focused generally on sustainability or specified environmental or social requirements. Environmental reporting instruments have been added alongside GHG emissions data requirements as GHG markets and regulations emerge. These reporting instruments varied by market and by country and had a range of requirements and guidelines for companies (Global Reporting, 2016). Sustainability reporting requirements and guidelines have continued to expand since 2016, such as the European Union (EU) requirement for large companies to report on social end environmental matters, which came into effect in 2018 (European Commission, 2020).

2.3 Isomorphism, Legitimacy Theory, and Organizational Façades

Isomorphism, in the context of corporations, refers to the tendencies of institutions to mimic their surroundings and, in doing so, incorporate external elements into their practices (Meyer &

Rowan, 1977; de Villiers & Alexander, 2014). The current understanding of corporate behaviour shows that through isomorphism, large-scale shifts in business practices can evolve including promotion of CSR reporting (Bondy, 2009; DiMaggio & Powell, 1983; Meyer & Rowan, 1977). This theory is based on the idea that to remain legitimate, corporations must partake in activities that either are already accepted as the norm for businesses, or those that are on their way to becoming institutionalized. In terms of the influence of outside sources on a firm, isomorphism is considered inevitable and has more impact the larger and more bureaucratic a corporation becomes (DiMaggio & Powell, 1983).

Legitimacy theory states that companies must or tend to act in ways that can confirm their legitimacy[7] in society (Cho et al., 2015; de Villiers & Alexander, 2014). It can therefore have a major impact on their reporting styles as reports act as a main source of interaction between the corporation and stakeholders. Current trends show that companies are increasing their reporting to remain legitimate as the practice becomes institutionalized, but this does not mean that quality reporting is increasing (Cho et al., 2015). Because reporting on context is not common, the reporting frameworks becoming institutionalized are not addressing sustainability. While sustainability and sustainable development have been commonly discussed in sustainability reports, the foundations of environmental sustainability have been left virtually untouched (i.e., issues of footprint, carrying capacities, development scale and its limits and constraints) (Milne & Gray, 2013).

Additionally, because of the voluntary system for reporting, companies may disclose what they choose, thus further allowing the process to be used as a means to change their appearance to stakeholders without much internal transformation (Cho et al., 2015).

This change of appearance can be observed as organized hypocrisy[8], which, born from the desire to satisfy conflicting demands from several stakeholders, results in this misalignment of

[7] "Legitimacy is a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (Suchman, 1995, p.574).

[8] "Organized hypocrisy attempts to explain the discrepancies between a corporation's talk, decisions, and actions, and how these discrepancies may allow for corporations flexibility in their management of conflicting stakeholder demands" (Cho et al., 2015, p.79).

corporate talk and actions (Cho et al., 2015). Adams (2004) points to shareholder accountability as opposed to stakeholder accountability as the root of this issue. This misalignment in accountabilities can encourage organizational façades[9], which were originally theorized only to exist to create legitimacy in the eyes of the organization's stakeholders (Cho et al., 2015). Misalignment of actions and values and organizational hypocrisy have been seen clearly when comparing a company's many façades[10], which can present opposing sets of goals and values (Cho et al., 2015). Some examples of façades include ceremonially adopting ISO 9000 Quality Management Standards, following GRI reporting standards, or reporting on the triple bottom line (TBL) (Cho et al., 2015; Milne & Gray, 2013).

When discussing the TBL, Milne and Gray (2013) has argued that its success may be due more to its ability to interact with stakeholders than its actual influence on the economic, social, and environmental impacts of a company, thus fulfilling the role of an organizational façade and maintaining a company's status as "legitimate" in the eyes of society. Beyond its use as a legitimacy tool, it may be doing little to improve company performance. Milne and Gray (2013) challenge the TBL's ability to sufficiently move society towards a truly sustainable future. The idea that sustainable development involves the economy, society, and the environment has melded into the idea that the TBL represents sustainability. While the intentions of the TBL may be to guide corporations towards considering their impact, it holds the potential to drive corporate action away from "sustainability" through misrepresentation. When these methods of reporting do not necessarily align with the actions of companies and are simply façades used to appease certain groups of stakeholders, it has been argued that the system itself needs to change (Adams, 2004). Attaining legitimacy in CSR reporting should require reporting on a

[9] "A symbolic front erected by organizational participants designed to reassure their organizational stakeholders of the legitimacy of the organization and its management" (Abrahamson & Baumard, 2008, p.437).

[10] A rational façade facilitates market legitimacy and feeds into the necessity of following rational market norms (Cho et al., 2015; Meyer and Rowan, 1977). A progressive façade allows organizations to discuss new ideas for improvement without commitment to changing the organization's fundamental decision-making strategies or creating realistic and feasible plans of action. A reputational façade represents the image of a company through symbols and language common in codes of ethics or mission statements (Cho et al., 2015).

company’s actual sustainability, which further enforces the need to use reference points (i.e., PBs).

2.4 Initiatives for Sustainability Reporting

Inconsistency in reporting can make it hard to compare companies as well as gauge their performance over time. This has led to the development of international guidelines and the creation of global organizations focused on sustainability reporting.

Some examples relevant to the brewing industry include the Global Reporting Initiative (GRI) and the CEO Water Mandate. Moreover, for companies that wish to participate in programs that align with the United Nations Sustainable Development Goals, making water-resources management a priority is a clear responsibility for companies in the brewing industry (United Nations, 2018).

Context-based sustainability is increasingly being incorporated into global standards and other initiatives relevant to sustainability reporting in the brewing industry. For example, the GRI Standards state that reports “shall present the reporting organization’s performance in the wider context of sustainability” (Global Reporting Initiative, 2016, p.9). In order to apply this, the report must articulate the company’s performance as related to the greater context of sustainability, both locally and globally depending on the outcome of the factor to be discussed, i.e., global resource use or pollution limits (Global Reporting Initiative, 2016). This principle paired with the GRI Standards shows that the idea of adding sustainability context into reporting is becoming more mainstream and institutionalized. Additionally, the Science Based Targets initiative has been providing tools for companies to set GHG emissions reduction targets that align with the Paris Agreement (Science Based Targets, 2018).

A summary of these and other relevant initiatives and frameworks can be found in Table 2.

Table 2: Environmental initiatives relevant to the brewing industry.

Initiative/Framework	**Goals**	**Main Aspects**
Sustainability Accounting Standards Board (SASB)	“Connects businesses and investors on the financial impacts of	Produces standards/guidelines for specific industries including the

Initiative/Framework	Goals	Main Aspects
	sustainability" (SASB, 2018a).	alcoholic beverage industry (SASB, 2018a; SASB, 2018b).
Alcoholic Beverages Sustainability Accounting Standards	Focuses on providing sustainability disclosure topics, standards, accounting metrics, and general guidance for alcoholic beverage industry reporting (SASB, 2018b).	Provides sustainability accounting standards for U.S. corporations while expanding into developing standards for other countries (SASB, 2018b).
Alliance for Water Stewardship (AWS)	Focuses on context-based water-use by governing catchments to ensure sustainable water balance, water quality, and managing water-related areas (Alliance for Water Stewardship, 2014).	Provides a framework that allows individual sites to manage their water use through the lens of sustainability by putting their use into the context of local catchments (Alliance for Water Stewardship, 2014).
B Corporation Certification	Recognize and certify companies that create benefit for all stakeholders: social and environmental performance (B Lab, 2019)	Provides companies with the evaluation tools necessary to become certified as well as guides for becoming certified (B Lab, 2019).
CEO Water Mandate	"The CEO Water Mandate is a UN Global Compact initiative that mobilizes business leaders on water, sanitation, and the Sustainable Development Goals." (United Nations, n.d.)	Endorsers must commit to improvement regarding 6 core elements: direct operations, supply chain and watershed management, collective action, public policy, community engagement, and transparency (United Nations, n.d.).

Initiative/Framework	Goals	Main Aspects
Global Reporting Initiative G4 Guidelines	"to help reporters prepare sustainability reports that matter – and to make robust and purposeful sustainability reporting standard practice." (Global Reporting Initiative, n.d.).	Reporting organizations can generate standardized and reliable sustainability reports by following the guidelines, which are designed to be applicable to a variety of organizations and reporting styles. They provide a list of indicators based on the issues each corporation's stakeholders deem important (Global Reporting Initiative, n.d.).
Greenhouse Gas Protocol Reporting Standards	"Develop internationally accepted greenhouse gas (GHG) accounting and reporting standards for businesses and to promote their broad adoption" (WBCSD & WRI, 2004, p.2).	Provides information on scopes of GHG emissions and determining organizational boundaries for emissions reporting as well as steps to calculate and track GHG emissions (WBCSD & WRI, 2004).
HM Government Environmental Reporting Guidelines	"Designed to help all organisations with voluntary reporting on a range of environmental matters." (HM Government, 2019, p.5)	Provides reporting guidelines and steps for corporations to follow in order to report on environmental matters as well as comply with the Companies Act 2006 (HM Government, 2019).
Key Performance Indicators for Environmental, Social & Governance Issues 3.0 (KPIs for ESG 3.0)	To integrate the principles of ESG into corporate reporting by providing requirements and guidelines for the presentation and content of reports (Garz et al., 2010).	Industry-specific performance indicators are given for a variety of industries, including the beverage industry, that can be used by companies to create a complete ESG report (Garz et al., 2010).
OECD Key Environmental Indicators	Communicate key environmental indicators relevant to	Provides a list of key environmental indicators that considers policy relevance, analytical soundness and measurability (OECD, 2008a).

Initiative/Framework	Goals	Main Aspects
	OECD countries (OECD, 2008a).	
Science Based Targets Initiative Call to Action	To promote science-based targets to help companies transition to the low-carbon economy (Science Based Targets, 2018).	They define best-practices in science-based target setting and work with companies throughout the process of science-based target setting by assessing and approving companies' targets (Science Based Targets, 2018).
Sustainable Agriculture Initiative (SAI) Platform	Promotes the adoption of sustainable agricultural practices through member collaboration (Sustainable Agriculture Initiative, 2018).	Members (food and beverage companies) share knowledge and best practices to support the development and implementation of sustainable agricultural practices (Sustainable Agriculture Initiative, 2018).
United Nations Sustainable Development Goals (SDGs)	Focuses on picking up where the Millennium Development Goals left off and creating an inclusive framework for world improvement (United Nations, 2018).	Provides standards and targets for 2030 that range from poverty, to climate change, to peace (United Nations, 2018).
Water Footprint Network	"To use the water footprint concept to promote the transition towards sustainable, fair and efficient use of freshwater resources worldwide" (Water Footprint Network, 2020).	Shares best practices and develops tools and materials to share knowledge, raise awareness, and influence policy and practice (Water Footprint Network, 2020).

These initiatives are used by a variety of industries from mining, to paper, to food and beverage (Garz et al., 2010). Several initiatives do have aspects specifically focused on the brewing industry. The KPIs for ESG 3.0, for example, have a section designated for brewers which lists industry-specific indicators (Garz et al., 2010). The SAI Platform's active members include producers of malt and hops, as well as Diageo, a corporation which owns several beer producers. As far as the participation of breweries, several have endorsed the CEO Water Mandate including Molson Coors, Mahou San Miguel, Heineken, Diageo, Bavaria SA, Carlsberg Group, and Anheuser-Busch InBev (United Nations Global Compact, 2018). Additionally, Molson Coors is an Alliance for Water Stewardship (AWS) member (AWS, 2017).

Several reporting systems and guidelines have been developed for breweries or the beverage industry specifically. The SASB has produced a set of alcoholic beverage industry reporting guidelines that focus on energy, water, packaging, ingredient supply chain and sourcing, and scale of direct operations (SASB, 2015). The KPIs for ESG 3.0 (2010) have a set of beverage industry-specific performance indicators. Environmental KPIs include energy efficiency, emissions, waste, packaging, water, sustainable products, sites with ISO 14001 certification and supply chain management (Kasem et al., 2015).

Beverage and brewery associations are also interested in tracking environmental performance. The Brewers Association 2017 Sustainability Benchmarking Report chose to focus on water use ratios, energy use ratios, carbon dioxide emissions ratios and noted electricity usage and natural gas usage (Brewers Association, 2017). The Beverage Industry Environmental Roundtable (BIER) has also produced a member benchmarking report: 2018 Benchmarking Study Trends & Observations. This report focused on water use ratios, energy use ratios, and emissions ratios (BIER, 2019). The water and energy use boundaries were clear and only included the brewing process itself without considering agriculture, malting or distribution (BIER, 2019).

However, despite these initiatives and frameworks for increasing environmental standards and a push for more context- and science-based sustainability, little is known of the impact on sustainability reports and how companies are using these in their target setting (Haffar & Searcy 2018a).

2.5 Sustainability in the Brewing Industry

The brewing industry has been changing through the growth of the craft beer sector and has prompted new research on sustainability in the industry, specifically around craft beer (e.g., Ness, 2018; Herold et al., 2017). Sustainability is also a selling point for the brewing industry. Sanya and Yahng (2018) found that American consumers were willing to pay more for sustainable beer. Indicators of willingness to pay more for sustainable beer included a consumer responsibility to consider the Earth and an existing willingness to pay for a premium product. However, in order to achieve environmental sustainability, the impacts of brewing beer on the environment must be known. Several recent papers have investigated the environmental impacts of breweries (e.g., Shin & Searcy, 2018; Cimini & Moresi, 2016; Olajire, 2012).

The literature demonstrates the importance of measuring environmental sustainability in the brewing industry (e.g., Shin & Searcy, 2018; Kasem et al., 2015; Mattila et al., 2012; Tokos et al., 2012; Zhou et al., 2012; Talve, 2001), as well as the need for context- and science-based targets and indicators in corporate reporting (Whiteman et al., 2013; McElroy & van Engelen, 2012).

Previous work establishes clear ties between environmental concerns and the brewing industry and several key environmental performance indicators have been identified (e.g., Olajire, 2012; Tokos et al., 2012; Cordella et al., 2008). These findings include inorganic emissions, energy use, water use, wastewater and effluents, GHG emissions, land use, material inputs, solid waste, spent grain and by-products, and fossil fuel consumption (Olajire, 2012; Tokos et al., 2012; Cordella et al., 2008).

There has also been some investigation of the environmental efforts of breweries and where their sustainability efforts have been focused (e.g., Ness, 2018; Herold et al., 2017). The themes include solid waste, water use, energy use, containers and packaging, locally sourced ingredients, and spent grain and by-products (Ness, 2018; Herold et al., 2017). However, these efforts do not match up with the environmental impacts investigated (e.g., Cordella et al., 2008). While there is some clear overlap between the environmental concerns of the brewing industry and known environmental efforts of breweries, there are several aspects of environmental sustainability that are not being publicly reported. Shin and Searcy (2018) were able to look beyond the GHG emissions value commonly reported by companies and worked with company-provided information that goes into calculating GHG emissions. Primary company data, supplemented with secondary data, were used to account for the GHG emissions of a case brewery. Some of the challenges observed when accounting for GHG emissions as a craft brewery included cost, lack of personnel, and a lack of technical capital and knowledge (Shin & Searcy, 2018).

Whiteman et al. (2013) discuss the need for a more holistic approach to sustainability management with regards to merging business management and scientific research such as the Planetary Boundaries introduced by Rockström et al. (2009) and updated by Steffen et al. (2015b). The research proposed in this thesis heeds the call by Whiteman et al. (2013) to apply the PBs in a corporate context by creating a composite-indicator that considers science- or context-based metrics. Whiteman et al. (2013) describes resilience thinking, as opposed to sustainability, as how natural sciences tend to view the issue of the declining Earth system. "There is little cross-over from the pages of *Nature* and that of top business management journals" (Whiteman et al., 2013, p.309).

Resilience thinking is an approach that considers the complexity of the Earth system and the interactions at varying scales, be that local ecosystems or a planetary scale. However, it must be translated such that it can be meaningfully applied to environmental management at the corporate level. The PBs build on the idea that environmental issues cannot be individually managed, and one must consider all processes as they interact and affect each other in complex and non-linear ways (Whiteman et al., 2013). Through the PBs and their associated indicators, it may be possible to demonstrate science-based environmental impact through brewing company indicators. Methods for model development that address how to incorporate the PBs have been discussed (e.g., Bjørn et al., 2019; Meyer & Newman, 2018).

Previously explored models for determining sustainability miss the idea of ecological context. As McElroy and van Engelen argue, "all implementations of the triple bottom line have thus far been context-free" (McElroy & van Engelen, 2012, p.30). There are several methods currently being adopted to indicate environmental sustainability in industry, but the lack of context seems to have been overlooked. As stated by McElroy and van Engelen in *Corporate Sustainability Management:* "the necessity to include context in sustainability measurement and reporting is advocated by the leading international sustainability reporting standard in the world (i.e., the GRI) and has been so advocated for more than a decade" (p.75). However, despite the determined need for context-based metrics, the inclusion of context in mainstream sustainability reports is rare to non-existent. McElroy and van Engelen go on to state that even in GRI reports, "The requirement to include context is simply not enforced in this regard" (p.77), which further demonstrates the need for an investigation into this area.

In the case of an environmental sustainability composite-indicator, the context or science-based targets may be developed from the PBs discussed by Rockström et al. (2009). Whiteman et al. (2013) used PBs to elaborate on the lack of science- and context-based research in corporate sustainability. They may be used to highlight the current state of publicly available data from large breweries and help address the current lack of a holistic approach in industry when it comes to environmental impact. Whiteman et al. (2013) emphasizes the need for science-based targets to be incorporated into business management practices. This research will verify the extent to which that is true in the brewing industry as well as provide a solution to move towards the systems thinking approach and increase the scientific influence on corporate sustainability management, as proposed by Whiteman et al. (2013).

2.6 Using the Planetary Boundaries to Assess Sustainability Reporting

Quaak et al. (2007) found that larger breweries were more likely to prepare sustainability reports as smaller breweries saw these reports as too costly and preferred to focus on initiatives rather than reporting. This was determined after conducting interviews with breweries in the Netherlands regarding the drivers of sustainability reporting and CSR.

Outside of the brewing industry, there have been several cases of analyzing the efforts of corporations to account for environmental context in their sustainability reporting (Bjørn et al., 2017; Haffar & Searcy, 2018a; Haffar & Searcy 2018b). However, no research has looked at applying the PBs to the brewing industry.

Haffar and Searcy (2018a) use the nine PBs to determine the extent to which resilience-based approaches are being applied to the environmental target-setting used in the sustainability reports of Canadian corporate leaders in sustainability. Their research included a content analysis of corporate sustainability reports to determine if the environmental performance targets used were science-based, with reference to the PBs. It was determined that there was a significant lack of science-based targets among sustainability leading firms in Canada and that based on the targets reported, these corporations still lack the ability to determine if their efforts are encouraging environmental sustainability (Haffar & Searcy, 2018a).

Haffar and Searcy (2018b) continued along with the same theme; this time looking into the indicator choices for environmental performance in sustainability reports. After collecting and analyzing the indicators used in the sustainability reports of 50 Canadian companies ranked highly for sustainability efforts, context-based environmental performance indicators were not found (Haffar & Searcy, 2018b). Instead, the environmental indicators identified were self-referential. This paper also identified two new types of indicators, not mentioned by McElroy and van Engelen (2012): equivalent and benchmark. The indicators found in the reports included absolute (e.g., total energy use), relative (e.g., energy intensity), equivalent (e.g., energy used in terms of number of houses that could be powered), and benchmark (e.g., proportion above or below industry average energy use).

Bjørn et al. (2017) also looked at reporting trends in industry, with a focus on determining whether ecological limits are being referenced. They found that only 5% of 40,000 reports in the CorporateRegister database contained references to ecological limits. These references were then sorted into three categories each with increasing use of the ecological limit to influence targets or indicators.

Overall, there has been a need expressed for brewery-specific sustainability models, and to include context-based sustainability into corporate metrics and reporting. Whiteman et al. (2013) demonstrates the need for research that measures the impact of corporations on the PBs. Yet a lack of context-based sustainability is apparent in both the tools used to determine sustainability and the reporting of large corporations.

2.7 Using Composite-Indicators to Measure Sustainability

Several authors agree that a brewery-specific sustainability assessment is necessary and have gone on to create composite-indicator sustainability models (i.e., Kasem et al., 2015; Tokos et al., 2012; Zhou et al., 2012). These models weigh multiple brewery metrics, chosen from the key performance indicators (KPIs) based on GRI guidelines and the guideline KPIs for ESG 3.0, against industry standards, GRI guidelines, and legal regulations. Previous composite-indicators for brewing company sustainability have not been focused in strong sustainability. Instead, the CIs developed have included a combination of economic, social, environmental, and governance indicators.

The literature also describes other methods of analyzing corporate sustainability: scorecard (e.g., McElroy & Thomas, 2015), benchmarking (e.g., Tokos et al., 2012; Zhou et al., 2012), accounting framework (e.g., Meyer & Newman, 2018), life cycle assessment (e.g., Li et al., 2016; Cordella et al., 2008), and absolute environmental sustainability assessment (e.g., Bjørn et al., 2019; Chandrakumar & McLaren, 2018). Composite-indicators can draw upon these frameworks and are a common approach to summarize complex issues such as sustainability (e.g., Arbolino & De Simone, 2015; Li et al., 2012; Zhou et al., 2012) (OECD, 2008b).

Some of the drawbacks of using composite-indicators are their potential to mislead interpretations, to be misused to support a desired policy, to have the selection of indicators and weights disputed, and to disguise large failings in some categories (OECD, 2008b). In order to ensure an accurate representation of the indicators and a transparent composite-indicator, it is important to consider the desired outcomes when selecting methods.

When selecting indicators, Li et al. (2012) considered “policy relevance and representativeness, analytical soundness, and readily available and reliable data” (Li et al., 2012, p.595). Both Li et al. (2012) and Arbolino and De Simone (2015) used principal component analysis for their multivariate analysis, a method that can go on to use the correlation of components for weighting and aggregation.

When constructing their composite-indicator, Zhou et al. (2012) tested several model options by varying the weighting, normalization, and aggregation methods, with the goal of retaining the most information in the final indicator. Their solution was to use "distance to a reference" for normalization, "benefit of the doubt" for weighting, and linear aggregation (Zhou et al., 2012). The OECD outlines several method options for multivariate analysis, normalization, weighting, and aggregation (OECD, 2008b).

The examples of sustainability composite-indicators in the literature combine indicators from all three pillars of sustainability: economic, social, and environmental (e.g., Arbolino & De Simone, 2015; Li et al., 2012; Zhou et al., 2012). While this represents a well-rounded indicator and can provide useful information, environmental impacts may be overshadowed or misinterpreted.

This has allowed the resulting CIs to be comprehensive, but as CI scores can already be considered vague and can lack transparency, meaning can be lost when considering too many variables. These previously constructed brewing industry CIs are detailed below in Table 3.

Table 3: Summary of previous brewery sustainability models.

Model	Indicators	Reference Points	Calculations
Kasem et al. (2015)*	Combination of economic, environmental, social, and governance related KPIs for breweries subsector (ESG 3.0)	Value of weighted input indicators related to value of weighted output indicators determined relative brewery performance.	Data envelopment analysis.
Tokos et al. (2012)*	Combination of environmental, social, economic, and integrated. GRI reported data for inputs. Direct impacts of the company only, no external impacts considered (e.g., raw material cultivation or emissions from electricity generation).	Benchmark values used for measuring brewery performance.	Distance to a reference for normalization. Expert opinion used to weigh variables. Linear summation of weighted and normalized variables.

Model	Indicators	Reference Points	Calculations
Zhou et al. (2012)*	Combination of environmental, societal, and economical. GRI guidelines and case company data for inputs. Indicators added based on company collaboration and excluded if not measured or seen as unimportant.	Benchmark values used for measuring brewery performance.	Distance to a reference was chosen for normalization. Benefit of the doubt was chosen weighting. Linear aggregation was chosen for aggregation.
Li et al. (2012)	Goal to represent corporate sustainability with a combination of economic performance, environmental impacts, and social benefits. GRI guidelines and literature for input variables. Used industry surveys to collect information on which indicators were used most commonly in industry and their importance.	Benchmark values used to measure corporate sustainability for a selection of case study manufacturing companies.	Principle component analysis.
Arbolino and De Simone (2015)	Goal to represent industrial sustainable ecology with variables related to policy and company choices relevant to industrial ecology. Divided into two groups: resources and management.	Compared regional performance to the average value of all considered regions and ranked them accordingly.	Principle component analysis for variable analysis. Average variable value for the regions was used for normalization. Factor method for weighting and aggregation based on principle component analysis results.

*These models were specific to the brewing industry, while the others focused on manufacturing and industrial policies respectively.

Composite-indicators have been critiqued for being vague and lacking clarity (OECD, 2008b). Previous models for the brewing industry have focused on industry benchmark values or relating the score to company efficiency of inputs and outputs and have included several aspects of sustainability (i.e., environmental, social, economic, and governance related). These models also rely on inputs from the GRI framework which, while widespread and a source of consistency among reports, has been criticized for promoting the TBL as representative of sustainability (Milne & Gray, 2013).

This research promotes transparency by concentrating on only environmental sustainability and uses science-based limits as the points of reference, thus diverging from the TBL approach to sustainability. This specificity will move beyond previous work to give a better understanding of where breweries stand from the perspective of strong sustainability, wherein sustainability is not possible without an overarching environmental focus, and will also add innate context to the meaning of the scores through the PB limits.

2.8 Translating the PBs to the Corporate Scale Through Composite-Indicators

While the PBs developed by Rockström et al. (2009) have measured environmental issues at the global level, Butz et al. (2018) has taken these proposed boundaries and "operationalized" them such that they are applicable to individual companies using economic and environmental data from 2013. Their assessment considers the "current" level of the PB control variable, as well as the "current" economic intensity in units related to the PB indicator per million US$ and then relates those to the biophysical boundary level to come up with the economic intensity boundary. These economic intensities represent the "fair" distribution discussed by Bjørn and Røpke (2018) as GVA, which rely on the sum of all nations' gross domestic product. Their method realizes the complexity of the Earth system and has thus made assumptions as well as used values that corporations would have control over as the basis for determining the economic intensity boundary for each PB. However, despite these simplifications of a complex system, this research represents an application of the PBs that is relevant to corporations and measuring corporate environmental sustainability in a way that takes into account science-based targets.

Similarly, Meyer and Newman (2018) have translated the PBs into the planetary quotas (PQs), which are divisible global limits. This approach is aimed at addressing global environmental limits, such as the PBs, at other scales (e.g., companies). The process outlined provides a top down approach to applying the PQs. This involves selecting an allocation, such as the GVA distribution suggested by Butz et al. (2018), as well as a scale. Next, the share of each PQ for the given entity is calculated, deemed annual quota, and compared to the entity's annual impact. This is repeated and the tallies calculated in an "impact balance sheet". Some of the goals of this process are to inform behaviour change, business operations, and policy.

A summary of relevant research can be found below in Table 4.

Table 4: Literature review research summary.

Reference	Overview	Relevance
Amienyo and Azapagic (2016)	Completed a lifecycle analysis of beer production in the UK to identify "hotspots" in the beer production lifecycle.	Production of raw materials and packaging were identified as major "hotspots" based on contribution to impacts and life cycle costs. The global warming potential of several stages was considered: packaging, raw materials, retail, beer production, waste management, transport. Impact categories considered: primary energy demand, global warming potential, water demand, abiotic depletion potential, acidification potential, eutrophication potential, human toxicity potential, marine aquatic ecotoxicity potential, freshwater aquatic ecotoxicity potential, terrestrial ecotoxicity potential, ozone depletion potential, photochemical oxidants creation potential, dichlorobenzene.
Bjørn et al. (2017)	Discussed ecological limits in the context of creating indicators for environmental reporting. Reviewed all English-written corporate responsibility reports in the CorporateRegister database, searching for references to ecological limits with chosen search words. Only a small portion of the reports contained these references (about 5%).	Used content analysis to assess the corporate reports and sorted the companies with ecological references based on the action taken surrounding each reference.

Reference	Overview	Relevance
Butz et al. (2018)	The nine PBs were "translated" to be appropriate for monitoring corporations' contributions to the declining Earth system. Boundaries were set that can relate a corporation's contributions to global gross domestic product to the maximum negative contributions to each PB.	The method for "translating" can be repeated using updated values for global gross domestic product to assist in binding the "desirable" side of the composite-indicator.
Cordella et al. (2008)	A life cycle analysis of an Italian lager beer was performed to compare bottles vs kegs for environmental impact. It was found that the consumption phase rather than the production had a greater impact on the environment.	Identified some main points of environmental impact along the brewing process including inorganic emissions, land use, and fossil fuel consumption.
Haffar and Searcy (2018a)	The nine PBs were used as a way of determining how much attention was being paid to environmental sustainability in the environmental target setting of corporations. While there was some reference to the PBs in the targets, none were found to be PB-based.	Used the PBs to determine the extent of ecological focus when analyzing environmental sustainability in corporate reports.
Haffar and Searcy (2018b)	Indicators used in environmental sustainability reports were collected and sorted based on type, including whether they were context-based or not. The reports analyzed were those deemed the "Top 50 most sustainable corporations in Canada" in 2014 and included some of the largest corporations in Canada. Of the environmental indicators analyzed from these reports, none were found to be context-based.	Identified four types of indicators common to corporate environmental sustainability reports: absolute, relative, equivalent, and benchmark. Identified a need to interview companies on their use of context in their reporting.

Reference	Overview	Relevance
Herold et al. (2017)	The craft beer industry in Australia investigated for themes in the sustainability initiatives of breweries on their websites.	The main themes found were waste, water, and energy. It was also noted that "there seems to be a lack of willingness to generate metrics that would identify and measure sustainable performance during the beer production process" (p.65).
Kasem et al. (2015)	Indicators pertaining to environment, social, and economic sustainability were collected to determine the relative efficiencies of Czech breweries.	Identified brewing-specific sustainability indicators drawn from the GRI 4 guidelines and the KPIs for ESG 3.0.
McElroy and van Engelen (2012)	Discussed the history of sustainability and the types of indicators as well as the need for context to determine "true" sustainability.	Identified the need for context-based metrics in sustainability reports.
Meyer and Newman (2018)	Translated the PBs into divisible limits called the planetary quotas.	Developed a process for analyzing the PB limits from the perspective of other operational scales (i.e. companies).
Ness (2018)	The reports and websites of 70 craft breweries were reviewed for environmental sustainability themes.	There was an emphasis on water efficiency/conservation in their reports and over half of breweries used renewable energy or had measures in place for energy reduction. There was also an emphasis on spent grain use, solid waste, containers/packaging, and locally sourced ingredients.
Olajire (2012)	Highlighted the main environmental challenges related to the brewing industry.	Water use, energy use, wastewater, solid waste and by-products, and emissions were highlighted as main concerns.
Quaak et al. (2007)	Targeted the CSR practices of Dutch breweries by analyzing their online information then conducted interviews to determine the drivers of CSR.	Interviewed breweries using a narrative-style interview. Found large breweries to be more likely to produce sustainability reports.
Rockström et al. (2009)	Defined the nine PBs and the associated thresholds and	Discussed the need for focus on all PBs as they are part of complex Earth

Reference	Overview	Relevance
	indicators as well as the thresholds that had been already overstepped.	systems that interact; therefore, stating a need to monitor and manage all PB thresholds.
Shin and Searcy (2018)	Provided a case study for GHG emissions accounting in the brewing industry.	Detailed the limitations associated with breweries expanding their environmental sustainability initiatives.
Steffen et al. (2015b)	Updated the thresholds for the indicators of the associated PB.	Identified the risk zone of the PB (safe, increasing, high, or not yet quantified) and proposed indicators for each PB.
Tokos et al. (2012)	Created a composite sustainability indicator for the brewing industry using industry benchmarks based on standards, legal regulation and GRI reports.	Identified a need for brewery-specific sustainability assessments. Discussed the key indicators of environmental performance in the brewing industry: material, energy, and water use, as well as emissions, effluents, and waste.
Whiteman et al. (2013)	The nine PBs were used to categorize research done on environmental impact and bring to light the need for systems-based approach when dealing with the varying scale and effect of local impacts.	Used the PBs to categorize analysis information and determine completeness of the work done on measuring and reporting on environmental concerns.
Wilson (2013)	Identified common environmental reporting practices in the consumer goods industry related to carbon-equivalent emissions.	Found frequency of companies reporting on scope 1, scope 2, scope 3, and total carbon-equivalent emissions related to supply chain position. Determined representation of breweries among companies filing CSR reports with the corporate register in 2011 (3/491).
Zhou et al. (2012)	Constructed a sustainability composite-indicator using the GRI guidelines.	Tested several methods for weighting, normalization, and aggregation of the indicator's variables.

Public reports and webpages are examples of façades that companies create to engage with stakeholders (Cho et al., 2015). However, the nature of these façades may cause them to fall short of expectations. Reports tend to fail when it comes to addressing company performance relative to what would be truly sustainable (Milne & Gray, 2013). This “true” sustainability can be derived from science-based limits, such as the PBs. A case for using the PBs is furthered by the need for a holistic approach to environmental sustainability (Whiteman et al., 2013). Measuring and managing one environmental impact (e.g., carbon emissions), may come at the cost of degrading other natural resources (e.g., water quality, habitat, and biodiversity loss) (Milne & Gray, 2013). The strength of the PBs is that they are intended to represent the global Earth system and provide indicators from a variety of vital sub-systems (Rockström et al., 2009).

As the extent to which environmental sustainability is found in company reports is becoming more researched (e.g., Haffar & Searcy, 2018a; Bjørn et al., 2017), methods for relating the PBs to company activities are also emerging (e.g., Bjørn et al., 2019; Butz et al., 2018; Meyer & Newman, 2018). These frameworks have yet to be applied. This research aims to address both the knowledge gap when it comes to how the brewing industry is reporting on environmental impacts, as well as determine whether the data they are reporting are complete enough to meet the demands of the sustainability frameworks using science-based limits.

3.0 Methods

This research was conducted in two main parts: a content analysis and the development of a composite-indicator. The content analysis was completed as a way to inform the composite-indicator as well as provide data for testing. Figure 1 outlines the main steps of the research process[11].

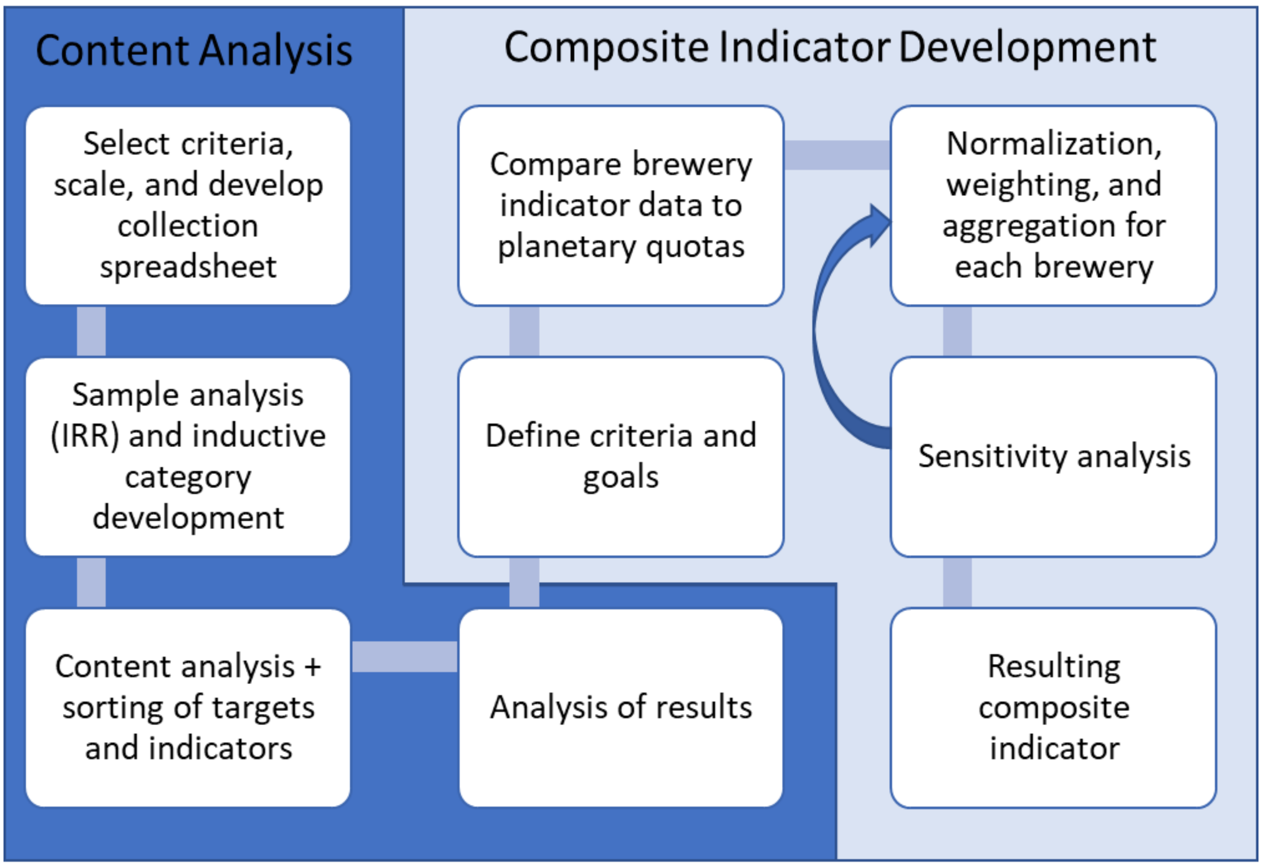

Figure 1: Outline of research methods, developed from Bjørn et al. (2019), Meyer and Newman (2018), Burgass et al. (2017), OECD (2008b), and Krippendorf, (2004).

3.1 Content Analysis

In order to establish the current status of environmental reporting in the brewing industry, sustainability reports and relevant webpages of brewing companies were analyzed through a

[11] Industry interviews were also conducted as part of this research but the sample size was not great enough to influence the development of a composite-indicator. The methods, results, and discussion for the interviews can be found in Appendix B.

content analysis with the goal of collecting environmental sustainability related indicators and targets. The goals of the content analysis were to determine the extent to which breweries are reporting on environmental issues and to understand commonly reported indicators. Specifically, the completeness of indicators and targets was measured against the Planetary Boundaries (PBs) and the breadth determined by sorting them into environmentally relevant categories. Table 5 outlines the steps adapted from Krippendorf (2004) as they were applied to this content analysis.

Table 5: Steps for conducting a content analysis, adapted from Krippendorf (2004).

Content Analysis of Sustainability Reports

- **Uniting:** The sustainability reports and webpages of breweries represent the units to be analyzed.
- **Sampling:** The sample is directly related to the research question in that the collection of reports to be analyzed is the population of relevant texts.
- **Recording and coding:** Manually record the environmental indicators and targets found in each report in an excel document while reading each report or webpage. Mark the environmental indicators used in each report according to aspect e.g. input or output, category e.g. water or emissions, type e.g. absolute or relative, related PB. Mark the environmental targets based on category, associated PB, and note whether the company mentions a target as science-based and/or the target's impact on the environment.
- **Reducing data:** Categorize the environmental targets and indicators
- **Inferring (abductively):** Create a visual representation of the collected and sorted data to allow for general trends to be determined.
- **Narrating:** Ensure results are comprehensible to others through reccomendations for both industry and further work.

A visual analysis of the documents and webpages was chosen instead of using keyword searches or coding software such as NVivo. As the extent of environmental sustainability topics covered in brewery report are not known, searching documents for keywords may have resulted in important information being missed. Instead, each document or website was read in order to collect environmental indicators and targets.

3.1.1 Company Selection

Sustainability reports are non-compulsory investments made by larger brewing companies to indicate their economic, social, and environmental stewardship to investors and the public. In order to maintain the environmental-specific focus of this analysis, companies more likely to include environmental information were the focus during company selection. Larger firms usually have more capability to include more environmental information in their reports, and as a result were emphasized in this research (Quaak et al., 2007; Andrikopoulos & Ariklani, 2013). To broaden the potential findings regarding environmental sustainability reporting in the brewing industry, brewing companies that have committed to environmental sustainability were sought after as well. Companies chosen for this analysis included large breweries, i.e., those who represent a large portion of the industry, and brewing companies that have committed to environmental performance, i.e., those who are likely to report on environmental sustainability.

The sample chosen to represent large breweries was selected as the top 10 largest beer companies globally as of 2018 (Technavio, 2018). This list includes Anheuser-Busch InBev, Heineken, China Resources Snow Breweries, Carlsberg, Molson Coors Brewing, Tsingtao Brewery Group, Asahi, Yangjing, Kirin, and Groupe Castel (Technavio, 2018). The first five of these companies alone represented over half of the global beer market in 2016 and include hundreds of smaller beer producers through constantly acquiring beer brands (Roach, 2016).

To represent companies committed to environmental sustainability, two groups were selected: Certified B Corporation brewing companies and Beverage Industry Environmental Roundtable (BIER) members producing beer. Companies that wish to become B Corporations must meet a minimum B Corporation score of 80 to become certified, and "are legally required to consider the impact of their decisions on their workers, customers, suppliers, community, and the environment" (B Corporation, 2019). The certification process asks applicants to answer questions related to the extent of their social and environmental considerations with points allocated depending on the answer. Certified B Corporation brewing companies were determined by searching the Certified B Corporation online directory using the following terms: “beer”, “brewery”, and “brewing”. Certified B Corporations added 22 breweries to the list for analysis. BIER is an industry organization that “works to reduce consumption, mitigate impacts, and ensure sustainable continuity and future of the global beverage industry” (BIER, 2019). Additionally, their beer-producing members tend to be larger brewing companies with some overlap between the largest beer companies and BIER members (BIER, 2019). In order to identify BIER members producing beer products, their company websites were used to determine if beer was in their list of products. 8 BIER members were found to produce beer; however, due to overlap, this added only 3 new brewing companies to the analysis. The final list of selected companies included a total of 34 breweries.

3.1.2 Report and Website Collection

Company reports were collected through Google searches including “[company name] sustainability report”. Manual searches were conducted on company websites, looking specifically under pages with titles such as “about us”, “info”, “sustainability”, “responsibility”, “corporate social responsibility”, “environment”, and “reporting”. If a company listed several reports, the most recent report was collected. If a company produced different kinds of reports (e.g., sustainability reports, annual reports, CSR reports), the most recent of each name was collected. This search was performed during spring 2019 and a total of 26 reports were collected, representing 21 companies. Of those reports, one was in a language unable to be understood by the principal investigator. Thirteen of the companies to be investigated did not produce a publicly available sustainability report that was either searchable or available on their website: 12 B Corporations and 1 BIER member.

Company webpages were collected using manual searches of company websites, with each webpage being marked down for inclusion if it contained at least one environmental sustainability indicator or target. A total of 29 webpages were collected, representing 18 companies. Sixteen of the companies investigated did not have a webpage with at least one environmental indicator or target: 3 of the top ten largest brewing companies, 12 B Corporations and 1 BIER member.

If a company had both a report and a webpage, both sources contributed to the list of indicators and targets. If an indicator or target was reported in both sources it was noted twice, but it was not double-counted when analyzing the frequency of indicators and targets.

The complete list of companies, webpages, and reports can be found in Appendix A. As one of the reports was not in English and therefore able to be properly interpreted for containing environmental information, the associated company was not included in the content analysis, which brought the total companies to be analyzed to 33.

3.1.3 Sample Content Analysis and Intra-Rater Reliability Test

In order to ensure consistent indicator and target collection from reports by the primary investigator, a sample content analysis was performed with 5 of the collected reports and then repeated two weeks later[12]. The resulting lists of indicators and targets were compared looking for inconsistencies. A total of 111 different indicators and targets were identified. One hundred and five appeared in both lists; 6 appeared in only one, representing an overlap of 94.6%. A thorough review was conducted to explore the reasons for the difference, which was determined to be inconsistent application of definitions. These definitions were then adjusted and applied for the analysis of the entire collection of documents and webpages.

3.1.4 Collecting Indicators and Targets

The analysis itself involved first collecting the environmental sustainability targets and indicators used in each report and sorting them on several levels. Environmental sustainability targets are considered the company’s goals to improve their environmental impact. Environmental sustainability indicators represent the values collected by the company to show their progress towards targets, compare to previous performance, or simply report the current state of operations.

[12] Rounds were completed with time in between such that the analyzer would not recall specific indicators and targets from reports when completing the second round.

Figure 2 describes how environmental sustainability indicators were included. To be considered, an indicator had to be measurable and either listed in the environmental section of a report or related directly to either a PB or one of the environmental categories developed in the sample content analysis[13]. An indicator was only collected for the most recent year given. If several benchmark values were given, either that which was representative of an original target or the largest span was taken, with comparison to a previous benchmark preferred (e.g., if both “reduction in water use from 2007” and “reduction in water use from 2015” were both present, the former would be selected and noted). Each indicator collected was noted in a Microsoft Excel spreadsheet along with company name, report or website name, its numerical value, units, year, and whether it was from a report or a website.

[13] Categories for indicators were developed inductively from the targets and indicators seen in the reports read as part of the sample content analysis. These categories include emissions, energy, water, biodiversity/forest, packaging/waste, and general environment.

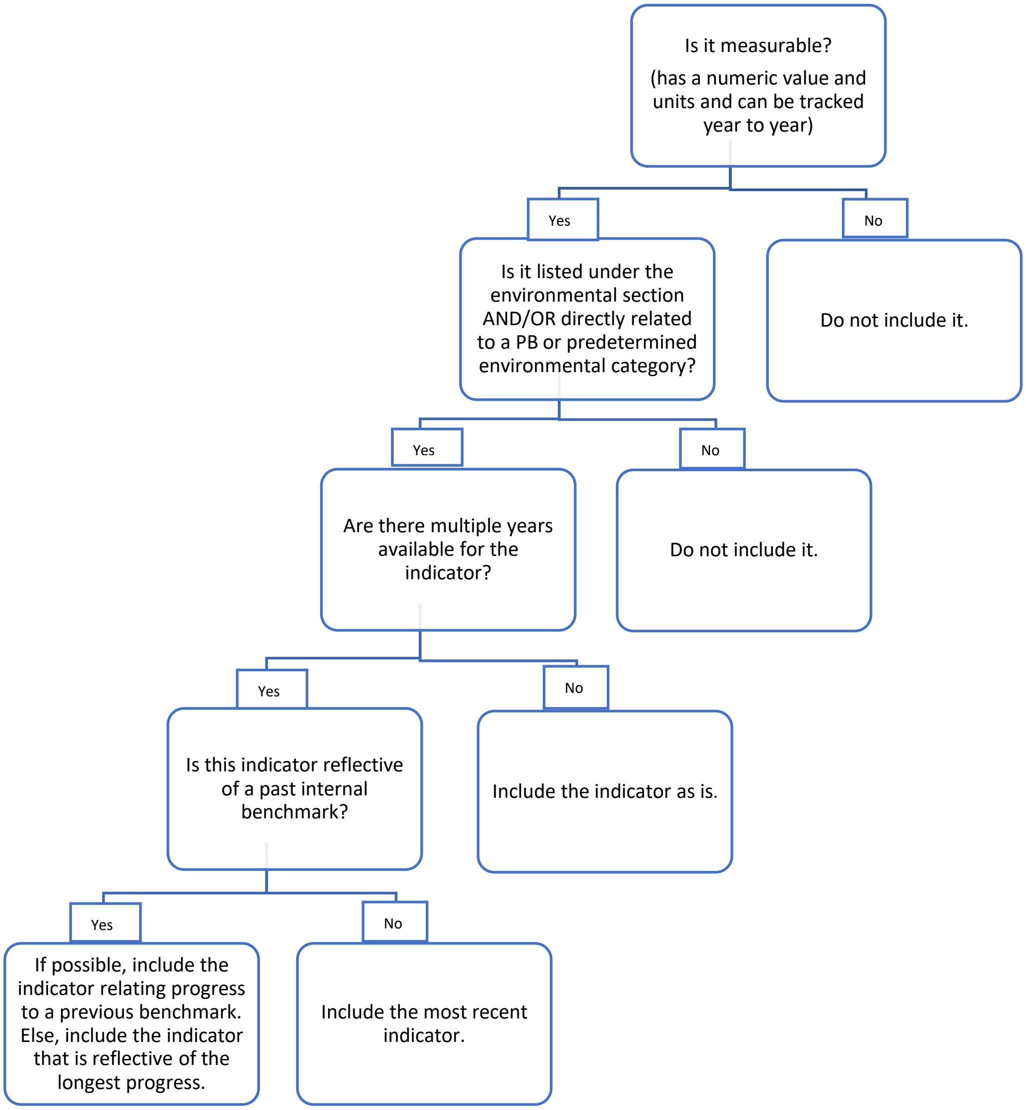

Figure 2: Content analysis indicator collection decision chart.

Environmental sustainability targets were identified in a similar manner. The targets collected had to be environmental in nature, either by location (having been found in the environmental section of a report or website), being identified as such in the "targets" or "goals" section of a report or website, or relating directly to a PB or one of the categories identified during the sample content analysis.

The literature points to a standard for effective environmental goal setting called rational goal setting (Edvardsson, 2007). A target had to include a direction (i.e., increase or decrease), an indicator (e.g., GHG emissions), completive precision (e.g., 50% from 2004 baseline) or a descriptive goal that could be checked for completion (yes/no), and temporal precision (e.g., by 2030).

3.1.5 Indicator Categorizing

First, indicators were categorized as either input or output. Input categories identified what goes into the brewing process or making of the product (e.g., amount of water or electricity used). Output indicators represented a produced product or waste from brewing activities or the brewing process (e.g., waste to landfill or GHG emissions). Indicators were then sorted based on environmental category: water, emissions, energy, biodiversity/forest, packaging/waste, general environment, or other. These categories were developed after the sample content analysis was completed and were based on the environmental themes that were present, as interpreted by the principal investigator.

As was done by Haffar and Searcy (2018b), indicators were also categorized as either absolute, relative, equivalent, or benchmark. Indicators noted as absolute represented a stand-alone value, such as water used, or number of trees planted. Relative indicators were marked as such if they were reliant on more than one variable and generally represented efficiency, for example the water or energy used per hectolitre of beer produced. Equivalent indicators were those that used outside comparisons to describe the numeric value, for example flights around the world saved to measure GHG emission reduction. Indicators noted as benchmark were those that were reflective of the company's past performance, for example a 40% reduction in coal use from 2007.

3.1.6 Target Categorizing

Haffar and Searcy (2018a) used PBs to sort the targets of top sustainability companies in Canada by naming them as either PB-based, PB-referencing, or non-PB targets. PB-based targets were reflective of both a PB and its associated safe limit, PB-referencing must have had a qualitative link to a PB, and other targets were considered non-PB targets. Because the PBs represent a reference to science-based target setting, they were used in this research as a measure for science-based targets in the sustainability reports. As they were collected, the targets were gathered in groups: science-based, science-referencing, or neither. If the environmental targets collected were described in the report or on the website as being science-based with reference to scientific limits[14], they were considered science-based. If they were accompanied with a reference to their connection to a PB or environmental scientific phenomena, they were considered science-referencing. If targets were not accompanied with environmental scientific information, they were marked as “neither”.

The indicator and target information were used to understand the extent to which the sustainability reports are addressing the nine PBs and what is being focused on with regards to reporting and targets.

3.1.7 Assigning Associated PBs to Indicators and Targets

The Earth system is complicated in its interactions between the PBs, therefore, both direct and indirect impacts were considered when categorizing the targets and indicators. Because of the inter-relatedness of all PBs, all targets and indicators were noted with a PB directly influenced, as well as secondary PBs that would be affected. The two core PBs are climate change and biosphere integrity (CISL, 2019). These boundaries relate to all other PBs and represent boundaries, once crossed, that will be individually devastating to the Earth System far beyond the trespassing of any other individual PB. These core PBs are most likely linked to a wide variety of indicators and targets.

Both indicators and targets were sorted based on the related PB or PB indicator[15], as set out by Steffen et al. (2015b). Indicators and targets were marked with the PBs that are affected by the activity, both directly and indirectly, and noted as such whether the impacts would positively or negatively impact the PB. As explained below, connections between brewing company activities, including their supply chains, and PBs were developed from the literature.

Given the example of the indicator “boxes used that are certified and come from responsibly managed forests”, the main PB affected would be due to deforestation, therefore “land-system

[14] Science-based targets were only considered such when an explicit reference was made to a scientific limit (e.g., Paris Agreement temperature goal).
[15] For example, atmospheric CO_2 concentration for the climate change PB, global area of forested land as % of original forest cover for land-system change, and maximum amount of consumptive blue water use for freshwater use (Steffen et al., 2015b).

change”. The secondarily affected PBs are “change in biosphere integrity”, “climate change”, and “ocean acidification” (CISL, 2019; Doney et al., 2009). Indicators relating to energy use or GHG emissions were marked with “climate change” for the primary PB and “ocean acidification” for the secondary as carbon dioxide (CO_2) in the atmosphere affects the pH of the oceans (Doney et al., 2009). Table 6 below provides an overview of how the literature was applied to the indicators and targets.

Table 6: Examples on assigning PBs to indicators and targets.

Indicator or Target Type	**Primary PBs**	**Secondary PBs**
Forestry related (e.g., paper products) (CISL, 2019; Lindenmayer et al., 2012; Doney et al., 2009; McNeely, 1994)	Land-system change	Change in biosphere integrity, climate change, ocean acidification
Agriculture related (Heck et al., 2018; Lindenmayer et al., 2012; Doney et al., 2009)	Land-system change, freshwater use, altered biogeochemical activities	Change in biosphere integrity, climate change, ocean acidification
GHG emission related (Hoegh-Guldberg, 2011; Doney et al., 2009)	Climate change	Ocean acidification, change in biosphere integrity
Nitrogen release related (Meyer & Newman, 2018; Doney et al., 2009)	Ocean acidification	Change in biosphere integrity
Water use related (Verones et al., 2013; Pittock et al., 2008)	Freshwater use	Change in biosphere integrity
Habitat destruction related (Meyer & Newman, 2018)	Change in biosphere integrity	
Energy use related (Hoegh-Guldberg, 2011; Doney et al., 2009)	Climate change	Ocean acidification, change in biosphere integrity

Indicator or Target Type	Primary PBs	Secondary PBs
Plastic waste related (Villarrubia-Gomez et al., 2018)	Novel entities	Altered biogeochemical activities, change in biosphere integrity, climate change, ocean acidification

3.1.8 Finding Unique Indicators and Targets

Once all indicators and targets were collected and categorized, the number of unique indicators and targets were determined in two steps. First, duplicates of indicators and targets within each company were removed. This involved sorting the indicators and targets by company and then by category to group potential duplicates visually. For indicators, the exact or almost exact language was used to identify duplicates as well as the associated value and units. For example, when both “donations to environmental non-profit organizations” (2018, US$ 6157.08) and “community allocations to environmental causes” (2017, US$ 6142.23) were listed as indicators for the same company, they were considered duplicates. For targets, those with similar language that represented the same underlying issue were counted as duplicates. For example, “reduce carbon emissions by 30% from 2008 baseline by 2030” and “reduce carbon emissions by 50% from 2008 baseline by 2040” were considered duplicate targets as they represent the same efforts on different time scales. Identified duplicates were marked and only unmarked indicators and targets were included in a new spreadsheet. This new list of indicators represents the total unique indicators for each company and can be found in Appendix C.

In order to determine the breadth of indicator choices used across brewing companies, duplicates between companies were removed. Indicators were sorted based on category, input/output, and type, while indicator names and units were used to determine if indicators were similar enough to be considered the same. For example, “renewable energy purchased” (%) and “renewable energy purchased” (kWh) would be considered dissimilar and therefore unique indicators. Once an indicator was considered “unique”, other similar indicators were identified and highlighted. For example, “emissions as nitrogen oxides” (240 lbs) and “total NO_x

emissions" (1,027 tons) would be considered similar indicators and grouped together, described as "NO_x emissions". In a new spreadsheet, the name of each unique indicator, its categorizers, and the number of companies who reported it were noted.

A similar method was used to determine the breadth of target choices across brewing companies. Targets were grouped as either similar or unique based on the description recorded from each company. Unique targets had to be unique in their efforts. For example, "reduce GHG emissions across entire value chain by 50% from 1990 values by 2050" and "reduce GHG emissions by 25% per beverage across supply chain from 2017 baseline by 2025" were considered similar due to the shared goal of supply chain GHG reduction from a baseline by a given year. In this case, these targets would be grouped as one in a separate spreadsheet as "reduction in supply chain GHG emissions" along with the number of companies reporting the target.

3.2 Composite-Indicator Development

Building a composite-indicator (CI) was selected to expand on and apply the information collected during the content analysis. The main benefit of a composite-indicator is the ability to include multiple aspects of environmental sustainability in a single value, which can then be used for comparison year-to-year as well as between companies.

This CI was set to be developed with brewing companies in mind such that they may assess their environmental sustainability relative to global limits. This composite-indicator framework was developed based on the planetary boundaries (PBs) through the planetary quotas (PQs). Each PB indicator was broken down into the pieces associated with the environmental impacts of breweries. The data collected from the reports and webpages of brewing companies were compared to each PQ. The disconnect between the indicators reported by brewing companies and gaps in the data relative to the PBs did not allow for a composite-indicator using primary data to be developed. As the gaps then became apparent, the literature was used to fill in the missing data to give an idea of which information, specifically, was required to determine a brewery's contribution to a given PQ. Therefore, as the framework was set up to be used with primary data inputs, the version developed has substituted secondary literature data in the current company gaps. This secondary data have been used in sample calculations and highlights potential key areas for expanding on the current data reported by brewing companies.

Some of the major concerns when creating a composite-indicator are ensuring proper weighting of indicators and maintaining model transparency. Therefore, the top priorities of the CI developed in this study are as follows:

- To address all areas of environmental sustainability by using the PBs as a guide, thus ensuring a holistic approach to the degrading Earth system.
- To be transparent (i.e., ensure non-compensability of variables) and sensitive to changes in variable inputs, as to reflect the range of "sustainability" in this industry.
    - A good score for one variable should not make up for a poor score for another - high scores should be capped[16].

Three main method sources were brought together to develop this CI. The OECD Handbook on Constructing Composite Indicators (OECD, 2008b) was the outline for building a CI, Bjørn et al. (2019) outlined methods for a context-based absolute environmental sustainability assessment (AESA), and Meyer and Newman (2018) translated the PBs into the Planetary Quotas which can be used to assess the environmental impacts of organizations. Adapted from Bjørn et al. (2019), the high-level steps followed can be seen in Figure 3 with the OECD Handbook selected to fill in the requirements of the third and fourth steps and the framework developed by Meyer and Newman (2018) being used to inform decision-making in the first two steps.

[16] An upper limit on category scores ensures that high performance in one category will not overinfluence the final composite-indicator score. For example, if a company is very low in water usage, this would not make up for higher than sustainable carbon emissions. The best score would be capped at the PQ limit itself.

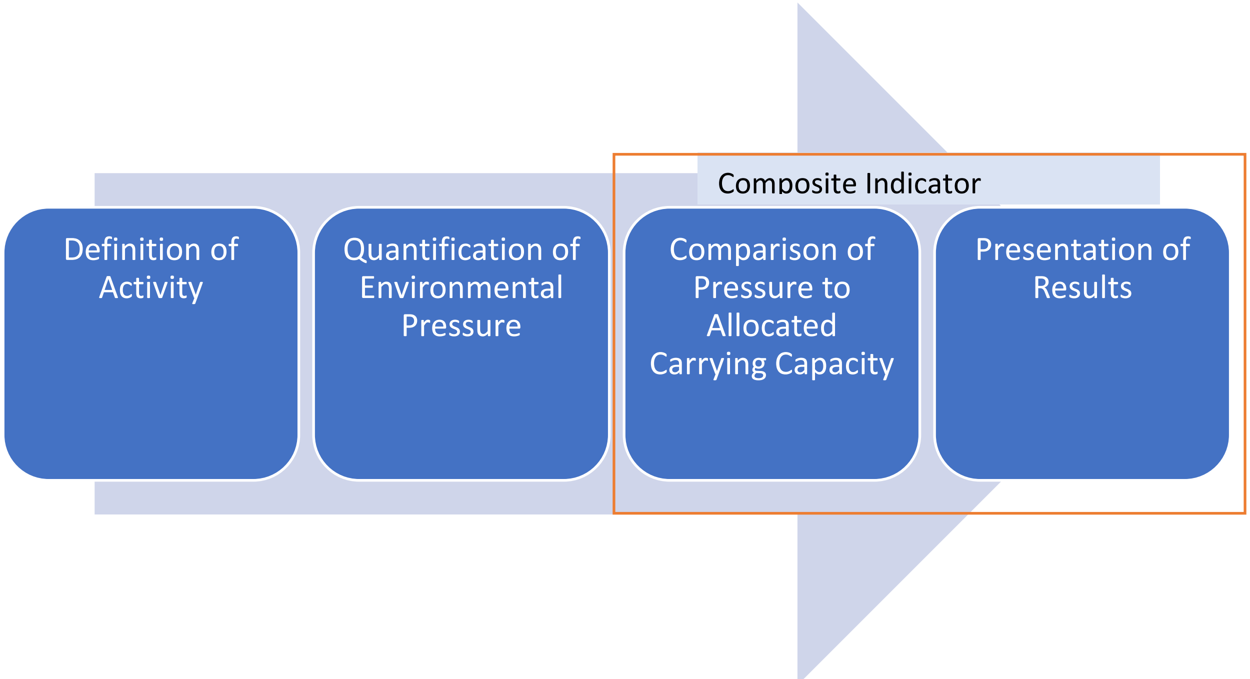

Figure 3: Outline for developing a context-based environmental sustainability composite-indicator, adapted from (Bjørn et al., 2019).

3.2.1 Definition of Activity[17]

An organization scale was chosen at this phase to represent the brewery to be analyzed by the composite-indicator. The scale of this composite-indicator was chosen to assess individual companies within the same industry. This allows for individual comparisons year to year as well as between companies as the results are normalized based on brewing company production.

Choice 1: approach to setting boundaries

There are two choices set out by Bjørn et al. (2019): territorial[18] and consumption[19]. For this case, the whole supply chain was considered, and a consumption-based boundary chosen to represent this. By simply reporting on the environmental impacts due to brewery direct operations, much of the bigger picture is missing. Not only does this misrepresent the impact reported to consumers but also leaves out the responsibility of brewing companies to make

[17] This section also covers the first three steps of preliminary CI development: develop theoretical framework, select variables, and imputation of missing data (OECD, 2008b).
[18] The territorial approach relies on physical boundaries to set limits on the included activities, for example, the land owned by a company (Bjørn et al., 2019).
[19] The consumption approach chooses boundaries to include all processes required by the activity no matter their location (Bjørn et al., 2019).

informed supplier decisions. Therefore, by choosing consumption-based approach for setting the boundaries of this analysis, the entire supply chain is considered. This was reflected in the framework development by considering PQ impacts beyond direct company operations. For example, water used for agricultural inputs to the brewing process is considered.

Choice 2: environmental sustainability objective

This step requires choosing what aspects of environmental sustainability[20] are important, or what must be protected to achieve environmental sustainability, which becomes more ambitious when ecocentric (focused on the wellbeing of an entire ecosystem rather than simply the portions important for human-wellbeing) (Bjørn et al., 2019). An example of this ecocentric objective, as outlined by Bjørn et al. (2019), are the planetary boundaries. They represent a way to define this through the selected 9 Earth System indicators developed by Rockström et al. (2009) and go beyond the issues typically covered in LCA. Land use, for example, related to land-system change, is not typically considered in LCA (Mattila et al., 2012).

Choice 3: quantification of carrying capacity

The carrying capacity[21] chosen defines the parameter limit that is to be compared to each chosen variable. The PBs and the subsequently developed PQs (Meyer & Newman, 2018) defined the carrying capacity for the CI by providing a global-scale limit on anthropogenic activities.

Choice 4: data collection approach

The data collection approach chosen for the CI was influenced by the process approach described by Bjørn et al. (2019) as well as the data already collected during the content analysis phase of this research. Data inputs were from the indicator values provided on brewery websites and in public reports, as well as industry averages and literature values where required to fill in unreported data. The literature was searched for contributors to each PQ

[20] This definition is based on the long-term sustainability of the environmental pressure of an activity. Environmental sustainability occurs when the environmental pressure of an activity is lower than the environment's carrying capacity (Bjørn et al., 2019).
[21] Carrying capacity, when discussing anthropogenic impact on the environment, is considered "the maximum 'load' that can safely be imposed on the environment by people" (Rees, 1996, p. 197).

indicator with values related to brewing industry activities and its up- and down- stream activities as necessary. Where possible, reported brewery values were used for calculations, supplemented with industry averages and data from research related to each PQ indicator. As several PQs were lacking a link to brewery-reported indicators, a range of secondary data was compared to get an idea of the variety of outcomes possible.

3.2.2 Quantification of Environmental Pressure

The quantification of environmental pressure relies on allocating the responsibility of maintaining ecological boundaries among potential users. Context-based sustainability requires this allocation to be based in justice[22] (McElroy and Van Engelen, 2012). Allocation was required to determine the share of each PQ allotted to the organization. The PQs are directly translated from the PBs and represent a way to divide responsibility for managing each PB. For example, the PB for global land-system change is the area of forested land as a percent of original forest cover where the limit is 75% (Steffen et al., 2015b). The associated PQ is net deforested land area and the limit is deforestation ≤-11Mha/year (Meyer & Newman, 2018). In this case the percentage limit for the PB has been translated into a divisible limit.

Choice 5: allocation principle

As these PQs are meant to be divisible and represent global scale consumption, contribution to value-added[23] was chosen as the allocation method. This method is based on the idea that the carrying capacity allocated to an activity can be considered proportional to its produced economic value (Bjørn et al., 2019). In order to calculate PQ shares for the industry, first the brewing industry's value-added was determined relative to global GDP (Equation 1), then each PQ was translated into a limit for the brewing industry (Equation 2).

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[22] In this case, justice refers to using distributive justice when allocating the responsibility of managing resources and waste. According to Daly (1992), relative balance should be at the core of allocation and an economic line should prevent economic activity from causing ecosystem damage.

[23] Other common options included grandfathering, where an activity's allocation is inherited from historical environmental pressure, and equal per capita principle, where carrying capacity is allocated equally among all individuals in a given region (Bjørn et al., 2019).

Equation 1: Using contribution to value-added to determine percent allocation of the PQs for the brewing industry using 2017 data.

$$\frac{brewing\ industry\ global\ value}{global\ GDP} \times 100\% = percent\ allocation\ for\ brewing\ industry^{24}$$

For example for 2017,

$$\frac{\$593\ billion\ USD^{25}}{\$80,262\ billion\ USD^{26}} \times 100\% = \sim 0.74\%$$

Using the contribution to value-added allocation method, the portion of the global PQ for nitrogen[27] to be allocated to the brewing industry is calculated below. The relative contribution of the brewing industry to global GDP (calculated above with Equation 1) is multiplied by the global nitrogen PQ to allocate a portion of the global limit to the brewing industry (Equation 2). This step was repeated for all PQs.

Equation 2: Allocation of planetary quotas to the brewing industry.

$$fraction\ allocation\ for\ brewing\ industry \times PQ\ value = brewing\ industry\ PQ\ value$$

For example,

$$0.0074 \times \frac{62\ Tg\ nitrogen^{28}}{year} = 0.458\ Tg\ nitrogen/year$$

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[24] The "value" of the brewing industry is difficult to calculate, and no global industry contribution to GDP has been determined; only data for the brewing industry on a national or regional basis have been collected. The Brewers Association 2018 Impact Report noted that the craft brewing industry alone contributed $79.1 billion (USD) to the U.S. economy, ~0.4% of GDP (Brewers Association, 2019). In Canada, the brewing industry accounted for ~0.7% of Canadian GDP in 2016 (Hermus, 2018). The brewing industry in the EU contributed 0.40% to total EU GDP in 2012 (Berkhout et al., 2013). The value added by a given industry is difficult to quantify relative to global values such as GDP; when considering supply chain impacts, this becomes more difficult still. Randers (2012) developed a method to calculate corporate value added relative to GHG emissions. In this calculation, the economic value added ("gross profit" in US accounting or "operating profit" in European accounting) is related to scope 1 emissions (those associated with direct operations) to give GHG emissions per unit of value added. However, this relates "value added" from direct corporate activities to direct emissions and therefore does not consider the supply chain impacts. The approach taken in this study likely overstates the PQ portion allocated to the brewing industry and was based on the methods explained by Bjørn and Røpke (2019) where an industry's value can be related to global GDP, which was estimated through the global value of the brewing industry AMR (2020). However, while the value in the calculations may overstate the contribution of the brewing industry to the global economy, these calculations are used as an illustrative example of applying the PQs to corporate activity through a composite-indicator approach rather than to give a definitive numerical value for a company's environmental impact.

[25] 2017 Brewing industry global value (AMR, 2020)

[26] 2017 Global GDP (Plecher, 2019)

[27] 62 Tg active nitrogen/year

[28] PQ for nitrogen (Meyer & Newman, 2018)

In order to determine how much of this allocation a brewing company may influence through their activities, their production volume relative to the global beer production volume will be considered as a brewery's contribution to the industry target (Equation 3). Using beer production by volume is a way to assess each brewery relative to their scale and track efficiencies. It also equalizes companies who act in different local economies and, instead, focuses on the volume of production and their efficiencies. It would not be "just" to allocate more global resources to a brewery who is able to sell their product for more than a brewery of the same production size operating in a region where their product is commonly sold for less.

Equation 3: Brewing company production relative to global beer production to assess brewing-company-specific value added using 2017 data for Carlsberg.

$$\frac{brewing\ company\ production}{global\ beer\ production} \times 100\% = allocation\ for\ brewing\ company$$

For example,

$$\frac{0.0979\ billion\ hl^{29}}{1.95\ billion\ hl^{30}} \times 100\% = \sim 5.02\%$$

Each brewing company's contribution to the industry can then be applied to the brewing industry's allocation for each PQ (Equation 4).

Equation 4: Applying brewing company value-added to the PQs.

$$allocation\ for\ brewing\ company \times brewing\ industry\ PQ\ value$$
$$= brewing\ company\ PQ\ value$$

For example,

$$0.0502 \times \frac{0.458\ Tg\ nitrogen}{year} = 0.023\ Tg\ nitrogen/year$$

This step was repeated for each PQ using relevant data from the content analysis as well as secondary data

[29] Carlsberg 2017 beer production (Carlsberg, 2017)
[30] 2017 global beer production (Conway, 2019)

3.2.3 Comparison of Pressure to Carrying Capacity

In order to determine the sustainability of a brewery's activities compared to the global limits (PQs), a method must be chosen, and results aggregated.

Choice 6: aggregation

A multivariate analysis, normalization of data, weighting and aggregation, and robustness and sensitivity analysis would be completed as part of this step. However, this step was unable to be fully completed as several necessary pieces of data were missing from the reports of breweries. Instead, the data from one brewery (Carlsberg[31]), as well as supplemented secondary data from literature values, were used to fill in gaps from the reports in order to assess performance relative to the PQs developed from the PBs. The choices for normalization, weighting, and aggregation are detailed in the following sections with sample calculations shown for relevant brewery data.

Sample calculations using some of the relevant public data from breweries were completed and are shown in the following sections.

Multivariate analysis: check the data along various dimensions to form groups

This step involved assessing the available data and using them to inform decisions for data normalization, weighting, and aggregation. Due to the nature of the data as well as reference points, the following sections have already filtered through the appropriate options for CI construction (OECD, 2008b).

Normalization of data: code the data to get rid of units such that it can be added

There were two potential options selected for data normalization. The first normalization option was distance to a reference where entries are given a value based on how far away from a given reference they are (Equation 5). In this case the reference would be each PQ.

Equation 5: Distance to a reference calculation for each normalized variable (OECD, 2008b).

[31] Carlsberg was selected for these calculations as there was information about their annual brewery production and fairly comprehensive environmental data provided in their reports relative to the other brewing companies studied. They were also the case study used by research relevant to brewery land-use (i.e., Mattila et al., 2012).

$$I_{qc}^{t} = \frac{x_{qc}^{t} - x_{qc=\bar{c}}^{t0}}{x_{qc=\bar{c}}^{t0}}$$

Where x = value of indicator q for company c in year t, and $c = \bar{c}$ is the PQ company-scaled reference point. Using the PQ reference point for water consumption (i.e., ≤8500 km3/year blue, green and grey water consumption), the values for Carlsberg's 2017 production, and the global average water footprint for beer produced with barley (Mekonnen & Hoekstra, 2011), the water consumption variable is normalized below in a sample calculation. The values for industry allocation and allocation for brewing company were used as calculated above.

$$Global\ PQ\ value \times \frac{industry\ GDP}{Global\ GDP} \times \frac{company\ production}{industry\ production} = company\ allocation$$

$$Global\ PQ\ value \times industry\ allocation \times allocation\ for\ brewing\ company$$
$$= brewing\ company\ PQ\ value = x_{qc=\bar{c}}^{t0}$$

$$x_{water,Carlsberg=\bar{c}}^{2017} = 8500\frac{km^3}{year} \times 0.074 \times 0.0503 = 3.153\ \frac{km^3}{year}$$

$$x_{water,Carlsberg}^{2017} = 97.9\ million\ hl \times \frac{km^3}{1 \times 10^{10} hl} \times \frac{300\ km^3\ water}{km^3\ beer}{}^{32} = \ 2.937\ km^3\ water$$

$$I_{water,Carlsberg}^{2017} = \left(\frac{|2.937 - 3.153|}{|3.153|}\right)\frac{km^3/year}{km^3/year} = 0.0685$$

As $I_{water,Carlsberg}^{2017}$ is positive, the threshold is not surpassed. However, looking at the difference between $x_{water,Carlsberg}^{2017}$ and $x_{water,Carlsberg=\bar{c}}^{2017}$ and the relatively small value for $I_{water,Carlsberg}^{2017}$, the water use is close to its PQ threshold.

The other normalization option was minimum-maximum, where variables were scored based on where they lay throughout the range of given data. Typically, this method is used for relating the scores of organizations to each other (OECD, 2008b). The highest score among those being compared scores a 1 and the lowest scores a 0, with others being ranked between the two. This case typically requires the data from several organizations to work and could be useful if comparable data from several companies were obtained. However, because the data reported

[32] Water footprint of beer made with barley, global average (Mekonnen & Hoekstra, 2011).

by the brewing companies needed to be supplemented by secondary data and industry averages to complete several calculations and industry averages were not available for several of the chosen CI variables, this method was not able to be used. Minimum-maximum is outlined in Appendix D and could prove useful if more primary company-specific data, as well as industry averages, were available.

Weighting and aggregation: determine the relative importance of each variable and how much it will contribute to the CI score

The goals of variable weighting are to ensure that each PB is considered and that importance is given to variables that have crossed their limit. These considerations have been chosen because ignoring one or more PB disregards the importance of seeing the Earth System as a multi-faceted unit. Milne and Gray (2013) argue that specific attention paid to one aspect of environmental sustainability can contribute to the degradation of another. When it comes to measuring impacts on the PBs, one may argue that because they all must be considered (Whiteman et al., 2013), they should all have equal weighting. Without accounting for all of them, the activity cannot be deemed sustainable. The PQ system has accounted for interactions between its quotas and estimates of the current global status of the PQs shows that they are all either exceeded, very close to being exceeded, or unknown (Meyer & Newman, 2018).

The weighting method chosen for the composite-indicator was equal weighting. This method gives all variables the same weight, thus associating the same value to their contribution to the composite-indicator. The other weighting methods considered are mentioned in Appendix D.

The aggregation method chosen was linear aggregation, where all variables are added up to produce the final score or value of the composite-indicator. In this case, a high degree of compensability can occur (i.e., a high score can easily make up for a low score, thus reducing the transparency of the final composite-indicator).

Robustness and sensitivity: Conduct a sensitivity analysis using alternative normalization methods, weighting schemes and values, and aggregation systems

This step ensures the transparency of the model and will allow for various methods to be tested so that those that give a good range of outcomes for the CI will be considered more transparent

- more “sensitive” to changes in data inputs. This step was not conducted due to the limited relevant data from the reports and webpages of the brewing companies. As this step was missing, the results may have shown low sensitivity to a variety of inputs and pointed towards other normalization, weighting, and aggregation methods as being better suited to display the range of industry values.

3.2.4 Presentation of Results

The results were displayed in a Microsoft Excel spreadsheet containing all the inputs, calculations for each variable, and preliminary results for each variable, using a combination of primary data from Carlsberg and secondary literature values.

4.0 Results

4.1 Content Analysis

The goals of the content analysis were to analyze the current reporting habits of breweries related to the PBs, to determine which kinds of indicators were most common, whether or not science-based target setting was practiced in the brewing industry, and which are the most common indicators used related to each PB.

4.1.1 Indicators

About 73% of the breweries investigated (24/33) reported environmental indicators on their website or through a report. The environmental sustainability indicators collected from brewery reports and websites totaled 670. After accounting for duplicates within a company, indicators totaled 538, with 351 indicators determined to be unique across companies, i.e., groups of conceptually similar indicators became one new "unique" indicator. Of the unique indicators, 78 were found in the reports/webpages of more than 1 brewing company. The most common indicators and their categorization can be found below in Table 7.

Table 7: Most frequently reported environmental sustainability indicators noted by the content analysis (n≥5).

Indicator	Brewing Companies (n=)	Category
Water use per volume production	16	Water
Water use, volume	11	Water
Energy use per volume production	8	Energy
Waste to landfill, mass	8	Packaging/Waste
Greenhouse gas emissions, total	7	Emissions
Waste recycled, mass	7	Packaging/Waste
NO_x emissions, mass	6	Emissions
Energy as electric power	6	Energy

Indicator	Brewing Companies (n=)	Category
Waste diverted from landfill, %	6	Packaging/Waste
Carbon footprint contribution from packaging, %	5	Emissions
Waste, recycling rate	5	Packaging/Waste
B Corp score	5	Other

After the sample content analysis was performed, some main categories were developed inductively based on the indicators and targets collected. These categories and their frequency among the unique indicators found are depicted below in Figure 4.

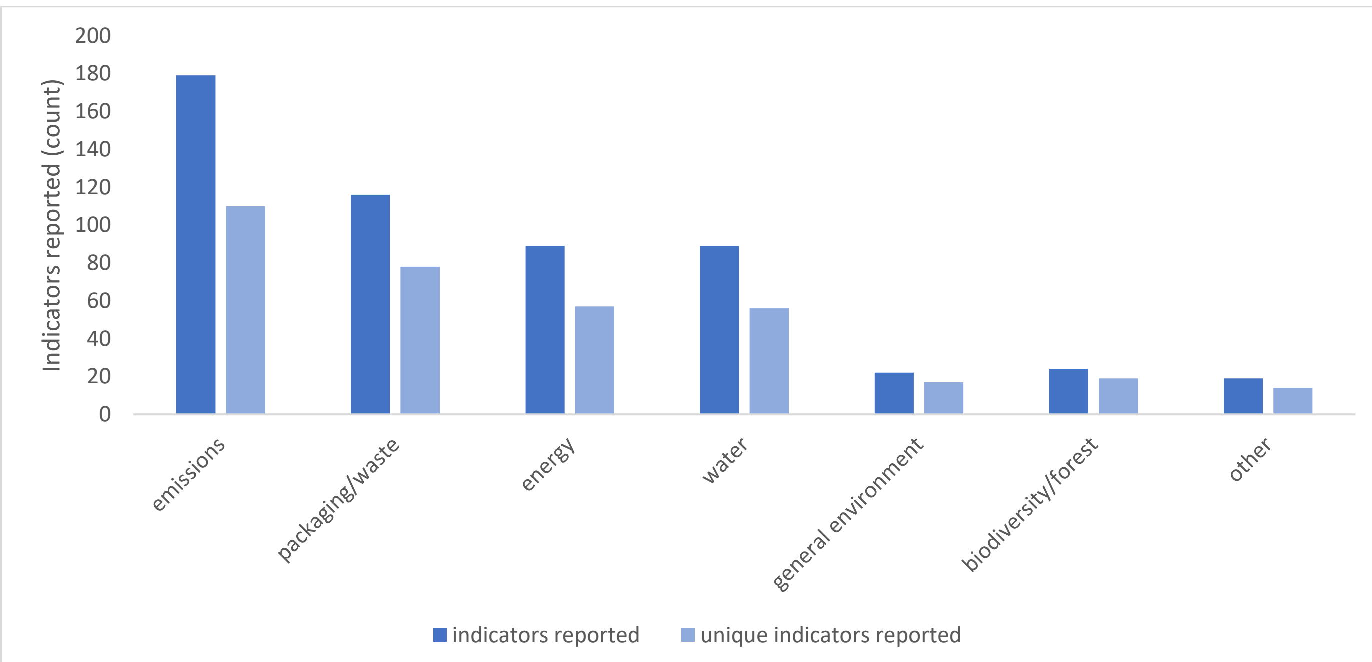

Figure 4: Unique indicators in each environmental category.

"Indicators reported" includes all the environmental indicators collected once those duplicated within companies were removed. "Unique indicators reported" includes only the environmental indicators that were deemed unique across companies; similar indicators were grouped to represent one unique indicator. "Indicators reported" represents the frequency of reporting on a given environmental issue (i.e., how common is this indicator category), while "unique indicators reported" represents the varied ways in which breweries are reporting on certain areas of environmental concern (i.e., how many ways was this category reported on). Emissions reporting was the most prominent in both cases, while biodiversity/forest was less likely to be reported on. Packaging/waste, energy, and water were also major contributors to the collected indicators. In all categories there was some overlap between companies noted by the difference between the reported indicators and the unique indicators.

Emissions

The "emissions" category is the largest and includes 179 environmental sustainability indicators, 110 being unique among the companies, and 3 of the 12 most reported indicators. Indicators in this category encompass GHG emissions, SOx emissions, NOx emissions, and emissions related to refrigeration. Inorganic emissions and GHG emissions have been mentioned as important environmental indicators for the brewing industry (Olajire, 2012; Tokos et al., 2012; Cordella et al., 2008). The most common indicators for emissions are total GHG emissions (n=7), NO_x emissions (n=6), carbon footprint from packaging (n=5), carbon footprint from production (n=4), contribution to carbon footprint from malting and adjuncts (n=4), and total scope 1 emissions (n=4).

Packaging/Waste

The "packaging/waste" category includes 116 environmental sustainability indicators, 78 being unique among the companies, and 4 of the 12 most reported indicators. This category represents indicators that describe the brewery's waste management practices, material use in packaging, and spent grain use. Solid waste, brewing by-products, material inputs, and spent grain have been identified as important environmental sustainability indicators for the brewing industry (Olajire, 2012; Tokos et al., 2012). Solid waste, brewing by-products, containers and packaging, and spent grain have also been identified as important themes found through the analysis of craft brewery reports and websites (Ness, 2018; Herold et al., 2017). Packaging was also found to be one of the largest contributors to the global warming potential of the beer production (Amienyo & Azapagic, 2016). The most common indicators for packaging/waste are weight of waste to landfill (n=8), weight of waste recycled (n=7), % waste diverted from landfill (n=6), recycling rate for waste (n=5), and total weight solid waste (n=4).

Energy

The “energy” category includes 89 environmental sustainability indicators, 57 being unique among the companies, and 2 of the top 12 most reported indicators. This category represents indicators related to energy sources, efficiency, and total energy use. Previous research has found fossil fuel consumption and energy use to be key to environmental sustainability in the brewing industry (Olajire, 2012; Tokos et al., 2012; Cordella et al., 2008). Energy use has also been found to be a main theme in the environmental efforts of craft breweries (Herold et al., 2017). The most common indicators for energy are energy use per volume of production (n=8), energy as electric power (n=6), natural gas (n=4), total energy (n=4).

Water

The “water” category includes 89 environmental sustainability indicators, 56 being unique among companies, and encompasses both wastewater and water use and efficiency. The top two most reported indicators from this analysis are based in water use, representing its importance to the reporting breweries. Water use has been highlighted as a key performance indicator for the brewing industry (Olajire, 2012; Tokos et al., 2012). It has also been discussed as a main theme for craft breweries (Herold et al., 2017). The most commonly reported indicators for water are total water use (n=16), volume water usage (n=11), water efficiency improvement from baseline (n=4), and at-risk brewery watersheds with stewardship programs (n=4).

Biodiversity/forest

The “biodiversity/forest” category includes 24 environmental sustainability indicators with 19 being unique among the companies. The “biodiversity/forest” category includes indicators such as number of trees planted, Red List species and national conservation list species with habitats in areas affected by operations as endangered, and boxes used that are certified and come from responsibly managed forests. These have not been specifically mentioned as key environmental indicators or as main themes reported by breweries in the past. The most commonly reported indicators for biodiversity/forest are number of trees planted (n=3), paper/boxes used that are certified and come from responsibly managed forests (n=3), and participants involved in forest preservation activities (n=2). All other biodiversity/forest indicators were unique to the company that reported them but included themes of species at risk, forest preservation, and land saved or restored.

General Environment

The "general environment" category includes 22 environmental sustainability indicators with 17 being unique among the companies. This category was created to further sort indicators originally categorized as "other". These indicators include donations to environmental organizations, B Corporation environmental impact score, environmental releases and violations, and environmental protection projects and investment. The most commonly reported general environment indicators are B Corporation environmental impact score (n=4) and environmental violations (n=3). All other general environment indicators were unique to the company that reported them but included themes of environmental training and audits and donations to environmental causes.

Other

If an indicator did not fit into one of the determined environmental categories, it was classified as "other". This category represents a total of 19 environmental sustainability indicators with 14 being unique among the companies. Some indicators from this category include weight of ingredient inputs, farmer participation in sustainability programs, B Corporation company score, and sustainably sourced materials. Related to sustainable farming practices, land use has been mentioned as a main environmental influence point of the brewing process (Cordella et al., 2008). Previous research has identified locally sourced ingredients as a main theme among craft breweries (Ness, 2018). The most commonly reported indicators in the "other" category are B Corporation score (n=5) and weight of ingredients for beer-type beverages (n=2). All other "other" indicators were unique to the company that reported them but include themes of materials from sustainable sources and sustainable agriculture efforts.

4.1.2 Representation of the PBs in brewery indicator reporting

As the PBs represent a complex system, some focus must be given to each of them in order to represent a complete image of environmental impact. Change in biosphere integrity and climate change are considered the core PBs as they can be impacted by fluctuations related to other PBs (CISL, 2019; Rockström et al., 2009). For example, the loss of forested land under the land-system change PB impacts CO_2 sequestration and can cause habitat fragmentation, therefore contributing to both climate change and change in biosphere integrity (CISL, 2019; Lindenmayer et al., 2012; Doney et al., 2009; McNeely, 1994). Several of the most commonly reported indicators have direct links to the PBs. These direct links are based on scientific knowledge (e.g., GHG emissions affecting global temperature increases) and not explicit references to the PBs made in the reports.

Emissions

The "emissions" category represents impacts to climate change through GHG emissions. The first secondary affected PB is ocean acidification; ocean pH decreases as the atmospheric concentration of carbon dioxide increases (Doney et al., 2009). Change in biosphere integrity is also affected as the thermal and acidification stress of climate change negatively impacts coral reefs and other marine life (Hoegh-Guldberg, 2011).

Packaging/waste

The "packaging/waste" category contains indicators related to the novel entities PB. Plastic waste (Villarrubia-Gomez et al., 2018) and net imperishable waste (Meyer & Newman, 2018) have been discussed as potential indicators of the undefined novel entities PB. Several indicators in this category are representative of plastic and imperishable waste and show that novel entities have, in general, been considered by the brewing industry.

Energy

The "energy" category is linked to climate change through the GHG emissions related to many typical energy sources. This category also represents a shift away from fossil fuels, towards green electricity and the use of solar panels for example. Similar to emissions, the impacts of energy use also affect ocean acidification and change in biosphere integrity. Addressing climate change is a main consideration in environmental reports, as energy was a widely reported category.

Water

The "water" category is directly linked to the freshwater use PB and goes on to impact change in biosphere integrity (Pittock, et al., 2008). However, the impacts on change in biosphere integrity vary greatly depending on geographic location and the source of water (Verones et al., 2013). While water is a strongly reported category and several indicators mention volume drawn, the geographic location and water source types are less frequently reported.

Biodiversity/forest

The "biodiversity/forest" category represents impacts to change in biosphere integrity and land-system change. While it is the least commonly reported category directly related to the PBs, its representation in reports shows that land-system change and change in biosphere integrity are starting to be considered.

4.1.3 Targets

About 48% of breweries analyzed were found to have environmental targets (16/33). Of those, about 21% of breweries (7/33) listed at least one science-based environmental target, these were all carbon reduction targets referencing the 2016 Paris Agreement and the commitment to limit global temperature increase. 190 environmental targets were collected. After accounting for duplicates within companies, targets totaled 93, with unique targets among the companies totaling 43. The most common reported targets are listed below in Table 8.

Table 8: Most common reported environmental sustainability targets among analyzed breweries.

Target	Brewing Companies (n=)	Category
Increase beer to water ratio/water use efficiency	9	Water

Target	Brewing Companies (n=)	Category
Reduce emissions from scope 1 and 2[33]/operations	6	Emissions
Reduce value/supply chain carbon emissions	5	Emissions
Increase electricity from renewable sources	5	Energy
Protect local water resources	5	Water
Reduce energy intensity/energy per unit	4	Energy
Reduce waste to landfill	4	Packaging/Waste
Reduce environmental effects of cooling	3	Emissions
Increase sustainably sourced material inputs	3	Other
Zero waste to landfill	3	Packaging/Waste

The most common targets reported by the breweries analyzed show trends similar to the indicators found.

The methods used to sort the indicators into categories were repeated for the targets. Figure 5 shows the frequency of category appearance among the environmental targets collected and represents the frontrunning categories for target setting as well as the variety of targets set within each category.

[33] Scope 1 GHG emissions include on-site fossil fuel combustion and fleet fuel consumption from sources owned or controlled by the organization, scope 2 GHG emissions include emissions from the generation of electricity, heat, or steam purchased by the organization from a utility provider (US EPA, 2018).

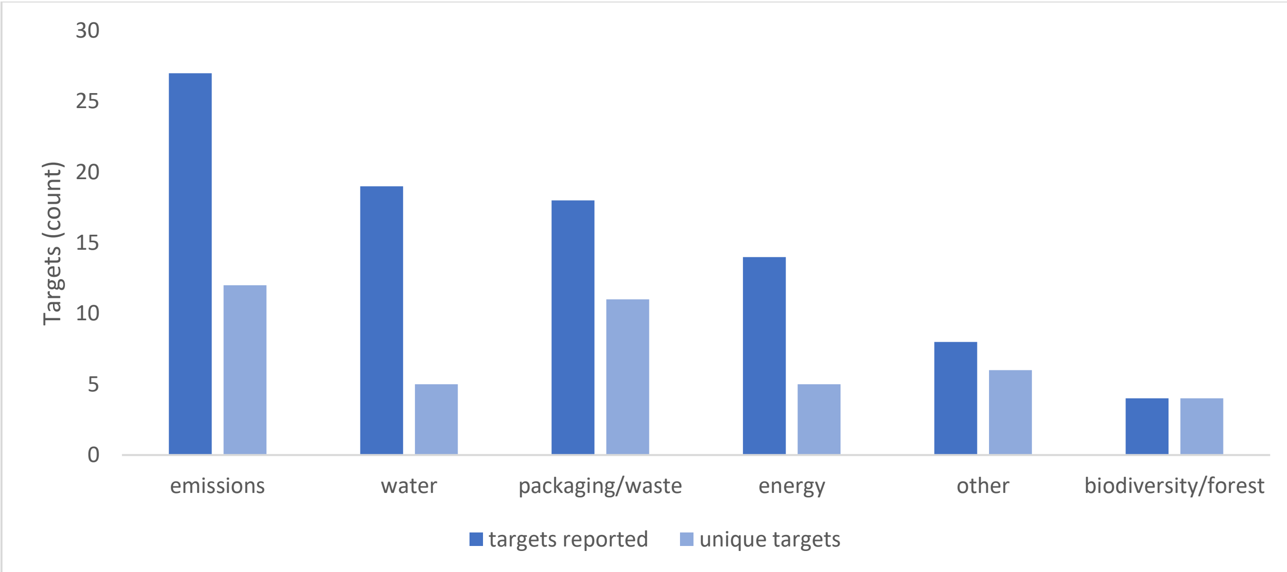

Figure 5: Frequency of category appearance among unique targets.

Emissions reporting is by far the most commonly reported target while biodiversity/forest continues to remain an underreported area for environmental target setting. Emissions targets varied in terms of scope, reduction commitment, and goal year. Some examples of emissions targets include “reduce carbon emissions by 25% across value chain by 2025” and “zero carbon emissions at breweries by 2030”. Biodiversity/forest targets were related to deforestation or plans to account for biodiversity specifically in the future. Some examples include “sustainably source all paper and board packaging to ensure zero net deforestation by 2020” and “establish medium to long term environmental targets consistent with scientific knowledge for biodiversity by 2019”.

Of the 33 breweries analyzed during the content analysis, 16 reported at least one environmental sustainability target. Of those reporting targets, the average number of categories covered per company was 3.4 (median = 3.5). Table 9 shows the frequency of categories appearing in a given company’s targets.

Table 9: Frequency of target categories among breweries.

Category	**Breweries reporting at least one target in this category**
Energy	12
Packaging/Waste	11

Category	Breweries reporting at least one target in this category
Emissions	10
Water	10
Biodiversity/forest	3
Other	8

The frequency of target categories among breweries show similarly popular categories among companies. Targets regarding packaging/waste, energy, water, and emissions are far more common than biodiversity/forest targets and those in other categories.

4.1.4 Range and degree of context in target-setting

Information on target reporting from a company-by-company perspective was also collected. Of the 16 breweries that reported environmental sustainability targets, 7 reported at least one science-based target while 6 reported neither a science-based target nor a PB-referencing target. Of the 93 environmental sustainability targets collected (duplicate targets within the same company were not considered), 27 were considered science-based and 33 considered PB-referencing. The science-based targets were restricted to the emissions and energy categories while the PB-referencing targets included more variety: energy, water, biodiversity/forest, emissions, other. A PB-referencing target means that there was some verbal environmental context given when the target was mentioned. This context would have direct links to a PB and would recognize that ecological limits exist. For example, that local watersheds must be functionally maintained despite water withdrawals or that some areas of brewery operation are water-stressed.

The only target category to not be discussed either in the context of science-based limits or within its ecological significance when mentioned on a website or in a report was packaging/waste.

The proportion of breweries reporting targets with combinations of varying degrees of context can be seen in Figure 6.

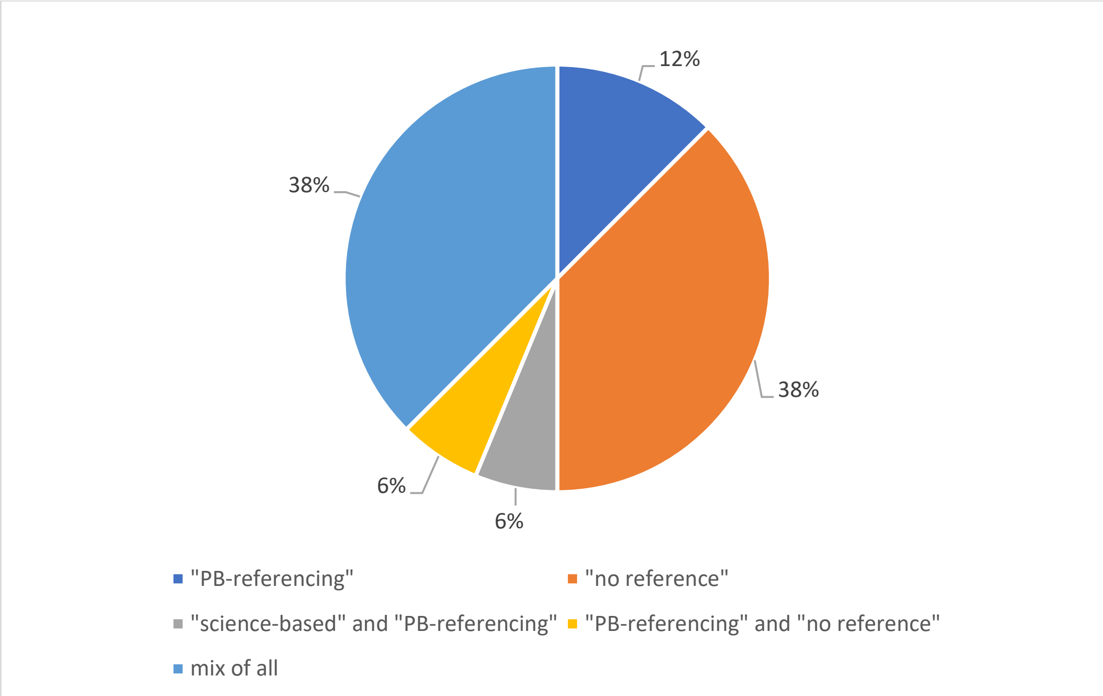

Figure 6: Portion of breweries reporting environmental targets with a given combination of target types representing environmental context.

The two most common combinations of target types regarding environmental context were only “no-reference” targets and a mix of all levels of context. Most breweries reported at least one science-based or PB-based target showing some amount of environmental context when setting targets among breweries. However, only 7 breweries of the 16 that reported environmental targets included a science-based target. Table 10 shows the average distribution of target types among breweries who reported at least one environmental target. There is a lack of emphasis on science-based targets. However, this is not surprising given the lack of category diversity among the science-based targets collected.

Table 10: Average distribution of target types among breweries who reported at least one environmental target.

Average targets per company	5.8
Average science-based targets per brewery	1.7
Average PB-referencing targets per brewery	2.1
Average non-referencing targets per brewery	2.1

An individual target set as “science-based” may have also been “PB-referencing” - each target was scored at the highest achieved level of context.

4.1.5 Representation of the PBs in brewery target reporting

Two of the PBs were missing from those affected by the target-setting of breweries: aerosol loading and atmospheric ozone depletion. The average number of PBs (out of a total of 9) influenced by a given company's targets was 3.25 (median=3). The largest correlation between a given company's targets and the number of PBs influenced by their targets was the inclusion of a target relating to agriculture or plastic waste as these each impact 5 of the PBs. The number of breweries setting targets influencing each of the PBs can be seen in Figure 7.

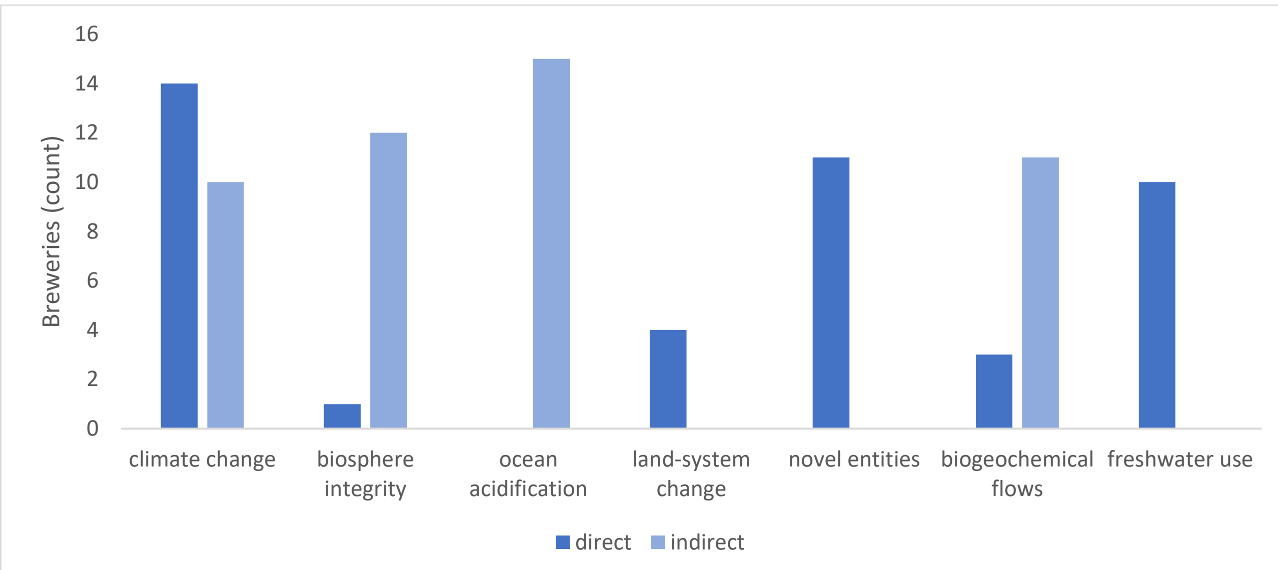

Figure 7: The number of companies reporting targets that affect a given PB.

The two core PBs, biosphere integrity and climate change (as well as ocean acidification through its relationship to atmospheric CO_2), were both influenced through the targets of several breweries. However, biosphere integrity was only directly influenced by one. Land-system change, an influencer of several other PBs, was only influenced by the targets of 4 breweries. These PBs were represented by the biodiversity/forest category for indicators and targets.

While a wide-variety of PBs are influenced by the target-setting of breweries, direct impact across the PBs is lacking. There is also a lack of consistency between breweries when it comes to impactful environmental target setting.

The number of targets categorized by PBs, either direct or indirect, can be seen below in Figure 8.

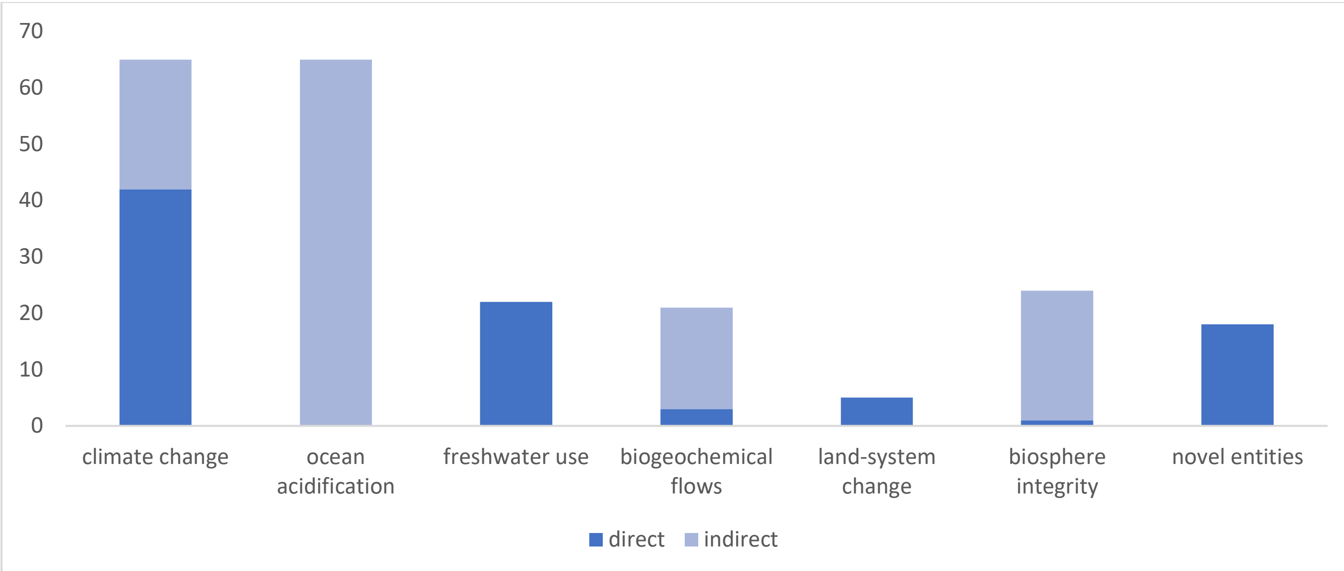

Figure 8: Count of targets focusing on each PB.

These target counts show trends similar the prevalence of emission reduction targets among breweries. Freshwater use is directly addressed through water efficiency targets. Biosphere integrity remains an underrepresented environmental concern and despite being a core PB, it is only related indirectly to the environmental target-setting of these breweries.

4.2 Composite-Indicator

The following sections compare the indicators from the content analysis to the PQs and describe the resulting data gaps and potential fillers for each PB and subsequent PQ. Sample normalization calculations and a division of the PQ per hL of beer production are displayed for each PQ. Table 11 shows the values for the calculations of the following PQ allocations. The value of the PQ limits can be found in Appendix E.

Table 11: Variables and values used in PQ composite-indicator calculations.

Variable	**Value**
Global GDP 2017	80,262.15 trillion USD[1]
Global Value of Brewing Industry 2017	593.02 trillion USD[2]

Variable	Value
Global Beer Production 2017	1.95 billion hL[3]
Company Production 2017	0.0979 billion hL[4]

[1]Plecher (2019), [2]AMR (2020),[3]Conway (2019), [4]Carlsberg (2018)

4.2.1 Climate Change

The climate change PB set up by Steffen et al. (2015b) was given two control variables with limits: an atmospheric CO_2 concentration of 350 ppm and an increase in top-of-atmosphere radiative forcing of +1.0 W/m^2 relative to preindustrial levels. In order to translate these boundaries to ensure their responsibility is divisible, Meyer and Newman (2018) developed two PQs: carbon dioxide and Me-NO.

Several companies reported on their emissions; however, the indicators relevant to carbon used were a mix of CO_2 emissions and GHG emissions. Based on the GRI guidelines, GHG emissions (scope 1, scope 2, and scope 3) include both CO_2 and methane (Me), among others, and NO_x emissions are reported separately (GRI, 2016). For companies following this reporting standard, not only are land use related emissions not necessarily included, but the Me-NO cannot be calculated as it has been mixed in the reported value. When reporting their CO_2e emissions, brewing companies tended to call the indicator CO_2 emissions (n=3), carbon footprint (n=3), or GHG emissions (n=9).

4.2.1.1 Carbon Dioxide

This PQ is represented by net CO_2 emissions, including land use and land-use change emissions, and has a global limit of ≤-73 Gt CO_2/year (Meyer & Newman, 2018). This equates to not only achieving net zero CO_2 emissions, but then going beyond to ensure more carbon sequestration is occurring than emissions, and by a difference of at least the ≤-73 Gt CO_2/year goal. The timeline associated with this quota requires net zero CO_2 emissions by 2030 and the PQ must be met by 2050 (Meyer & Newman, 2018). Two similar targets were mentioned by breweries as part of the content analysis: zero CO_2 emissions by 2050 and zero carbon emissions at breweries by 2030.

The per hectoliter (hL) reduction required to meet the PB by the end of the century is calculated below.

$$\frac{CO_2\ PQ\ limit \times \frac{value\ of\ brewing\ industry}{global\ GDP}}{global\ beer\ production} = \frac{-276.6\ kg\ CO_2e}{hL \cdot year}$$

Several brewing companies reported on their CO_2 emissions in some form (n=15). However, the variety of indicators used, along with the lack of context for indicators, made differentiating CO_2 emissions and GHG emissions difficult. Additionally, whether land use was included for indicators is unclear. It is clear, however, that the boundaries used for most of the emissions indicators of brewing companies are not transparent and therefore cannot be assumed equal to the requirements of calculating this PQ.

As an example, assuming the reported indicators do indeed account for land use and cover the entire supply chain, the normalized score for Carlsberg's CO_2 variable is calculated below using distance to a reference.

Distance to a Reference Method

$$Global\ PQ\ value \times \frac{industry\ GDP}{Global\ GDP} \times \frac{company\ production}{industry\ production} = company\ allocation$$

$$Global\ PQ\ value \times industry\ allocation\ factor \times company\ allocation\ factor = company\ allocation$$

$$x^{2017}_{CO_2,Carlsberg=\bar{c}} = -73\frac{GtCO_2}{year} \times 0.00739 \times 0.0502 = -0.0271\frac{GtCO_2}{year}$$

$$x^{2017}_{CO_2,Carlsberg} = 802\ kt\ CO_2\ emissions^{34} \times \frac{Gt}{1 \times 10^6 kt} = 0.000802\frac{GtCO_2}{year}$$

$$I^t_{qc} = \frac{x^t_{qc} - x^{t0}_{qc=\bar{c}}}{x^{t0}_{qc=\bar{c}}}$$

$$I^{2017}_{CO_2,Carlsberg} = \left(\frac{0.000802 - (-0.0271)}{|-0.0271|}\right)\frac{GtCO_2/year}{GtCO_2/year} = 1.02962$$

[34] Total CO_2 emissions (location-based), 2017, 2018 Sustainability Report (Carlsberg, 2018)

As $I^{2017}_{CO_2,Carlsberg}$ is positive this indicates that the PQ limit has been crossed. However, as the value is relatively close to 0, the CO_2 emissions are relatively close to the limit.

4.2.1.2 Me-NO

This PQ is represented by the total warming potential of methane and nitrous oxides emissions and nitrous oxides emissions in terms of equivalent CO_2 emissions (CO_2e) and has a global quota of ≤5.4 $GtCO_2e$/year (Meyer & Newman, 2018). This idea to consider both methane and nitrous oxides emissions when considering warming potential was also mirrored by Tian et al. (2015).

None of the breweries from the content analysis reported specifically on methane emissions. However, several reported their GHG emissions in annual CO_2e. This is not reliable for this calculation for several reasons: it is unclear if these values include methane emissions, it is also unclear what the scope of the GHG emissions is along the supply chain. Methane emissions would need to be accounted for separately in order to use the reported value as an input for this PQ.

Some of the breweries from the content analysis reported on their nitrous oxides emissions, however it was not widespread (n=6) and the scope was unclear. More context surrounding the reported value would be required to determine if it would be a reliable input for this PQ.

The Me-NO PQ limit has been calculated per hl production below.

$$\frac{MeNO\ PQ\ limit \times \frac{value\ of\ brewing\ industry}{global\ GDP}}{global\ beer\ production} = \frac{20.46\ kg\ CO_2e}{hL \cdot year}$$

As there is a lack of available data from brewing companies as well as industry average reports, the contribution of Carlsberg to the Me-NO PQ limit and the subsequent indicator were not calculated.

4.2.2 Biosphere Integrity

The biosphere integrity PB was developed by Steffen et al. (2015b) and includes two interim and non-ideal control variables: global extinction rate and Biodiversity Intactness Index (BII).

Current measures of species variability and functional diversity are lacking global data and are difficult to apply to the global scale (Steffen et al., 2015b).

As a way to translate the interim variables to become a divisible responsibility, Meyer and Newman (2018) have defined the biodiversity PQ using species extinction by calculating percentage disappeared fraction (PDF) of species which is an estimation based on land-use data. This biodiversity PQ is represented by the net percentage disappearing fraction of species due to land occupation and transformation and has a global quota of ≤1E-4 PDF/year (Meyer & Newman, 2018). This PQ is not only difficult to divide responsibility for, but also to measure, as species disappearance is complicated, influenced by several factors, and related to the state of the other PBs (CISL, 2019; Meyer & Newman, 2018). The PDF/year PQ is an indicator developed as a proxy for biodiversity loss related to land-use types; it is not meant to be divisible but rather applicable at all scales (Meyer & Newman, 2018). Therefore, the responsibility at any scale is to manage environmental impact such that ≤1E-4 PDF/year is achieved.

The key drivers of biodiversity loss, as collected by Meyer and Newman (2018), are climate change, pollution, overexploitation of species, spread of invasive species or genes outcompeting native species, and habitat loss, fragmentation, or change. These drivers are directly related to several PBs and the first two have been accounted for directly or indirectly through the development of the PQs. However, there is a lack of available information on calculating the others in relation to company activities. As there is a lack of available data on biodiversity loss from brewing companies as well as industry average reports, the contribution of Carlsberg to the biodiversity loss PQ limit and the subsequent indicator were not calculated.

4.2.3 Land System Change

This PQ is represented by net deforested land area and has a global quota of ≤-11 Mha/year (Meyer & Newman, 2018). This PQ was determined based on a century of reforestation in order to restore the PB limit of ≥75% of original forest area.

Some of the contributors to land use for the brewing industry are agriculture and forestry requirements for the raw materials needed for the beer brewing itself as well as packaging production (Mattila et al., 2012). Few of the brewing companies from the content analysis reported on contributors to deforestation. Some indicators from the content analysis included themes of packaging material consumption (n=8), recycled content in packaging (n=3), and mass of ingredients purchased (n=3).

Land use may be offset through reforestation, best practices for agriculture, and using spent grain for animal feed, thus offsetting the grain and land required to feed cattle (Meyer & Newman, 2018; Mattila et al., 2012). The brewing companies from the content analysis reported several indicators related to forested land. Forestry-related indicator themes included reforestation activities (n=5), sourcing materials from sustainably managed forests (n=2), and forest preservation activities (n=6). Some brewing companies reported on spent grains as animal feed (n=3) as well as grains reused through food recovery programs (n=1). Supporting sustainable agriculture (n=2) was also reported by two of the breweries.

Table 12: Indicators collected with impacts on land use.

Category	Indicators
Packaging material consumption (overall and paper-based specific)	• use of resources for containers and packaging (mass) • container and packaging materials for beer-type beverages (mass) • packaging used (mass) • increase in packaging material consumption of carton from 2016 (%) • packaging material consumption of carton (mass) • packaging materials by volume as cartons (%) • packaging materials by volume as corrugate (%) • packaging materials by volume as labels and sleeves (%)
Recycled content in packaging	• cardboard for beer packaging made from recycled materials (%) • baseline for recycled content in product packaging • recycled input materials used (%)
Mass of ingredients purchased	• brewer's grains and brewer's yeast utilized (mass)

Category	Indicators
	• ingredients for beer-type beverages (mass) • agricultural raw materials used (mass)
Reforestation activities	• trees planted (count) • trees planted in Kenya (count) • trees and shrubs planted by volunteers (count) • trees planned to be planted over next 3 years (count) • reforested land in Uganda (area)
Sourcing materials from sustainable managed forests	• sustainably sourced paper and board packaging (%) • boxes used that are certified and come from sustainably managed forests (%) • cardboard for beer packaging that is certified by the SFI (%)
Forest preservation activities	• sites involved in forest preservation activities (count) • events involving forest preservation activities (count) • sites for water source forest preservation project (count) • projects for water source forest preservation project (count) • participants involved in forest preservation activities (count) • participants involved in water source forest preservation project (count)
Spent grain as animal feed	• spent grain distributed as livestock feed (%) • waste to cattle feed (mass) • grain to cattle (mass)
Grains reused through food recovery programs	• grains reused through food recovery program (mass)
Supporting sustainable agriculture	• donations supporting sustainable agriculture (%) • farmers who participated in SmartBarley Program (count)

These indicators do not provide enough information to determine net deforested land area.

The per hL allowance based on the PQ limits is calculated below for forestland.

$$\frac{Forestland\ PQ\ limit \times \frac{value\ of\ brewing\ industry}{global\ GDP}}{global\ beer\ production} = \frac{-0.4168\ m^2}{hL \cdot year}$$

Being able to quantify the land occupation required for beer production is not typically included in LCAs, however there are several existing land use indicators (Mattila et al., 2012). While there are several options that exist, "no single indicator was found to describe the full range of environmental impacts caused by land use" (Mattila et al., 2012, p.285). The calculations of Mattila et al. (2012) used primary data from Carlsberg and supplemented with secondary data where required to determine a supply chain net land use 0.2 m^2/unit/year, where a unit is 0.33 L of beer. Given this value, the PQ for Carlsberg and the current estimated contributions are calculated below.

$$Carlsberg\ land\ use\ PQ = x^{2017}_{land\ use, Carlsberg=\bar{c}} = 0.00739 \times 0.0502 \times \frac{-11 Mha}{year}$$

$$= -0.00408 \frac{Mha}{year} = -4080.4 \frac{ha}{year}$$

$$Carlsberg\ deforestation\ contribution = x^{2017}_{land\ use, Carlsberg} = \frac{0.2 m^2}{0.33 L} \times 0.0979\ billion\ hL$$

$$= 0.594\ Mha$$

Distance to a reference is used for normalization below.

$$I^t_{qc} = \frac{x^t_{qc} - x^{t0}_{qc=\bar{c}}}{x^{t0}_{qc=\bar{c}}}$$

$$I^{2017}_{land\ use, Carlsberg} = \left(\frac{0.594 - (-0.00408)}{|-0.00408|}\right) \frac{Mha/year}{Mha/year} = 146.56$$

As $I^{2017}_{land\ use, Carlsberg}$ is positive and relatively far away from 0, this indicates that the PQ limit has been crossed by quite a bit.

4.2.4 Freshwater Use

This PQ is represented by the global net green, blue, and grey water consumption and has a global quota of ≤8500 km^3/year (Meyer & Newman, 2018).

The divided management responsibility is calculated for brewery water use below.

$$\frac{Fresh\,water\,use\,PQ\,limit \times \frac{value\,of\,brewing\,industry}{global\,GDP}}{global\,beer\,production} = \frac{322\,hL\,water}{hL \cdot year}$$

The freshwater use indicators reported by brewing companies tended to only include water usage of the production facility for tasks such as cleaning bottles and the liquid found in the final product. However, the true water footprint of a unit of beer is much more complicated. The water needed to produce agricultural inputs such as barley, hops, wheat, cassava, and other beer ingredients tends to far exceed the water used by the brewery itself (WWF & SAB Miller, 2009). When determining the water usage to be allocated to a product, the idea of virtual water becomes important. Virtual water can be explained as the volume of water used to produce a commodity (Allan, 1996). In the case of brewing companies, the virtual water associated with ingredients entering the processing facility must be included when calculating the freshwater use per volume of beer. This concept is also reflected in the intentions of the freshwater use PQ with the inclusion of blue, green, and grey water (Meyer & Newman, 2018).

The virtual water for an agricultural product can be calculated as the ratio of the volume of water used during the entire period of crop growth (volume/area) and the corresponding crop yield (mass/area), where the volume of water used includes both rainfall and irrigation water (i.e., green and blue water respectively) (Chapagain et al., 2006). Based on the indicators collected during the content analysis, these data are not typically in the scope of brewing company reports. The main indicators used to report on brewery water use included water use by volume of production (n=15) and total water usage (n=9). While these values capture the water used directly by breweries, and are relevant to local watersheds, the global water use PQ was developed to include virtual water, which is traded globally through the “water value” of goods (Meyer & Newman, 2018). Only one company from the content analysis reported on their water footprint but did not include a total or relate it to their production. They reported the percent of water use associated with raw ingredients, packaging, production, transport, and retail and customer.

The idea of assigning a water footprint to consumable goods has been explored in depth for agricultural products: rice and cotton (i.e., Chapagain & Hoekstra, 2011; Chapagain, et al., 2006). Typical values for the water required to grow barley and produce beer have also been investigated (e.g., Mekonnen & Hoekstra, 2011; Mekonnen & Hoekstra, 2010). One study conducted for SABMiller found the water footprint of their beer to range from 155 L water/L beer to 45 L water/L beer (WWF & SAB Miller, 2009). The global average for beer made with barley was found to be much higher at 300 m^3/ton beer (or about 300hL water/hL beer) (Mekonnen & Hoekstra, 2011). Comparing two countries with varying reliance on blue water (irrigated) and green water (rain-fed) for crops, the average water required to produce barley beer was found to be 730 m^3 water/ton beer in Afghanistan and 212 m^3 water/ton beer in Canada (Mekonnen & Hoekstra, 2010).

The discrepancies found between this range of values indicates that while a global average may be useful for the brewing industry as a whole or as a comparison, regional data would be required to determine the water use impacts of a specific company.

The distance to a reference method is shown below.

The PQ for freshwater use for Carlsberg is calculated below.

$$Carlsberg\ water\ PQ = x^{2017}_{water,Carlsberg=\bar{c}} = 0.00739 \times 0.0502 \times \frac{8500\ km^3}{year}$$

$$= 3.153\,\frac{km^3\ water}{year}$$

Using the global average for water use in barley beer production, the estimated annual water use for Carlsberg is calculated below.

$$brewery\ water\ use = water\ use\ ratio \times company\ production\ volume$$

$$x^{2017}_{water,Carlsberg} = \frac{300\ km^3\ water}{km^3\ beer} \times 0.00979\ km^3\ beer = 2.937\ km^3\ water$$

$$I_{qc}^{t} = \frac{x_{qc}^{t} - x_{qc=\bar{c}}^{t0}}{x_{qc=\bar{c}}^{t0}}$$

$$I_{water,Carlsberg}^{2017} = \left(\frac{2.937 - 3.153}{|3.153|}\right)\frac{km^3\ water/year}{km^3\ water/year} = -0.0685$$

As $I_{water,Carlsberg}^{2017}$ approaches 0, $x_{water,Carlsberg}^{2017}$ approaches the PQ limit. In this case, the water use is very close to the limit, but has not crossed it yet. $I_{water,Carlsberg}^{2017}$ is still negative

Given the global average, the water use calculated is very close to the PQ limit. Depending on how the current values have changed for crop water requirements globally, from the 1996-2005 data set used by Mekonnen and Hoekstra (2010), the new average may be higher or lower and moving the brewing industry closer or further away from the PQ limit. Additionally, as mentioned above, the values reported by Mekonnen and Hoekstra (2011) had a large range overall and the ratio of green to blue water use largely dependent on region. Therefore, where the grain is coming from has the potential to push a brewery's global water consumption footprint past the PQ and must be known for an accurate estimate.

4.2.5 Biogeochemical Flows

4.2.5.1 Nitrogen

This PQ is represented by the net reactive nitrogen released to the environment and has a global quota of ≤62 Tg/year (Meyer & Newman, 2018). Sources of reactive nitrogen include the agricultural run-off of fertilizers as well as the combustion of fossil fuels and subsequent emissions of nitrogen oxides (UNEP & WHRC, 2007). Both these major sources are relevant to the brewing industry through the cultivation of grain and the energy requirements of brewing and transportation.

The equivalent brewing industry-scaled PQ value for net reactive nitrogen is calculated below.

$$\frac{Nitrogen\ PQ\ limit \times \frac{value\ of\ brewing\ industry}{global\ GDP}}{global\ beer\ production} = \frac{0.2349\ kg}{hL \cdot year}$$

Agriculture

While barley is the most traditionally used ingredient in beer brewing, several grains and plants can be used depending on the company and recipe. For example, barley, wheat, oat, and rye are all relevant to the Danish beer market (Zhuang et al., 2017). When it comes to managing nitrogen released to the environment from agriculture, nitrogen-use efficiency[35] is a key metric (Zhang et al., 2015). The literature gives examples of typical nitrogen leached into the environment from barley crops and the given yield (e.g., Tidaker et al., 2016). When this is known, the supposed nitrogen lost to the environment per weight of grain that is used by a brewing company may be calculated using typical values for barley crops in their area and would contribute to their "allowed" contribution to the global quota. This may be difficult information to obtain, however regional data or estimations based on nitrogen application and barley absorption rates may be useful placeholders.

Tidaker et al. (2016) completed a cradle to gate[36] LCA for spring barley using two Swedish growing areas, both comparable to many barley-growing regions in Europe and around the world. Relevant to this section, the nitrogen applied to barley crops as well as the nitrogen released to the environment through leaching was discussed. Two other scenarios use the nitrogen efficiency typical of cereal grains (Raun & Johnson, 1999), high and low fertilizer to application rates for stubble[37] (Government of Manitoba, n.d.), and a typical barley yield (OMAFRA, 2018). The Maltster's Association of Great Britain was used for information on malt production per weight of grain and malt per hL beer production (MAGB, 2011). The active nitrogen released to the environment was calculated for all four scenarios (Appendix E) and the results displayed below on a per hL basis in Table 13.

Table 13: Nitrogen released to the environment using a range of values for yield, nitrogen application, and crop nitrogen retention/seepage.

Scenario	N released to environment
A	0.1521 kg/hL
B	0.0274 kg/hL
C	0.2430 kg/hL
D	0.3977 kg/hL

[35] Nitrogen-use efficiency is the fraction of N input harvested as product (Zhang et al., 2015).
[36] This scope relates to inputs and emissions from the production of fertilizers to the semi-processed barley ready to be shipped (Tidaker et al., 2016).
[37] The plant stalks left after harvest.

From Table 13, the numbers can vary drastically when using industry averages to make assumptions about a brewing company's contributions towards the release of reactive nitrogen through agriculture. Therefore, primary data, specific to the suppliers of farm products, would be the most accurate input for this PQ.

Fossil Fuel Combustion

In order to calculate the contributions of a brewing company's fossil fuel use to their reactive nitrogen released, the fossil fuel consumption must be known. While there were companies from the content analysis reporting specifically on their natural gas and oil use, using those data may not be indicative of the bigger picture.

Several companies from the content analysis reported on emissions as nitrogen oxides (n=6). However, the scope of these emissions is unknown and the value required to determine a brewing company's contribution to the global quota would require the emissions of nitrogen oxides spanning the entire supply chain. Carlsberg reported "total NO_x emissions" of 1,075 metric tons for 2017 (Carlsberg, 2018).

Calculating a Company-specific Nitrogen PQ

Assuming the 2017 NOx emissions indicator to represent the emissions from fossil fuels, and the agricultural active nitrogen released based on Scenario D along with the reported malting weight value of 301.1 kt (Carlsberg, 2018), the contribution towards the nitrogen PQ for Carlsberg is calculated below.

The agricultural calculation is based on Carlsberg's malt requirements, the lower of literature yield values, and the higher of literature N application values. The N leached from agriculture, simplified to include barley only, is calculated below.

$$malted\ barley \times convertion\ ratio = harvested\ barley$$

$$301{,}100\ metric\ tons\ malted\ barley^{38} \times \frac{1.3\ tons\ barley}{ton\ malt}^{39} = 391{,}430\ metric\ tons\ barley$$

[38] Carlsberg (2018)
[39] MAGB (2011)

$$barley\ required \div yield \times N_{applied} \times N_{loss\ ratio} = N\ lost\ to\ environment$$

$$391{,}430\ metric\ tons \times \frac{ha}{3.2925\ metric\ tons}{}^{40} \times \frac{100.89\ kg\ N}{ha}{}^{41} \times 0.67^{42} = 8{,}036{,}174\ kg\ N$$

Summing the two active nitrogen sources gives $x^{2017}_{N,Carlsberg}$.

$$x^{2017}_{N,Carlsberg} = 1{,}075{,}000\ kg + 8{,}036{,}174\ kg = 0.00911\ Tg$$

In this case, the value is lower than the PQ limit, however, the nitrogen emissions reported may not be comprehensive when considering the fossil fuel impacts along entire supply chain.

The normalized variable for Carlsberg for distance to a reference is calculated below.

In order to calculate nitrogen PQ shares for Carlsberg, Equation 1 and Equation 2 were combined to calculate Carlsberg's company PQ limit below.

$$Global\ PQ\ value \times \frac{industry\ GDP}{Global\ GDP} \times \frac{company\ production}{industry\ production} = company\ allocation$$

$$Global\ PQ\ value \times industry\ allocation \times allocation\ for\ brewing\ company = company\ PQ\ limit = x^{2017}_{N,c=\bar{c}}$$

$$x^{2017}_{N,Carlsberg=\bar{c}} = \frac{62\ Tg\ N}{year} \times 0.00739 \times 0.0502 = 0.023\ \frac{Tg\ N}{year}$$

$$x^{2017}_{N,\ Carlsberg} = 0.00911\ \frac{Tg\ N}{year}$$

$$I^{t}_{qc} = \frac{x^{t}_{qc} - x^{t0}_{qc=\bar{c}}}{x^{t0}_{qc=\bar{c}}}$$

$$I^{2017}_{N,Carlsberg} = \left(\frac{0.00911 - 0.023}{|0.023|}\right)\frac{Tg\ N/year}{Tg\ N/year} = -0.604$$

As $I^{2017}_{N,Carlsberg}$ is negative, the limit has not been surpassed. However, the value is close to zero, showing that it is relatively close to the PQ limit.

[40] Tidaker et al. (2016)
[41] Government of Manitoba (n.d.)
[42] Raun & Johnson (1999)

4.2.5.2 Phosphorus

This PQ is represented by the net phosphorus released to the environment and has a global quota of ≤11 Tg/year (Meyer & Newman, 2018). Phosphorus, similar to nitrogen, is released through fertilizer leaching and run-off. It is primarily added to the environment by humans through fertilizers (Manuel, 2014).

The equivalent brewing industry-scaled phosphorus PQ value is calculated below on per hL production basis.

$$\frac{Phosphorus\ PQ\ limit \times \frac{value\ of\ brewing\ industry}{global\ GDP}}{global\ beer\ production} = \frac{0.04168\ kg\ P}{hL \cdot year}$$

Results from calculating phosphorus lost to the environment in four scenarios using barley data from Tidaker et al. (2016) and Yläranta et al. (1996) (Appendix E) are displayed in Table 14.

Table 14: Spring barley data for phosphorus losses compared to field application, A and B (Tidaker et al., 2016) and the high and low loss values for fallow barley and grass ley C and D (Yläranta et al., 1996).

Scenario	P added to field	P losses	P to environment
A	9 kg/ha	0.27 kg/ha	9.33×10^{-4} kg P/hL
B	9 kg/ha	0.81 kg/ha	3.702×10^{-3} kg P/hL
C	-	0.02 kg/ha	1.18×10^{-4} kg P/hL
D	-	0.26 kg/ha	1.53×10^{-3} kg P/hL

Similar to the ranges seen with nitrogen losses, phosphorus losses can vary. In order to be accurately representing a company's contribution to PQs, primary data would be required. A sample calculation is shown below for the limit and standing of phosphorus release from brewery-related agriculture using Carlsberg indicator data and Scenario B from Table 14 to represent the highest loss potential from literature data.

$$Carlsberg\ phosphorus\ PQ = 0.00739 \times 0.0502 \times \frac{11\ Tg}{year} = 0.004085344\ Tg/year$$

$$malted\ barley \times convertion\ ratio = harvested\ barley$$

$$301{,}100\ metric\ tons\ malted\ barley^{43} \times \frac{1.3\ tons\ barley}{ton\ malt}^{44} = 391{,}430\ metric\ tons\ barley$$

$$barley\ required \div yield \times P_{loss} = P\ lost\ to\ environment$$

$$391{,}430\ metric\ tons \times \left(\frac{ha}{3.292515\ tonnes} \times \frac{0.81\ kg\ P}{ha}\right)^{45} = 96{,}296.69\ kg\ P$$

The distance to a reference method is shown below.

$$x^{2017}_{P,Carlsberg=\bar{c}} = \frac{11\ Tg\ P}{year} \times 0.00739 \times 0.0502 = 0.00408\ \frac{Tg\ P}{year}$$

$$x^{2017}_{P,Carlsberg} = 0.00096297\ \frac{Tg\ P}{year}$$

$$I^{t}_{qc} = \frac{x^{t}_{qc} - x^{t0}_{qc=\bar{c}}}{x^{t0}_{qc=\bar{c}}}$$

$$I^{2017}_{P,Carlsberg} = \left(\frac{0.00096297 - 0.00408}{|0.00408|}\right)\frac{Tg\ P/year}{Tg\ P/year} = -\,0.764$$

As $I^{2017}_{P,\ Carlsberg}$ approaches 0, $x^{2017}_{P,Carlsberg=\bar{c}}$ approaches the PQ limit. The negative value shows that $x^{2017}_{P,Carlsberg=\bar{c}}$ is lower than the PQ limit.

4.2.6 Ocean Acidification

There is no PQ directly related to the ocean acidification PB. As ocean acidification is directly affected by atmospheric CO_2 concentrations, it has been accounted for in the carbon dioxide PQ (Meyer & Newman, 2018).

4.2.7 Atmospheric Aerosol Loading

This PQ is represented by the emissions of aerosols and precursor gases expressed in terms of equivalent aerosol optical depth (AODe) with a range of 0.04 to 0.1 AODe. This equivalent value has been developed through relating emissions to their effect on average global aerosol optical depth (Meyer & Newman, 2018). The range is given to reflect that while zero is ideal for human health, a small amount in the atmosphere has a cooling affect which can counteract the

[43] Carlsberg (2018)
[44] MAGB (2011)
[45] Tidaker et al. (2016)

warming effects of GHGs. Because this PQ is meant to represent a global average, the PQ is not divided, but should rather represent the average at all scales (Meyer & Newman, 2018). Therefore, the responsibility at every scale is to manage environmental impact such that AODe remains between 0.04 and 0.01.

Anthropogenic aerosol emissions are related to the following source categories: "(i) fuel combustion, (ii) industrial processes, (iii) nonindustrial fugitive sources (roadway dust from paved and unpaved roads, wind erosion of cropland, construction, etc.), and (iv) transportation activities with cars, ships, airplanes, and other vehicles" (Tomasi et al., 2017, p.48-49). Some specific sources related to the brewing industry include coal and fossil fuel combustion, waste incineration, biomass burning, vehicles, SO_2, oil refineries, paper mills, fertilizers and agricultural activities, and industrial dust (Tomasi et al., 2017). The indicators from the content analysis are compared to the sources of aerosols below in Table 15.

Table 15: Sources and reported indicators for aerosol emissions.

Source	**Reported Indicators**
Coal	• reduction in coal use over past 3 years (%) • thermal energy as coal (%) • energy consumption from coal (mass) • coal-burning boilers phased out since 2015 (count) • reduction in coal consumption from 2015 (%) • drop in coal consumption per unit product from 2015 (%) • coal consumption decrease from 2016 (%)
Fossil fuels	• proportion of breweries using steam or natural gas (%) • city gas (volume) • liquified natural gas (mass) • A-grade heavy oil (volume) • natural gas (therms) • natural gas (volume) • thermal energy as natural gas (%) • thermal energy as heavy fuel (%) • thermal energy as light fuel (%) • energy consumption from natural gas (volume) • energy consumption from gasoline (mass)

Source	Reported Indicators
	• energy consumption from diesel oil (mass) • energy consumption from non-renewable energy (TJ) • green natural gas (%) • increase in energy consumption from natural gas from 2016 (%) • decrease in energy consumption from gasoline from 2016 (%) • decrease in energy consumption from diesel oil from 2016 (%) • decrease in vehicle gasoline consumption from 2016 (%)
Waste incineration	• solid waste to incineration (mass) • waste to incinerator (%) • solid waste incinerated (mass)
Biomass burning	• energy from renewable thermal and electricity sources (including biomass, biogas, and solar) (%)
Vehicles	• miles saved from car and carbon impacts from staff commuting choices (miles driven) • staff that commutes by bicycle, walking, public transportation, or carpool (%) • scope 3 emissions contribution from upstream transportation and distribution (CO_2e) • scope 3 contributions from upstream transportation and distribution (CO_2e) • scope 3 contributions from downstream transportation and distribution (CO_2e) • total scope 3 emissions (CO_2e) • GHG emissions scope 3 (CO_2e) • scope 3 emissions (CO_2e) • GHG emissions from scope 3 (%) • scope 3 (indirect emissions) contribution (%) • scope 3 emissions contribution from employee commuting (CO_2e) • energy consumption from road and rail transport (GJ)
SO_2	• total SO_2 emissions (mass) • SO_2 emissions (mass) • SO_x emissions (mass) • decrease in SO_2 emissions from 2015 (%) • decrease in SO_2 emissions from 2016 (%)
VOCs	• VOC emissions (mass)

Source	Reported Indicators
	• emissions as VOCs (mass)
Agricultural activities	• farmers who participated in SmartBarley Program (count) • farmers working diligently to ensure we have full transparency of farmers in the direct supply chain (count) • donations supporting sustainable agriculture (%) • agriculture contribution to total carbon emissions (%) • contribution to carbon footprint of agriculture (%) • GHG emission contributions from agriculture • GHG contributions from barley (%)
Paper mills	• sustainably sourced paper and board packaging (%) • boxes used that are certified and come from responsible managed forests (%) • cardboard for beer packaging that is certified by the SFI (%) • cardboard for beer packaging made from recycled materials (%) • use of resources for containers and packaging (mass) • baseline for recycled content in product packaging (%) • recycled input materials used (%) • container and packaging materials for beer-type beverages (mass) • packaging used (mass) • packaging material consumption of carton (mass) • packaging materials by volume as cartons (%) • packaging materials by volume as beverage cartons (%) • packaging materials by volume as labels and sleeves (%) • increase in packaging material consumption of carton from 2016 (%)
Industrial dust*	-

*No environmental indicators from the content analysis were directly related to industrial dust.

From the range of indicators above, there are many sources of aerosol emissions related to the brewing industry being tracked by brewing companies. However, the information provided by the reports and webpages is not enough to quantify a company's contribution to atmospheric aerosol loading. The contribution of Carlsberg to the aerosol PQ limit and the subsequent indicator were therefore not calculated.

4.2.8 Stratospheric Ozone Depletion

This PB was given a boundary of 275 Dobson units (Steffen et al., 2015b) and has been translated into a PQ by Meyer and Newman (2018) to allow for divided management responsibility. This PQ is represented by the emissions of gases controlled or due to be controlled under the Montreal Protocol in terms of ozone depleting potential weighted kilograms (ODPkg) and has a global quota of ≤0 ODPkg/year (Meyer & Newman, 2018).

The stratospheric ozone depletion PQ responsibility is divided per hL below.

$$\frac{Stratospheric\ ozone\ depletion\ PQ\ limit \times \frac{value\ of\ brewing\ industry}{global\ GDP}}{global\ beer\ production} = \frac{0\ ODPkg}{hL \cdot year}$$

From the content analysis, one company reported emissions related to both HCFCs and HFCs. An another reported "% of new equipment sourced HFC-free from 2015 onward" and some companies also mentioned opting for eco-friendly coolers (n=2). While HFCs have an ODP very close to zero, HCFCs are ozone depleting substances and both contribute to GHG emissions.

As there is a lack of available data from brewing companies as well as industry average reports, the contribution of Carlsberg to the ozone depletion PQ limit and the subsequent indicator were not calculated.

4.2.9 Novel Entities

This PQ is represented by imperishable waste released to the environment less imperishable waste removed from the environment and has a global quota ≤0 kg (Meyer & Newman, 2018). This limit represents a goal of no imperishable waste ultimately ending up in the environment. This can be calculated, in a best-case scenario, from the waste produced by a company during the brewing process, combined with the packaging produced with downstream recyclability accounted for, as well as upstream typical waste from processes required to produce and ship agricultural products and packaging materials.

The per hL allowance based on the PQ limits is calculated below for novel entities.

$$\frac{Novel\ entities\ PQ\ limit \times \frac{value\ of\ brewing\ industry}{global\ GDP}}{global\ beer\ production} = \frac{0\ kg}{hL \cdot year}$$

Waste created at the brewery level was reported by several companies from the content analysis: waste to landfill (tonnes) (n=8) and total solid waste (tonnes) (n=4). Packaging and recyclability were also considered by some: use of resources for containers and packaging (tonnes) (n=3) and baseline for recycled content in product packaging (%) (n=3).

Downstream and upstream impacts on waste production were not found to be reported by brewing companies. In order to calculate downstream waste production, some additional information must be known: the type and amount of packaging shipped with the product, local recycling or reuse rates for all types of packaging at their destination, and the weight of non-recyclable packaging. For upstream waste production, waste production rates for packaging production and agricultural inputs must be known. Some examples of agricultural waste include cardboard boxes, seed bags, plastic jugs, twine, plastic film, pesticides, and engine oil (Sonnevera, 2011).

Below, distance to a reference is used to normalize the waste to landfill value for Carlsberg.

$$Carlsberg\ waste\ PQ = x^{2017}_{waste,Carlsberg=\bar{c}} = 0.00739 \times 0.0502 \times \frac{0.1\ kg^{46}}{year}$$

$$= 3.71 \times 10^{-6} \frac{kg}{year}$$

$$x^{2017}_{waste,Carlsberg} = 68{,}600\ metric\ tons\ waste$$

$$I^{t}_{qc} = \frac{x^{t}_{qc} - x^{t0}_{qc=\bar{c}}}{x^{t0}_{qc=\bar{c}}}$$

$$I^{2017}_{waste,Carlsberg} = \left(\frac{6.86 \times 10^{7} - 3.71 \times 10^{-6}}{|3.71 \times 10^{-6}|}\right)\frac{kg\ waste/year}{kg\ waste/year} = 1.85 \times 10^{13}$$

[46] To avoid a zero-value denominator, 0.1 kg was chosen to represent the PQ limit for the calculations.

The positive value of $I_{waste,Carlsberg}^{2017}$ and its great distance from zero show that it is far above the PQ waste limit. In this case, $I_{waste,Carlsberg}^{2017}$ is quite large even without considering upstream and downstream contributions.

4.2.10 Bringing Together the Composite Indicator

Bringing together the individual indicators would involve a summation of the normalized values for each PQ limit (Equation 6).

Equation 6: Composite indicator aggregation using equal weighting.

$$CI_{Carlsberg} = \sum_{q=CO_2}^{waste} I_{q,Carlsberg}^{2017}$$

However, not all individual indicators were able to be calculated. The lack of environmental data available for brewing companies through their reports, industry associations, and the literature meant some of the PQs were not able to be related to brewery activities. The values for each sub-indicator are summarized in Table 16. While there were clear ties to brewery activities, the Me-NO, biodiversity, aerosols, and ozone indicators were not able to be calculated.

Table 16: Summary of the sub-indicator calculations

Indicator	PQ limit for breweries	$x_{q,Carlsberg}^{2017}$	$I_{q,Carlsberg}^{2017}$
Carbon Dioxide	$\frac{-276.6\ kg\ CO_2e}{hL \cdot year}$	$0.000802 \frac{GtCO_2}{year}$	1.02962
Me-NO	$\frac{20.46\ kg\ CO_2e}{hL \cdot year}$	-	-
Biodiversity*	$1 \times 10^{-4} PDF/year$	-	-
Forestland	$\frac{-0.4168\ m^2}{hL \cdot year}$	$-0.00408 \frac{Mha}{year}$	146.56
Water	$\frac{322\ hL\ water}{hL \cdot year}$	$3.153 \frac{km^3\ water}{year}$	-0.0685
Nitrogen	$\frac{0.2349\ kg}{hL \cdot year}$	$0.00911 \frac{Tg\ N}{year}$	-0.604

Indicator	PQ limit for breweries	$x_{q,Carlsberg}^{2017}$	$I_{q,Carlsberg}^{2017}$
Phosphorus	$\frac{0.04168\ kg\ P}{hL \cdot year}$	$0.00096297\ \frac{Tg\ P}{year}$	-0.764
Aerosols*	$0.04 \leq AODe \leq 0.1$	-	-
Ozone	$\frac{0\ ODPkg}{hL \cdot year}$	-	-
Novel Entities	$\frac{0\ kg}{hL \cdot year}$	$68{,}600\ metric\ tons\ waste$	1.85×10^{13}

*These PQs are not meant to be divided, but rather applied the same at every scale.

5.0 Discussion

This research shows that despite the prevalence of widely accepted reporting methods (e.g., GRI) there is still an obvious disconnect between brewing companies when it comes to environmental sustainability reporting. This disconnect continues when comparing indicators the literature deems important to environmental sustainability and the data that brewing companies are actually reporting. While there were areas where environmental importance lined up with the brewery reports, there were also some obvious gaps. These gaps, when judging environmental sustainability based on the PBs, made it unfeasible to determine the environmental sustainability of a brewery based on their reported data. By recognizing the limitations of the data reported by brewing companies, the data necessary in order to understand the full picture of brewing company sustainability were more easily highlighted.

5.1 Content Analysis

Through the content analysis, it became apparent that while the indicators and targets of brewing companies were able to be grouped consistently into the same categories, the indicators themselves were not consistent between companies. For example, emissions indicators were reported several ways (e.g., carbon footprint, total GHG emissions, scope 1 emissions) and the reason for choosing specific language was not always clear.

When there is a lack of agreement on terms, it becomes difficult to determine both relative environmental performance between brewing companies and a company's contribution to global consumption.

5.2 Composite-Indicator

The development of a composite-indicator was not possible given the limited information reported in the brewing company reports and webpages. However, the frameworks developed by Meyer and Newman (2018) and Bjørn et al. (2019) were able to be applied to the industry and specific gaps highlighted. Decisions made while following these frameworks for allocation principle and defining carrying capacity were based on ideas from McElroy and van Engelen (2012) and Whiteman et al. (2013), wherein ensuring broader socio-economic context while maintaining relevance to the PBs were the main goals. When choosing the PBs to represent carrying capacity, local variances and environmental requirements were left unconsidered. For example, when considering global water consumption, a company may be using less than their allocated share, but if the local sources used are in peril then the activity is not sustainable. Meyer and Newman (2018) suggests that their model represents large-scale sustainability and that a multi-scalar approach is required when determining sustainability. This research and application of the PQs to the brewing industry is also representative of requirements for global sustainability and local usage may still be unsustainable.

A lack of consistency when reporting on similar issues also added difficulties when extracting information from the indicators. It was not possible to extract the required data from the reported indicators, or to know if the reported data lined up with the requirements of a given PQ. Based on the data currently reported by brewing companies through their environmental indicators, there is not enough information to determine if the activities of a brewery are sustainable at the global scale, relative to the planetary boundaries. There are clear gaps both when looking at the breadth of indicators, with little focus given to measuring impacts related to biodiversity loss, and the depth, as indicators related to supply chain impacts were rare.

As it stands, developing a composite-indicator representative of the environmental impacts of a brewing company at the global scale, given the gaps in the indicators reported in the reports and on the websites of brewing companies, is not possible. While secondary data related to water and land use may give some indication of whether the activities associated with a brewing company are sustainable, their range relative to location and management practices were too large to make an appropriate assumption. In order to calculate a brewery's contribution towards other planetary quotas, there were some relevant indicators from the content analysis, but some data were missing and unable to be filled-in with secondary data relevant to the brewing industry.

5.3 CSR Reporting and Institutionalized Practices

There are several noted drivers of corporate green activities: competitiveness, legitimation, and ecological responsibility (Bansal & Roth, 2000). Similarly, drivers of practices becoming institutionalized include competition and stakeholder values (DiMaggio & Powell, 1983).

Of the brewing companies from the content analysis, 20/33 produced a report and 18/33 produced a webpage containing at least one environmental indicator. This is consistent with trends that suggest reporting on corporate sustainability has been increasing and has indeed been institutionalized (Cho et al., 2015; Bondy, 2009).

While the same categories were repeated throughout the reports and reporting environmental indicators was quite common, there was an apparent phrasing disconnect between brewing companies when describing indicators. This phrasing disconnect was also seen by Wilson (2013) when looking at GHG emissions reporting among manufacturing companies and made comparing environmental impact difficult.

Previous research examining the extent to which companies are considering environmental sustainability has shown that science-based target setting is uncommon (e.g., Haffar & Searcy 2018a; Bjørn et al., 2017). Bjørn et al. (2017) showed that around 5% of companies with reports in the CorporateRegister database at the time (2000-2014) referred to ecological limits. Most of the limits collected by Bjørn et al. (2017) referred to climate change or avoiding the 2 ^{o}C global temperature increase. Haffar and Searcy (2018a) found that none of the companies studied reported targets based on the planetary boundaries (ecological limits), but that some referred to ecological limits, mainly climate change. The content analysis in this research showed that 7/33 (~21%) of breweries reported at least one science-based target and that science-based targets represented 27/93 (29%) of all targets collected. All science-based targets collected from reports or webpages referred to climate change limits such as the Paris Agreement. These trends may be indicative of science-based target setting moving towards becoming the norm for targets related to climate change in the brewing industry.

Consumers as well as governing bodies are demanding more transparency from companies when it comes to environmental impact. For example, as of 2018, the EU requires large companies to report on social and environmental matters in their reports through Directive 2014/95/EU (European Commission, 2020). In response to these kinds of demands, companies must adapt to remain legitimate. These trends towards more science-based target setting as well as reporting environmental indicators and targets in reports and on webpages can be deemed attempts to remain legitimate in the eyes of stakeholders.

It should also be noted that several economic markets and countries have regulations as well as guidelines that may be influencing the style of reporting undertaken by brewing companies. For example, some markets require companies to reports the amount of money spent on CSR activities or state their GHG emissions (Thacker, 2019).

5.4 Environmental Indicators and Targets

The main themes found among the indicators were water use, solid waste, energy use, GHG emissions, NO_x emissions, and packaging. The targets showed themes of increasing water and energy efficiencies, reducing emissions, moving away from fossil fuels, and reducing waste.

The top indicators from the content analysis line up with some of the main environmental concerns for the brewing industry: GHG emissions, inorganic emissions, energy use, water use, and solid waste (Olajire, 2012; Tokos et al., 2012; Cordella et al., 2008). The themes that became apparent from the indicators and targets also represented some of the main topics previously highlighted by breweries: water use, energy use, solid waste, and locally sourced ingredients (Ness, 2018; Herold et al., 2017).

While the themes of indicators and targets were expected, comparing them to the literature on the environmental concerns for breweries shows that some key environmental indicators are not being addressed across the industry, namely land use and materials. When looking for indicators that represented a brewery's impact along the supply chain, they were not common. Some breweries reporting on scope 3 GHG emissions and one that looked at their water footprint. These are good steps towards supply chain consideration but were not common among the breweries assessed. Additionally, a couple of the companies in this assessment reported indicators related to suppliers or set targets related to developing supplier standards. While these standards may show that companies are looking towards their supply chains when it comes to sustainability, the information was qualitative and did not relay the details necessary to position brewery impact within the PQs. Without considerations of agriculture and other material sourcing, much of the bigger picture of a brewery's environmental impact is lost.

5.5 Considering Planetary Boundaries

The PBs represent a complex system, so in order to address them some focus must be given to each (CISL, 2019; Rockström et al., 2009). The representation of the PBs in the reports of breweries shows that some areas of environmental importance are recognized. The two core PBs, as discussed by CISL (2019), are "climate change" and "biosphere integrity". These core PBs are defined by their connectedness to the other PBs. All the other PBs have some impact on either "climate change" or "biosphere integrity". For example, land-system change affects both biosphere integrity as well as climate change; climate change and biogeochemical flows impact ocean acidification, which would then affect change in biosphere integrity. In order to address the full picture, all the PBs must be considered.

5.5.1 Positive Aspects of Report Trends

Climate change was the most discussed PB throughout the brewery reports and websites among the indicators and targets. It also encompassed the largest range of indicators. Indicators for GHG emissions considered a broader look at the supply chain by including scope 1, 2, and 3 GHG emissions. Targets were also set requiring a decrease in supply chain emissions which demonstrates a desire for some companies to make responsible supply chain decisions. Wilson (2013) looked at companies reporting on total carbon-equivalent emissions and scope 1, 2, and 3 GHG emissions. The findings suggest that among consumer goods companies, the indicators used to report on GHG emissions were not consistent across companies. This trend was mirrored in this research when comparing the range of indicators reported by brewing companies.

The only type of science-based target reported by the companies in this research was set to reflect the goals of the Paris Agreement and thus furthers the focus on climate change by the brewing industry. This is not surprising as existing methods for setting corporate science-based targets focus primarily on climate change, through scope 1, 2, and 3 GHG emissions (SBTi, 2019). While this level of reporting on GHG emissions is commendable, it is contrasted by the lack of focus given to other aspects of environmental impact. For example, the CEO Water Mandate is working with corporations to add local catchment context to their water use targets, yet science-based water use targets were not apparent from the reports or webpages of brewing companies (CEO Water Mandate, 2019).

Overall, the ability of the reported indicators to be applied to the PQs was limited. The variety of terms used to describe CO_2e emissions did not allow for simple comparison between companies and the indicators themselves were not clear enough to use as variable inputs for the CI. Specific values for CO_2, land-use emissions, methane, and NO_x were required by the PQ framework to determine relative environmental impact. Reported instead were GHG emissions, sometimes separately reported as scope 1, 2, and 3, and NO_x emissions. While supply chain emissions can be accounted for through scope 3 emissions, land-use emissions were not explicitly reported, or mentioned as part of total GHG emissions, and are not always included in scope 3 emissions (WRI, 2006).

5.5.2 Negative Aspects of Report Trends

Land-use emissions are predominantly related to agriculture, forestry, and land-use change and have been found to represent nearly one third of total GHG emissions (Davis et al., 2014). Not accounting for these impacts not only means potentially missing out on a large portion of GHG emissions, as agriculture and forestry are major inputs for brewery ingredients and packaging, but also contributes to a lack of reporting on land use more broadly (Mattila et al., 2012; Cordella et al., 2008).

Land use was under-represented in both the indicators and targets and land-system change was the least represented PB overall despite its importance in the brewing industry through agricultural and packaging material inputs (Mattila et al., 2012; Cordella et al., 2008). Land use has direct links to several PBs including “land-system change”, “loss of biosphere integrity”, “climate change”, “ocean acidification”, and “altered biogeochemical flows” (Heck et al., 2018; Meyer and Newman, 2018; Doney et al., 2009). While some of the indicators alluded to positive land management (e.g., purchasing paper products from sustainably managed forests, ensuring sustainable sources for agricultural inputs), these kinds of indicators were not common, and land management specifically was not found among any of the collected targets. Similarly, land use for breweries, as part of LCAs, is not commonly accounted for (Mattila et al., 2012).

Other considerations are simply not reported on. Take the example of packaging, the type and weight of packaging used was commonly reported, however, the upstream impacts on water use, land use, and climate change through deforestation were not discussed. Attempts to cover this area by reporting the percentage of sustainably sourced paper and board packaging (n=3) do not quantify environmental impact. Because the upstream industries required to produce packaging such as mining, drilling for petroleum, and forestry are not related to the direct operations of a brewery, their impact is easily missed if a company chooses to report solely on their own operations. As availability and ease of acquiring data have been found to be large determinants of sustainability report quality which may explain why supply chain information is not commonly found among the reported indicators (Wilson, 2013). This gap in upstream impacts hides environmental damage that can be directly linked to the under-reported categories from the content analysis: biodiversity/forest due to land use.

5.6 Gaps in Reported Information

In the case of breweries, there is an obvious gap related to industrial impacts that are not encompassed when considering direct operations. For example, as is evident from the reported indicators and targets, the impacts of upstream industries such as forestry, mining and agriculture are not considered, thus issues such as land use are not present in the reports of breweries.

Agriculture-related activities (i.e., the cultivation of barley, fertilizer production, and energy production) and the production of auxiliary materials (e.g., bottle caps, glues, boards and labels) were found to be the two largest contributors to a brewery's environmental impacts based on a LCA (Talve, 2001). The most relevant contributions of agriculture to environmental damage include climate change and phosphorus and nitrogen production (Talve, 2001). Agriculture also contributed somewhat to acidification and summer smog through NO_x and SO_2 production. The weighted impacts of agriculture represented an environmental degradation contribution of more than ten times any other category, followed by production of auxiliary material and production of bottled beer (Talve, 2001). The production of auxiliary material also contributed significantly to climate change and oxygen depletion (CODe) (Talve, 2001). The environmental impacts of these activities are therefore worth consideration when reporting on a brewery's environmental impact, yet they were missing from the reports and webpages of brewing companies.

This gap was further accentuated when secondary data sources used during the CI framework development showed that the global average water footprint of beer is 300 L water/L beer, mostly owing to the water required to grow barley (Mekonnen & Hoekstra, 2011). Contrastingly, brewing companies who reported to BIER reported an average of 3.35 L water/L beer, a value that considers only brewery-scale water use (BIER, 2017). The discrepancy in these values is staggering, and it represents a larger issue seen in the reports of brewing companies: upstream environmental impact accounting is limited and tends to only include GHG emissions. Without including the environmental impacts of upstream processes, indicators and targets are missing the mark. A company with a target to reduce brewery process level water use by 50%, even if met, does little to address the biggest use of freshwater.

But why does this data gap exist? Agriculture and material inputs are considered inputs to the brewing process, but not considered part of the brewing process itself: the part of the lifecycle that breweries have the most control over (Tokos et al., 2012; Cordella et al., 2008; Talve, 2001). Additionally, availability and ease of acquiring data have been found to be large determinants of sustainability report quality which may explain why supply chain information is not commonly found among the reported indicators (Wilson, 2013).

5.7 Contributions

This research provides information on the reporting habits of brewing companies and the gaps in the reported data when calculating environmental sustainability in relation to global science-based limits. This was furthered by assessing the prevalence of science-based target setting in the brewing industry. This research also provides an application of theoretical models for assessing corporate environmental sustainability through the PBs. This is furthered by detailing the limitations of using such models without a comprehensive set of company environmental data.

This research shows that brewing companies are starting to integrate science-based target setting and environmental context into their public reports and on their webpages. The science-based targets collected as part of this research were limited to GHG emissions, however, there was some written context given for other environmental impact categories. These references to ecological processes demonstrate that some brewing companies are considering environmental context when reporting on some targets. This research builds on research that has examined the extent to which companies are considering environmental sustainability in their reporting (e.g., Haffar and Searcy 2018a; Bjørn et al., 2017). The results of this previous research show that environmental science-based target setting is not common in corporate reporting. This study shows that trends may be changing, at least in the brewing industry; several brewing companies are starting to include science-based target setting for environmental impacts. These findings may be encouraging as well as inspiring. Trends towards science-based target setting may encourage an industry shift through isomorphism, the theory that companies are more likely to become more similar than dissimilar and thus adopt similar practices. This research may also demonstrate that the emergence of environmental science-based target setting is on its way to becoming an institutionalized practice for climate change-related targets. As institutionalization is partially driven by competition (DiMaggio & Powell, 1983), large companies using science-based target setting are likely to influence others to do the same.

The results from the development of the composite-indicator framework demonstrate that there is a significant lack of data available when relying on the environmental indicators reported by brewing companies. This research shows trends towards both vague reporting, with little background given on the values reported, as well as a lack of supply chain consideration, with focus given to direct operations. This is not a transparent look at the environmental impacts of brewing companies and tends towards being an organizational façade performing the role of environmental consideration, as has been linked to sustainability reporting by Cho et al. (2015). These results confirm the gap between research in business and the natural sciences highlighted by Whiteman et al. (2013) and further the need for research that bridges this gap.

Some of the implications of this research include informing and encouraging further work on the application of the PBs to the corporate scale and offering an industry-specific application of current methods. This study also shows a need for more research on choosing indicators to account for corporate environmental impact, specifically when it comes to areas not commonly reported or well quantified such as biodiversity. Those working in corporate reporting may also be interested in the results of this study as a means to enhance current reporting practices as well as understand industry trends in environmental reporting. Reporting frameworks such as the GRI may also be interested in understanding the gaps between what brewing companies are reporting and the information required to understand impact on global ecological limits. By incorporating this information into the development of reporting guidelines, some of these gaps may be considered by companies in future reports.

6.0 Conclusions

While there was a large range of target and indicator categories found in the reports and webpages of brewing companies, the targets and indicators were skewed towards GHG emissions reporting and utilities including energy and water use. As these are metrics more easily obtained (e.g., through utility bills) as well as directly related to company spending, the information may not only be readily available, but there are financial reasons to limit utility use. Additionally, some markets require GHG emissions reporting, which may be encouraging this practice. However, while these areas were consistently reported on, the indicators used were not thorough. Reported indicators for water use, specifically, were not comprehensive. Brewing companies failed to report on water used for agricultural inputs, a major contributor to water use for the brewing industry. This may be an opportunity to encourage LCA as a means to monitor supply chain environmental impact.

6.1 Addressing the Research Questions

RQ1: What context-based environmental information is publicly disclosed by brewing companies?

Brewing companies have tended to focus on GHG emissions with some accounting for both upstream and downstream emissions through scope 3 emissions reporting (6/33). Additionally, some science-based targets have been set by brewing companies (7/33). All science-based targets from this study's content analysis referred to the Paris Agreement. These strides for adding context to the reporting habits of large breweries show that science-based targets are being integrated into the reports of breweries. However, as these efforts are focused on one area (GHG emissions) detrimental effects on other aspects of environmental sustainability, such as biodiversity loss, may be suffering as a result (Milne & Gray, 2013).

RQ2: Are the public disclosures of brewing companies sufficient to develop a context-based composite environmental indicator?

The environmental information found in the reports and webpages of the brewing companies from this study were neither comprehensive nor clear enough to support a fully developed composite-indicator. The scope of information included in the reported of brewing companies was limited. There was a major focus on the brewing process itself and a lack of information on the supply chain, which consists of major contributors to environmental degradation such as agriculture and packaging material requirements. The environmental information that was reported more extensively was not clear enough to confidently extract the required data. A lack of context was present for GHG emissions reporting, which went by several names between companies, and did not include context for the indicator name choice. While emissions indicators represented the category most reported on, the meaning behind the numbers was missing. For emissions specifically, a more comprehensive report would include the methods used for calculations, the steps included along the product supply chain (e.g., land use, raw material production, brewery operations), and the emissions themselves broken down by type (e.g., methane, carbon dioxide, nitrous oxides).

6.2 Limitations

This research is limited through the availability of data, the global scope of the PBs and subsequent PQs, the decisions made for allocation, normalization, weighting, and aggregation methods, as well as the lack of industry input. The data used to determine the extent to which breweries are reporting on their environmental impacts were limited to publicly available data, self-reported by brewing companies. As companies choose what to report on, this is likely not the full extent of primary data available to a brewery. The calculation of the climate change PQ, for example, requires details on specific GHG emission rates (CO_2, methane, and nitrous oxides) which were not typically reported individually, but rather as total GHG emissions, carbon footprint, or total carbon emissions with some brewing companies reporting on NO_x emissions.

The PQ framework itself is limited in its ability to account for local variations as it does not account for a spatial representation of impacts. Instead, while the global limits are accounted for, issues that vary geographically such as water use require more local attention when determining sustainability. This issue of spatially variable impacts also arose when it came to regional variance for agricultural water intensity wherein the grain grown in certain regions is much more water-intensive than the global average.

As part of applying the PQs to create the composite-indicator framework, decisions had to be made for allocation, normalization, weighting, and aggregation. Contribution to global GDP was used as the allocation principle for the brewing industry itself which was then divided between companies based on beer production. The industry allocation is not necessarily representative of the brewing industry's global value-added as beer prices vary regionally and GDP doesn't fully capture societal value. In this case, it was used to give an approximation and could be replaced by other methods or modifications. Typically, as part of selecting methods for normalization, weighting, and aggregation, a sensitivity analysis is used to determine the combination of methods that reacts best to data fluctuations. While the choices made for this framework took into account previous work and the available data, a full sensitivity analysis with a full set of data would allow for a more secure selection of final calculation methods.

By using Carlsberg as a sample corporation for the framework calculations, the amount of information available from reports may be overstated. The values used in the sample do not represent the average amount of environmental information reported by the breweries in this study. Therefore, breweries who reported less information would likely have more gaps in their reporting when it comes to comparing their reported performance to the PQs.

Industry input was also lacking, knowledge about what information companies collect, the difficulty of obtaining information from suppliers, and which information breweries find important and believe to be important to their stakeholders was unclear. The interviews conducted as part of this research were not complete enough to warrant influencing the results.

6.3 Future Work

As part of developing the composite-indicator framework further, a full set of primary and secondary data, specific to a company is suggested. Context behind the reported values may then become clear and values could be attributed to a PQ limit with confidence. While secondary data were used to supplement the sample calculation for this study, there were large geographic differences seen in the literature data available. For example, being able to specify the country or region that barley is sourced from would provide a more accurate image of a brewing company's water footprint.

As the PBs are ever evolving and developing themselves, work in this area and on applications such as the PQs would add value to and would help develop the framework presented in this research. Additionally, research on the planetary accounting framework methods highlighted by Meyer and Newman (2018) and how the allocation of global environmental limit management can be applied to sustainability reporting would help expand this area of research.

Industry interviews would also help develop a better picture of environmental reporting in the brewing industry: how companies choose which information to collect, what information they find valuable for themselves and stakeholders, and what information they can obtain from their supply chain. It would also be interesting to explore their views on the PBs and science-based targets and indicators. Information from a variety of brewing companies would allow for a better look at what information is consistently available to brewing companies but missing from their public disclosures.

Appendix A: Content Analysis Documents and Webpages Analyzed

Table 17: Summary of brewing company reports and webpages, used for the content analysis completed Spring 2019.

Brewing Company	Reports	Webpages
4 Pines Brewing	Save the Pines Report 2016	-
AB InBev	2018 Annual Report	Climate Action; Smart Agriculture; Circular Packaging
Asahi Group	Integrated Report 2017	Environmental Achievements
Aslan Brewing	2018 Sustainability Report	Sustainability
Beau's All Natural Brewing Co	-	Sustainable Craft Brewing: A look at Beau's green initiatives; About Us - Sustainability
Brasserie New Deal	-	-
Brewery Vivant	2018 Beer the Change Report	-
Brewgooder	-	-
Bull City Burger and Brewery, Pie Pan Inc. DBA	Pie Pan Inc. Sustainability Report 2018	-
Carlsberg Group	Sustainability Report 2018	Zero Carbon Footprint; Zero Water Waste
Cervecera Guayacan SpA	-	-
China Resources Beer	2016 Corporate Social Responsibility Report; Environmental, Social, and Governance Report 2017	-
Commonhouse Ales	-	-
Constellation Brands	FY18 CSR Report	Sustainability

Brewing Company	Reports	Webpages
Diageo	Annual Report 2018; Sustainability and Responsibility Addendum to the Annual Report 2018; Knowing our footprint: Guiness	Reducing our environmental impact
Groupe Castel	-	-
Heineken	Heineken N.V. Annual Report 2018	Sustainability
High Park Brewing	-	Back Story
Hopworks Urban Brewery	HUB Sustainability Report: 2014	Environment; About Us
Kirin Holdings Company	Kirin Report 2018; Environmental Report 2017	ESG Data
Molson Coors	Our Beer Print Report 2018; Environmental, Social, and Governance (ESG) Report 2018	2025 Targets: Raising the Bar on Beer; Promoting a Circular Philosophy
New Belgium Brewing	2018 Force for Good Report	Waste Reduction; Carbon Emissions; Good Water Means Good Beer; Energy
North Coast Brewing Co.	2017 Sustainability Report	Zero Waste Certification; Solar Energy
Persephone Brewing Company	-	-
Roadhouse Brewing	-	Sustainability at Roadhouse
Stone and Wood Brewing Company	Green Feet Summary Report	-
Stroud Brewery	-	Stroud Brewery; Stroud Brewery Certified B Corporation
Sufferfest Beer Co.	-	-
The Alchemist	-	-
Toast Ale	Impact Report 2016-18	Brewing a Better Planet
Tsingtao Brewery Co.	Environmental, Social, and Governance Report 2016	-

Brewing Company	Reports	Webpages
Upslope Brewing Company	Sustainability 2017 Summary	Our Story
Upstreet Craft Brewing	-	-
Yanjing	[..] 2017*	-

*This report was in a language unknown to the primary investigator and excluded from the analysis.

Table 2: The categories and degree of PB referencing found during content analysis for brewing company environmental targets.

company name	unique targets	categories covered in targets	categories covered in targets	science-based targets	categories covered in science-based targets	PB-ref. targets	categories covered in PB-ref. targets	no-ref.
4 Pines Brewing Company	4	3	packaging/waste, energy, other	0		0		4
AB InBev	5	5	water, packaging/waste, energy, emissions, other	1	emissions	2	energy, water	2
Asahi Group Holdings	5	3	packaging/waste, emissions, biodiversity/forest	3	emissions	1	biodiversity/forest	1
Aslan Brewing Company	1	1	energy	0		1	energy	0
Brewery Vivant	4	4	emissions, energy, packaging/waste, water	0		0		4
Carlsberg Group	9	3	water, energy, emissions	7	emissions, energy	2	water	0
China Resources Beer	1	1	energy	0		0		1

Diageo	15	6	water, packaging/waste, energy, emissions, other, biodiversity/forest	4	emissions, energy	5	biodiversity/forest, water	6
Heineken	11	4	water, energy, emissions, other	0		10	water, energy, emissions, other	1
Hopworks Urban Brewery	1	1	packaging/waste	0		0		1
Kirin Holdings Company	15	6	water, packaging/waste, energy, emissions, other, biodiversity/forest	7	emissions, energy	5	water, biodiversity/forest	3
Molson Coors	8	4	water, packaging/waste, emissions, other	3	emissions	4	water, other	1
New Belgium Brewing	5	4	emissions, energy, packaging/waste, water	2	emissions	2	energy, water	1
North Coast Brewing Co.	5	5	emissions, energy, water, other, packaging/waste	0		0		5
Stone and Wood Brewing Company	3	3	energy, packaging/waste, water	0		0		3
Toast Ale	1	1	other	0		1	other	0

Appendix B: Industry Interviews

Methods

Industry interviews took place as a pre-emptive measure for developing the composite-indicator. Because the indicator development required some choices for indicator selection and weighting, consulting with those in industry was chosen to inform the selected inputs as well as identify potential barriers for industry use of the composite-indicator (e.g., lack of available data). The relevant employees at brewing companies were interviewed to determine what kind of data are available to them regarding their operations. This is important because data that are not collected or able to be collected may not be justifiable variables when constructing the composite-indicator.

Table 3 describes the steps surrounding the interview development and analysis.

Table 3: Steps for the industry interview phase.

Industry Interviews

- Design preliminary interview questions based on the research questions and requirements for the composite-indicator.
- Obtain Ryerson Research Ethics Board approval.
- Contact relevant employees from the companies in the content analysis stage.
- Confirm interview time slots and complete interviews.
- Follow-up with interviewees to confirm transcription of interview.
- Design analysis criteria and coding style for the interviews.
- Code the responses/information according to analysis criteria.

The interview structure itself was modeled after the method used by Quaak et al. (2007) who interviewed breweries on their CSR activities after analyzing the reports of Dutch breweries. In this case, Quaak et al. (2007) chose a narrative-style interview with a topic guide then added company-specific questions. The interviews were recorded to be verified post-interview. The advantage of this method is that it leaves the discussion open and could give unsuspected insight into the topic. The main limitation of this method is the chance to go off topic, which may make later coding difficult, because the interviews do not necessarily follow the same path. However, by adding some specific questions and creating a topic guide, some of this may be avoided (Quaak et al. 2007). Rubin and Rubin (2012) described semi-structured interviews as those that may be used to discuss specific topics with more focus on the research question. In this case, there are a distinct number of questions with some follow-up questions planned. This style allows for detailed and lengthy responses. In addition to recording and transcribing the interview, tentative conclusions to the interviewee's responses should be discussed during the interview (Rubin & Rubin, 2012). This research used semi-structured, narrative-style phone interviews that were recorded then transcribed to be verified post-interview with the interviewee. During the interviews, responses were clarified with follow-up questions where possible.

The questions are set as to understand the reporting styles or breweries beyond what can be obtained from a report or website, as well as any motivators or barriers regarding science-based targets and indicators. Example questions include exploring how companies set targets and indicators, how they determine what to disclose publicly, and their view on the use of science-based targets and context-based indicators in sustainability reporting. The interviews also explore targets and indicators companies are using internally but have chosen to not disclose publicly, key indicators that should be included in a composite environmental sustainability indicator, and how those indicators should be weighted. The list of questions was discussed and edited for clarity in the questions as well as relation to the research questions as necessary.

This research was reviewed and approved by the Ryerson University Research Ethics Board, REB file number (2018-413).

The list of companies from the content analysis stage provided websites and sustainability reports from which contact information was later drawn. When listed, employees with contact information were contacted directly. However, general company inquiry was also used as an initial contact because few companies listed employee contacts on their websites. A secondary list of contact companies was developed in Spring/Summer 2019 to expand the potential pool of interviewees to include large and regional sized Canadian members of the Brewers Association. This group was approved by the Ryerson Ethics Board through changes made to the application.

The initial contact involved an email to confirm an interest in research participation. The email template is attached at the end of this appendix. If they were interested in learning more, a consent form with a brief overview of the goals of the interviews, how it will assist in the next stages of this thesis, and the risks and benefits of participation was sent. This was followed by an interview outline if the potential interviewee was interested in participating. If the potential interviewee responded to the initial email eager to participate, both the interview outline and the consent form were sent in response. The interview outline and the most recent version of this consent form is attached at the end of this appendix. If a contact had either shown initial interest but did not respond to a subsequent email, or had not given a response, a follow-up email was sent out. The follow-up email template is attached at the end of this appendix.

Several initial emails resulted in a response copying a specific employee that would be suited to answer the questions. In this case, the process was repeated with the new contact.

Should a potential interviewee have wished to continue with participation after reading the consent form, the form was signed, returned, and stored by the principal investigator and a date and time were set for the interview. Interviews themselves were conducted over the phone with a list of main questions supplied in advance, stating that follow-up questions may also arise.

Once the interview was completed, it was transcribed by the principal investigator and a transcript emailed to the interviewee for approval. Edits were made if necessary (i.e., spelling of a company mentioned).

The data collected through interviews were qualitative, but the responses themselves were analyzed to extract overall quantitative data such as how many mentioned certain indicator(s) as important or difficult to track. Each main question (and follow-up question if necessary) was summed up in a main theme(s). For example, if the question was asking about environmental indicators the interviewee deemed most important to the brewing industry, the themes for that question would be a list of those indicators. The analysis of the interviews resulted in a table that listed of themes related to each main question, from which frequency or patterns could be seen.

Results

41 emails were sent out in the first round and another 41 with the additional breweries added. The initial contact emails received 18 responses, positive responses (n=10), auto-responses (n=4), and declines (n=4). Of the initially positive responses, some did not respond to follow-up emails (n=4), were initially positive but later declined (n=2), or passed the information on to colleagues more suited (2), both of which were initially positive but did not respond to follow-up emails. Reasons for declining included not believing they could answer the questions (n=2), not having time (n=2), not having the capacity to participate (n=1), and not wishing to participate (n=1). Only two interviews were conducted, one from each round of companies contacted.

The first interview was conducted with a brewpub's Sustainability Steward. The brewpub produced a sustainability report in 2018 and chose what to report based on providing a few key numbers they believed would be interesting to the report's audience. They tracked electricity, gas, and waste, specifically trying to ensure zero spent grain to landfill. Electricity use, gas, and what is known about water use are reported to the city as part of a local workplace challenge. Water was a main topic of concern for the brewpub as the water utilities are not separate from their restaurant and thus difficult to track. The cost of fitting a separate meter simply for measuring their water use was considered a large investment where investing in water-reduction measures might be better suited. Because of the scale considered, targets were set based on goals of zero wasted grain and maintaining proper procedure to ensure minimal water spills or waste. Implementing best practices was a more feasible option than specific targets for their scale and tracking. These practices were drawn from the initiatives of other breweries. The brewpub also compares their environmental indicators against information from the Brewer's Association for similarly sized operations. The brewpub was keen on science-based target setting and listed a potential benefit as the ability to use science-based targets to drive momentum for environmental sustainability at a management level. However, they were unable to use science-based target setting due to difficulties tracking their impact: lack of formal tracking to collect the necessary data, calculation tools (e.g., for carbon footprint).

The second interview was conducted with a brewing company's National Environmental Health and Safety Manager. The brewing company does not publicly report information as that is covered by their parent company. However, several environmental indicators: water, energy, waste, CO_2 and CO_2e emissions are tracked at each brewery using scorecards which are reviewed quarterly with management. Agriculture was mentioned as an area of importance to the brewing industry that the brewing company is not currently tracking and that they believed to be an important aspect of environmental sustainability. Brewery scale and a lack of direct connection with suppliers were noted as barriers to tracking agricultural impacts. The environmental indicators deemed most important to the brewing industry by the interviewee were those currently tracked as well as agriculture considerations. The brewing company was also looking at comparing their environmental performance against industry reports such as that produced by the Beverage Industry Environmental Roundtable. It was also stated that reports such as those would have the potential to influence target setting for the brewing company in the future. Currently, target setting is based on previous years' performance from the scorecards and then choosing a feasible improvement target. These targets are brewery-specific, not company-wide, and are influenced by the scale of each brewery with the overall goal of continuously improving efficiencies at each brewery. This idea of continuously improving has resulted in expanding local environmental certifications to other brewery locations and looking into investing in green infrastructure such as CO_2 recovery.

How operational scale influences investment versus impact decisions regarding environmental sustainability as well as looking to other breweries or industry organisations for guidance on best practices and target setting were common themes between the two interviews. The cost to invest in new environmental initiatives was also brought up by both companies. The collective list of environmental indicators measured by the breweries: waste, water, CO_2 emissions, CO_2e emissions, energy, electricity use, and gas use.

Discussion

Both breweries looked to peers or industry groups for environmental reporting information and to compare their environmental performance which is supported by institutional theory and isomorphism (DiMaggio and Powell, 1983). Additionally, the brewpub was influenced in their reporting style by the report's potential audience and what they believed would be interesting to readers, thus catering to stakeholders. Both companies were aware of industry approaches to environmental sustainability and were looking forward to include more "green" initiatives. This is an example of corporate greening (Kleindorfer et al., 2005; Cronin et al., 2011).

The list of indicators that the breweries track or are interested in tracking are supported by the findings from the content analysis. Water, waste, CO_2 emissions, CO_2e emissions, energy, electricity use, and gas use are all areas that were mentioned during brewery interviews and, in general, represent the categories that formed during the content analysis.

Some barriers to furthering environmental data collection and reporting from the breweries align with the literature; high upfront cost and uncertain future benefits of environmental actions were found to be perceived facility barriers to environmental management plan development (Ervin et al., 2012). Additionally, lack of resources and the complexity and difficulty of implementing CSR are researched obstacles to CSR in India (Arevalo & Aravind, 2011).

Documents

Initial Interview Contact Email

Dear [insert name or position if known],

OR

To whom it may concern at [Brewery Name],

My name is Sigrid Grosseth. I am a graduate student at Ryerson University in the Environmental Applied Science and Management Program. I am contacting you to see if you might be interested in participating in a research study.

This research is being done as part of my master's thesis under the supervision of Dr. Cory Searcy. The focus of the research is to get an industry perspective on the use of environmental indicators and targets in the sustainability reports of breweries. Topics such as key performance indicators and science-based targets will be the focus of this research.

To participate you need to be associated with environmental management or reporting at a brewery. Specifically, we are recruiting those holding one of the following positions: Potential titles will include sustainability/corporate social responsibility/environment managers, analysts, etc. as well as any senior-level executives with oversight of these areas.

If you agree to volunteer, you will be asked to be interviewed over the phone.

Your participation will involve one audio-recorded phone call lasting less than 30 minutes and a follow up email to confirm the researcher's transcription of the responses. A complete list of questions to be asked in the interview will be provided prior to the interview.

This research has been reviewed and approved by the Ryerson University Research Ethics Board, REB file number (2018-413).

If you are interested in more information about the study or would like to volunteer, please reply to this email.

Sigrid Grosseth

Graduate Student, MASc Candidate, Environmental Applied Science and Management

sigrid.grosseth@ryerson.ca

Ryerson University

Follow-up Interview Contact Email

Dear [insert name if known],

OR

To whom it may concern at [Brewery Name],

I am contacting you to follow up on your interest in participating in my Graduate research.

The research consists of a 30 minute telephone interview (with questions provided in advance), and pertains to the environmental sustainability reporting of breweries. I have attached the consent form which has more information on the research itself. Should you be interested in participating, the consent form must be signed and returned, and from there we can set a date.

This research has been reviewed and approved by the Ryerson University Research Ethics Board, REB file number (2018-413). Please let me know if you have any questions or would like to participate.

Sigrid Grosseth

Graduate Student, MASc Candidate, Environmental Applied Science and Management

sigrid.grosseth@ryerson.ca

Ryerson University

Outline for Interviews

The following questions and definition were provided to interviewees prior to the interview for their review. These questions represent the outline for the semi-structured interview and were a guide for the primary investigator during the phone call. However, follow-up questions as well as questions pertaining to clarifying answers from the interviewees arose during the interviews.

1. How does your company determine which environmental performance indicators to include in public reports? (e.g., industry trends)
2. Are there other environmental aspects that your company measures and tracks internally but does not publicly disclose? If so, what does your company track?
3. Does your company measure its environmental performance indicators against peers? If so, what indicators does it use?
4. Are there other environmental performance indicators that you believe are relevant to the brewing industry that you are not currently tracking? If so, what barriers do you see in tracking those indicators?
5. In your opinion, what are the most important environmental performance indicators for the brewing industry? Why do you believe these are the most important?
6. Does your company set targets for all of its environmental performance indicators? If not, how does your company determine which indicators to set targets for?
7. If your company sets any environmental targets, please describe how it does so. If your company does not set environmental targets, please explain why it chooses not to do so.
8. Does your company use science-based* reference points in your target setting? If so, which science-based targets does it use? How does your company identify those science-based reference points? What benefits do you see of using science-based reference points in target setting? What barriers do you see to using science-based reference points?

*science-based targets refer to targets set for performance that align with current science. For example, a science-based emissions target would align with climate change science and the Paris Agreement to keep global temperature increases to below 2^{o} C above pre-industrial levels.

Interview Consent Form

Ryerson University

Consent Agreement

You are being invited to participate in a research study. Please read this consent form so that you understand what your participation will involve. Before you consent to participate, please ask any questions to be sure you understand what your participation will involve.

PROJECT TITLE:

A context-based composite environmental sustainability indicator for the brewing industry

INVESTIGATORS:

This research study is being conducted by Sigrid Grosseth, a master's student in the Environmental Applied Science and Management Program at Ryerson University. This research study is being supervised by Dr. Cory Searcy, a Professor from the Department of Mechanical and Industrial Engineering at Ryerson University.

If you have any questions or concerns about the research, please feel free to contact the primary researcher, Sigrid Grosseth, at Sigrid.grosseth@ryerson.ca.

PURPOSE OF THE STUDY:

This research will be conducted to better understand the way breweries choose what they report and any barriers to adopting science-based environmental performance targets. The interviews will serve as a basis for developing a tool that will provide a way to incorporate science-based targets into the evaluation of the environmental sustainability of breweries. This tool will require the opinions industry professionals to describe which environmental performance indicators are most relevant, including their relative importance, as well as what data are collected by breweries. In order to answer these questions, the employees of breweries, involved in environmental sustainability management, will be contacted as prospective research participants. Ideally, ten to fifteen participants will be interviewed. The results of this research will contribute to Sigrid Grosseth's thesis as part of a MASc in Environmental Applied Science and Management.

PARTICIPANT INCLUSION/EXCLUSION CRITERIA:

To participate you need to be associated with environmental management or reporting at a brewery. Specifically, we are recruiting those holding one of the following positions: Potential titles will include sustainability/corporate social responsibility/environment managers, analysts, etc. as well as any senior-level executives with oversight of these areas.

WHAT YOU WILL BE ASKED TO DO:

If you volunteer to participate in this study, you will be asked to do the following things:

Participate in a recorded phone interview lasting no longer than 30 minutes by responding to questions relevant to your professional experience. Prior to the interview, you will be required to email a signed copy of the consent form. You will also have the opportunity to ask any questions about the research and participation prior to the interview and to skip any questions. Questions will be provided to you prior to the interview, however, follow-up questions may arise depending on answers given. These questions will be based on your professional experience and opinions. Sample questions may include: "How are environmental performance indicator reduction targets chosen?" and "How are environmental performance indicators chosen to be included in public reports?".

You have the option to withdraw your participation before, during or after the interview. Following the interview, the primary researcher will transcribe the recorded interview. A follow-up email will be sent to you to confirm the transcription. Should you wish to view the results of the study, you may indicate so at the end of this form.

POTENTIAL BENEFITS:

The potential benefits of participating in this study include contributing to the literature surrounding corporate environmental reporting and target-setting and understanding the barriers breweries may face while trying to adopt science-based performance targets. The information collected in these interviews will then go on to support the development of an environmental analysis tool specific to breweries which may be of interest to the participants.

There is no guarantee, however, that you will receive any benefits from participating in this study.

WHAT ARE THE POTENTIAL RISKS TO YOU AS A PARTICIPANT:

The potential risks of participation are very low. Your name or company will not be disclosed. However, there is a small risk that you could be identified, resulting in a potential loss of privacy, depending on your responses. You will be able to skip any questions that may you believe may reveal your identity or to avoid questions that make you uncomfortable. Participants will also be able to review their responses once the interviews have been transcribed. Additionally, only the primary investigator will have access to the identifying information as it will be encrypted and stored on a password-protected private computer. Pseudonyms will be used for both the company and the participants; the company's name will not be associated with data dissemination.

Participants will also be able to withdraw their data completely, up until September 30, 2019.

<u>CONFIDENTIALITY</u>:

The primary investigator, Sigrid Grosseth, will be the only researcher to have direct interaction with the participants. Their personal information will be encrypted, password protected, and stored separately from the response data on a private computer. Pseudonyms will be used when discussing the transcribed interviews as well as the resulting data. The anonymized data, such the transcription files may also be viewed by the supervisor, Dr. Cory Searcy.

The recorded interview will be reviewed and transcribed by the primary researcher, and a follow-up email will be sent to participants to review and confirm the transcription.

<u>DATA STORAGE:</u>

Audio files will be accessed by the primary investigator and destroyed after the interviews have been transcribed by deleting them from the recording device. Contact information of the participants will be accessed by the primary investigator and will be deleted after the interview transcriptions have been confirmed by the interviewees. The consent forms, list of participants, and the transcribed interviews will be encrypted and stored on a password-protected personal computer. This information kept until seven years after the research is published, as per Ryerson University's Records Retention Schedule for Research Projects. As these are electronic files, they will be deleted at this time from the personal computer.

<u>DATA DISSEMINATION:</u>

The data collected will be presented as part of a master's thesis and will be submitted to a journal for peer review and publication. If participants wish to access the results of this study, the master's thesis will be published and accessible through the Ryerson University Digital Repository at https://digital.library.ryerson.ca/.

<u>VOLUNTARY PARTICIPATION AND WITHDRAWAL:</u>

Participation in this study is completely voluntary. You can choose whether to be in this study or not. If any question makes you uncomfortable, you can skip that question. You may stop participating at any time without consequence. If you choose to stop participating, you may also choose to not have your data included in the study. You will have until June 31, 2019 to choose to remove your data from the research after the interview.

Your choice of whether or not to participate will not influence your future relations with Ryerson University or the investigators, Sigrid Grosseth and Dr. Cory Searcy, involved in the research.

<u>QUESTIONS ABOUT THE STUDY</u>: If you have any questions about the research now, please ask. If you have questions later about the research, you may contact:

Sigrid Grosseth, Primary Investigator

Graduate Student, MASc Candidate, Environmental Applied Science and Management

sigrid.grosseth@ryerson.ca

Dr. Cory Searcy, Research Supervisor

Professor, Mechanical and Industrial Engineering

Associate Dean, Programs in the Yeates School of Graduate Studies

cory.searcy@ryerson.ca

(416) 979-5000 x2095

This study has been reviewed by the Ryerson University Research Ethics Board. If you have questions regarding your rights as a participant in this study please contact:

Research Ethics Board

c/o Office of the Vice President, Research and Innovation

Ryerson University

350 Victoria Street

Toronto, ON M5B 2K3

416-979-5042

rebchair@ryerson.ca

A CONTEXT-BASED COMPOSITE ENVIRONMENTAL SUAINABILITY INDICATOR FOR THE BREWING INDUSTRY

CONFIRMATION OF AGREEMENT:

Your signature below indicates that you have read the information in this agreement and have had a chance to ask any questions you have about the study. Your signature also indicates that you agree to participate in the study and have been told that you can change your mind and withdraw your consent to participate at any time. You have been given a copy of this agreement.

You have been told that by signing this consent agreement you are not giving up any of your legal rights.

____

Name of Participant (please print)

______________________________________ ___________________

Signature of Participant Date

I agree to be audio-recorded for the purposes of this study. I understand how these recordings will be stored and destroyed.

______________________________________ ___________________

Signature of Participant Date

Appendix C: Brewery Data Collected

Table 4: Environmental targets collected during the content analysis (duplicates within companies have been merged).

Company	Document(s)	Target	Category	Source
4 Pines Brewing Company	Save the Pines Report 2016	5% reduction in energy intensity from 2016 baseline	energy	report
4 Pines Brewing Company	Save the Pines Report 2016	50% sustainable suppliers who share our values	other	report
4 Pines Brewing Company	Save the Pines Report 2016	95% waste reduction throughout out venues from 2016 base year	packaging/waste	report
4 Pines Brewing Company	Save the Pines Report 2016	40% waste reduction in the brewery from 2016 base year	packaging/waste	report
AB InBev	2018 Annual Report + Climate Action + Sustainability Goals	reduce GHG emissions by 25% per beverage across supply chain from 2017 baseline	emissions	report + website
AB InBev	2018 Annual Report + Climate Action + Sustainability Goals	100% of purchased electricity from renewable sources	energy	report + website
AB InBev	2018 Annual Report + Smart Agriculture	100% of direct farmers will be skilled, connected, and financially empowered	other	report + website
AB InBev	2018 Annual Report + Sustainability Goals + Circular Packaging	100% of products in packaging that is returnable or made from a majority recycled content	packaging/waste	report + website
AB InBev	2018 Annual Report + Water Stewardship	100 % of communities in water stressed areas will have measurably improved water availability and quality	water	report + website
Asahi Group Holdings	Integrated Report 2019	establish medium to long term environmental targets consistent with scientific knowledge for biodiversity	biodiversity/forest	report
Asahi Group Holdings	Integrated Report 2020	scope 1 and 2 Co2 emission reduction target 30% from 2015 base year	emissions	report
Asahi Group Holdings	Integrated Report 2022	zero CO2 emissions	emissions	report
Asahi Group Holdings	Integrated Report 2021	scope 3 Co2 emission reduction target 30% from 2015 base year	emissions	report

Company	Document(s)	Target	Category	Source
Asahi Group Holdings	Integrated Report 2018	establish medium to long term environmental targets consistent with scientific knowledge for recycling-based society	packaging/waste	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	purchase 100% renewable energy	energy	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report + Sustainability	Annual Reduction in Carbon Footprint/Sales	emissions and energy	report + website
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report + Sustainability	10% Onsite Renewable Electricity	energy	report + website
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report + Sustainability	Zero Waste to Landfill	packaging/waste	report + website
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report + Sustainability	Water to Beer Ratio 3:1	water	report + website
Carlsberg Group	Sustainability Report 2018 + Zero Carbon Footprint	15% reduction in beer-in-hand carbon footprint (value chain carbon emissions)	emissions	report + website
Carlsberg Group	Sustainability Report 2018 + Zero Carbon Footprint	30% reduction in beer-in-hand carbon footprint (value chain carbon emissions)	emissions	report + website
Carlsberg Group	Sustainability Report 2018 + Zero Carbon Footprint	50% reduction in carbon emissions at breweries	emissions	report + website
Carlsberg Group	Sustainability Report 2018 + Zero Carbon Footprint	zero carbon emissions at breweries	emissions	report + website
Carlsberg Group	Sustainability Report 2018 + Zero Carbon Footprint	100% low climate impact cooling	emissions	report + website
Carlsberg Group	Sustainability Report 2018 + Zero Carbon Footprint	30 partnerships to reduce shared footprint	emissions	report + website
Carlsberg Group	Sustainability Report 2018 + Zero Carbon Footprint	100% electricity from renewable sources at breweries	energy	report + website
Carlsberg Group	Sustainability Report 2018 + Zero Carbon Footprint	zero coal at breweries	energy	report + website
Carlsberg Group	Sustainability Report 2018 + Zero Water Waste	25% reduction in water usage at breweries (2.5 hl/hl)	water	report + website

Company	Document(s)	Target	Category	Source
Carlsberg Group	Sustainability Report 2018 + Zero Water Waste	50% reduction in water usage at breweries (1.7 hl/hl)	water	report + website
Carlsberg Group	Zero Water Waste	explore going below 2.0 hl/hl at all high-risk breweries	water	website
Carlsberg Group	Sustainability Report 2018 + Zero Water Waste	partner to safeguard shared water resources in high-risk areas	water	website
China Resources Beer	Environmental, Social, and Governance Report 2017	eliminate coal-burning boilers at more than 5 breweries	energy	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact	sustainably source all paper and board packaging to ensure zero net deforestation	biodiversity/forest	report + website
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact + Knowing Your Footprint: Guiness	reduce total supply chain GHG emissions by 30%	emissions	report + website
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact	reduce absolute GHG emissions from direct operations by 50%	emissions	report + website
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact	ensure all new refrigeration equipment in trade is HFC-free, with a reduction in associated GHG emissions from 2015	emissions	report + website
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	procure 100% of electricity from renewables	energy	report
Diageo	Sustainability & Responsibility Performance Addendum to the	establish partnerships with farmers to develop sustainable agricultural supplies of key raw materials	other	report

Company	Document(s)	Target	Category	Source
	Annual Report 2018 + Annual Report 2018			
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact	achieve zero waste to landfill	packaging/waste	report + website
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact	increase recycled content to 45%	packaging/waste	report + website
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018	achieve 40% average recycled content in plastic bottles	packaging/waste	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018	achieve 100 % recycled content in plastic bottles	packaging/waste	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact	make all packaging recyclable or reusable	packaging/waste	report + website
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018	ensure 100% of plastic used is designed to be widely recyclable (or reusable/compostable)	packaging/waste	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact	reduce total packaging weight by 15 %	packaging/waste	report + website
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 +	reduce water use through a 50% improvement in water-use efficienct from 2007	water	report + website

Company	Document(s)	Target	Category	Source
	Annual Report 2018 + Reducing our environmental impact + Knowing Your Footprint: Guiness			
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact	equip suppliers with tools to protect water resources in most water-stressed locations	water	report + website
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact	replenish the amount of water used in final product in water-stressed areas	water	report + website
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018 + Reducing our environmental impact	return 100% of wastewater from operations to the environment safely	water	report + website
Heineken	Heineken N. V. Annual Report 2018 + Sustainability	reduce CO2 emissions from fridges by 50% from 2010 baseline	emissions	report + website
Heineken	Heineken N. V. Annual Report 2018 + Sustainability	reduce CO2 emissions from production by 40% to 6.4 kg CO2eq/hl from 2008 baseline	emissions	report + website
Heineken	Heineken N. V. Annual Report 2018	80% reduction in carbon emissions per hl from 2008 levels	emissions	report
Heineken	Sustainability	lower emissions in distribution by 20%	emissions	website
Heineken	Heineken N. V. Annual Report 2018	70% renewable energy in production	energy	report
Heineken	Heineken N. V. Annual Report 2018	science-based targets for packaging, distribution, and cooling within 2 years	energy	report
Heineken	Heineken N. V. Annual Report 2018 + Sustainability	aim for 50% of agricultural raw materials to come from sustainable sources	other	report + website
Heineken	Heineken N. V. Annual Report 2018 + Sustainability	compliance with supplier code procedure	other	report + website

Company	Document(s)	Target	Category	Source
Heineken	Heineken N. V. Annual Report 2018	reduce average water consumption in breweries to 3.5 hl/hl	water	report
Heineken	Heineken N. V. Annual Report 2019	reduce average water consumption in breweries in water-stressed areas to 3.3 hl/hl	water	report
Heineken	Sustainability	reduce water consumption in breweries by 30%	water	website
Heineken	Heineken N. V. Annual Report 2018 + Sustainability	ensure all wastewater volumes are treated before being discharged into surface water	water	report + website
Hopworks Urban Brewery	HUB Sustainability Report: 2014	Break through the 90% waste diversion barrier (not including spent grain)	packaging/waste	report
Kirin Holdings Company	Kirin Report 2018 + Environmental Report 2017	switch all paper containers and packaging to FSC certified paper	biodiversity/forest	report
Kirin Holdings Company	Environmental Report 2017	work toward sustainable use of biological resources	biodiversity/forest	report
Kirin Holdings Company	Environmental Report 2017	keep CO2 emissions across our value chain within the Earth's capacity to absorb them by 2050	emissions	report
Kirin Holdings Company	Environmental Report 2017	reduce GHG emissions across entire value chain by 50% from 1990 values	emissions	report
Kirin Holdings Company	Environmental Report 2017	reduce scope 1 and 2 emissions by 30% from 2015 values	emissions	report
Kirin Holdings Company	Environmental Report 2017	reduce scope 3 emissions by 30% from 2015 values	emissions	report
Kirin Holdings Company	Kirin Report 2018	formulate GHG roadmap for 2018-2030	emissions	report
Kirin Holdings Company	Kirin Report 2018	expand renewable energy ratio for plant purchased electric power to 50%	energy	report
Kirin Holdings Company	Kirin Report 2018	install 10 MW solar power generation facilities	energy	report
Kirin Holdings Company	The Environment	realize a society based on 100% resource circulation	other	website

Company	Document(s)	Target	Category	Source
Kirin Holdings Company	Kirin Report 2018	raise recyclable material packaging rate to 90% or more	packaging/waste	report
Kirin Holdings Company	Environmental Report 2017	work toward sustainable use of packaging and containers	packaging/waste	report
Kirin Holdings Company	Kirin Report 2018	25% reduction in unit water usage from 2015 levels	water	report
Kirin Holdings Company	Kirin Report 2018 + Environmental Report 2017	reduce water usage by 30% from 2015 levels	water	report
Kirin Holdings Company	Environmental Report 2020	strive to see that water resources in each region can be ensured on a permanent basis	water	report
Molson Coors	Our Beer Print Report 2018 + Environmental, Social, and Governance Report 2018 + 2025 Targets: Raising the Bar on Beer + Sustainably Brewing + Promoting a Circular Philosophy	reduce carbon emissions throughout value chain by 20% from 2016 baseline	emissions	report + website
Molson Coors	Our Beer Print Report 2018 + Environmental, Social, and Governance Report 2018 + 2025 Targets: Raising the Bar on Beer + Sustainably Brewing	reduce carbon emissions across operations by 50% from 2016 baseline	emissions	report + website
Molson Coors	Our Beer Print Report 2018 + Environmental, Social, and Governance Report 2018 + Promoting a Circular Philosophy	achieve a 26% emissions reduction in packaging materials from 2017 baseline (-6.88 kg CO21/hl)	emissions	report + website
Molson Coors	Our Beer Print Report 2018 + Environmental, Social, and Governance Report 2018 + 2025 Targets: Raising the Bar on Beer + Growing Best Practice in Agriculture	100% of barley and hops sourced from sustainable suppliers in key growing regions	other	report + website
Molson Coors	Our Beer Print Report 2018 + Environmental, Social, and Governance Report 2018 + 2025 Targets: Raising the Bar on Beer + Promoting a Circular Philosophy	achieve zero waste to landfill at all brewing and major manufacturing facilities	packaging/waste	report + website

Company	Document(s)	Target	Category	Source
Molson Coors	Our Beer Print Report 2018 + Environmental, Social, and Governance Report 2018 + 2025 Targets: Raising the Bar on Beer + Water	improve water-use efficiency by 22% from 2016 baseline to 2.8 hl/hl water-to-beer ratio	water	report + website
Molson Coors	Our Beer Print Report 2019 + 2025 Targets: Raising the Bar on Beer	protect local water resources	water	report + website
Molson Coors	Our Beer Print Report 2018 + Environmental, Social, and Governance Report 2018 + 2025 Targets: Raising the Bar on Beer + Growing Best Practice in Agriculture	improve water-use efficiency of agricultural supply chain and malting operations by 10% (baseline not established)	water	report + website
New Belgium Brewing	Carbon Emissions	reduce absolute scope 1-2 emissions by 50% from 2014 baseline	emissions	website
New Belgium Brewing	Business as a Force For Good + Carbon Emissions	GHG emission intensity to 16 kg CO2e/hl beer packaged (scope 1 and 2 only)	emissions	report + website
New Belgium Brewing	Business as a Force For Good + Energy	energy intensity of 108 MJ/hl	energy	report + website
New Belgium Brewing	Business as a Force For Good + Waste Reduction	landfill waste to 60g/hl	packaging/waste	report + website
New Belgium Brewing	Business as a Force For Good + Good Water Means Good Beer	water intensity to 3.5 hl water/hl beer packaged	water	report + website
North Coast Brewing Co.	Annual Sustainability Report	measure GHG emissions and set specific reduction targets in subsequent years	emissions	report
North Coast Brewing Co.	Annual Sustainability Report	maximize energy efficiency and track energy usage	energy	report
North Coast Brewing Co.	Annual Sustainability Report	understand how NCBC's environmental metrics compare to other breweries	other	report
North Coast Brewing Co.	Annual Sustainability Report	reduce waste and promote conservation through company-side operations	packaging/waste	report
North Coast Brewing Co.	Annual Sustainability Report	measure and maximize water efficiency throughout brewery operations	water	report

Company	Document(s)	Target	Category	Source
Stone and Wood Brewing Company	Green Feet Summary report	140 MJ/hl	energy	report
Stone and Wood Brewing Company	Green Feet Summary report	>99% solid waste recycled/diverted from landfill (including grain)	packaging/waste	report
Stone and Wood Brewing Company	Green Feet Summary report	3.5 L/L water to beer	water	report
Toast Ale	Impact Report 2016-2018 + Brewing a Better Planet	1 billion slices diverted from landfill	other	report + website

Table 5: Environmental indicators collected during the content analysis (duplicates within companies have been merged).

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
4 Pines Brewing Company	Save The Pines Report 2016	energy intensity	energy	relative	input	report
4 Pines Brewing Company	Save The Pines Report 2016	Environment Impact B Corp	general environment	other	other	report
4 Pines Brewing Company	Save The Pines Report 2016	B Corp Score	other	other	other	report
4 Pines Brewing Company	Save The Pines Report 2016	waste recycled	packaging/waste	absolute	output	report
4 Pines Brewing Company	Save the Pines Report 2016	waste to landfill	packaging/waste	absolute	output	report
4 Pines Brewing Company	Save The Pines Report 2016	water intensity	water	relative	input	report
AB InBev	Climate Action	global cooler purchases that meet standards for eco-friendly coolers	emissions	absolute	output	website
AB InBev	2018 Annual Report	total direct and indirect GHG emissions (Scopes 1 and 2)	emissions	absolute	output	report
AB InBev	2018 Annual Report	total direct and indirect GHG emissions (Scopes 1, 2, and 3)	emissions	absolute	output	report
AB InBev	2018 Annual Report	cars off the road every day by transitioning to renewable electricity	emissions	equivalent	output	report
AB InBev	2018 Annual Report	scope 1 and 2 GHG emissions	emissions	relative	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
		per hl of production				
AB InBev	2018 Annual Report	scope 1, 2 and 3 GHG emissions per hl of production	emissions	relative	output	report
AB InBev	2018 Annual Report	contracted electricity from renewable sources	energy	absolute	input	report
AB InBev	2018 Annual Report	operational contracts for electricity from renewable sources	energy	absolute	input	report
AB InBev	2018 Annual Report	renewable energy agreements signed	energy	absolute	input	report
AB InBev	2018 Annual Report	total GJ of energy	energy	absolute	input	report
AB InBev	2018 Annual Report	total GJ of energy purchased	energy	absolute	input	report
AB InBev	2018 Annual Report	energy purchased per hl production	energy	relative	input	report
AB InBev	2018 Annual Report	Energy usage per hl production	energy	relative	input	report
AB InBev	2018 Annual Report + Smart Agriculture	farmers who participated in SmartBarley Program	other	absolute	input	report + website
AB InBev	2018 Annual Report + Smart Agriculture	farmers working diligently to ensure we have full transparency of farmers in the direct supply chain	other	absolute	input	report + website
AB InBev	Circular Packaging	baseline for recycled content in product packaging	packaging/waste	absolute	input	website
AB InBev	2018 Annual Report	percent of volume in returnable packaging	packaging/waste	absolute	input	report
AB InBev	2018 Annual Report	percent recycled content in primary packaging for cans	packaging/waste	absolute	input	report
AB InBev	2018 Annual Report	percent recycled content in primary packaging for glass	packaging/waste	absolute	input	report
AB InBev	2018 Annual Report	percent recycled content in primary packaging for PET	packaging/waste	absolute	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
AB InBev	Circular Packaging	recycling rate	packaging/waste	absolute	output	website
AB InBev	2018 Annual Report	total water use	water	absolute	input	report
AB InBev	2018 Annual Report	water usage decrease from 2017	water	benchmark	input	report
AB InBev	2018 Annual Report	water use by hl of production	water	relative	input	report
Asahi Group Holdings	Integrated Report 2017	events involving forest preservation activities	biodiversity/forest	absolute	output	report
Asahi Group Holdings	Integrated Report 2017	participants involved in forest preservation activities	biodiversity/forest	absolute	output	report
Asahi Group Holdings	Integrated Report 2017	sites involved in forest preservation activities	biodiversity/forest	absolute	output	report
Asahi Group Holdings	Environmental Achievements	CO2 absorption by corporate-owned Asahi Forest	emissions	absolute	output	website
Asahi Group Holdings	Environmental Achievements	CO2 emissions (gross)	emissions	absolute	output	website
Asahi Group Holdings	Integrated Report 2017 + Environmental Achievements	CO2 emissions after Tradable Green Certificates have been accouted for	emissions	absolute	output	report + website
Asahi Group Holdings	Environmental Achievements	NOx emissions	emissions	absolute	output	website
Asahi Group Holdings	Environmental Achievements	SOx emissions	emissions	absolute	output	website
Asahi Group Holdings	Integrated Report 2017	CO2 emissions per basic unit	emissions	relative	output	report
Asahi Group Holdings	Environmental Achievements	A-grade heavy oil	energy	absolute	input	website
Asahi Group Holdings	Environmental Achievements	city gas	energy	absolute	input	website
Asahi Group Holdings	Environmental Achievements	energy as electric power	energy	absolute	input	website
Asahi Group Holdings	Environmental Achievements	energy as fuel/heat	energy	absolute	input	website
Asahi Group Holdings	Environmental Achievements	liquified natural gas	energy	absolute	input	website
Asahi Group Holdings	Environmental Achievements	purchased electric power	energy	absolute	input	website
Asahi Group Holdings	Environmental Achievements	total energy	energy	absolute	input	website
Asahi Group Holdings	Integrated Report 2017	cans of product sold using green electricity	energy	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Asahi Group Holdings	Environmental Achievements	ingredients for beer-type beverages	other	absolute	input	website
Asahi Group Holdings	Integrated Report 2017	suppliers contacted that has previously taken a CSR survey	other	absolute	input	report
Asahi Group Holdings	Environmental Achievements	container and packaging materials for beer-type beverages	packaging/waste	absolute	input	website
Asahi Group Holdings	Environmental Achievements	generated volume of waste and by-products	packaging/waste	absolute	output	website
Asahi Group Holdings	Environmental Achievements	recycled volume of waste and by-products	packaging/waste	absolute	output	website
Asahi Group Holdings	Environmental Achievements	recycling rate	packaging/waste	absolute	output	website
Asahi Group Holdings	Integrated Report 2017	recycling ratio of by-products and waste	packaging/waste	absolute	output	report
Asahi Group Holdings	Integrated Report 2017 + Environmental Achievements	water consumption	water	absolute	input	report + website
Asahi Group Holdings	Integrated Report 2017	water consumption per basic unit	water	relative	input	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	trees planted	biodiversity/forest	absolute	output	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	GHG emissions	emissions	absolute	output	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	natural gas	energy	absolute	input	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	renewable electricity purchased	energy	absolute	input	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	renewable purchasing	energy	absolute	input	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	total electricity	energy	absolute	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report + Sustainability	donations to environmental non-profit organizations	general environment	absolute	output	report + website
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	Environment Impact B Corp	general environment	other	other	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	B Corp Score	other	other	other	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	grains reused through food recovery program	packaging/waste	absolute	output	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	plastic film recycled	packaging/waste	absolute	output	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	total waste diverted	packaging/waste	absolute	output	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	waste diverted from landfill (not including grains)	packaging/waste	absolute	output	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	water used by brewery	water	absolute	input	report
Aslan Brewing Company	Aslan Brewing Co 2018 Sustainability Report	water to beer ratio	water	relative	input	report
Beau's All Natural Brewing Company Ltd.	Sustainable Craft Brewing: A look at Beau's green initiatives	environmental footprint reduction through supporting renewable energy	emissions	absolute	output	website
Beau's All Natural Brewing Company Ltd.	Sustainable Craft Brewing: A look at Beau's green initiatives	environmental footprint reduction through supporting renewable energy equivalent	emissions	equivalent	output	website
Beau's All Natural Brewing Company Ltd.	About Us - Sustainability + Sustainable Craft Brewing: A look at Beau's green initiatives	green electricity	energy	absolute	input	website
Beau's All Natural	About Us - Sustainability +	green natural gas	energy	absolute	input	website

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Brewing Company Ltd.	Sustainable Craft Brewing: A look at Beau's green initiatives					
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	employees living within 5 miles	emissions	absolute	other	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	employees living within one mile	emissions	absolute	other	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	carbon footprint	emissions	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	carbon footprint with offset	emissions	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	total scope 1 emissions	emissions	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	total scope 2 emissions	emissions	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	total scope 3 emissions	emissions	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	electricity	energy	absolute	input	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	electricity produced by solar panels	energy	absolute	input	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	natural gas	energy	absolute	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	percent onsite renewable electricity	energy	absolute	input	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	percent of donations supporting the environment	general environment	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	cans displaced by selling reusable growlers	packaging/waste	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	latex gloves recycled	packaging/waste	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	waste composted	packaging/waste	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	waste recycled	packaging/waste	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	waste to cattle feed	packaging/waste	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	waste to incinerator	packaging/waste	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	waste to trash	packaging/waste	absolute	output	report
Brewery Vivant	Beer the Change Brewery Vivant's 2018 Sustainability Report	water usage	water	absolute	input	report
Bull City Burger and Brewery	Pie Pan Inc. Sustainability Report 2027	fresh compost created to build soil	packaging/waste	absolute	output	report
Bull City Burger and Brewery	Pie Pan Inc. Sustainability Report 2026	paper waste diverted from landfill	packaging/waste	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Bull City Burger and Brewery	Pie Pan Inc. Sustainability Report 2021	waste as food compost	packaging/waste	absolute	output	report
Bull City Burger and Brewery	Pie Pan Inc. Sustainability Report 2020	waste as paper compost	packaging/waste	absolute	output	report
Bull City Burger and Brewery	Pie Pan Inc. Sustainability Report 2019	waste as spent grain	packaging/waste	absolute	output	report
Bull City Burger and Brewery	Pie Pan Inc. Sustainability Report 2024	waste diverted	packaging/waste	absolute	output	report
Bull City Burger and Brewery	Pie Pan Inc. Sustainability Report 2023	waste to landfill	packaging/waste	absolute	output	report
Bull City Burger and Brewery	Pie Pan Inc. Sustainability Report 2022	waste to recycling	packaging/waste	absolute	output	report
Bull City Burger and Brewery	Pie Pan Inc. Sustainability Report 2025	water usage	water	absolute	input	report
Bull City Burger and Brewery	Pie Pan Inc. Sustainability Report 2018	percent less water used than other breweries of same size	water	benchmark	input	report
Carlsberg Group	Sustainability Report 2018	absolute CO2 emissions	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	agriculture contribution to total carbon emissions	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	brewery contribution to total carbon emissions	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	distribution contribution to total carbon emissions	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	malting contribution to total carbon emissions	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	newly purchased commercial fridges and beer coolers that live up to specifications for low-climate-impact cooling	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	packaging contribution to carbon emissions in value chain	emissions	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Carlsberg Group	Sustainability Report 2018	refrigeration contribution to total carbon footprint	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	total CO2 emissions (direct and indirect, location-based)	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	total CO2 emissions (direct and indirect, market-based)	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	total CO2 emissions from refrigerants	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	total NOx emissions	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	total SO2 emissions	emissions	absolute	output	report
Carlsberg Group	Sustainability Report 2018	carbon emissions reduction from 2015 baseline	emissions	benchmark	output	report
Carlsberg Group	Sustainability Report 2018	reduction in coal use over past 3 years	emissions	benchmark	output	report
Carlsberg Group	Sustainability Report 2018	relative carbon emissions	emissions	relative	output	report
Carlsberg Group	Sustainability Report 2018	energy from renewable thermal and electricity sources (including biomass, biogas, and solar)	energy	absolute	input	report
Carlsberg Group	Sustainability Report 2018	renewable energy	energy	absolute	input	report
Carlsberg Group	Sustainability Report 2018	thermal energy as coal	energy	absolute	input	report
Carlsberg Group	Sustainability Report 2018	thermal energy as district heating	energy	absolute	input	report
Carlsberg Group	Sustainability Report 2018	thermal energy as heavy fuel	energy	absolute	input	report
Carlsberg Group	Sustainability Report 2018	thermal energy as light fuel	energy	absolute	input	report
Carlsberg Group	Sustainability Report 2018	thermal energy as natural gas	energy	absolute	input	report
Carlsberg Group	Sustainability Report 2018	thermal energy as renewable energy	energy	absolute	input	report
Carlsberg Group	Sustainability Report 2018	total electricity consumption	energy	absolute	input	report
Carlsberg Group	Sustainability Report 2018	total thermal energy consumption	energy	absolute	input	report
Carlsberg Group	Sustainability Report 2018	relative electricity	energy	relative	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Carlsberg Group	Sustainability Report 2018	relative energy efficiency	energy	relative	input	report
Carlsberg Group	Sustainability Report 2018	relative thermal energy	energy	relative	input	report
Carlsberg Group	Sustainability Report 2018	weight reduction of bottles	packaging/waste	absolute	input	report
Carlsberg Group	Sustainability Report 2018	brewer's grains and brewer's yeast utilized	packaging/waste	absolute	output	report
Carlsberg Group	Sustainability Report 2018	solid waste as special waste	packaging/waste	absolute	output	report
Carlsberg Group	Sustainability Report 2018	solid waste disposed for land applications	packaging/waste	absolute	output	report
Carlsberg Group	Sustainability Report 2018	solid waste incinerated	packaging/waste	absolute	output	report
Carlsberg Group	Sustainability Report 2018	solid waste recycled	packaging/waste	absolute	output	report
Carlsberg Group	Sustainability Report 2018	solid waste to sanitary landfill	packaging/waste	absolute	output	report
Carlsberg Group	Sustainability Report 2018	total solid waste	packaging/waste	absolute	output	report
Carlsberg Group	Sustainability Report 2018	total wastewater discharged	water	absolute	input	report
Carlsberg Group	Sustainability Report 2018	total water consumption	water	absolute	input	report
Carlsberg Group	Sustainability Report 2018	water consumption reduction from 2015 baseline	water	benchmark	input	report
Carlsberg Group	Sustainability Report 2018	relative water consumption	water	relative	input	report
China Resources Beer	Corporate Social Responsibility Report 2016	amount invested into energy conservation and emission reduction projects	emissions	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	chemical oxygen demand	emissions	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	NOx emissions	emissions	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	scope 1 GHG emissions	emissions	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	scope 1 GHG emissions density	emissions	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
China Resources Beer	Environmental, Social, and Governance Report 2017	scope 2 GHG emissions	emissions	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	scope 2 GHG emissions density	emissions	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	SO2 emissions	emissions	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	total GHG emissions	emissions	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	total GHG emissions density	emissions	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in NOx emissions from 2016	emissions	benchmark	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in SO2 emissions from 2016	emissions	benchmark	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017 + Corporate Social Responsibility Report 2016	decrease in COD from 2016 (and from 2015 in 2016 report)	emissions	benchmark	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in scope 1 GHG emissions density from 2016	emissions	benchmark	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in scope 1 GHG emissions from 2016	emissions	benchmark	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in scope 2 GHG emissions density from 2016	emissions	benchmark	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in scope 2 GHG emissions from 2016	emissions	benchmark	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in total GHG emissions density from 2016	emissions	benchmark	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in total GHG emissions from 2016	emissions	benchmark	output	report
China Resources Beer	Corporate Social Responsibility Report 2016	reduction in SO2 emissions from 2015	emissions	benchmark	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017 + Corporate Social Responsibility Report 2016	coal-burning boilers phased out since 2015	energy	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	comprehensive energy consumption per unit	energy	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	energy consumption from coal	energy	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	energy consumption from diesel oil	energy	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	energy consumption from electricity	energy	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	energy consumption from gasoline	energy	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	energy consumption from heat consumption	energy	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	energy consumption from natural gas	energy	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	proportion of breweries using steam or natural gas	energy	absolute	input	report
China Resources Beer	Corporate Social Responsibility Report 2016	proportion of breweries using steam or natural gas	energy	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	coal-consumption decrease from 2016	energy	benchmark	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in energy consumption from diesel oil from 2016	energy	benchmark	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in energy consumption from electricity from 2016	energy	benchmark	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in energy consumption from gasoline from 2016	energy	benchmark	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in energy consumption from heat consumption from 2016	energy	benchmark	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in vehicle gasoline consumption from 2016	energy	benchmark	input	report
China Resources Beer	Corporate Social Responsibility Report 2016	decrease year-on-year in comprehensive energy consumption per unit of product	energy	benchmark	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	increase in energy consumption from natural gas from 2016	energy	benchmark	input	report
China Resources Beer	Corporate Social Responsibility Report 2016	reduction in coal consumption from 2015	energy	benchmark	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017 + Corporate Social Responsibility Report 2016	projects on environmental protection, energy conservation, and emissions reduction	general environment	absolute	output	report
China Resources Beer	Corporate Social Responsibility Report 2016	total environmental protection investment	general environment	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	distiller's grains output	packaging/waste	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	packaging material consumption of bottle	packaging/waste	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
China Resources Beer	Environmental, Social, and Governance Report 2017	packaging material consumption of can	packaging/waste	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	packaging material consumption of carton	packaging/waste	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	packaging material consumption of plastic film	packaging/waste	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	recycling rate of distiller's grains and waste yeast	packaging/waste	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	waste yeast output	packaging/waste	absolute	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in packaging material consumption of can from 2016	packaging/waste	benchmark	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	increase in packaging material consumption of bottle from 2016	packaging/waste	benchmark	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	increase in packaging material consumption of carton from 2016	packaging/waste	benchmark	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	increase in packaging material consumption of plastic film from 2016	packaging/waste	benchmark	output	report
China Resources Beer	Environmental, Social, and Governance Report 2017	water consumption	water	absolute	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017 + Corporate Social Responsibility Report 2016	decrease in per unit water consumption from 2016	water	benchmark	input	report
China Resources Beer	Environmental, Social, and Governance Report 2017	decrease in water consumption from 2016 (from 2015 in 2016 report)	water	benchmark	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
China Resources Beer	Environmental, Social, and Governance Report 2017	water density	water	relative	input	report
Constellation Brands	FY18 CSR Report	global GHG emissions (scope 1 and 2)	emissions	absolute	output	report
Constellation Brands	Sustainability	metric tonnes CO2e	emissions	absolute	output	website
Constellation Brands	FY18 CSR Report	carbon disclosure project climate change grade	emissions	other	other	report
Constellation Brands	FY18 CSR Report	global GHG emissions intensity (scope 1 and 2)	emissions	relative	output	report
Constellation Brands	FY18 CSR Report	solar energy generated	energy	absolute	input	report
Constellation Brands	Sustainability	solar power	energy	absolute	input	website
Constellation Brands	Sustainability	solar power equivalent carbon entering atmosphere saved	energy	equivalent	output	website
Constellation Brands	Sustainability	solar power equivalent miles driven saved each year	energy	equivalent	output	website
Constellation Brands	FY18 CSR Report	metric tonnes of landfill material generated	packaging/waste	absolute	output	report
Constellation Brands	FY18 CSR Report	metric tonnes of material recycled, composted, or diverted	packaging/waste	absolute	output	report
Constellation Brands	FY18 CSR Report	total water diversion rate for production facilities globally	water	absolute	input	report
Constellation Brands	FY18 CSR Report	water withdrawals	water	absolute	input	report
Constellation Brands	FY18 CSR Report	carbon disclosure project water grade	water	other	other	report
Constellation Brands	FY18 CSR Report	water intensity	water	relative	input	report
Diageo	Annual Report 2018	sustainably sourced paper and board packaging	biodiversity/forest	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	operational sites and owned land that is near or adjacent to areas designated as having	biodiversity/forest	absolute	other	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
		biodiversity value (UN designation or other national conservation lists)				
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	Red List species and national conservation list species with habitats in areas affected by operations as critically endangered	biodiversity/forest	absolute	other	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	Red List species and national conservation list species with habitats in areas affected by operations as endangered	biodiversity/forest	absolute	other	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	Red List species and national conservation list species with habitats in areas affected by operations as least concern	biodiversity/forest	absolute	other	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	Red List species and national conservation list species with habitats in areas affected by operations as near threatened	biodiversity/forest	absolute	other	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	Red List species and national conservation list species with habitats in areas affected by operations as vulnerable	biodiversity/forest	absolute	other	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	reforested land in Uganda	biodiversity/forest	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the	trees planted in Kenya	biodiversity/forest	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
	Annual Report 2018					
Diageo	Annual Report 2018	% of new equipment sourced HFC-free from 2015 onward	emissions	absolute	output	report
Diageo	Annual Report 2018	carbon emissions	emissions	absolute	output	report
Diageo	Knowing Your Footprint: Guiness	carbon footprint contribution from packaging	emissions	absolute	output	report
Diageo	Knowing Your Footprint: Guiness	carbon footprint contribution from production	emissions	absolute	output	report
Diageo	Knowing Your Footprint: Guiness	carbon footprint contribution from raw ingredients	emissions	absolute	output	report
Diageo	Knowing Your Footprint: Guiness	carbon footprint contribution from retail and consumer	emissions	absolute	output	report
Diageo	Knowing Your Footprint: Guiness	carbon footprint contribution from transport	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018	direct GHG emissions (market-based)	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	emissions from HCFC	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	emissions from HFC	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018	indirect GHG emissions (market-based)	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the	NOx emissions	emissions	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
	Annual Report 2018					
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	scope 3 emissions contribution from business travel	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	scope 3 emissions contribution from capital goods	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	scope 3 emissions contribution from employee commuting	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	scope 3 emissions contribution from fuel and energy related activites not included in scope 1 and 2	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	scope 3 emissions contribution from purchased goods and services	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	scope 3 emissions contribution from upstream transportation and distribution	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	scope 3 emissions contribution from waste generated in operations	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	SOx emissions	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	total direct GHG emissions (location-based)	emissions	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	total indirect GHG emissions (location-based)	emissions	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	GHG emission reduction from operations from 2007 baseline	emissions	benchmark	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018	GHG emission reduction from supply chain from 2007 baseline	emissions	benchmark	output	report
Diageo	Knowing Your Footprint: Guiness	keg of guiness carbon equivalent as miles driven in a car	emissions	equivalent	output	report
Diageo	Knowing Your Footprint: Guiness	keg of guiness carbon equivalent as milk	emissions	equivalent	output	report
Diageo	Knowing Your Footprint: Guiness	pint of guiness carbon equivalent as watching TV	emissions	equivalent	output	report
Diageo	Knowing Your Footprint: Guiness	carbon efficiency	emissions	relative	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	location-based intensity ratio of GHG emissions	emissions	relative	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	market-based intensity ratio of GHG emissions per L packaged product	emissions	relative	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	energy consumed from chilling and refrigertion equipment	energy	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	energy consumption from non-renewable energy	energy	absolute	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	energy consumption from renewable energy	energy	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	energy consumption of road and rail transport	energy	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	non-compliance incidents for environmental consents	general environment	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018	raw materials used	other	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018	packaging used	packaging/waste	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	recycled input materials used	packaging/waste	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	hazardous waste to landfill	packaging/waste	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	hazardous waste used or recycled	packaging/waste	absolute	output	report
Diageo	Annual Report 2018	packaging materials by volume as beverage cartons	packaging/waste	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Diageo	Annual Report 2018	packaging materials by volume as cans	packaging/waste	absolute	output	report
Diageo	Annual Report 2018	packaging materials by volume as cartons	packaging/waste	absolute	output	report
Diageo	Annual Report 2018	packaging materials by volume as closures and crowns	packaging/waste	absolute	output	report
Diageo	Annual Report 2018	packaging materials by volume as corrugate	packaging/waste	absolute	output	report
Diageo	Annual Report 2018	packaging materials by volume as glass	packaging/waste	absolute	output	report
Diageo	Annual Report 2018	packaging materials by volume as labels and sleeves	packaging/waste	absolute	output	report
Diageo	Annual Report 2018	packaging materials by volume as PET	packaging/waste	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	spilled material	packaging/waste	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	spills or incidents	packaging/waste	absolute	output	report
Diageo	Annual Report 2018	total waste to landfill	packaging/waste	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	waste to landfill	packaging/waste	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	waste used or recycled	packaging/waste	absolute	output	report
Diageo	Annual Report 2018	improvement in recyclable packaging content by weight from 2009	packaging/waste	benchmark	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Diageo	Annual Report 2018	total weight of packaging reduced from 2009 baseline	packaging/waste	benchmark	output	report
Diageo	Annual Report 2018	waste to landfill reduction from 2007	packaging/waste	benchmark	output	report
Diageo	Annual Report 2018	key suppliers engaged in water management practices	water	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	total effluent volume	water	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	volume of water recycled or reused	water	absolute	input	report
Diageo	Knowing Your Footprint: Guiness	water footprint contribution from packaging	water	absolute	input	report
Diageo	Knowing Your Footprint: Guiness	water footprint contribution from production	water	absolute	input	report
Diageo	Knowing Your Footprint: Guiness	water footprint contribution from raw ingredients	water	absolute	input	report
Diageo	Knowing Your Footprint: Guiness	water footprint contribution from retail and consumer	water	absolute	input	report
Diageo	Knowing Your Footprint: Guiness	water footprint contribution from transport	water	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	water withdrawal from ground	water	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	water withdrawal from surface water	water	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the	water withdrawals from mains	water	absolute	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
	Annual Report 2018					
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	withdrawal from a wetland listed in the Ramsar Conservation 78 or other nationally or internationally recognized conservation area	water	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	withdrawals from a water source identified to have a high biodiversity value	water	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	withdrawals from water bodies recognized by professionals to be particularly sensitive (size, function, status of the system, support of endangered species of plant or animal)	water	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	withdrawals that account for an average of 5% or more of the annual average volume of a given water body	water	absolute	input	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percent of total water withdrawals recycled or reused	water	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percentage of the final BOD to the environment - land	water	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percentage of the final BOD to the environment - river	water	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percentage of the final BOD to the environment - sea	water	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percentage of the final BOD to the environment - third-party municipal	water	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percentage of the final BOD to the environment - wetland	water	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percentage of total effluent volume to land	water	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percentage of total effluent volume to river	water	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percentage of total effluent volume to sea	water	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percentage of total effluent volume to third-party municipal	water	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018	percentage of total effluent volume to wetland	water	absolute	output	report
Diageo	Sustainability & Responsibility Performance Addendum to the Annual Report 2018 + Annual Report 2018	total BOD	water	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Diageo	Annual Report 2018	water efficiency improvement from 2007 baseline	water	benchmark	input	report
Diageo	Annual Report 2018	% of water replenished in water-stressed areas from 2007 baseline	water	benchmark	output	report
Diageo	Annual Report 2018	reduction in wastewater polluting power from 2007 baseline	water	benchmark	output	report
Diageo	Knowing Your Footprint: Guiness	water equivalent of a keg of guiness	water	equivalent	input	report
Diageo	Knowing Your Footprint: Guiness	water equivalent of a keg of guiness	water	equivalent	input	report
Diageo	Knowing Your Footprint: Guiness	water efficiency	water	relative	input	report
Diageo	Annual Report 2018	water efficiency	water	relative	input	report
Heineken	Heineken N. V. Annual Report 2018	carbon footprint	emissions	absolute	output	report
Heineken	Heineken N. V. Annual Report 2018	contribution to carbon footprint of agriculture	emissions	absolute	output	report
Heineken	Heineken N. V. Annual Report 2018	contribution to carbon footprint of beverage production	emissions	absolute	output	report
Heineken	Heineken N. V. Annual Report 2018	contribution to carbon footprint of cooling	emissions	absolute	output	report
Heineken	Heineken N. V. Annual Report 2018	contribution to carbon footprint of logistics	emissions	absolute	output	report
Heineken	Heineken N. V. Annual Report 2018	contribution to carbon footprint of malting and adjuncts	emissions	absolute	output	report
Heineken	Heineken N. V. Annual Report 2018	contribution to carbon footprint of packaging materials	emissions	absolute	output	report
Heineken	Heineken N. V. Annual Report 2018	CO2 emissions reductions from 2008 baseline	emissions	benchmark	output	report
Heineken	Heineken N. V. Annual Report 2018	reduction in CO2 emissions from fridges from 2010 baseline	emissions	benchmark	output	report
Heineken	Heineken N. V. Annual Report 2018	carbon intensity	emissions	relative	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Heineken	Heineken N. V. Annual Report 2018	CO2 emissions in distribution	emissions	relative	output	report
Heineken	Heineken N. V. Annual Report 2018	CO2 emissions in production	emissions	relative	output	report
Heineken	Heineken N. V. Annual Report 2018	electrical energy from renewables	energy	absolute	input	report
Heineken	Heineken N. V. Annual Report 2018	thermal energy from renewables	energy	absolute	input	report
Heineken	Heineken N. V. Annual Report 2018	agricultural raw materials from sustainable sources	other	absolute	input	report
Heineken	Heineken N. V. Annual Report 2018	compliance with Supplier Code Procedure	other	absolute	input	report
Heineken	Heineken N. V. Annual Report 2018	sites in water-stressed areas (of 23) that have begun water balancing projects	water	absolute	input	report
Heineken	Heineken N. V. Annual Report 2018	total water withdrawal	water	absolute	input	report
Heineken	Heineken N. V. Annual Report 2018	sites without a wastewater treatment plant	water	absolute	output	report
Heineken	Heineken N. V. Annual Report 2018	total wastewater volume	water	absolute	output	report
Heineken	Heineken N. V. Annual Report 2018	waste water that is treated before being discharged into surface water	water	absolute	output	report
Heineken	Heineken N. V. Annual Report 2018	water consumption reduction from 2008 baseline	water	benchmark	input	report
Heineken	Heineken N. V. Annual Report 2018	water saved compared to 2017	water	equivalent	input	report
Heineken	Heineken N. V. Annual Report 2018	relative average water consumption	water	relative	input	report
Heineken	Heineken N. V. Annual Report 2018	relative average water consumption in water-stressed areas	water	relative	input	report
High Park Brewery	Back Story	percent of gross earnings donated to charitable and	general environment	absolute	output	website

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
		environmental causes				
Hopworks Urban Brewery	Environment	grain grown less than 300 miles away	emissions	absolute	input	website
Hopworks Urban Brewery	HUB Sustainability Report: 2014	carbon footprint	emissions	absolute	output	report
Hopworks Urban Brewery	HUB Sustainability Report: 2014	carbon footprint neutralized by purchased offsets	emissions	absolute	output	report
Hopworks Urban Brewery	Environment	miles saved from car and carbon impacts from staff commuting choices	emissions	absolute	output	website
Hopworks Urban Brewery	HUB Sustainability Report: 2014	net carbon footprint	emissions	absolute	output	report
Hopworks Urban Brewery	Environment	staff that commutes by bicycle, walking, public transportation, or carpool	emissions	absolute	output	website
Hopworks Urban Brewery	Environment	renewable energy purchased	energy	absolute	input	website
Hopworks Urban Brewery	About Us	pint sale proceeds donated to environmental non-profits	general environment	absolute	output	website
Hopworks Urban Brewery	HUB Sustainability Report: 2014	grain to cattle	packaging/waste	absolute	output	report
Hopworks Urban Brewery	Environment	waste (non spent grain) recycled or composted	packaging/waste	absolute	output	website
Hopworks Urban Brewery	Environment	waste (non spent grain) to landfill	packaging/waste	absolute	output	website
Hopworks Urban Brewery	HUB Sustainability Report: 2014	waste diverted to compost or recycling	packaging/waste	absolute	output	report
Hopworks Urban Brewery	HUB Sustainability Report: 2014	waste recycled	packaging/waste	absolute	output	report
Hopworks Urban Brewery	HUB Sustainability Report: 2014	waste to compost	packaging/waste	absolute	output	report
Hopworks Urban Brewery	HUB Sustainability Report: 2014	waste to landfill	packaging/waste	absolute	output	report
Hopworks Urban Brewery	HUB Sustainability Report: 2014	water offsets purchased	water	absolute	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Hopworks Urban Brewery	HUB Sustainability Report: 2014	water intensity	water	relative	input	report
Kirin Holdings Company	Environmental Report 2017	participants involved in water source forest preservation project	biodiversity/forest	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	projects for water source forest preservation project	biodiversity/forest	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	sites for water source forest preservation project	biodiversity/forest	absolute	output	report
Kirin Holdings Company	ESG Data	emissions of class 1 designated chemical substances under PRTR Act	emissions	absolute	output	website
Kirin Holdings Company	ESG Data	GHG emission intensity per unit of net sales	emissions	absolute	output	website
Kirin Holdings Company	ESG Data	GHG emissions	emissions	absolute	output	website
Kirin Holdings Company	Kirin Report 2018 + Environmental Report 2017	GHG emissions scope 1 and 2	emissions	absolute	output	report
Kirin Holdings Company	Kirin Report 2018 + Environmental Report 2017	GHG emissions scope 3	emissions	absolute	output	report
Kirin Holdings Company	ESG Data	NOx emissions	emissions	absolute	output	website
Kirin Holdings Company	Environmental Report 2017	scope 1 emissions	emissions	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	scope 2 emissions	emissions	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	scope 3 contributions from business travel	emissions	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	scope 3 contributions from downstream transportation and distribution	emissions	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	scope 3 contributions from employee commuting	emissions	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	scope 3 contributions from end-of-life treatment of sold products	emissions	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Kirin Holdings Company	Environmental Report 2017	scope 3 contributions from fuel and energy related activities not included in scope 1 or 2	emissions	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	scope 3 contributions from purchased goods and services	emissions	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	scope 3 contributions from upstream transportation and distribution	emissions	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	scope 3 contributions from use of sold products	emissions	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	scope 3 contributions from waste generated in operations	emissions	absolute	output	report
Kirin Holdings Company	ESG Data	SOx emissions	emissions	absolute	output	website
Kirin Holdings Company	ESG Data	VOC emissions	emissions	absolute	output	website
Kirin Holdings Company	ESG Data	energy use	energy	absolute	input	website
Kirin Holdings Company	ESG Data	number of companies reviewed in environmental audits	general environment	absolute	input	website
Kirin Holdings Company	ESG Data	number of participants in environmental training	general environment	absolute	input	website
Kirin Holdings Company	Environmental Report 2017	number of soil contamination investigations	general environment	absolute	output	report
Kirin Holdings Company	ESG Data	number of violations of environment-related laws and regulations	general environment	absolute	output	website
Kirin Holdings Company	ESG Data	use of resources for containers and packaging	packaging/waste	absolute	input	website
Kirin Holdings Company	Environmental Report 2017	disposed waste	packaging/waste	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	recycled waste	packaging/waste	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Kirin Holdings Company	Environmental Report 2017	recycling rate	packaging/waste	absolute	output	report
Kirin Holdings Company	ESG Data	waste generation	packaging/waste	absolute	output	website
Kirin Holdings Company	Environmental Report 2017	waste treated on site	packaging/waste	absolute	output	report
Kirin Holdings Company	Environmental Report 2017	weight of 350ml cans	packaging/waste	absolute	output	report
Kirin Holdings Company	ESG Data	freshwater consumption	water	absolute	input	website
Kirin Holdings Company	ESG Data	recycled water consumption at plants and offices	water	absolute	input	website
Kirin Holdings Company	ESG Data	reused water consumption at plants and offices	water	absolute	input	website
Kirin Holdings Company	ESG Data	drainage volume	water	absolute	output	website
Kirin Holdings Company	Environmental Report 2017	decrease in water intensity of Kirin Brewery from 1990	water	benchmark	input	report
Kirin Holdings Company	Environmental Report 2017	water intensity Japan	water	relative	input	report
Molson Coors	Our Beer Print Report 2018	trees and shrubs planted by volunteers	biodiversity/forest	absolute	output	report
Molson Coors	Our Beer Print Report 2018	trees planned to be planted over next 3 years	biodiversity/forest	absolute	output	report
Molson Coors	Our Beer Print Report 2018	GHG emission contributions from agriculture	emissions	absolute	output	report
Molson Coors	Our Beer Print Report 2018	GHG emission contributions from end of life	emissions	absolute	output	report
Molson Coors	Our Beer Print Report 2018	GHG emission contributions from logistics	emissions	absolute	output	report
Molson Coors	Our Beer Print Report 2018	GHG emission contributions from manufacturing	emissions	absolute	output	report
Molson Coors	Our Beer Print Report 2018	GHG emission contributions from other	emissions	absolute	output	report
Molson Coors	Our Beer Print Report 2018	GHG emission contributions from packaging materials	emissions	absolute	output	report
Molson Coors	Our Beer Print Report 2018	GHG emission contributions from processing brewing ingredients	emissions	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Molson Coors	Our Beer Print Report 2018	GHG emission contributions from product cooling	emissions	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	GHG emissions from scope 1	emissions	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	GHG emissions from scope 2	emissions	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	GHG emissions from scope 3	emissions	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	scope 1 emissions	emissions	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	scope 2 emissions (location-based)	emissions	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	scope 2 emissions (market-based)	emissions	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	scope 3 emissions	emissions	absolute	output	report
Molson Coors	Our Beer Print Report 2018	carbon emission reduction in operations from 2016	emissions	benchmark	output	report
Molson Coors	Our Beer Print Report 2018	carbon emission reduction in value chain from 2016	emissions	benchmark	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	energy use	energy	absolute	input	report
Molson Coors	Environmental, Social, and Governance Report 2018	renewable energy generated	energy	absolute	input	report
Molson Coors	Environmental, Social, and Governance Report 2018	total electricity purchased	energy	absolute	input	report
Molson Coors	Environmental, Social, and Governance Report 2018	decrease in energy intensity from 2016	energy	benchmark	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Molson Coors	Environmental, Social, and Governance Report 2018	energy intensity	energy	relative	input	report
Molson Coors	Environmental, Social, and Governance Report 2018	environmental releases	general environment	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	environmental violations	general environment	absolute	output	report
Molson Coors	Our Beer Print Report 2018	facilities with zero waste to landfill	packaging/waste	absolute	input	report
Molson Coors	Environmental, Social, and Governance Report 2018	percentage of waste to the landfill of total solid waste	packaging/waste	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	solid waste to energy	packaging/waste	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	solid waste to incineration	packaging/waste	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	total solid waste	packaging/waste	absolute	output	report
Molson Coors	Our Beer Print Report 2018	volunteers participated in a trash clean up	packaging/waste	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	waste recycled	packaging/waste	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	waste reused total	packaging/waste	absolute	output	report
Molson Coors	Environmental, Social, and Governance Report 2018	waste to compost and soil amendment	packaging/waste	absolute	output	report
Molson Coors	Our Beer Print Report 2018	waste to landfill	packaging/waste	absolute	output	report
Molson Coors	Our Beer Print Report 2018	total waste to landfill reduction from 2016	packaging/waste	benchmark	output	report
Molson Coors	Our Beer Print Report 2018	at-risk brewery watersheds with stewardship programs	water	absolute	input	report
Molson Coors	Environmental, Social, and	total water usage	water	absolute	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
	Governance Report 2018					
Molson Coors	Environmental, Social, and Governance Report 2018	water restored to source	water	absolute	input	report
Molson Coors	Our Beer Print Report 2018	water-use efficiency	water	relative	input	report
New Belgium Brewing	Business as a Force For Good	donations supporting bicycle advocacy	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from aluminum	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from barley	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from CO2 purchases	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from corporate flights	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from customer use	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from distribution	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from fiber packaging	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from flaring	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from fugitive	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from glass	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from malt	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from manufacturing waste	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from natural gas	emissions	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
New Belgium Brewing	Business as a Force For Good	GHG contributions from NBB vehicle fleet	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from purchased electricity	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG contributions from retail	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	scope 1 (direct emissions) contribution	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	scope 2 (indirect emissions) contribution	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	scope 3 (indirect emissions) contribution	emissions	absolute	output	report
New Belgium Brewing	Business as a Force For Good	GHG emission intensity (scope 1 and 2 only)	emissions	relative	output	report
New Belgium Brewing	Business as a Force For Good	renewable electricity produced on site	energy	absolute	input	report
New Belgium Brewing	Business as a Force For Good	energy intensity	energy	relative	input	report
New Belgium Brewing	Business as a Force For Good	donations supporting youth environmental education	general environment	absolute	output	report
New Belgium Brewing	Business as a Force For Good	Environment Impact Score	general environment	other	other	report
New Belgium Brewing	Business as a Force For Good	donations supporting sustainable agriculture	other	absolute	output	report
New Belgium Brewing	Business as a Force For Good	Overall B Impact Score	other	other	other	report
New Belgium Brewing	Business as a Force For Good	waste (by weight) that escaped final death in the landfill	packaging/waste	absolute	output	report
New Belgium Brewing	Business as a Force For Good	waste as recycling	packaging/waste	absolute	output	report
New Belgium Brewing	Business as a Force For Good	waste as spent grain	packaging/waste	absolute	output	report
New Belgium Brewing	Business as a Force For Good	waste composted	packaging/waste	absolute	output	report
New Belgium Brewing	Business as a Force For Good	waste reused	packaging/waste	absolute	output	report
New Belgium Brewing	Business as a Force For Good	waste to landfill	packaging/waste	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
New Belgium Brewing	Business as a Force For Good	relative landfill waste	packaging/waste	relative	output	report
New Belgium Brewing	Business as a Force For Good	donations supporting water stewardship	water	absolute	output	report
New Belgium Brewing	Business as a Force For Good	water intensity	water	relative	input	report
North Coast Brewing Co.	Annual Sustainability Report	charitable giving to marine mammal research & rescue	biodiversity/forest	absolute	output	report
North Coast Brewing Co.	Annual Sustainability Report	direct GHG footprint for all NCBC facilities	emissions	absolute	output	report
North Coast Brewing Co.	Solar Energy	GHG reduction since solar installation	emissions	absolute	output	website
North Coast Brewing Co.	Annual Sustainability Report	CO2 emission equivalent mitigated from solar power installment since June 2013	emissions	equivalent	output	report
North Coast Brewing Co.	Annual Sustainability Report	rooftop solar array production since June 2013	energy	absolute	input	report
North Coast Brewing Co.	Annual Sustainability Report	energy use per barrel of beer packaged	energy	relative	input	report
North Coast Brewing Co.	Annual Sustainability Report	Environment Impact Score	general environment	other	other	report
North Coast Brewing Co.	Annual Sustainability Report	taproom's expenditures for sustainably sourced goods	other	absolute	output	report
North Coast Brewing Co.	Annual Sustainability Report	Overall B Impact Score	other	other	other	report
North Coast Brewing Co.	Annual Sustainability Report	brewhouse raw materials shipped in bulk	packaging/waste	absolute	input	report
North Coast Brewing Co.	Annual Sustainability Report	solid waste diverted from landfill	packaging/waste	absolute	output	report
North Coast Brewing Co.	Annual Sustainability Report	water from the brewing process captured and re-used	water	absolute	output	report
North Coast Brewing Co.	Annual Sustainability Report	gallons of water used to make one gallon of packaged beer in 2017	water	relative	input	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Roadhouse Brewing	Sustainability at Roadhouse	installed rooftop solar energy system	energy	absolute	input	website
Stone and Wood Brewing Company	Green Feet Summary report	CO2 emissions as trees mitigated from solar power installment since 2015	emissions	equivalent	output	report
Stone and Wood Brewing Company	Green Feet Summary report	installed solar system production	energy	absolute	input	report
Stone and Wood Brewing Company	Green Feet Summary report	energy usage	energy	relative	input	report
Stone and Wood Brewing Company	Green Feet Summary report	solid waste recycled/diverted from landfill (including grain)	packaging/waste	absolute	output	report
Stone and Wood Brewing Company	Green Feet Summary report	water usage	water	relative	input	report
Stroud Brewery	Stroud Brewery Certified B Corporation	B Corp Score	other	other	other	website
Stroud Brewery	Stroud Brewery	weight of bottles	packaging/waste	absolute	output	website
Toast Ale	Brewing a Better Planet	land saved to date using bread instead of barley	biodiversity/forest	absolute	output	website
Toast Ale	Brewing a Better Planet	football pitches of land saved to date using bread instead of barley	biodiversity/forest	equivalent	output	website
Toast Ale	Brewing a Better Planet	CO2 saved from diverting bread from landfill to date	emissions	absolute	output	website
Toast Ale	Brewing a Better Planet	CO2 saved from the barley never grown to date	emissions	absolute	output	website
Toast Ale	Brewing a Better Planet	CO2 saved from using bread total to date	emissions	absolute	output	website
Toast Ale	Brewing a Better Planet	flights saved from using bread to date	emissions	equivalent	output	website
Toast Ale	Brewing a Better Planet	money donated to replenish the environment and feed people to date	general environment	absolute	output	website
Toast Ale	Brewing a Better Planet	slices of toast rescued to date	other	absolute	input	website

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Toast Ale	Brewing a Better Planet	breweries directly collaborated with to use surplus bread	other	absolute	output	website
Toast Ale	Impact Report 2016-2018	breweries inspired	other	absolute	output	report
Toast Ale	Brewing a Better Planet	breweries inspired (only) to use surplus bread	other	absolute	output	website
Toast Ale	Brewing a Better Planet	height of slices rescued todate	other	equivalent	other	website
Toast Ale	Brewing a Better Planet	water saved to date using bread instead of barley	water	absolute	input	website
Toast Ale	Brewing a Better Planet	pints of water saved to date using bread instead of barley	water	equivalent	input	website
Tsingtao Brewery Co.	Environmental, Social, and Governance Report 2016	increase in CO2 recovery per kl cold wort from 2015	emissions	benchmark	output	report
Tsingtao Brewery Co.	Environmental, Social, and Governance Report 2016	drop in coal consumption per unit product from 2015	energy	benchmark	input	report
Tsingtao Brewery Co.	Environmental, Social, and Governance Report 2016	drop in comprehensive energy consumption per unit product from 2015	energy	benchmark	input	report
Tsingtao Brewery Co.	Environmental, Social, and Governance Report 2016	events featuring environmental protection	general environment	absolute	output	report
Tsingtao Brewery Co.	Environmental, Social, and Governance Report 2016	growth in investment in the upgrading of environmental protection facilities from 2015	general environment	absolute	output	report
Tsingtao Brewery Co.	Environmental, Social, and Governance Report 2016	volunteers for environmental activities	general environment	absolute	output	report
Tsingtao Brewery Co.	Environmental, Social, and Governance Report 2016	recycle rate for usable waste	packaging/waste	absolute	output	report
Tsingtao Brewery Co.	Environmental, Social, and Governance Report 2016	effluent discharge standards met	water	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Tsingtao Brewery Co.	Environmental, Social, and Governance Report 2016	drop in water consumption per unit product from 2015	water	benchmark	input	report
Upslope Brewing Company	Sustainability 2017 Summary	boxes used that are certified and come from responsible managed forests	biodiversity/forest	absolute	input	report
Upslope Brewing Company	Our Story	cardboard for beer packaging that is certified by the SFI	biodiversity/forest	absolute	input	website
Upslope Brewing Company	Our Story	Upslope Craft Lager sales donated to local Trout Unlimited chapter	biodiversity/forest	absolute	output	website
Upslope Brewing Company	Sustainability 2017 Summary	emissions as carbon dioxide	emissions	absolute	output	report
Upslope Brewing Company	Sustainability 2017 Summary	emissions as nitrogen oxides	emissions	absolute	output	report
Upslope Brewing Company	Sustainability 2017 Summary	emissions as VOCs	emissions	absolute	output	report
Upslope Brewing Company	Sustainability 2017 Summary	monthly electricity usage average	energy	absolute	input	report
Upslope Brewing Company	Our Story	energy as gasoline saved per month from purchasing renewable energy certificates	energy	equivalent	input	website
Upslope Brewing Company	Our Story	energy as planted trees saved per month from purchasing renewable energy certificates	energy	equivalent	input	website
Upslope Brewing Company	Our Story	relative electricity usage	energy	relative	input	website
Upslope Brewing Company	Sustainability 2017 Summary	relative energy used	energy	relative	input	report
Upslope Brewing Company	Our Story	cardboard for beer packaging made from recycled materials	packaging/waste	absolute	input	website
Upslope Brewing Company	Sustainability 2017 Summary	plastic wrap recycled	packaging/waste	absolute	output	report

Company	Document(s)	Indicator	Category	Type	Input or Output	Source
Upslope Brewing Company	Our Story	solid waste by volume (not including spent grain) diverted through recycling and composting efforts	packaging/waste	absolute	output	website
Upslope Brewing Company	Our Story	spent grain distributed as livestock feed	packaging/waste	absolute	output	website
Upslope Brewing Company	Our Story	spent yeast distributed as livestock feed	packaging/waste	absolute	output	website
Upslope Brewing Company	Sustainability 2017 Summary	waste diverted from landfill	packaging/waste	absolute	output	report
Upslope Brewing Company	Sustainability 2017 Summary	water used that is discharged as wastewater	water	absolute	output	report
Upslope Brewing Company	Our Story	water to beer ratio	water	relative	input	website

Appendix D: Composite-Indicator Options

The min-max option considered for normalization is detailed below.

For this case, the meaning of the values was modified to relate the organization to the PQ limit on the upper end (i.e., score of 1), and the industry average as a middle case (i.e., score of 0.5). The low end (i.e., score of 0) would be calculated using the difference between the industry average and the PQ limit (Equation 7). In this case the range would be [0,1] with the industry average scoring 0.5 and a science-based limit (brewing company specific PQ) scoring 1. This allows the score to represent relativity to the industry average as well as the PQ limit.

Assuming the indicator value is positively associated with increased environmental damage and is higher that the PQ limit, Equation 7, below, can be used to determine the minimum variable value.

Equation 7: Calculating the value for the minimum variable value.

$$min_c\left(x_q^{t0}\right) = \left(industry\ average - \ max_c\left(x_q^{t0}\right)\right) \times 2 + industry\ average$$

Equation 8: Minimum-maximum calculation for each normalized variable (OECD, 2008b).

$$I_{qc}^{t} = \frac{x_{qc}^{t} - min_c(x_q^{t0})}{max_c\left(x_q^{t0}\right) - min_c(x_q^{t0})}$$

The score for Carlsberg in the waste category was calculated as follows:

First, the waste allocated to Carlsberg, the maximum variable value in this case, was calculated using Equation 4 and their annual production.

$$max_{Carlsberg}(x_{waste}^{2017}) = 0.00739 \times \frac{0.0979\ billion\ hl\ (company)}{1.95\ billion\ hl\ (industry)} \times \frac{0\ kg}{year} = \ 0\ kg/year$$

The variable value for Carlsberg was their reported indicator for waste to sanitary landfill[47].

$$x_{waste,Carlsberg}^{2017} = 68{,}600\ metric\ tons\ waste\ to\ landfill$$

[47]Waste to sanitary landfill, 2018 Sustainability Report (Carlsberg, 2018)

The 0.5 score represents the industry average and was calculated to match the production of Carlsberg using average waste production (lbs/bbl) from the Brewers Association[48].

$$average\ (min, max) = \frac{4.23\ lb}{bbl} \times \frac{tonne}{2200\ lb} \times \frac{bbl}{159\ L} \times \frac{100\ L}{hl} \times \frac{97.9\ million\ hl}{year}$$
$$= 118{,}386.8 \frac{tonnes}{year}$$

The 0 value was set as twice the value of the distance between 1 and 0.5 and calculated using Equation 7.

$$min_{Carlsberg}(x_{waste}^{2017}) = \frac{(118{,}386.8 - 0)tonnes}{year} \times 2 + 0\ tonnes = 236{,}773.6\ tonnes/year$$

The final waste score was calculated using Equation 8.

$$I_{waste,Carlsberg}^{2017} = \frac{(68{,}600 - 236{,}773.6)tonnes/year}{(0 - 236{,}773.6\ )tonnes/year} = 0.710$$

The carbon dioxide emissions variable for Carlsberg is normalized using min-max below.

$$max_{Carlsberg}\left(x_{CO_2 emissions}^{2017}\right) = \ -0.0271\ \frac{GtCO_2}{year}$$

$$min_c\left(x_q^{t0}\right) = \left(industry\ average -\ max_c\left(x_q^{t0}\right)\right) \times 2 + industry\ average$$

$$min_{Carlsberg}(x_{waste}^{2017}) = \left((0.00642)\frac{GtCO_2}{year} - (-0.0271)\frac{GtCO_2}{year}\right) \times 2 + -0.02708\ \frac{GtCO_2}{year}$$
$$= 0.0399 \frac{GtCO_2}{year}$$

$$x_{CO_2,Carlsberg}^{2017} = 0.000802 \frac{GtCO_2}{year}$$

$$I_{qc}^{t} = \frac{x_{qc}^{t} - min_c(x_q^{t0})}{max_c\left(x_q^{t0}\right) - min_c(x_q^{t0})}$$

[48]Median waste generated, 2017 Brewers Association Benchmarking Report (Brewers Association, 2017)

$$I_{qc}^{t} = \frac{0.000802 - 0.0399}{-0.02708 - 0.0399} = 0.584$$

The score is lower than 1, therefore the threshold has been surpassed.

As part of the composite-indicator framework development, several options were considered for the various steps. The options for weighting and aggregation are discussed below and are based on *Handbook on constructing composite indicators: Methodology and user guide* (OECD, 2008b).

Potential methods for weighting:

- Equal weighting where all variables are given the same weight, thus associating the same "value" to their contribution to the composite-indicator.
- Principle component analysis/factor analysis (PCA/FA) which relies on a statistical model which groups variables based on their degree of correlation and transforms them into a new set of non-correlated variables.
- Budget allocation process (BAP): This method uses a "budget" of points that are then allocated to each variable based on the chosen effect on the composite-indicator. This is generally used when consulting professionals wherein they are given the task of allocating points to each variable based on their knowledge on the topic.
- Benefit of the Doubt (BOD): a statistical method that allows the data to decide the weighting. In this case, the composite-indicator is defined as the ratio of a member's actual performance to its benchmark performance.

Potential methods for aggregation:

- Linear: all variables are added up to produce the final score or value of the composite-indicator. A high degree of compensability can occur (a high score can easily make up for a low score, thus reducing the transparency of the final composite-indicator). Can be used with all weighting methods.
- Geometric: The variables to the power of their individual weightings are multiplied to produce the composite-indicator value. Still allows for compensability, but to a lesser

extent than linear aggregation. Can be used in combination with EW, BAP, and PCA/FA weighting methods.

- Non-compensatory multi-criteria approach: Does not reward outliers and only retains ordinal information. Can be used in combination with EW, BAP, and PCA/FA weighting methods.

Appendix E: Composite-Indicator Calculations and Reference Values

Reference Values

Table 6: Input values for PQ normalization calculations.

Variable	**Value**
PQ for Carbon Dioxide	-73 Gt CO_2/year[1]
PQ for Me-NO	5.4 Gt CO_2e/year[1]
PQ for Biodiversity	1E-4 PDF/year
PQ for Nitrogen	62 Tg N/year[1]
PQ for Phosphorus	11 Tg P/year[1]
PQ for Stratospheric Ozone Depletion	0 ODP kg/year[1]
PQ for Fresh Water Use	8500 km^3/year[1]
PQ for Forestland	-11 Mha/year[1]
PQ for Imperishable Waste	0 kg/year[1]
PQ for Aerosol Emissions	0.04 – 0.1 AODe[1]
Global GDP 2017	80,262.15 trillion USD[2]
Global Value of Brewing Industry 2017	593.02 trillion USD[3]
Brewing Industry Production 2017	1.95 billion hL[4]
Carlsberg Production 2017	0.0979 billion hL[5]
Malted barley/beer	1 metric tons/54 bbl[6]
Malted barley/barley (12% moisture)	0.83 ton/ton[6]
Moisture of harvested barley	15%[6]
$Yield_A$	5603 kg barley/ha[7]
N leaching $rate_A$	44 kg N/ha[7]
P leaching $rate_A$	0.27 kg/ha[7]
$Yield_B$	4239 kg barley/acre[7]
N leaching $rate_B$	6 kg/ha[7]
P leaching $rate_B$	0.81 kg/ha[7]

Variable	Value
$Yield_C$	61.2 bushels/acre[8]
N $applied_C$	55 lbs/acre[9]
N lost to $environment_C$	67%[10]
P leaching $rate_C$	0.02 kg/ha[11]
$Yield_D$	61.2 bushels/acre[8]
N $applied_D$	90 lbs/acre[9]
N lost to $environment_D$	67%[10]
N leaching $rate_D$	0.26 kg/ha[11]

[1]Meyer & Newman (2018), [2]Plecher (2019), [3]AMR (2020),[4]Conway (2019), [5]Carlsberg (2018), [6]MAGB (2011), [7]Tidaker et al. (2016), [8]OMAFRA (2018), [9]Government of Manitoba (n.d.), [10]Raun & Johnson (1999), [11]Yläranta et al. (1996)

Calculating Relative PQs

$$relative\ PQ\ limit = \frac{PQ\ limit \times \frac{global\ value\ of\ brewing\ industry}{global\ GDP}}{global\ beer\ production}$$

$$carbon\ dioxide\ PQ\ limit = \frac{\frac{-73\ GtCO_2}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL} = \frac{-276.6\ kg\ CO_2}{hL \cdot year}$$

$$MeNO\ PQ\ limit = \frac{\frac{5.4\ GtCO_2e}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL} = \frac{20.46\ kg\ CO_2e}{hL \cdot year}$$

$$biodiversity\ PQ\ limit = \frac{\frac{1^{-4}\ species\ lost}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL} = \frac{3.789 \times 10^{-16}\ PDF}{hL \cdot year}$$

$$nitrogen\ PQ\ limit = \frac{\frac{62\ Tg\ N}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL} = \frac{0.2349\ kg\ N}{hL \cdot year}$$

$$phosphorus\ PQ\ limit = \frac{\frac{11\ Tg\ P}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL} = \frac{0.04168\ kg\ P}{hL \cdot year}$$

$$stratospheric\ ozone\ depletion\ PQ\ limit = \frac{\frac{0\ ODP\ kg}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL}$$

$$= \frac{0\ ODPkg}{hL \cdot year}$$

$$water\ use\ PQ\ limit = \frac{\frac{8500\ km^3}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL} = \frac{322\ hL\ water}{hL \cdot year}$$

$$forestland\ PQ\ limit = \frac{\frac{-11\ Mha}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL} = \frac{-0.4168\ m^2}{hL \cdot year}$$

$$aerosol\ emissions\ upper\ PQ\ limit = \frac{\frac{0.1 AODe}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL}$$

$$= 3.79 \times 10^{-13} \frac{AODe}{hL \cdot year}$$

$$aerosol\ emissions\ lower\ PQ\ limit = \frac{\frac{0.04\ AODe}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL}$$

$$= 1.515 \times 10^{-13} \frac{AODe}{hL \cdot year}$$

$$waste\ PQ\ limit = \frac{\frac{0\ kg}{year} \times \frac{593.02\ trillion\ USD}{80{,}262.15\ trillion\ USD}}{1.95\ billion\ hL} = 0 \frac{kg}{hL \cdot year}$$

Calculations for Active Nitrogen Release

Equation 9: Barley required to be harvested per year for a given beer production.

$$harvested\ barley = \frac{\frac{volume\ beer}{year} \times \frac{malted\ barley}{volume\ beer}}{\frac{malted\ barley}{barley\ (12\%\ moisture)}} \times \frac{harvested\ barley}{barley\ (12\% moisture)}$$

$$= \frac{\frac{1\ hL}{year} \times \frac{0.83864\ bbl}{hL} \times \frac{0.0185\ metric\ tons\ malted\ barley}{bbl}}{\frac{0.83\ tons\ malted\ barley}{1\ ton\ barley\ (12\%\ moisture)}} \times \frac{0.88\ tons\ harvested\ barley}{0.85\ tons\ barley\ (12\%\ moisture)}$$

$$= 0.01937\ metric\ tons\ harvested\ barley/year$$

Scenario A

Equation 10: Calculating leached active nitrogen from Tidaker et al. (2016) data.

$$N\ leached = \frac{harvested\ barley\ required}{yield} \times N\ leaching\ rate$$

$$N\ leached = \frac{(0.01937\ metric\ tons\ barley/year) \times \frac{1000kg}{ton}}{\frac{5603\ kg\ barley}{ha}} \times \frac{44\ kg\ N}{ha} = \frac{0.152\ kg\ N}{year}$$

Scenario B

Equation 10,

$$N\ leached = \frac{(0.01937\ metric\ tons\ barley/year) \times \frac{1000kg}{ton}}{\frac{4239\ kg\ barley}{ha}} \times \frac{6\ kg\ N}{ha} = \frac{0.027\ kg\ N}{year}$$

Scenario C

Equation 11: Calculating leached active nitrogen using literature values for yield, nitrogen application and nitrogen retention.

$$N\ leached = \frac{harvested\ barley\ required}{yield} \times N\ applied \times N\ lost\ to\ environment$$

$$N\ leached = \frac{\left(0.01937\ \frac{metric\ tons\ barley}{year}\right)}{\frac{61.2\ bushels\ barley}{acre} \times \frac{metric\ ton}{45.93\ bushels\ barley}} \times \frac{55\ lbs\ N}{acre} \times \frac{kg}{2.2lbs} \times 0.67$$
$$= \frac{0.243\ kg\ N}{year}$$

Scenario D

Using Equation 11,

$$N\ leached = \frac{\left(0.01937\ \frac{metric\ tons\ barley}{year}\right)}{\frac{61.2\ bushels\ barley}{acre} \times \frac{metric\ ton}{45.93\ bushels\ barley}} \times \frac{90\ lbs\ N}{acre} \times \frac{kg}{2.2lbs} \times 0.67$$

$$= \frac{0.398\ kg\ N}{year}$$

Calculations for Phosphorus Release

Using the same harvested barley requirements as the nitrogen calculations for 1 hL/year production,

$$harvested\ barley = \frac{0.01937\ metric\ tons\ harvested\ barley}{year}$$

Scenario A

Equation 12: Calculating phosphorous to the environment using literature values for yield and phosphorous leaching rates.

$$P\ to\ environment = \frac{harvested\ barley}{yield} \times P\ leaching\ rate$$

$$\frac{\frac{0.01937\ metric\ tons}{year} \times \frac{1000\ kg}{ton}}{\frac{5603\ kg}{ha}} \times \frac{0.27\ kg\ P}{ha} = \frac{9.33 \times 10^{-4} kg\ P}{year} = P\ to\ environment$$

Scenario B

Using Equation 12,

$$\frac{\frac{0.01937\ metric\ tons}{year} \times \frac{1000\ kg}{ton}}{\frac{4239\ kg}{ha}} \times \frac{0.81\ kg\ P}{ha} = \frac{3.70 \times 10^{-3} kg\ P}{year} = P\ to\ environment$$

Scenario C

Using Equation 12,

$$\frac{\frac{0.01937\ metric\ tons}{year}}{\frac{61.2\ bushels\ barley}{acre} \times \frac{metric\ ton}{45.93\ bushels\ barley} \times \frac{2.471\ acres}{ha}} \times \frac{0.02\ kg\ P}{ha}$$

$$= \frac{1.18 \times 10^{-4} kg\ P}{year} = P\ to\ environment$$

Scenario D

Using Equation 12,

$$\frac{\frac{0.01937\ metric\ tons}{year}}{\frac{61.2\ bushels\ barley}{acre} \times \frac{metric\ ton}{45.93\ bushels\ barley} \times \frac{2.471\ acres}{ha}} \times \frac{0.26\ kg\ P}{ha}$$

$$= \frac{1.53 \times 10^{-3} kg\ P}{year} = P\ to\ environment$$

References

Abrahamson, E., & Baumard, P. (2008). What lies behind organizational façades and how organizational façades lie: An untold story of organizational decision making. In G. Gerard, P. Hodgkinson, & W. H. Starbuck (Eds.), *The Oxford Handbook of Organizational Decision Making* (pp. 437– 452). Oxford: Oxford University Press.

Adams, C.A. (2004) The ethical, social and environmental reporting-performance portrayal gap. Accounting, Auditing & Accountability Journal. 17(5):731-757. DOI:10.1108/09513570410567791

Allan, J.A. (1996). Policy responses to the closure of water resources. In Water Policy: Allocation and Management in Practice, ed. P. Howsam and R. Carter. London: Chapman and Hall.

Alliance for Water Stewardship. (2014). The AWS International Water Stewardship Standard. Retrieved from https://a4ws.org/wp-content/uploads/2017/04/AWS-Standard-Full-v-1.0-English.pdf

Amienyo, D. & Azapagic, A. (2016). Life cycle environmental impacts and costs of beer production and consumption in the UK. International Journal of Life Cycle Assessment. 21:492-509. DOI:10.1007/s11367-016-1028-6.

AMR. (2020). Beer market expected to reach $685,354 million, globally, by 2025. Allied Market Research. Retrieved from https://www.alliedmarketresearch.com/press-release/beer-market-is-expected-to-reach-6884-billion-globally-by-2020-allied-market-research.html

Andrikopoulos, A. & Kriklani, N. (2013). Environmental disclosure and financial characteristics of the firm: The case of Denmark. Corporate Social Responsibility and Environmental Management. 20(1):55-64. DOI:10.1002/csr.1281

Arevalo, J.A. & Aravind, D. (2011). Corporate social responsibility practices in India: approach, drivers, and barriers. Corporate Governance. 11(4):399-414. DOI:10.1108/14720701111159244

AWS. (2017). Members. Alliance for Water Stewardship. Retrieved from https://a4ws.org/membership/members/

B Corporation. (2019. Certified B Corporation. Retrieved from https://bcorporation.net/

B Lab. (2019). Certification. Retrieved from https://bcorporation.net/certification

Bansal, P. & Hoffman, A.J. (2012). The Oxford handbook of business and the natural environment. Oxford, New York.

Bansal, P. & Roth, K. (2000). Why companies go green: A model of ecological responsiveness. The Academy of Management Journal. 43(4):717-736. DOI:10.2307/1556363

Bansal, P. & Song, H. (2017). Similar but not the same: Differentiating corporate sustainability from corporate responsibility. Academy of Management Annals. 11(1):105-149. DOI:10.5465/annals.2015.0095

Beermann, M. (2011). Linking corporate climate adaptation strategies with resilience thinking. Journal of Cleaner Production. 19(8):836-842. DOI:10.1016/j.jclepro.2010.10.017

Berkhout, B., Bertling, L., Bleeker, Y., de Wit, W., Kruis, G., Stokkel, R. & Theuws, R. (2013). The contribution made by beer to the European economy. The Brewers of Europe, Regioplan Policy Research and EY. Retrieved from https://www.ey.com/Publication/vwLUAssets/EY_-_The_Contribution_made_by_Beer_to_the_European_Economy/$FILE/EY-The-Contribution-made-by-Beer-to-the-European-Economy.pdf

BIER. (2019). 2018 Benchmarking Study Trends & Observations. Beverage Industry Environmental Roundtable. Retrieved from https://www.bieroundtable.com/publication/2018-water-and-energy-use-benchmarking-study/

BIER. (2018). Members. Beverage Industry Environmental Roundtable. Retrieved from https://www.bieroundtable.com/members

Bjørn, A., Richardson, K. & Hauschild, M.Z. (2019). A framework for development and communication of absolute environmental sustainability assessment methods. Journal of Industrial Ecology. 23(4):828-854. DOI:10.1111/jiec.12820

Bjørn, A. & Røpke, I. (2018). What does it really mean to be a strongly sustainable company? – A response to Nikolaou and Tsalis. Journal of Cleaner Production. 198:208-214. DOI:10.1016/j.jclepro.2018.06.268

Bjørn, A., Bey, N., Georg, S., Røpke, I. & Hauschild, M.Z. (2017). Is Earth recognized as a finite system in corporate responsibility reporting?. Journal of Cleaner Production. 163:106-117. DOI:10.1016/j.jclepro.2015.12.095

Boerner, H. & Coppola, L. (2017). Musing about the alphabet soup of ESG – SRI – CSR … et al!. Governance & Accountability Institute. Retrieved from https://ga-institute.com/Sustainability-Update/2017/03/20/musing-about-the-alphabet-soup-of-esg-sri-csr-et-al/

Bondy, K. (2009) Isomorphism in the practice of corporate social responsibility: Evidence of an institution and its decline. University of Bath School of Management Working Paper Series. Retrieved from https://www.bath.ac.uk/management/research/pdf/2009-10.pdf

Brewers Association. (2019). Brewers Association releases 2018 Economic Impact Report. Retrieved from https://www.brewersassociation.org/press-releases/brewers-association-releases-2018-economic-impact-report/

Brewers Association. (2017). 2017 Sustainability Benchmarking Report. Brewers Association. Retrieved from https://s3-us-west-2.amazonaws.com/brewersassoc/wp-content/uploads/2019/01/2017-Sustainability-Benchmarking-Report.pdf

Burgass, M.J., Halpern, B.S., Nicholson, E. & Milner-Gulland, E.J. (2017). Navigating uncertainty in environmental composite indicators. Ecological Indicators. 75:268-278 DOI:10.1016/j.ecolind.2016.12.034

Butz, C., Liechti, J., Bodin, J. & Cornell, S.E. (2018). Towards defining an environmental investment universe within planetary boundaries. Sustainability Science. 13:1031-1044. DOI:10.1007/s11625-018-0574-1

Cao, Y., Feng, M. & Wang, X. (2016). Corporate social responsibility reporting: a descriptive study across industries. Journal of Applied Business and Economics. 18(7):11-22.

CEO Water Mandate. (2019). Setting Site Water Targets Informed by Catchment Context: A Guide for Companies. UN Global Compact CEO Water Mandate, Pacific Institute, CDP, The Nature Conservancy, World Resources Institute, WWF, UNEPDHI Partnership Centre for Water and Environment. Retrieved from https://ceowatermandate.org/watertargets/wp-content/uploads/sites/30/2019/08/CEOWaterMandateSiteWaterTargetsGuide.pdf

Chandrakumar, C. & McLaren, S.J. (2018). Towards a comprehensive absolute sustainability assessment method for effective Earth system governance: Defining key environmental indicators using an enhanced-DPSIR framework. Ecological Indicators. 90:577-583. DOI:10.1016/j.ecolind.2018.03.063

Chapagain, A.K., Hoekstra, A.Y., Savenije, H.H.G. & Gautam, R. (2006). The water footprint of cotton consumption: An assessment of the impact of worldwide consumption of cotton products on the water resources in the cotton producing countries. Ecological Economics. 186-203. DOI:10.1016/j.ecolecon.2005.11.027

Chapagain, A.K. & Hoekstra, A.Y. (2011). The blue, green and grey water footprint of rice from production and consumption perspectives. Ecological Economics. 70:749-758. DOI:10.1016/j.ecolecon.2010.11.012

Cherian, J. & Jacob, J. (2012). Green marketing: A study of consumers' attitude towards environment friendly products. Asian Social Science. 8(12):117-126. DOI:10.5539/ass.v8n12p117

Cho, C.H., Laine, M., Roberts, R.W., & Rodrigue, M. (2015). Organized hypocrisy, organizational façades, and sustainability reporting. Accounting, Organizations and Society. 40:78-94.

Cimini, A. & Moresi, M. (2016). Carbon footprint of a pale lager packed in different formats: Assessment and sensitivity analysis based on transparent data. Journal of Cleaner Production. 112:4196-4213.

CISL. (2019). Linking planetary boundaries to business. Cambridge Institute for Sustainability Leadership. Retrieved from https://www.cisl.cam.ac.uk/resources/publication-pdfs/linking-planetary-boundaries.pdf

Conway, J. (2019). Global beer production 1998-2018. Statista. Retrieved from https://www.statista.com/statistics/270275/worldwide-beer-production/

Cordella, M., Tugnoli, A., Spadoni, G., Santarelli, F. & Zangrando, T. (2008). LCA of an Italian lager beer. International Journal of Life Cycle Assessment. 13(2):133-139. DOI:10.1065/lca2007.02.306

Cronin, J.J., Smith, J.S., Gleim, M.R., Ramirez, E. & Martinez, J.D. (2011). Green marketing strategies: An examination of stakeholders and the opportunities they present. Journal of the Academy of Marketing Science. 39(1):158-174. DOI:10.1007/s11747-010-1227-0

Cruzten, P.J. & Stoermer, E.F. (2000). The “Anthropocene”. Global Change Newsletter. 14:17-18.

Daly, H.E. (1992). Allocation, distribution, and scale: Towards an economics that is efficient, just, and sustainable. 6(3):185-193.

Danish Business Authority. (2013). Corporate social responsibility and reporting in Denmark: impact of the third year subject to the legal requirements for reporting CSR in the Danish financial system. Retrieved from https://samfundsansvar.dk/sites/default/files/csr_rapport_2013_eng.pdf

DanWatch. (2011). The impact of the Danish law on CSR reporting. European Coalition on Corporate Justice. Retrieved from https://germanwatch.org/de/download/10649.pdf

Daub, C.-H. (2007). Assessing the quality of sustainability reporting: An alternative methodological approach. Journal of Cleaner Production. 15:75-85. DOI:10.1016/j.clepro.2005.08.013

Davidson, K.M. (2011). Reporting systems for sustainability: What are they measuring?. Social Indicators Research. 100(2):351-365. DOI:10.1007/s11205-010-9634-3

Davis, S.J, Burney, J.A., Pongratz, J. & Caldeira, K. (2014). Methods for attributing land-use emissions to products. Carbon Management. 5(2):233-245.

Dearing, J.A., Wang, R., Zhang, K., Dyke, J.G., Haberl, H., Hossain, M.S., Langdon, P.G., Lenton, T.M., Raworth, K., Brown, S., Carstensen, J., Cole, M.J., Cornell, S.E., Dawson, T.P., Doncaster, C.P., Eigenbrod, F., Flörke, M., Jeffers, E., Mackay, A.W., Nykvist, B. & Poppy, G.M. (2014). Safe and just operating spaces for regional social-ecological systems. Global Environmental Change. 28: 227-238. DOI: 10.1016/j.gloenvcha.2014.06.012

de Villiers, C. & Alexander, D. (2014). The institutionalization of corporate social responsibility reporting. The British Accounting Review. DOI:10.1016/j.bar.2014.03.001

DiMaggio, P., & Powell, W. W. (1983). The iron cage revisited: Collective rationality and institutional isomorphism in organizational fields. American Sociological Review. 48(2):147-160.

Doney, S.C., Fabry, V.J., Feely, A., Kleypas, J.A. (2009). Ocean acidification: The other CO_2 problem. Annual Review of Marine Science. 1:169-192. DOI:10.1146/annurev.marine.010908.163834

Edvardsson, K. (2007). Setting rational environmental goals: Five Swedish environmental quality objectives. Journal of Environmental Planning and Management. 50(2):297-316. DOI:10.1080/09640560601156540

Ervin, D., Wu, J., Khanna, M., Jones, C. & Wirkkala, T. (2012). Motivations and barriers to corporate environmental management. Business Strategy and the Environment. 22(6):390-409. DOI:10.1002/bse.1752

European Commission. (2020) Non-financial reporting. Retrieved from https://ec.europa.eu/info/business-economy-euro/company-reporting-and-auditing/company-reporting/non-financial-reporting_en#review

Ekins, P., Simon, S., Deutsch, L., Folke, C., De Groot, R. (2003). A framework for the practical application of the concepts of critical natural capital and strong sustainability. Ecological Economics. 44:165-185.

Garz, H., Schnella, F. & Frank, R. (2010). KPIs for ESG 3.0. DVFA Society for Investment Professionals in Germany. Retrieved from https://www.effas-esg.com/wp-content/uploads/2011/07/KPIs_for_ESG_3_0_Final.pdf

Global Reporting. (2016). Carrots & sticks: Global trends in sustainability reporting regulations and policy. KPMG International, GRI, United Nations Environment Programme & Centre for Corporate Governance in Africa. Retrieved from https://www.globalreporting.org/resourcelibrary/Carrots%20and%20Sticks-2016.pdf

Global Reporting Initiative. (2018). About GRI. Retrieved from https://www.globalreporting.org/information/about-gri/Pages/default.aspx

Global Reporting Initiative. (2016). GRI 101: Foundation 2016. Retrieved from https://www.globalreporting.org/standards/media/1036/gri-101-foundation-2016.pdf

Global Reporting Initiative. (2013). Sustainability Context. Retrieved from https://g4.globalreporting.org/how-you-should-report/reporting-principles/principles-for-defining-report-content/sustainability-context/Pages/default.aspx

Global Reporting Initiative. (n.d.). An Introduction to G4. https://www.globalreporting.org/resourcelibrary/GRI-An-introduction-to-G4.pdf

Government of Manitoba. (n.d.). Agriculture: Barley production and management. Retrieved from https://www.gov.mb.ca/agriculture/crops/production/print,barley.html

Gunderson, L.H. (2000). Ecological resilience – in theory and application. Annual Review on Ecology and Systematics. 31:425-439.

Haffar, M. & Searcy, C. (2018a). Target-setting for ecological resilience: Are companies setting environmental sustainability targets in line with planetary thresholds?. Business Strategy and the Environment. 27(7):1079-1092. DOI:10.1002/bse.2053

Haffar, M. & Searcy, C. (2018b). The use of context-based environmental indicators in corporate reporting. Journal of Cleaner Production. 192:496-513. DOI:10.1016/j.jclepro.2018.04.202

Hermus, G. (2018). Brewing up benefits: The economic footprint of Canada's beer economy – January 2018. Ottawa. The Conference Board of Canada. Retrieved from https://www.conferenceboard.ca/e-library/abstract.aspx?did=9329&AspxAutoDetectCookieSupport=1

Herold, D., Manwa, F., Sen, S., Wilde, S. (2017). It's the yeast we can do: Untapping sustainability trends in Australian craft breweries. Journal of Asia Entrepreneurship and Sustainability. 13(3):59-73.

Herzig, C. & Schaltegger, S. (2016). Corporate sustainability reporting: An overview. In: Schaltegger, S., Bennet, M. & Burritt, R.L. (Eds.). Sustainability Accounting and Reporting. Springer, Dordrecht. 301-324.

HM Government. (2019). Environmental reporting guidelines: Including streamlined energy and carbon reporting guidance. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/791529/Env-reporting-guidance_inc_SECR_31March.pdf

Hoegh-Guldberg, O. (2011). The impact of climate change on coral reef ecosystems: 391-403, In: Dubinsky, Z. & Stambler, N. Coral reefs: An ecosystem in transition. Springer.

Jones, P., Hillier, D. & Comfort, D. (2013). The leading spirits and beer companies and corporate social responsibility. Corporate Governance: The International Journal of Business in Society. 13(3): 249-260. DOI:10.1108/CG-03-2011-0023

Kasem, E., Trenz, O., Hrebicek, J. & Faldik, O. (2015). Key sustainability performance indicator analysis for Czech breweries. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis. 63(209):1937-1944. DOI:10.11118/actaun201563061937

Kleindorfer, P.R., Singhal, K. & van Wassenhove, L.N. (2005). Sustainable operations management. Production and Operations Management. 14(4):482-492. DOI:10.1111/j.1937-5956.2005.tb00235.x

Krabbe, O., Linthorst, G., Blok, K., Crijns-Graus, W., van Vuuren, D.P., Höhne, N., Faria, P., Aden, N. & Pineda, A.C. (2015). Aligning corporate greenhouse-gas emissions targets with climate goals. Nature Climate Change. 5:1057-1060. DOI:10.1038/nclimate2770

Krippendorff, K. (2004). Content analysis: An introduction to its methodology – 2nd ed. Sage Publications.

Li, T., Wang, Y., Roskilly, A.P. (2016). Measuring sustainability: Life cycle approach to regional sustainability assessment on electricity options. 2016 International Conference for Students on Applied Engineering (ICSAE). DOI:10.1109/ICSAE.2016.7810206

Li, T., Zhang, H., Yuan, C., Liu, Z. & Fan, C. (2012). A PCA-based method for construction of composite sustainability indicators. Journal of Life Cycle Assessment. 17:593-603. DOI:10.1007/s11367-012-0394-y

Lindenmayer, D., Cunningham, S. & Young, A. (2012). Land use intensification: effects on agriculture, biodiversity and ecological processes. CRC Press.

MAGB. (2011). Malt Facts. The Maltster's Association of Great Britain. Retrieved from http://www.ukmalt.com/malt-facts

Manuel, J. (2014). Nutrient pollution: A persistent threat to waterways. Environmental Health Perspectives. 122(11):A304-A309. DOI:10.1289/eph.122-A304

Mattila, T., Helin, T. & Antikainen, R. (2012). Land use indicators in life cycle assessment: A case study on beer production. International Journal of Life Cycle Assessment. 17:277-286.

Mavrommati, G., Bithas, K., Borsuk, M.E. & Howarth, R.B. (2016). Integration of ecological thresholds in conservation decision making. Conservation Biology. 30(6):1173-1181. DOI:10.1111/cobi.12745

McElroy, M.W. & Thomas, M.P. (2015). The multicapital scorecard. Sustainability Accounting, Management and Policy Journal. 6(3): 425-438. DOI:10.1108/SAMPJ-04-2015-0025

McElroy, M.W. & van Engelen, J.M.L. (2012). Corporate sustainability management. Earthscan.

McElroy, M.W. (2015). Science- vs. context-based metrics – what's the difference?. Retrieved from https://www.sustainablebrands.com/news_and_views/new_metrics/mark_mcelroy/science-_vs_context-based_metrics_%E2%80%93_what%E2%80%99s_difference

McKinnon, A.C. & Pieck, M.I. (2012). Setting targets for reducing carbon emissions from logistics: Current practice and guiding principles. Carbon Management. 3(6): 629-639.

Mebratu, D. (1998). Sustainability and sustainable development: Historical and conceptual review. Environmental Impact Assessment Review. 18(6): 493-520.

Mekonnen, M.M. & Hoekstra, A.Y. (2011). The green, blue and grey water footprint of crops and derived crop products. Hydrology and Earth System Sciences. 15(5): 1577-1600. DOI:10.5194/hess-15-1577-2011

Mekonnen, M.M. & Hoekstra, A.Y. (2010). The green, blue and grey water footprint of crops and derived crop products. Value of Water Research Report Series No. 47. UNESCO-IHE. Delft, the Netherlands.

Meuer, J., Koelbel, J. & Hoffman, V.H. (2019). On the nature of corporate sustainability. Organization & Environment. 00(0):1-23. DOI:10.1177/1086026619850180

Meyer, J.W. & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. American Journal of Sociology. 83(2): 340-363.

Meyer, K. & Newman, P. (2018). The Planetary Accounting Framework: a novel, quote-based approach to understanding the impacts of any scale of human activity in the context of the Planetary Boundaries. Sustainable Earth. 1(4):1-21. DOI:10.1186/s42055-018-0004-3

Milne, M.J. & Gray, R. (2013). W(h)ither ecology? The triple bottom line, the global reporting initiative, and corporate sustainability reporting. Journal of Business Ethics. 118:13-29. DOI: 10.1007/s10551-012-1543-8

Montiel, I. (2008). Corporate social responsibility and corporate sustainability: Separate pasts, common futures. Organization and Environment. 21(3):245-269. DOI:10.1177/1086026608321329

Ness, B. (2018). Beyond the pale (ale): An exploration of the sustainability priorities and innovative measures in the craft beer sector. Sustainability. 10(11):4108. DOI:10.3390/su10114108

Olajire, A.A. (2012). The brewing industry and environmental challenges. Journal of Cleaner Production. 1-21. DOI:10.1016/j.jclepro.2012.03.003

OECD. (2008a). Key environmental indicators. Organisation for Economic Co-Operation and Development. Retrieved from https://www.oecd.org/env/indicators-modelling-outlooks/37551205.pdf

OECD. (2008b). Handbook on constructing composite indicators: Methodology and user guide. Organisation for Economic Co-Operation and Development. Retrieved from https://www.oecd.org/sdd/42495745.pdf

OMAFRA. (2018). Area, yield, production and farm value of specific field crops, Ontario, 2012-2017 (imperial and metric units). Ontario Ministry of Agriculture, Food and Rural Affairs. Retrieved from http://www.omafra.gov.on.ca/english/stats/crops/estimate_new.htm

Pelenc, J., Ballet, J. & Dedeurwaerdere, T. (2015). Weak sustainability versus strong sustainability. Brief for GSDR 2015. Retrieved from https://sustainabledevelopment.un.org/content/documents/6569122-Pelenc-Weak%20Sustainability%20versus%20Strong%20Sustainability.pdf

Pittock, J., Hansen, L.J., Abell, R. (2008). Running dry: Freshwater biodiversity, protected areas and climate change. Biodiversity. 9(3-4):30-38.

Plecher, H. (2019). Global gross domestic product (GDP) 2024. Statista. Retrieved from https://www.statista.com/statistics/268750/global-gross-domestic-product-gdp/

Quaak, L., Aalbers, T. & Goedee, J. (2007). Transparency of corporate social responsibility in Dutch breweries. Journal of Business Ethics. 76: 293-308. DOI:10.1007/s10551-006-9282-3

Randers, J. (2012). Greenhouse gas emissions per unit of value added ("GEVA") – A corporate guide to voluntary climate action. Energy Policy. 48:46-55. DOI:10.1016/j.enpol.2012.04.041

Rangan, K., Chase, L. & Karim, S. (2012). Why every company needs a CSR strategy and how to build it. Harvard Business School. Retrieved from http://www.hbs.edu/faculty/Publication%20Files/12-088.pdf

Raun, W.R. & Johnson, G.V. (1999). Improving nitrogen use efficiency for cereal production. Agronomy Journal. 91(3):357-363. DOI:10.2134/agronj1999.00021962009100030001x

Rees, W.E. (1996). Revisiting carrying capacity: Area-based indicators of sustainability. Population and Environment. 17(3):195-215.

Reid, W.V., Chen, D., Goldfarb, L., Hackmann, H., Lee, Y.T., Mokhele, K., Ostrom, E., Raivio, K., Rockström, J., Schnellnhuber, H.J. & Whyte, A. (2010). Science. 330(6006):916-917. DOI:10.1126/science.1196263

Roach, D. (2016). These 5 beer makers own more than half of the world's beer. Business Insider. Retrieved from https://www.businessinsider.com/biggest-beer-companies-in-the-world-2016-1

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C., Hughes, T., van der Leeuw, S., Rodhe, H., Sorlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. & Foley, J.A. (2009). A safe operating space for humanity. Nature. 461(124):472-475. DOI:10.1038/461472a

Rubin, H.J & Rubin, I.S. (2012). Qualitative interviewing: The art of hearing data – 3rd ed. Sage Publications.

Sanya, C. & Yahng, L. (2018). Willingness-to-pay for sustainable beer. PLoS ONE. 13(10):1-18. DOI:10.1371/journal.pone.0204917

SASB. (2018a). Home. Sustainability Accounting Standards Board. Retrieved from https://www.sasb.org

SASB. (2018b). Alcoholic beverages sustainability accounting standard. Sustainability Accounting Standards Board. Retrieved from https://www.sasb.org/wp-content/uploads/2018/11/Alcoholic_Beverages_Standard_2018.pdf

SBTi. (2019). Resources. Science Based Targets. Retrieved from https://sciencebasedtargets.org/resources/

Science Based Targets. (2018). SBTi Call to Action Guidelines. Retrieved from https://sciencebasedtargets.org/wp-content/uploads/2017/03/SBTi-C2A-Guidelines-March-15-2017.pdf

Scott, W.R. (2001). Institutions and Organizations 2e. London: Sage.

Searcy, C. & Buslovich, R. (2014). Corporate perspectives on the development and use of sustainability reports. Journal of Business Ethics. 121:149-169. DOI:10.1007/s10551-013-1701-7

Shin, R. & Searcy, C. (2018). Evaluating the green house gas emissions in the craft beer industry: An assessment of challenges and benefits of greenhouse gas accounting. Sustainability. 10:1-30. DOI:10.3390/su10114191

Sonnevera. (2011). Ontario Agricultural Waste Study: Environmental impacts of open-burning agricultural plastics. Sonnevera International Corporation. Retrieved from http://cleanfarms.ca/wp-content/uploads/2017/07/AgPlasticEnviroImpactOpenBurning_FINAL_201107.pdf

Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., & Ludwig, C. (2015a). The trajectory of the Anthropocene: The great acceleration. The Anthropocene Review. 2(1):81-98.

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B. & Sorlin, S. (2015b). Planetary boundaries: Guiding human development on a changing planet. Science. 347(6223):736-746. DOI:10.1126/science.1259855

Steffen, W., Persson, A., Deutsch, L., Zalasiewicz, J., Williams, M., Richardson, K., Crumley, C., Crutzen, P., Folke, C., Gordon, L., Molina, M., Ramanathan, V., Rockström, J., Scheffer, M., Schnellnhuber, H.J. & Svedin, U. (2011). The Anthropocene: From global change to planetary stewardship. Ambio. 40(7):739-761. DOI:10.1007/s13280-011-0185-x

Steffen, W.L., Tyson, P.D., Jäger, J., Matson, P.A., Moore, B., Oldfield, F., Richardson, K., Sanderson, R.A., Schellnhuber, H.J. & Turner, B.L. (2005). Global change and the Earth system: A planet under pressure. Springer.

Suchman, M.C. (1995). Managing Legitimacy: Strategic and Institutional Approaches. The Academy of Management Review. 20(3):571-610.

Sustainable Agriculture Initiative. (2018). Who we are. Retrieved from https://www.saiplatform.org/about-us/who-we-are

Talve, S. (2001). Life cycle assessment of a basic lager beer. The International Journal of Life Cycle Assessment. 6(5):293-298. DOI:lca2001.06.055

Technavio. (2018). Top 10 largest beer companies and their beer brands in the global beer market 2019. Retrieved from https://blog.technavio.com/blog/top-companies-global-beer-market

Thacker, H. (2019). CSR policies around the world. The CSR Journal. Retrieved from https://thecsrjournal.in/csr-policies-around-the-world/

Tian, H., Chen, G., Lu, C., Xu, X., Ren, W., Zhang, B., Banger, K., Tao, B., Pan, S., Liu, M., Zhang, C., Bruhwiler, L. & Wofsy, S. (2015). Global methane and nitrous oxide emissions from terrestrial ecosystems due to multiple environmental changes. Ecosystem Health and Sustainability. 1(1):4. DOI:10.1890/EHS14-0015.1

Tidaker, P., Bergvist, G., Bolinder, M., Eckersten, H., Johnsson, H., Katterer, T. & Weih, M. (2016). Estimating the environmental footprint of barley with improved nitrogen uptake efficiency – a Swedish scenario study. European Journal of Agronomy. 80:45-54. DOI:10.1016/j.eja.2016.06.013

Tokos, H., Pintaric, Z.N. & Krajnc, D. (2012). An integrated sustainability performance assessment and benchmarking of breweries. Clean Technologies and Environmental Policy. 14: 173-193. DOI:10.1007/s10098-011-0390-0

Tomasi, C., Fuzzi, S. & Kokhanovsky, A. (2017). Atmospheric aerosols: Life cycles and effects on air quality and climate. First Edition. Wiley-VCH Verlag GmbH & Co.

United Nations. (2018). Sustainable development goals. United Nations Development Programme. Retrieved from https://www.undp.org/content/undp/en/home/sustainable-development-goals/background/

United Nations. (n.d.) CEO Water Mandate mission and governance. Retrieved January 9, 2018, from https://ceowatermandate.org/about/mission-governance/

UNEP & WHRC. (2007). Reactive nitrogen in the environment: Too much or too little of a good thing. United Nations Environmental Programme. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/7761/Reactive_Nitrogen.pdf?sequence=3&isAllowed=y

United Nations Global Compact. (2018). Endorsing companies. CEO Water Mandate. Retrieved from https://ceowatermandate.org/about/endorsing-companies/

US EPA. (2018). Greenhouse gases at EPA. United Stated Environmental Protection Agency. Retrieved from https://www.epa.gov/greeningepa/greenhouse-gases-epa

Verones, F., Saner, D., Pfister, S., Baisero, D., Rondinini, C. & Hellweg, S. (2013). Effects of consumptive water use on biodiversity in wetlands of international importance. Environmental Science and Technology. 47(21):12248-12257. DOI:10.1021/es403635j

Villarrubia-Gomez, P., Cornell, S.E., Fabres, J. (2018). Marine plastic pollution as a planetary boundary threat – The drifting piece in the sustainability puzzle. Marine Policy. 96:213-220. DOI:10.1016/j.marpol.2017.11.035

Water Footprint Network. (2020). Aims & history. Water Footprint Network. Retrieved from https://waterfootprint.org/en/about-us/aims-history/

WBCSD & WRI (2004). The greenhouse gas protocol. World Resources Institute and World Business Council for Sustainable Development. Retrieved from https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf

Whiteman, G., Forbes, B.C., Niemela, J. & Chapin, F.S. (2004). Bringing feedback and resilience of high-latitude eco-systems into the corporate boardroom. Ambio. 33(6):371-376. DOI:10.1579/0044-7447-33.6.371

Whiteman, G., Walker, B. & Perego, P. (2013). Planetary boundaries: Ecological foundations for corporate sustainability. Journal of Management Studies. 50(2):307-336. DOI:10.1111/j.1467-6486.2012.01073.x

Wilson, M.C. (2013). A critical review of environmental sustainability reporting in the consumer goods industry: Greenwashing or good business? Journal of Management and Sustainability. 3(4): 1-13.

Woodward, A. (2019). Climate change: Disruption, risk and opportunity. Global Transitions. 1:44-49 DOI:10.1016/j.glt.2019.02.001

WRI. (2006). The land use, land-use change, and forestry guidance for GHG project accounting. World Resources Institute. Retrieved from https://ghgprotocol.org/sites/default/files/standards_supporting/LULUCF%20Guidance_1.pdf

WWF & SABMiller. (2009). Water Footprinting: Identifying & addressing risks in the value chain. Retrieved from https://waterfootprint.org/media/downloads/SABMiller-WWF-2009-waterfootprintingreport_1.pdf

Yläranta, T., Uusi-kämppä, J. & Jaakkola, A. (1996). Leaching of phosphorus, calcium, magnesium and potassium in barley, grass and fallow lysimeters. Acta Agriculturae Scandinavica, Section B – Soil & Plant Science. 46(1):9-17. DOI:10.1080/09064719609410941

Zhang, X., Davidson, E., Mauzerall, D.L., Searchinger, T.D., Dumas, P. & Shen, Y. (2015). Managing nitrogen for sustainable development. Nature. 528:51-59. DOI:10.1038/nature15743

Zhou, L., Tokos, H., Krajnc, D. & Yang, Y. (2012). Sustainability performance evaluation in industry by composite index. Clean Technologies and Environmental Policy. 14:789-803. DOI:10.1007/s10098-012-1454-9

Zhuang, S., Shetty, R., Hansen, M., Fromberg, A., Hansem, P.B. & Hobley, T.J. (2017). Brewing with 100% unmalted grains: Barley, wheat, oat and rye. European Food Research and Technology. 243:447-454. DOI:10.1007/s00217-016-2758-1