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Sustainability in Craft Breweries: A Systematic Literature Review



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ABSTRACT

Considering the future, sustainability is a major challenge as the population continues to grow, as does the demand for a better standard of living. Breweries, being a dependent industry on nature inevitably have an impact on it. Thus, as it brews on all continents the risks related to climate and resources are enormous. Among the brewing industry segments, the explosion of local craft breweries and the boom in craft beer consumption are making it evident that local consumption of beer can have a significant impact on local water resources. Being a new subject due to the exponential growth of the craft beer market being still recent, it is necessary to investigate the relationship between craft beer and sustainability. Therefore, this article aims to analyze how the relationship between microbreweries and sustainability through a systematic literature review is. This systematic review was guided by the following question: How have craft breweries related to sustainability? In the online search 847 articles were identified, after the elimination of duplicate studies, 756 articles resulted. A total of 724 studies were excluded after reading abstracts, resulting in 32 articles for reading in full text. At the end of the full-text reading, 24 articles were excluded. In this article, it was possible to see that some studies sought to understand what reasons make a microbrewer opt for environmentally-friendly management. As well, it is possible to perceive a greater focus on the environmental issue of sustainability, with the main focuses being energy and climate, water efficiency and conservation, reuse of spent grain, and community involvement in its various aspects.



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INTRODUCTION

Looking ahead, sustainability is a major challenge as the population continues to grow, as does the demand for a better standard of living. To all services related to their costs and social functions of impacts on natural resources. According to Wales (2015), both requirements require tailored adaptation and mitigation solutions for water and lower energy consumption – throughout product supply along product supply chains.

Breweries have an impact on it. Thus, as it is produced on all continents, the risks related to climate and resources are enormous. Therefore, there is a need to improve where and why risks increase and what to do to address them. Sustainability should not be presented as a single or simple solution. Instead, economics is paramount that we begin by embracing the complexity through the resources of the water-energy nexus so that the development of social equity works better. This line of thinking offers solutions that are rooted in the many challenges that are at the local level.

According to Ness (2018) craft beer proliferates, both in the total amount of production and in the number of breweries. There was significant growth in the United States, with particularly strong growth in Colorado, and Oregon. This growth has extended to other regions around the world. It's a trend where brewers and consumers alike have come to prioritize flavor and style variety in beer, while often enacting an environmental image in their operations.

Although both craft and industrial beers are not ecological, for the consumption of resources such as energy and water, the application of some sustainable practices is possible in the manufacture of craft beer to increase its sustainability (Brewers Association, 2020). While defining sustainability within the beer industry is difficult and potentially controversial, the vision of a sustainable brewery recognizes that environmental stewardship is not just important for craft brewers, but for society (Patterson *et al.*, 2016).

Brewing beer is a water-intensive process. According to the process, considering all the cultivation of crops such as hops and barley that are used in brewing beer to the end of the bottle, it was estimated that water is 300 liters to produce one liter of beer (Gardiner, 2011) The water/beer ratio in brewing is more variable, but the Brewers Association estimates an average ratio of 7 to 1 for craft brewers. These numbers indicate rates of brewing and water processing

throughout growth and production. Along with an explosion of local craft breweries and the boom in craft beer it is not evident that the local consumption of a beer can has a significant consumption on local water resources (Association of Local Cereiros, 2017).

There are six conservation areas, which were categorized under environmental parameters, and which were categorized by Ness (2018) from water, energy and climate, grain reuse, solid waste (which spent grain), beer containers, and packaging. The brewing process is water-intensive, often using many units of water for each brewing unit. Measures to increase water efficiency or quality to promote local or regional water were also widely publicized. The brewing process is also energy-intensive because of processes such as further boiling (unfermented beer), wort cooling, bottling/canning, and transporting beer, among others: this often leads to climate impacts.

In 2013, the Brewers Association (BA) introduced a set of sustainability manuals and benchmarking tools. The BA currently provides sustainability handbooks and corresponding supplemental materials for five key areas: (1) energy GHG reduction, efficiency, and load management; (2) solid waste reduction; (3) sustainable design and construction strategies; (4) water and wastewater treatment/reduction; and (5) wastewater management. The handbooks provide relevant background information on the topic, guidance on data management, and an overview of best practices, with a common point of emphasis on the value of benchmarking and tracking. BA also provides a Sustainability Benchmarking Tool system that helps brewers benchmark and track KPIs (Association of Brewers, 2019).

As it is a new subject due to the exponential growth of the craft beer market still recent, it is necessary to investigate the relationship between a craft beer and sustainability, since brewers' association studies show that this growth in craft production can have an impact on local resources, it is necessary to survey studies on sustainability in microbreweries. Therefore, this article aims to analyze the relationship between microbreweries and sustainability through a systematic literature review.

MATERIALS AND METHODS

This systematic review was guided by the following question: How have craft breweries been related to sustainability?

To answer this question, a search was carried out in two electronic databases on September 6, 2021: Web of Science and Scopus, between the 2015 and 2021 publication date and in English, Portuguese and Spanish. Studies from 2015 were chosen, as it was at that time that the Boom of craft breweries began.

The following search keys were used on both bases: (“sustainability” AND “Beer”) OR (“sustainable brewery”) OR (“sustainability” AND “Malt” AND “Beer”) OR (“Craft beer” AND “sustainability”) OR (“brewery” AND “sustainability”).

In the online search, 847 articles were identified, after the elimination of duplicate studies, resulting in 756 articles. The selection of articles in this review was conducted in two phases: reading of abstracts and reading of full articles, carried out by a reader independently. The inclusion criteria were Case studies relating to microbreweries and sustainability, studies on the use of sustainability tools in breweries, and Sustainability in the craft beer production chain. For exclusion, the following criteria were defined: studies that analyzed large breweries; Studies that analyzed the beer market in general.

A total of 724 studies were excluded after reading abstracts, resulting in 32 articles for full-text reading. At the end of reading the studies in full, 24 articles were excluded. Such articles were excluded for several reasons, such as: Covering a subject beyond breweries; focusing on the industrial beer market; not relating sustainability to the study area. At the end of the selection, nine articles were chosen to compose this systematic review. The main information from the publications was organized and summarized in a table, according to the following criteria: Author; Year; Methodology; Results. Data analysis was divided into two categories case studies in microbreweries and Sustainability tools used in microbreweries.

RESULT AND DISCUSSION

Nine studies were included in the present systematic review, two of which were case studies in the United States and one in Italy. The fourth search in microbrewery reports the priorities for these companies regarding sustainability, this study was carried out with companies from six countries. Another three studies were based on the presentation of tools or methods to make the microbrewery more sustainable, and finally, there is an article that analyzes the production chain of craft beers from the perspective of sustainability. Therefore, the results of this research will be

divided into two tables, a first one that includes case studies and the motivation for implementing environmental practices in microbreweries, and a second table with studies that present possibilities of applications, as well as an overview of the supply chain. craft beer production.

Rosburg and Grebitus (2021) conducted a case study with microbrewers in the State of Iowa, in the United States (Table 1). This study was conducted in 2019 and obtained responses from 23 microbreweries, however only 19 responded to the full questionnaire, this questionnaire was divided into five sections see. The first part of the survey entitled brewery characteristics analyzed information about the brewery production characteristics but also included questions about the respondent's position within the brewery.

The second Environmental and Sustainability Practices section investigated environmental and sustainability practices that rely heavily on the Iowa Green Brewery Certification (IGBC) assessment criteria. Respondents were asked to provide information on the brewery's tracking mechanisms, and environmental planning, whether the brewery conducts an annual planning environmental assessment, whether the brewery has a policy/mission that supports a commitment to environmental stewardship, and the brewery's familiarity. With the brewers association's sustainability manuals and their use and benchmarking tools. We also asked respondents to rate their brewery efforts on specific practices related to energy efficiency, water quality/conservation, and resource/solid waste management.

The third part classified as Network of breweries and use of knowledge and information sought to analyze the participation of the brewery in brewery groups (such as associations), as well as the relationship to the role of networking in the success of the brewery, the adoption of new practices (including sustainability practices), the degree of competitive pressure, demand for craft beer, and demand for sustainable products in your geographic area.

Finally, the interviewee's perceptions of consumer preferences regarding selected beer attributes and the consumer's willingness to pay for sustainably produced beer were evaluated. For this, a random list of 18 "attributes" was provided and asked to indicate the importance of each attribute to the brewery, as examples include price, style, brand/stock, ABV, sustainability efforts, organic recommendation, and family/friend. Specifically, they were asked to indicate the percentage of their customers who would be willing to pay up to each of the following premium amounts: "not

willing to pay any premium", "pay up to 1 to 5% more", "pay up to 5 to 10 % more", "pay up to 10-25% more", "pay up to 25-50% more", and "pay more than 50% more".

Table 1 - Case Studies relating to Sustainability and Craft Beer – Source: Author

Title / Author / Year	Method	Conclusion
<p>Título: Sustainable development in the craft brewing industry: A case study of Iowa brewers</p> <p>Autores: Alicia Rosburg; Carola Grebitus</p> <p>Ano: 2021</p>	<p>Participants were recruited via email directly from the authors using a list of Iowa craft brewers available online; the recruitment email was also distributed through the Iowa Guild brewers email lists and the IGBC program. To participate in the survey, a respondent was required to be: (1) 21 years of age or older, (2) a Primary brewer at an Iowa craft brewery, and (3) employed at their current brewery for more than 6 years. months. The survey contained four sections: Brewery and brewery characteristics; Environmental and sustainability practices; Brewery network and use</p>	<p>The results show that just under half of Iowa's microbreweries were conducting an annual assessment to assess operational procedures and identify opportunities for sustainability improvement. A similar percentage had a policy/mission supporting environmental stewardship. Also, while most breweries were tracking to some degree, many of them did not have environmental plans. So, while some brewers had established routines and practices that could be leveraged for a business case for sustainability, others were lacking in data collection and planning.</p>

	of knowledge and information; Perceptions of customer preferences.	
<p>Título: Craft breweries' environmental proactivity: an upper echelons perspective</p> <p>Autores: Erol Sozen; Imran Rahman; Martin O'Neill</p> <p>Ano: 2021</p>	<p>An online questionnaire was distributed to a convenience sample of US Craft Brewers via the Brewers Association Forum Blog. A total of 237 valid responses were received. Structural equation modeling was used to test hypothetical relationships between key constructs in the proposed research model: environmental values, environmental engagement, environmental sustainability practices, and business challenges.</p>	<p>The findings confirm the positive relationships between consumption values of craft brewery owners and environmental attitudes, consumption values and environmental proactivity, environmental attitudes, and proactivity.</p> <p>In addition, the business challenges of craft breweries weaken the relationship between owners' environmental attitudes and environmental proactivity. As environmental proactivity in craft breweries depends on the environment of owners with proper awareness and education, it is possible to improve owners' attitudes towards environmental attitudes that will ultimately lead to greater environmental proactivity.</p>
<p>Título: Exploring the antecedents and consequences of environmental performance in micro-</p>	<p>The study aims to test nine hypotheses, to test their data was collected using an online questionnaire distributed</p>	<p>From a management perspective, the research found that craft breweries, which are heavily dependent on the environment for resources, are</p>

<p>enterprises: The case of the Italian craft beer industry.</p> <p>Autores: Filippo Corsini; Francesco Paolo Appio; Marco Frey</p> <p>Ano:2019</p>	<p>to Italian craft beer companies. The questionnaire contained the following sections:</p> <ul style="list-style-type: none"> - A section that investigates the environmental performance improvements achieved in the last three years. - A section investigating the adoption of a proactive sustainability strategy. - A section that investigates the internal and external forces that can influence environmental strategy. -Entrepreneurs' environmental awareness. - A section investigating perceived cost advantages and perceived differentiation advantages. - A section investigating perceived operational performance. - Information related to 	<p>highly aware of environmental sustainability issues. The results allow us to affirm that the sustainability of the craft beer industry largely depends on the awareness of entrepreneurs about the importance of environmentalism and, consequently, on the recognition of the benefits that the pursuit of environmental practices produces in terms of profitability.</p> <p>Within this context, the role of environmental information seems to be essential entrepreneurs who do not have information about their environmental impacts are less likely to adopt a proactive environmental strategy. Sharing best practices among industry entrepreneurs could represent an important mechanism to raise awareness and consequently positively shape environmental performance.</p> <p>Also benchmarking tools would be essential to compare resource usage and costs across the industry, allowing craft brewers</p>
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	<p>the number of employees and annual beer production in hectoliters. 203 complete questionnaires were collected, representing 24.4% of the total population of craft beer companies operating in Italy.</p>	<p>to can compare their performance with "best-in-class" companies and identify areas for improvement.</p>
<p>Título: Green Beer: Why small to medium-sized enterprises adopt sustainable practices Autores: Elizabeth A. Embry Ano: 2018</p>	<p>This research was carried out in the state of Colorado, United States. It aimed to analyze which factors encouraged microbrewery owners to adopt sustainable practices. The qualitative inductive methodology was used, the data is obtained through interviews with the owners of microbreweries together with secondary data obtained from craft beer associations. These data were used to validate the responses obtained in the interviews.</p>	<p>In this research, it was possible to conclude that one of the difficulties for microbrewers to adopt sustainable practices was the difficulty of accessing sustainable technologies. Other perceived factors were the owner's enthusiasm and customer demand regarding environmental issues. Finally, another theme that was raised is that microbreweries are doing their best to be sustainable with existing resources. Therefore, the author of the article classifies the first factor the enthusiasm regarding environmental issues, then the issues of financial efficiency that sustainability can provide.</p>
<p>Título: Beyond the</p>	<p>Seventy craft breweries</p>	<p>The survey found that craft</p>

<p>Pale (Ale): An Exploration of the Sustainability Priorities and Innovative Measures in the Craft Beer Sector</p> <p>Autores: Barry Ness</p> <p>Ano:2018</p>	<p>were then identified from the searches; 53 of the breweries were in the United States, with the remainder spread across Canada, Australia, the United Kingdom, South Africa, and New Zealand.</p> <p>A detailed investigation of the 70 breweries' websites and/or written articles were then undertaken specifically to craft beer sustainability initiatives. Six areas were categorized under environmental parameters: water conservation, energy and climate, reuse of spent grain, solid waste (other than spent grain), containers and packaging, and beer ingredients</p>	<p>brewers have a broad interpretation of sustainability, encompassing environmental and socioeconomic parameters. Areas strongly perceived by brewers included energy and climate, water efficiency and conservation, grain reuse, and community involvement.</p> <p>The strong focus on the "local" by craft brewers points to priority areas of sustainability, the results also reveal that these priorities are often differentiated.</p> <p>Furthermore, among the 70 breweries analyzed, the results also exposed that the age of the brewing operation, in general, impacts how much emphasis is placed on the sustainability of the company.</p>
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It is possible to see in the table that the research by Embry (2018) and Corsini *et al.* (2019) follow a similar methodology, however, one is carried out in Colorado, the United States, and the other in Italy, while the third search. Both types of research focus on analyzing the factors that encourage craft breweries to practice sustainable actions in their production. An interesting

factor is that both surveys obtained approximate results. According to both surveys, the factor that the advantages of differentiation are not perceived positively influenced by environmental performance and do not translate into greater operational performance may be related to the fact that brewery artisans may struggle to build brands emphasizing sustainability issues. Thus, as well as these same microbreweries have a greater difficulty in accessing green technologies due to the volume of production that limits craft breweries in acquiring more sustainable equipment.

Other factors mentioned in both studies were the importance of the enthusiasm of the entrepreneur who owns microbreweries regarding environmental issues so that there is a proactive environmental strategy. Embry (2018) indicates that the first and main motivation that pushes the company on the path of sustainability is the entrepreneur's enthusiasm on this subject, and financial savings afterward. Meanwhile, Corsini *et al.* (2019) state that the sustainability of the craft beer industry largely depends on the awareness of entrepreneurs about the importance of environmentalism and the recognition of the benefits that the pursuit of environmental practices produces in terms of profitability.

Regarding these hypotheses of connections between craft brewers' values and the environment and their proactiveness to sustainable practices Sozen *et al.* (2021) states that there are positive relationships between the consumption values of craft brewery owners and environmental attitudes, consumption values, and environmental proactivity, environmental attitudes, and proactivity. However, even when the owners have high enthusiasm for environmental management. They may lend themselves to environmental stewardship in their craft breweries, due to the prevalence of certain business challenges that may be financial, legislative, production-related, distribution-related, marketing-based, and/or employee-related. Therefore, minimizing these challenges through better sharing practices, better consultation programs, and government incentives can facilitate the progression of environmental management programs in craft breweries.

In another study, Ness (2018) sought to present priorities and measures focused on craft beer sustainability objectives and to highlight a series of innovations followed by brewers to promote sustainability. In this study it was found that craft brewers have a broad interpretation of sustainability, encompassing environmental and socioeconomic parameters. Areas strongly

profiled by brewers include energy and climate, water efficiency and conservation, reuse of spent grain, and community involvement in its many forms.

Regarding water conservation, approximately half of the breweries mentioned organizational emphasis on water or participation in water conservation advocacy. Among the efficiency measures taken to decrease water use directly in the brewing process or restaurant operations, or other actions to promote local or regional water conservation. Actions ranged significantly from installing equipment (eg clean-in-place system) at the brewery as well as other water recovery systems to decreasing water usage in the brewing process. As for the energy issue, 41 out of 70 microbreweries use measures to reduce energy use and/or to use renewable energy sources in the company's operations. Efficient wort actions, the use of natural light, or the use of installing LED lighting systems, the construction of zero-energy buildings, biodiesel-powered beer delivery vehicles, the purchase of renewable energy credits, and/ or participation in electricity purchase programs. The installation of solar arrays on the roof by 13 of the 70 breweries or brewpubs was an electricity purchase measure that goes beyond rudimentary actions.

Approximately one-third (30 of 70) of brewers emphasized reusing grains spent by other brewing processes. The vast majority of these highlighted the reuse of spent grains as animal feed for cattle, cows, pigs, or chickens. However, alternative uses have been undertaken by some of the brewers, including using grains as a medium for ground cover, or as an ingredient for restaurant operations, for example for bread and pizza dough. Even more innovative, two breweries highlighted the reuse of spent grain for use as an ingredient in dog biscuits, promoting the creation of a small local business in one case. In addition, a San Francisco-area company was also passing grain from a brewery as the main ingredient for energy bars for human consumption.

In addition, 28 of the 70 breweries participate in some type of solid waste handling and/or recycling program. As with many of the other assessment areas, the priorities and examples of brewery sites are very varied. Many brewers have noted an adherence to different recycling programs, other solid waste diversion programs, or composting organic waste promotions for restaurant activities. Notable efforts included efforts by five breweries to become, or with ambitions to become, certified "no waste" companies.


Finally, Ness (2018) also brings factors such as packaging and ingredients into her research. Regarding packaging, twenty-seven craft breweries presented a more sustainable profile of beer containers or packaging for their products. Brewers have included moving from conventional bottles to lightweight bottles or cans; on the contrary, others emphasized their use of glass bottles composed of a large percentage of recycled glass. Numerous breweries also mentioned a strong priority on producers of returnable and refillable bottles, while others promoted reusable bottles or keg systems, or recycled cardboard for 6-packs, in general, the measures were not so creative. Meanwhile, sustainable ingredients were concentrated in three specific areas: locally produced, non-GMO, and organic. Twelve brewers profiled their local sources of ingredients for any of their beer or restaurant food operations. Three breweries referenced their use of non-GMO ingredients. Another 14 brewers highlighted their use of certified organic ingredients (often USDA) either in their beer or in restaurant operations. More innovative measures included on-site farming (eg hops, grains, or fruits) for brewing beer, as well as other fruits and vegetables for use in restaurant operations.

Table 2 – Sustainability tools and Craft Beer – Source: Author

Title / Author / Year	Method	Conclusion
<p>Título: Economic and environmental performance of instantaneous water heating system for craft beer production</p> <p>Autores: María Belén Salazar T., M. Fernanda San Martín-González, Hua Cai, Jen-Yi Huang</p> <p>Ano: 2021</p>	<p>A techno-economic analysis was carried out in a microbrewery with an annual production of approximately 3000 bbl in the state of Indiana, United States to evaluate its energy efficiency and the cost-benefit value associated with producing a keg of beer. The scope of this study was from door to door of the brewery, including</p>	<p>The Instant Water Heating System (IWHS) is a potential alternative to the steam boiler for brewing beer. This study developed an integrated techno-economic analysis (TEA) and life cycle assessment (LCA) to assess the economic and environmental consequences of implementing IWHS in a microbrewery. Although the IWHS can save labor and gas costs the</p>

	<p>the operations of brewing, fermentation and maturation, packaging, and storage. The treatments of the resulting spent grains (co-products) and wastewater were not considered.</p>	<p>calculated NPV and IRR indicated that this investment was not recommended for the microbrewery under its current productivity and operation. However, expanding the scale of production of the microbrewery and reducing the cost of IWHS can increase the net profit of implementing IWHS. The TEA-LCA integrated model developed in this study can help microbrewers in the decision-making process of implementing alternative hot water supplies such as tankless water heaters, considering both economic and environmental aspects</p>
<p>Título: Thirsty work: Assessing the environmental footprint of craft beer Autores: Dyfed Rhys Morgan, David Styles, Eifiona Thomas Lane Ano: 2021</p>	<p>This study aims to assess the environmental impact of craft beer production, particularly on a small scale in microbreweries, by developing a life cycle assessment (LCA) calculation tool for small independent breweries in Wales.</p>	<p>The study shows that the small-scale brewing industry has its own set of environmental challenges and focuses that are distinct from large organizations. In particular, distribution is an important access point for the beer footprint of microbreweries, especially</p>

	<p>Seven breweries participated in this study, each with unique characteristics, among others, beer production volumes, batch capacity, beer/water ratio, and packaging formats. Steps in the value chain included growing barley and hops, upstream processing, upstream distribution of brewing ingredients, beer production, packaging, downstream distribution of beers, and waste management.</p>	<p>for GWP (carbon footprints) and FRDP, due to the use of small commercial vans, then larger trucks. Cultivation is another stage in the beer life cycle that consistently contributes to several impact categories, most notably Acidification, Terrestrial Eutrophication, and Marine Eutrophication. Overall, these microbreweries had lower packaging contributions compared to larger breweries studied in previous studies due to a greater reliance on kegs and reusable kegs for localized distribution.</p>
<p>Título: A framework for a sustainable craft beer supply chain Autores: Harish C. Bahl; Jatinder N.D. Gupta; Kenneth G. Elzinga Ano: 2020</p>	<p>This study aims to propose a framework for the development of strategies for the craft beer supply chain that can make the business efficient and profitable and, at the same time, generate sustainability benefits from the reduction of waste, the conservation of natural</p>	<p>The article has managerial implications for craft brewers. With operational changes in their supply chains, craft brewers can manage sustainability by reducing waste, conserving natural resources, and improving their polluting footprint. Craft brewers can save water, grain, hops, and yeast by employing practices</p>

	<p>resources, and of reducing pollution.</p> <p>The proposed framework describes strategies to establish a sustainable craft beer chain. This structure consists of four categories that contribute to the craft beer sustainability: ingredient procurement, recycling efforts, energy use, and distribution systems.</p> 	<p>discussed in this document.</p> <p>They can use clean energy for electricity and reuse heat energy at different stages of the brewing process. Most of the waste generated in the process can be recycled rather than disposed of in landfills and polluting environments.</p> <p>Its distribution can be made more efficient by reducing intermediary distributors when government regulation allows and also choosing craft beer distribution in cans and bottles, considering consumer preferences, environmental impact and cost margins.</p>
<p>Título: Increasing the Value of Spent Grain from Craft Microbreweries for Energy Purposes</p> <p>Autores: Giulio Sperandio, Tiziana Amoriello, Katya Carbone, Marco Fedrizzi, Alessandro Monteleone, Serena Tarangioli, Mauro</p>	<p>The design of two different technical models (pellets and biochar production) for the recovery and valorization of spent grains by brewers (BSG) as an alternative to current practice. The economic analysis evaluated, through an analytical methodology,</p>	<p>The present study confirmed, both from a technological and economic point of view, the feasibility of using BSG as a fuel for energy use, thanks to its carbon and hydrogen content, which gives it a good calorific value.</p> <p>The proposed model offers the possibility of achieving discrete benefits capable of increasing the company's</p>

<p>Pagano Ano: 2017</p>	<p>the annual costs of pellet management, considering the annual depreciation of the invested capital, other annual fixed costs, and operational costs related to maintenance and repairs, electricity, labor, and overhead.</p>	<p>value. Economic balance, while avoiding the problem of disposing of this waste, could sometimes represent an increase in costs for microbreweries.</p>
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Thus, it is possible to perceive that in addition to studies that seek to link sustainability with craft beer, as well as the reasons for adhering to environmental practices in microbreweries (see table 1). An also studies that seek to demonstrate to microbrewers alternatives for environmentally friendly management (see table 2). For example, in the article by Salazar *et al.* (2021) a model was built that can help microbrewers in decision making in the process of implementing alternative hot water supplies such as tankless water heaters, considering both economic and environmental aspects. Morgan *et al.* (2021) developed a Life Cycle Assessment (LCA) calculation tool for small, independent breweries in Wales. Another study that seeks to help microbrewers is by Sperandio *et al.* (2017) in which he seeks alternatives different from those used for the use of grain residues from the brewing process. The two models proposed for the recovery and valorization of spent grains by brewers (BSG) proved to be efficient and capable of offering benefits capable of increasing the value of the company while avoiding the problem of disposing of these residues, which could sometimes represent a cost increase for microbreweries. Unlike these articles that analyzed specific areas of environmental practices in microbreweries, Bahl *et al.* (2020) developed a framework based on four categories that contribute to craft beer sustainability: ingredient procurement, recycling efforts, energy use, and distribution systems.

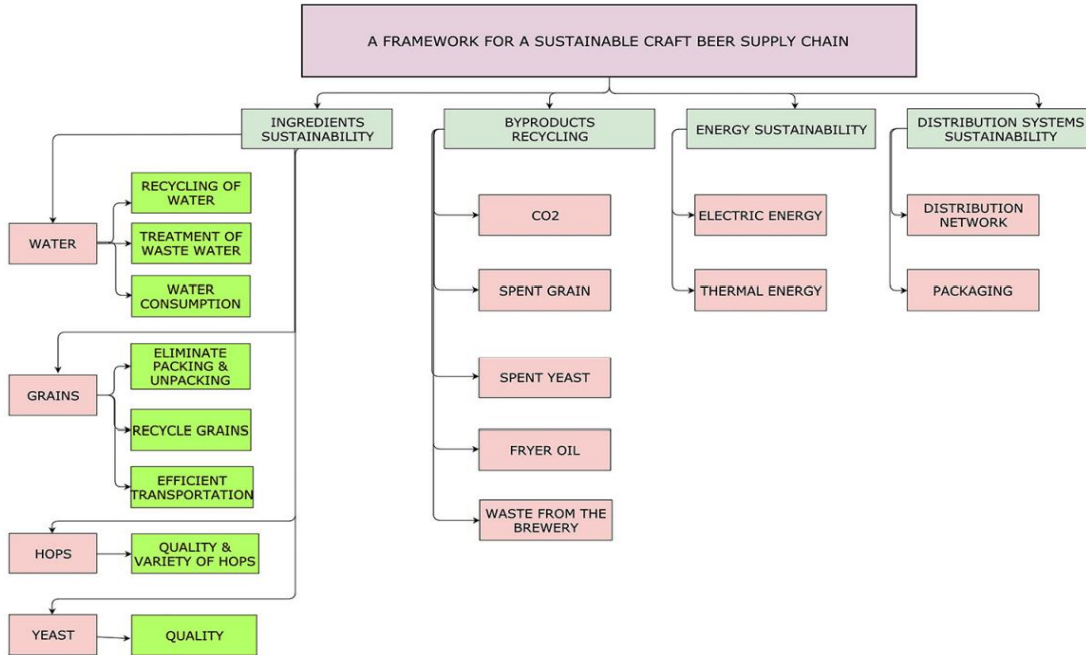


Figure 1- A proposed framework for a sustainable supply chain for craft beer- Source: (Bahl et al. 2020)

In this framework, several environmental practices are proposed that can be used in microbreweries. These practices were divided into five pillars: water, barley, hops, yeast, and energy.

- Water: 1-Recycle water (hot water recovery system in the brewhouse; recover the water used to rinse bottles); 2- Effluent treatment (water treatment station for waste removal; Donate weak must); 3- Conserve water (eliminate water-based lubricants; water treatment plant to use wastewater)
- Grain: 1- Eliminate packing and unpacking (use of grain loaders); 2- efficient transport (rail transport instead of trucks); 3- recycle the grains (Use spent grains to feed the animals)
- Hops: 1- Hop quality and variety (collaboration and long-term relationships with growers; cultivate your hops for experimentation)

- Yeast: 1- CO₂ (recycling of CO₂ produced from fermentation); 2- spent barley and yeast (send spent grain to regional farms and dairy); 3- Brewery waste (Compost to make fertilizer for agricultural use; convert into biodiesel with a processor)
- Energy 1- Clean Energy (solar panels; Tesla battery system; micro wind turbine); 2- Conserve energy (use of energy-efficient boilers and refrigeration systems; condensate recovery system)

Because of this proposed model Bahl *et al.* (2020) states that the proposed model focuses on the environmental pillar of sustainability, so further studies investigating the economic and social pillars of sustainability would be beneficial for an expanded structure for a sustainable craft beer.

CONCLUSION

Because of the studies and information obtained in this literature review, it is possible to see that studies related to sustainability in the craft beer production chain are still very recent, where most of the studies are gathered in the last 2 years. This is because the growth of this artisanal movement is still recent, which makes researchers realize the size of this current market and become interested in the subject.

In this article, it was possible to perceive that some studies sought to understand the reasons that make a microbrewer opt for environmentally-friendly management. In this regard, it was possible to observe that there is a positive relationship between the consumption values of craft brewery owners and environmental attitudes, consumption values, and environmental proactivity, and environmental attitudes and proactivity. However, due to its size, certain commercial challenges may impact this decision such as financial, legislative, production-related, distribution-based, marketing-based, and/or employee-related issues.

It is possible to perceive a greater focus on the environmental issue of sustainability, with the focus being on energy and climate, water efficiency and conservation, reuse of spent grains, and community involvement in its various forms. Among these issues, there are works focused on presenting solutions through environmental practices to reduce the footprint of the craft beer production process, as presented in the studies by Bahl *et al.* (2020), Salazar *et al.* (2021), Morgan *et al.* (2021) and Sperandio *et al.* (2017).

Finally, there is a need to both put these practices into action through new studies with pilot projects or partnerships with craft breweries. It was also necessary to create manuals, guides, and information and courses that seek to educate these new craft brewers by demonstrating ways for them to act proactively to sustainability and still become more efficient in their processes.

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