Reducing Coffee Shop's Negative Environmental Impact

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Abstract

Coffee consumption in Canada remains high, placing increased environmental responsibility on businesses within the coffee industry, particularly coffee shops. This research explores how coffee shops can adopt sustainable practices to minimize their ecological impact. Using a systematic literature review methodology, the research compiles both qualitative and quantitative data from diverse sources. Findings highlight practical solutions for food waste reduction, such as reusing spent coffee grounds (SCG) in agriculture, baking, textiles, cosmetics, construction and biodegradable product manufacturing. It also explores the potential of utilizing other coffee byproducts like chaff and husks in sustainable manufacturing. Additionally, the report addresses eco-conscious supply chain strategies, including sourcing coffee from geographically closer countries, utilizing electric roasters, and partnering with sailpowered cargo or electric trucks for transportation. Furthermore, the report emphasizes the importance of forming partnerships with sustainability-driven companies and offers practical suggestions for implementing change. The study concludes that while total sustainability is complex, informed and intentional choices can significantly reduce the environmental footprint of coffee shop operations.

Introduction

Coffee and coffee-based beverage consumption in Canada is significantly high these days, which means businesses related to the coffee industry should be increasingly mindful of the environmental impact of their operations. Coffee shops, in particular, have the opportunity to adopt sustainable practices which in this industry means "the ability to produce today without compromising the ability of future generations to produce" (Farah, 2019) and actively contribute to reducing the negative effects their day-to-day activities may have on the planet. There are many aspects of operations that can be adjusted in more environmentally friendly ways. "Strategies can be applied across three strategic levels: corporate, business and functional" which mean focusing on customers engagement, capitalizing on behavioral shifts toward eco-friendly spaces and products and creating a tech-driven and sustainable customers (Madepo et al., 2025). However, the only major need that will drive all other actions is greater awareness of the available sustainable options and practical guidance on how to integrate them into regular business processes. As long as coffee shop owners and managers remain informed and committed to taking action, they can play a meaningful role in eco-conscious business management and contribute to keeping a cleaner, healthier planet.

Methodology

The systematic literature review approach

The systematic literature review approach was selected as the most suitable method for this research report, as it allowed for the comprehensive collection of both qualitative and quantitative data. The primary research process involved several key stages: identifying relevant studies, screening them for suitability, analyzing and categorizing the data, and systematically documenting the findings. This structured approach ensured a thorough and organized examination of existing research on the environmental impact of coffee shops, thereby providing a strong foundation for drawing relevant and reliable conclusions.

Procedures

To gather the literature, a combination of techniques was employed, including keyword searching, berry picking, citation chaining, and pearl growing. Keyword searching involved using specific terms related to the research topic to locate primary sources. Berry picking allowed for a more refined selection of particularly relevant and specific data. Citation chaining and pearl growing further expanded the scope of the research by exploring references found within the most pertinent articles, helping to uncover additional sources that might not have surfaced through keyword searching alone.

Identified audience

This research is intended for individuals interested in running a sustainable business and minimizing the environmental impact of their operations. It is particularly useful for coffee shop and bakery owners who want to explore options and steps they can take to make their businesses less harmful to the Earth, and to understand which business practices cause minimal environmental damage. Environmental industry associations may also find this report valuable, as it offers ideas on how to better support business owners in their sustainability efforts.

Findings

Spend Coffee Grounds Reuse

The research showed that currently, the consumption of coffee per capita in Canada is around 5.5-5.6 kg (Statista, 2024), and almost all of this organic waste goes to the landfill. According to Adane Getachew and Byung Soo Chun, the production of instant coffee and coffee brewing generates worldwide approximately 6 million tons of spent coffee grounds (SCG) per year (2017), which takes years to decompose. This is an opportunity for coffee shops to consider how to reuse spent coffee grounds in other products or processes, thereby reducing environmental impact and contributing to more sustainable food waste management practices.

Figure 1



Per-capita consumption of coffee in Canada from 2019 to 2029 (in kilograms)

Note: From Statista [Graph], August 29, 2024 <u>https://www-statista-</u> com.ezproxy.capilanou.ca/forecasts/1268008/canada-coffee-market-volume-per-capita One option, which has already been adopted by some places, is to repurpose spent coffee grounds (SCG) in organic farming and gardening to enhance both the speed and quality of plant growth due to its presence of minerals. SCG serves as a valuable source of "nitrogen, phosphorus, and potassium, as well as nutrients like calcium and magnesium," making it suitable for use as a fertilizer to improve soil quality (Becker et al., 2024). This leads to healthier plants with qualities more suitable for human needs and may also be beneficial in the context of farm animal feed. For instance, because "SCGs are rich in polysaccharides, polymers that can be used as dietary fibers," they can be added in small amounts to the feed of cattle, such as sheep. This practice has been shown to increase milk production without impairing feeding behavior or apparent digestibility (Franca & Oliveira, 2022).

Another innovative practice is incorporating spent coffee grounds (SCG) into baking, particularly by adding them to cookie recipes. A study conducted by Mitra Ahanchi and colleagues showed that "in terms of moisture, cookies containing 10.0%, 17.5%, and 25.0% SCGs demonstrated a reduced moisture content compared to the control cookies that did not include SCGs," which is attributed to the water absorption capacity of SCG. This characteristic suggests that SCG powder can help extend the shelf life of baked goods. In addition to this benefit, cookies made with SCG also contain a higher percentage of fiber, offering a nutritional advantage. For similar reasons, SCG can be incorporated into a wide range of flour-based products, including pasta, bread, biscuits, and muffins (2024). Furthermore, since spent coffee grounds contain oil, they can serve as an effective substitute for butter in baking. As noted in the research, "The addition of 20% coffee oil to substitute butter showed high antioxidant properties and a softer texture of cookies," contributing to a reduced fat content in baked goods. This makes SCG an appealing ingredient for health-conscious or vegetarian-focused bakeries and food retailers. For those open to experimenting further, it is also possible to replace or blend wheat flour with SCG powder, while still achieving acceptable results (Meerasri & Sothornvit, 2022). In the food and beverage industry, coffee waste generated by cafés can be repurposed as a source of flavor and aroma, especially in the

production of alcoholic beverages like coffee-flavoured liqueurs. SCG extracts are known for their strong and distinctive aroma, which can impart a rich and robust coffee flavor profile to liqueurs and similar products. According to Franca and Oliveira, these extracts possess a highly expressed flavour and odor "with acceptable organoleptic qualities", meaning they meet sensory standards in terms of taste, smell, and overall enjoyment. By utilizing SCG in this way, producers can achieve a desirable depth of flavor without the need for synthetic additives or flavorings (2022).

In addition, as Payton Becker and his team state, "used coffee grounds (UCG) after brewing still provide a significant amount of natural dye suitable for dyeing textiles", offering another way to use UCG instead of simply disposing of it. The only need is to soak grounds in water which would create an UCG extract that can be used on most materials such as wool, cotton, silk, nylon, flax, polyester, and nylon; however, "the chemical composition and the proportions of the components in the UCG can vary based on the type of coffee plant (e.g., Arabica or Robusta), growth conditions (elevation, temperature), initial brewing method, and the brewing or extraction of the dye from the UCG." Generally, it provides vivid, better in terms of saturation and colorfastness results, especially on natural, without any synthetic components, textiles (2024).

On top of that, spent coffee grounds (SCG) can be incorporated into the production of cosmetics and personal care products. SCG can be utilized in a variety of formulations such as soaps, face and body creams, exfoliating scrubs, and even air fresheners. This is due to the rich composition of bioactive compounds naturally present in spent coffee grounds, which offer both functional and sensory benefits. As research shows, "SCG contains large amounts of organic compounds (more than 1000 individual compounds) such as proteins, carbohydrates, cellulose, non-protein nitrogenous compounds, fatty acids, amino acids, polyphenols, minerals, lignin, and polysaccharides, namely galactomannans and arabinogalactans." These components are commonly found in many commercial products used in the cosmetic and chemical industries (Atabani et al., 2019).

Finally, used coffee grounds can even find valuable applications in industries that are not directly related to coffee such as construction and materials engineering. One innovative and large-scale option involves including spent coffee grounds (SCG) into sustainable concrete mixes. This approach offers an effective solution for use large volumes of discarded coffee waste, helping to reduce landfill contributions while supporting the development of greener building materials. Construction professionals can add SCG to concrete formulations due to its high porosity, which makes the material lighter and can improve its physicochemical and mechanical properties (Rajeev et al., 2023).

Chaff, Pulp, Husk and Silverskin Use

During the process of preparing the final coffee grounds used in coffee shops, coffee beans undergo various stages, including drying, roasting, and grinding, each of which generates residues that are often discarded as waste. However, these byproducts could be used in different industries, offering new opportunities for sustainability. For example, during the roasting process, the silverskin separates from the coffee bean used for brewing. This byproduct is a rich source of "antioxidative agents" and can be utilized in cosmetic production, providing a natural alternative for skincare products (Rodrigues et al., 2014). Similarly, according to Franca and Oliveira, coffee husks and pulp residues "are obtained after dehulling of the coffee cherries during dry or wet processing." These byproducts can be repurposed by adding them to substrates to help produce an edible mushroom called Flammulina or mixing them with other agricultural waste to facilitate the aeration composting process (2009). Additionally, these residues can be used in applications where they are not ingredients themselves but serve as materials for creating products that are 100% compostable. For example, the Canadian brand Club Coffee uses chaff to make their coffee pods, which do not need to be disassembled and can be fully composted (Club Coffee, n.d.).

Processes and Supply Chain

The research also focused on the sustainability of coffee shops' operations and supply chains, as Canada imported 2.7 million 60-kilogram bags of coffee last year—equal to 162 million kilograms (Statista, 2024). This contributes to high carbon emissions, especially since "coffee's life-cycle carbon footprint ranges from around 70 grams per cup for instant to as much as 150 grams per cup for filter coffee" (Reay & Springer Nature, 2019). As shown in the graph, this is already a concern in Canada, where greenhouse gas emissions have shown a steady upward trend almost every year (Statista, 2024). Nonetheless, as research shows, there are numerous opportunities within coffee supply chains to reduce their climate impact — from 8 Climate-Smart Coffee practices, which refer to eight types of sustainable strategies aimed at reducing environmental impact, improving resilience to climate change, and often promoting fair trade, to using lower-emission ships and trucks for transportation, and adopting renewable energy during the processing and roasting phases (Reay & Springer Nature, 2019).

Figure 2



Volume of coffee bean imports to Canada from 2010/11 to 2023/24 (in million 60-kilogram bags)

Note: From Statista [Graph], USDA Foreign Agricultural Service, June 20, 2024 https://www-statistacom.ezproxy.capilanou.ca/statistics/448862/coffee-bean-imports-canada/

Figure 3

Greenhouse gas emissions in Canada



Annual greenhouse gas emissions in Canada from 1990 to 2022 (in million metric tons of CO_2 equivalent)

Note: From Statista [Graph], 2024 <u>https://www-statista-</u> com.ezproxy.capilanou.ca/study/109169/emissions-in-canada/

According to TrendEconomy, Canada currently sources the majority of its coffee supplies from the United States, which stands out as the geographically closest option. In addition to the U.S., other primary countries that export coffee to Canada include Colombia and Switzerland (n.d.), both of which play a significant role in the supply chain. On the other hand, Mexico, despite being the second-closest country to Canada by land distance, remains the least utilized source of coffee, highlighting a notable contrast in import patterns.





Figure 5



To minimize energy use, several common strategies can be implemented. These include adopting energyefficient roasters, making use of renewable energy sources, and optimizing roasting profiles to ensure that the roasting process is as efficient as possible. "The process of roasting typically involves heating green coffee beans to temperatures between 180 °C and 230 °C, requiring substantial energy input," so higher levels of roasting demand more energy, which leads to increased CO₂ emissions. "According to a study by the International Coffee Organization, the carbon footprint of roasting can range from 0.744 to 0.801 kg of CO₂ per kilogram of coffee, depending on the roasting equipment and energy source" (Tsai et al., 2025).

According to the World Coffee Portal, there have been significant innovations in commercial coffee roasting machines currently available for businesses. One example is from the German manufacturer Neuhaus Neotec, which developed a commercial coffee roaster with a capacity of nine million kilos. This machine is fully electric and has the potential to reduce emissions by approximately 800 tonnes annually within a single roasting facility. As a result, it offers a more sustainable option for operations, helping to lower the environmental impact associated with the coffee roaster, is designed with sustainability in mind. The operation is organized to minimize water consumption, incorporates the use of sustainable building materials, and is optimized for energy efficiency (2024). Furthermore, Café William has also partnered with the TransOceanic Wind Transport (TOWT) company to import coffee using sail-powered cargo ships, a move that significantly reduces carbon emissions. For situations where land transportation is necessary, they plan to transition to electric trucks such as Tesla semi-trucks for logistics, further contributing to decarbonization efforts (Patterson, 2024).

Another process that deserves attention is coffee grinding, as it results in the release of diacetyl and 2,3pentanedione - both of which cause "bronchiolitis obliterans, a rare and severe respiratory disease" of workers. The level of these emissions varies depending on the type of roast used: French roast has the highest mass emission factor of diacetyl, followed by medium espresso, and then espresso. Additionally, the duration of the grinding process influences the amount of emissions released. "It was determined that after 30 minutes from the start of grinding, more than 90% of emissions had been evacuated from the chamber," which means that the safest period is only the first half hour; after that, workers get progressively higher risk of exposure (Echt et al., 2021).

Discussion

Partnership Options

Based on research, there are several partnership options related to the circular economy for coffee shops that could be considered. The focus could be on recycling the used coffee grounds that accumulate after the preparation of nearly every drink. This large amount of byproduct, which is accumulated constantly, is a great opportunity for coffee shops to find partners while actively contributing to the sustainability of the industry. Due to the various elements still present in coffee grounds after brewing, companies from other industries might be interested in incorporating this "waste" into their processes. This exchange could provide cost and profit benefits for both parties, alongside ecological advantages for Canada.

The opportunities for places that could be interested in coffee shops providing them with spent coffee grounds (SCG) are almost endless. These include businesses, companies, and organizations in agriculture — more specifically, farms that grow plants and raise animals; medical and scientific fields that focus on different innovations and experiments involving diverse coffee product ingredients; the food industry —

particularly baking; the textile industry with its need for eco-friendly dyes; the construction industry, which is trying to make materials stronger, but cheaper and less demanding on resources of the planet; and small crafting industries that create decorative or everyday-use items that do not require perfect quality or durability.

Collaboration with cosmetic brands also presents endless opportunities for a circular economy because spent coffee grounds still contain beneficial elements for the human body. For example, coffee shops can consider providing their spent coffee grounds (SCG) to companies such as RFINE which is a Canadian innovator in the sustainable coffee industry. Currently, this company is conducting a pilot demonstration of the Kaffika Drying Appliance — a machine that dries SCG and transforms it into food-grade ingredients for both humans and animals (Canadian Food Innovation Network, 2024).

If offering more specific advice and actionable strategies, coffee shops can consider forming partnerships and doing business with other small, sustainability-focused brands. For instance, Etsy Co. in Vancouver features a line called "Grounds Up," which offers handcrafted products made from spent coffee grounds. Collaborating with such businesses not only supports the local economy but also helps reduce waste by giving coffee grounds a second life through creative, eco-friendly products.

Moreover, coffee shops can use not only coffee grounds, but also other residues from coffee-related processes and focus on collaboration with local small companies that specialize in innovation. For instance, Club Coffee has created 100% compostable coffee pods with a ring made from a material developed in Ontario, in partnership with the University of Guelph. This material includes coffee chaff — a natural byproduct of the coffee roasting process (Club Coffee, n.d.). This example shows that coffee shops can donate or sell the coffee chaff they collect during roasting to companies that use it in their material mixes. Speaking of modifying material mixes, a great amount of spent coffee grounds could be

needed in future construction projects, as companies begin to add it into concrete to make it lighter, cheaper, and still durable.

As an extra initiative, which may not generate profit but will still make an ecological difference, coffee shops can offer their customers the option to take some spent coffee grounds home for use in houseplants or gardens. To make this happen, coffee shops would only need to raise awareness among customers about this option and about the positive effects of coffee grounds on soil, which can lead to better plant growth. Even if demand isn't high, it would still have a positive environmental impact without requiring extra costs from the business.

Emission Reduction

Besides focusing on reusing waste, coffee shops could also focus on modifying their operations and supply chains to make them more sustainable, reducing emissions and pollution.

One adaptation for reducing carbon emissions is simply making more conscious choices about the countries from which Canada imports coffee. While continuing to import ready-to-brew coffee from the USA can still be the first option, there could be an increased focus on sourcing raw, unprocessed coffee from Mexico, as it is geographically closer to Canada than other more common suppliers like Colombia and Switzerland. This choice would result in a shorter transportation distance and less energy required by transport, which would lead to lower carbon emissions. Additionally, more coffee could be imported from countries where transportation by sea is a more convenient option than land transport, especially for coffee shops located in Vancouver, which has many ports and established shipping logistics because transport by sea causes less carbon emissions than air or land transport, further minimizing the carbon footprint (Lui & Ma, 2022).

Furthermore, when considering emissions and the supply chain, coffee shops could focus on the type of transport used to import their coffee products. As an alternative to commonly used transportation, coffee shops can opt for sail-powered cargo ships and electric trucks for their logistics. These alternatives require significantly less fuel and electricity, both of which contribute heavily to air and water pollution. Companies like TransOceanic Wind Transport (TOWT) already provide sail-powered cargo ships to deliver coffee from Latin America to Canada, so more coffee shops can switch to such partners and avoid older types of ships. They can also collaborate with Tesla to use their new semi-trucks for imports, particularly when import is from the United States (Patterson, 2024). Coffee shops need to keep seeking greener alternatives, as innovations are rapidly changing everything, and logistics routes should constantly adapt to become more sustainable. Moreover, coffee shops can collaborate with local delivery companies, such as Canada Post, to handle order deliveries. Since these companies already have highly optimized logistics systems, extending their delivery load slightly to include coffee shop orders and eliminate extra deliveries separately from each coffee place can help reduce carbon emissions.

In addition to the supply chain, large coffee shops can improve their internal operations to become more eco-friendly. One option is optimizing the roasting process by reducing roasting time and improving the efficiency of roasting machines (e.g., adopting advanced technology such as automated control systems, upgrading machinery to models with higher energy efficiency, and implementing multi-stage roasting profiles). "Electric and hybrid roasters, for example, have gained attention for their ability to reduce reliance on fossil fuels" (Tsai et al., 2025). By switching from current machines to new 100% electric coffee roasters, such as the one manufactured by Neuhaus Neotec, coffee shops can reduce their carbon emissions (World Coffee Portal, 2024). Smaller electric roasters are also available for small coffee shops (e.g., Bullet Roasters and Bellwether Roasters) (McCleery, 2024). "Additionally, technologies such as heat recovery systems can capture and reuse heat generated during the roasting process, further improving energy efficiency." Furthermore, using solar panels can reduce emissions by 25%, so installing solar panels at roasting facilities can replace a portion of grid electricity with clean energy (Tsai et al., 2025). Another aspect to consider is worker safety and health. Coffee shops that perform the grinding process on-site should focus on choosing coffee with an espresso roast instead of French or medium espresso roast types, as it results in lower emissions of diacetyl and 2,3-pentanedione, potentially saving workers' lungs. Additionally, grinding should be scheduled appropriately, limiting each batch to 30 minutes. If the process exceeds this time, emissions can increase significantly with each passing minute (Echt et al., 2021).

As Juliana Bechara, co-founder of Bioma Food Hub - Brazil's first hub dedicated to sustainably transforming the food system - emphasizes, industry players have a major role to play in advancing sustainability, and achieving meaningful progress requires both support and collaboration. This insight highlights the importance of collective action within the sector. Therefore, all businesses, regardless of size, are encouraged to form partnerships with local, innovative companies that are actively working on sustainable solutions (March 12, 2025). By doing so, they not only strengthen their own operations but also contribute to a broader movement toward environmental responsibility and systemic change. More specifically, in coffee industry, to support Canadian coffee shops in adapting their processes and logistics toward greater sustainability, businesses can seek guidance, support and resources from established organizations and associations. These include Reunion Coffee Roasters, Bullfrog Power, Fairtrade Canada, Rainforest Alliance, and the Canadian Coffee Association (CCA) etc. Each of these organizations has been active in the industry for years, offering expertise, certification programs, and practical tools aimed at helping businesses reduce their environmental footprint. By collaborating with or learning from these groups, coffee shops can implement more responsible sourcing practices, transition to renewable energy solutions, and improve overall sustainability throughout their operations. In addition to forming partnerships, coffee shops can also make more sustainable choices by carefully selecting their suppliers,

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as some farms operate with much stronger environmental and social responsibility than others. For instance, Bom Jesus Farm in Brazil was recognized as the most sustainable farm in 2023. Once a cattle farm, it was transformed by a family into a coffee farm focused on sustainability. The owners undertook efforts such as rainforest reforestation, organic farming, water conservation, carbon capture, and community support—all aimed at restoring ecosystems and creating a positive local impact (McCleery, 2024). Farms can also be chosen based on the type of coffee they cultivate, as different varieties have varying environmental impacts. For instance, coffee shops may opt to source their beans from regions that grow Robusta, which is more heat-tolerant than Arabica and requires significantly less water to cultivate. This makes it a more sustainable choice in terms of resource use. By selecting Robusta, businesses can promote water efficiency and also contribute to lower carbon emissions, since the reduced need for irrigation means less energy is consumed throughout the farming process (Reay & Springer Nature, 2019).

Conclusion

In conclusion, it is important to mention that coffee products do not have to be 100% sustainable due to the complexity of all the factors required for producing this beverage; however, some processes can definitely be organized in a much more sustainable way (Farah, 2019). Coffee shop owners just need to be conscious of their business actions and decisions that they take every day. By making meaningful changes that were mentioned in the report, they can contribute to a more responsible coffee industry while still maintaining a successful business. Adapting the business in even a few aspects will already demonstrate that a coffee shop is reliable and focused on long-term change. This example can influence other participants in the industry to become more conscious and start participating in sustainability. There is a chance for an eco-friendly future for the Earth; each of us is responsible for this future, and it

is time to take action toward a better tomorrow; otherwise, sustainability in the long run may no longer be an option — it will become a requirement (Farah, 2019).

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