Life-Cycle Assessment For Value Chain Blueprint And Carbon Footprint Analysis: A Case Study Of Pizza 4P's In Vietnam

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Abstract

This study investigates the sustainability practices of Pizza 4P's, a prominent figure in Vietnam's food industry, using a Cradle to Gate Life Cycle Assessment (LCA) approach with Open LCA software. Focusing on 4P's pizza production which has a 252 supplying partners, this study uncovers the environmental benefits of their sustainability endeavors, including the finding that the making of a 4P's pizza emits 28 percent less carbon dioxide than a normal pizza, and highlights strong partnerships with like-minded suppliers. However, it also suggests room for improvement, emphasizing the need to expand sustainable supplier networks, address technical challenges, and adopt circular economy principles for organic waste management. Encouraging customers to choose vegetarian pizzas is recommended for further sustainability. This offers practical insights for both the company and the wider food and beverage industry, underlining the crucial role of sustainable practices in shaping the future of food production and consumption.

Keywords

life-cycle assessment, circular economy, value chain, carbon footprint, food and beverage

1. Introduction

Food system activities are inextricably linked with climate and weather, environmental resources and human behaviour. GHG emissions from food systems are a major contributor to climate change. Globally, food system activities contribute 21-37 per cent of total anthropogenic GHG emissions, compared with about 10 per cent from food production alone and 18-29 per cent from food production and land use change (Rosenzweig et al., 2020). Land use change, especially deforestation, forest degradation and peatland conversion, contributes to substantial GHG emissions. Total GHG emissions from the food system were about 16 CO_2 eq per year in 2018, or one-third of the total global anthropogenic GHG emissions. Three quarters of these emissions, 13 Gt CO_2 eq per year, were generated either during on-farm production or in pre- and post-production activities, such as manufacturing, transport, processing, and waste disposal (Rosenzweig et al., 2021). The remainder was generated through land use change of natural ecosystems to agricultural land. Substantial CH_4 emission are best attributed to the specialized production of beef in large production systems. During 1990-2018, land use change emissions decreased while pre-and post-production emissions increased (Tubiello et al., 2021). Post-production food system activities contribute to GHG emissions, albeit to a lesser extent compared with production-related and land use activities. Post-production food system activities account for 18 per cent of total GHG emissions from the global food system compared with 58 per cent from food production and 24 per cent from land use change (Poore & Nemecek, 2018) .

In Vietnam, Pizza 4P's is one of the most influential entities in the country's food production industry due to its commitment to sustainability. This study aims to examine the company's value chain blueprint and carbon footprint in order to showcase lessons learned that may benefit other companies in the food and beverage industry.

2. Methodology

2.1. Life Cycle Assessment and the Open LCA

This study utilizes the Life Cycle Assessment (LCA) method to analyse the value chain of the Pizza 4P's. LCA is based on Life Cycle Thinking, a paradigm that considers the environmental impact at all stages of the life cycle. Therefore, at the global level, LCA is considered one of the most reliable methodologies to assess the environmental impacts of products/services or processes and to identify effective solutions to address sustainability issues (Notarnicola et al., 2017). The LCA technique can be applied with defined boundaries by adopting two strategies. The first strategy considers a complete life cycle analysis, so called “cradle-to-grave”; on the contrary, in the second strategy, only a part of the life cycle is investigated; it is called “cradle-to-gate”, “gate-to-gate”, or “gate-to-grave” depending on the

boundaries considered (Boenzi et al., 2022). Therefore, LCA is a widely recognized approach for both mapping the value chain and assessing the carbon footprint of products and services, particularly within the food and beverage industry.

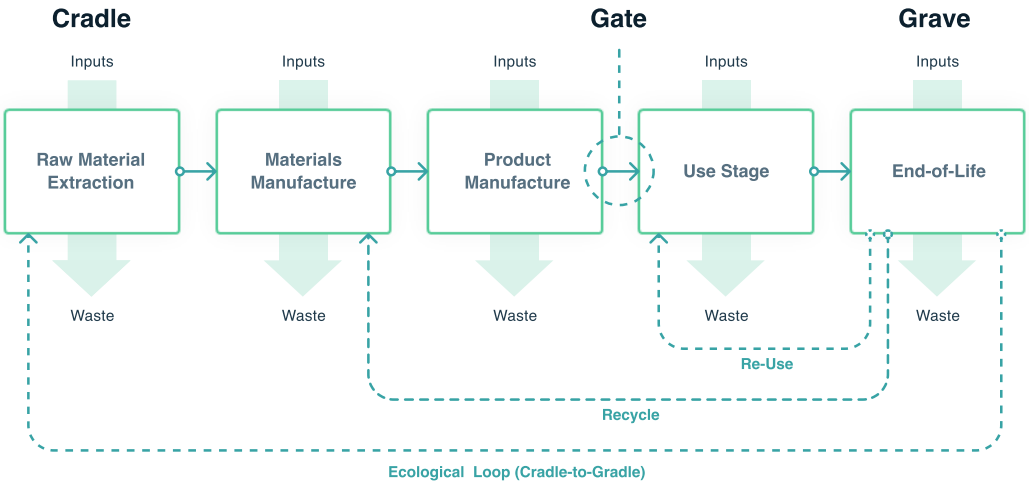

Figure 1. Boundaries of a LCA analysis

However, this study focuses on the Cradle to Gate instead of the entire Cradle to Grave to highlight the innovative approaches and practices of 4P's in the upstream value chain rather than the downstream parts (e.g. waste disposal, end-of-life equiments and vehice) which often require a larger scale of analysis, such as a group of companies in the F&B industry with similar waste types or within a geographical boundary (e.g. a city, an industrial zone), and should involve local landscape of waste management. Some landscape (e.g. government policies and strategies) are not determined by the 4P's.

In terms of GHG emission, the focusing on Cradle to Gate also allows us to identify opportunities for reducing carbon emissions in the production and supply of raw materials, production processes, and transportation of 4P's and partners. In details, we conduct analysis and provide insights into the carbon footprint of 4P's value chain and identify areas for improvement that can result in significant environmental benefits. The use of LCA in measuring carbon footprint provides a comprehensive and systematic approach to identify and quantify the environmental impacts associated with the entire life cycle of a product.

In addition, we employ Open LCA software to support our LCA calculation and analysis. Open LCA is an open-source software tool that allows for the creation and analysis of life cycle assessments. One of the key advantages of Open LCA is its flexibility in data entry and the ability to customize the analysis to suit specific requirements. Open LCA also provides access to a range of databases, which contains data on environmental impacts associated with various products and services. The use of Open LCA in this study allows for a comprehensive and robust assessment of the environmental impacts associated with 4P's value chain, providing valuable insights for decision-making and sustainability performance improvement.

Our LCA analysis examined the food processing of 4P's in order to provide a comprehensive map of 4P's value chain for pizzas. It is notewothy that there are plenty of other 4P's products (i.e. coffee, beer, pasta, salad, fried chicken, crab tomato cream spagetti, beaf tongue). However, we chose to focus on pizzas for 2 reasons: (i) Firstly, pizzas stand as the primary and iconic products of 4P's, which the company initiated its journey with; (ii) Secondly, the value chain of pizzas, encompassing over 20 different types, is already intricate. By concentrating on pizzas, we can conduct thorough analyses within the constraints of our time frame. Such comprehensive analyses are essential for deriving meaningful recommendations not only for 4P's but also for other companies in the food and beverage industry.

In addition, we employed EF method 3.0 (Adapted) for environmentnal footprint analysis. EF Method 3.0 is a widely used methodology for conducting environmental footprint analysis. The adapted version of EF Method 3.0 indicates that certain modifications have been made to tailor it specifically for the food processing sector. It provides a comprehensive framework for assessing the environmental impacts of various activities, including food processing. The method takes into account multiple environmental indicators, such as greenhouse gas emissions, water consumption, land use, and energy use. By quantifying these impacts, EF Method 3.0 (Adapted) enables a holistic understanding of the environmental footprint associated with food processing activities. Therefore, LCA is recommended as a tool for policy impact assessment and the EF method has been developed as reference (Sala et al., 2020).

2.2. Data collection

Data for analysis was collected from primary and secondary sources. The secondary data includes the reports of 4P's company, previous studies on estimating the intensity of GHG emission in agricultural production and food processing and databases of GHG emission.

- Information about the partners and main production activities and support in the value chain of the 4P's company is collected through the company's annual report and sustainability reports in the period of 2019-2022. Then an overall map of the value chain of 4P's was developed and serve as the basis for identifying key activities that contribute to the company's sustainable value chain.
- Information about the company's sustainable activities throughout the value chain such as purchasing raw materials, processing, selling products at restaurants, cafeteria and shops... is partially collected from the company's sustainability report. Collected data was integrated into the value chain blueprint.
- The intensity of GHG emission of agricultural and food production was obtained from previous studies and database. This information was then used to estimate the reduction in GHG emission from value chain of 4P's company to prove that it is sustainable and contribute to net zero emission.

Primary data was collected through observation and in-depth interview in a field trip to the partners in the value chains of 4P's company. This field trip was conducted in April 2023 to

the Pizza 4P's cheese factory and 06 partner farms/production sites (e.g., Thien Sinh farm, Zanya Coffee, Dalat Ecology, Orlar farm, Hasfarm Greens and Yoshimoto Mushroom) in Lam Dong Province. During the field trip, in-depth interviews were conducted with the managers, the agricultural engineers and the staffs to collect information on the operation of the factory and farms, their understanding of sustainable development and their intentions to apply more sustainable practices in the future. In addition, indepth interview was also conducted with the managing chef of 4P's on the management in the restaurant, components and the typical processing of 4P's pizza.

3. Results

3.1. Value chain blueprint of the Pizza 4P's

According to 4P's sustainability reports, the company set a vision to 'Make the World Smile for Peace' since its inception. Accordingly, 4P's has been on mission to provide access to inner peace, enabling individuals to engage in acts of compassion and fostering lasting happiness for everyone. To date, there are totally 252 supplying partners in 4P's value chain, with thousands of employees over all 3 regions of Vietnam and overseas (4P's, 2022). It is worth noting that many of Pizza 4P's partners share the same long-term vision of bringing smiles to their customers, spreading happiness, and promoting environmentally friendly solutions in their own business models. This unity of long-term vision is an impressive observation that likely guarantees the sustainability of their partnerships and demonstrates the positive impact of Pizza 4P on their partners.

Our LCA analysis resulted that there are 4,504 process links in the making of 1 typical 4P's pizza. The process links include not only direct inputs (i.e., ingredients) but also indirect inputs (i.e., electricity, diesel, water in different processes). To streamline the map's complexity, we simplify the complete value chain of the 4P's by categorizing partners as either 'sustainable' or 'certified sustainable' (referred to as sustainability here), as illustrated in Figures 2 and Figure 3 below.

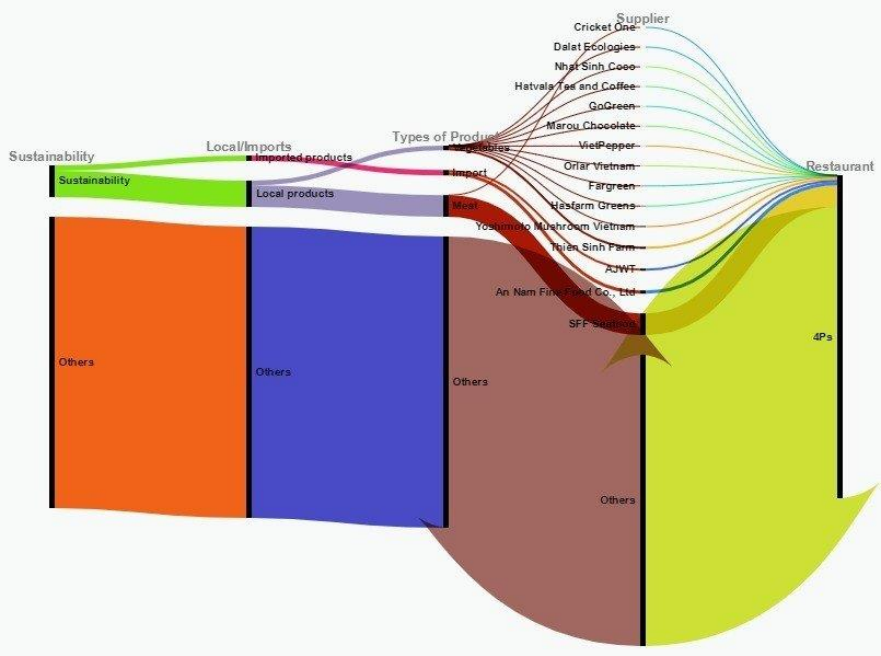

Figure 2. A map of Pizza 4P's value chain, by value (all partners)

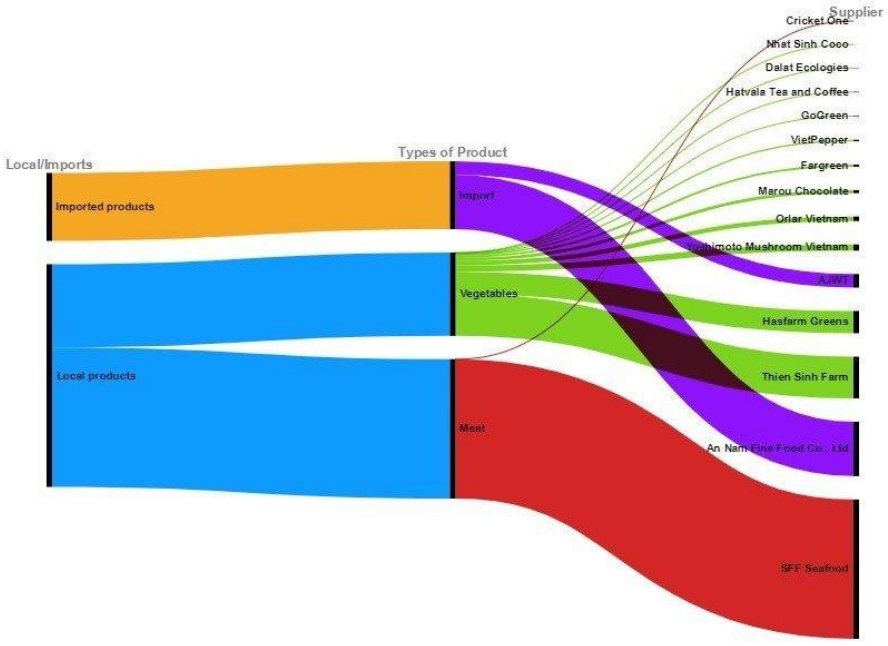

Figure 3. A simplified map of Pizza 4P's value chain, by weight ('Sustainable' and 'Identified sustainable' partners only)

Accordingly, there are some intriguing findings as follows.

Firstly, Pizza 4P's has a wide range of sustainable supplying partners for vegetables, meat, and even imported products. However, there is substantial room for improvement since, currently, these partners can only meet a small portion of Pizza 4P's ingredient demands.
Secondly, the majority of sustainable partners primarily provide local ingredients sourced from Vietnam. However, a few imported ingredients are necessary due to the unavailability of high-quality alternatives within Vietnam, such as wheat and olive oil.
Thirdly, vegetables (including rocket, capsicum, and carrots) play a crucial role in 4P's dishes, and the company has established several sustainable supplying partnerships for these ingredients. However, when it comes to meat, such as beef, pork, and shrimp, there is only one sustainable supplying partner available (SFF Seafood). It would be sensible for 4P's to look for some other sustainable partners in the market of meat.

3.2. Carbon footprint analysis

Table 1 below shows the environmental footprints of 1 kg pizza. Each selected indicator is displayed in the rows and the project variants in the columns. Here we calculate the environmental footprints of 3 different pizza types for comparison: 4P's vegetarian pizza, 4P's non-vegetarian pizza and the Baseline. In there,

(i) 4P's vegetarian pizzas include variety of dishes such as mushroom pizza, margherita pizza, kale pizza or zucchini pizza. However, to streamline and prevent confusion, we have selected the best-selling mushroom pizza to represent all the vegetarian options at 4P's. This choice was made following a consultation meeting with the head chef of Pizza 4P's in Ha Noi.
(ii) Similarly, the non-vegetarian pizza offerings at 4P's are epitomized by the Shrimp Mayonnaise Pizza, which stands as the top-selling choice among non-vegetarian selections.
(iii) Information regarding the baseline is derived from a typical pizza available in the market. However, owing to privacy considerations, we are unable to disclose the specific names associated with these pizzas.

Table 1. Environmental footprints of 1 kg pizza

#	Indicator	4P's vegetarian pizza	4P's non-vegetarian pizza	Baseline (Conventional non-vegetarian pizza	Unit
1	Climate change	9.78E+00	1.18E+01	1.64E+01	kg CO2 eq
2	Climate change - Biogenic	8.71E-01	8.76E-01	1.07E+00	kg CO2 eq
3	Climate change - Fossil	8.79E+00	8.03E+00	1.07E+01	kg CO2 eq

4	Climate change - Land use and LU change	1.11E-01	2.91E+00	4.63E+00	kg CO2 eq
5	Ecotoxicity, freshwater	1.25E+02	3.09E+02	4.64E+02	CTUe
6	Ecotoxicity, freshwater - inorganics	1.82E+01	2.32E+01	3.33E+01	CTUe
7	Ecotoxicity, freshwater - metals	8.34E+01	2.54E+02	3.85E+02	CTUe
8	Ecotoxicity, freshwater - organics	2.37E+01	3.24E+01	4.62E+01	CTUe
9	Land use	1.43E+02	5.09E+02	7.61E+02	Pt
10	Ozone depletion	1.75E-06	1.37E-06	1.78E-06	kg CFC11 eq
11	Particulate matter	6.22E-07	7.71E-07	9.98E-07	disease inc.
12	Photochemical ozone formation	4.32E-02	4.85E-02	6.52E-02	kg NMVOC eq
13	Resource use, fossils	1.28E+02	1.11E+02	1.46E+02	MJ
14	Resource use, minerals and metals	1.96E-05	2.59E-05	3.44E-05	kg Sb eq
15	Water use	2.39E+00	3.40E+00	4.53E+00	m3 depriv.

As can be seen, the carbon footprint analysis reveals that 1kg non-vegetarian pizza by 4P's emits 11.8 kg of CO2 eq (directly and indirectly) into the atmosphere. This data clearly shows that Pizza 4Ps is significantly more eco-friendly than the normal pizza (baseline),

which has a carbon footprint of 16.4 kg of CO2 eq with each kg of pizza. So, the making of a 4P's pizza is emitting 28 percent less carbon dioxite than a normal pizza.

Some key differences between 4P's pizza and the baseline were accounted in the calculation including:

- The utilization of organic ingredients, such as organic vegetables.
- Inclusion of distinctive ingredients, for instance, Roman lettuce and edible flowers for decorative purposes.
- Utilization of homemade cheeses in place of imports.
- Implementation of an iconic Supply Chain Management (SCM) system, resulting in only 10-15 percent waste.
- Reduction of baking time from 7 minutes to 1 minute 30 seconds, accompanied by an extended period for yeast fermentation and higher oven temperatures (up to 700 degrees Celsius).
- Implementation of recycling initiatives, including recycling whey from cheese production for dough kneading (internal use) and for cattle feed and irrigation (external collaboration with Thien Sinh Partner). However, the recycling of flowers/plants for fertilizer production at Hashfarm was not considered due to limited available data.

All of these initiatives explain why 4P's has significant smaller carbon footprint to the baseline (Figure 4)

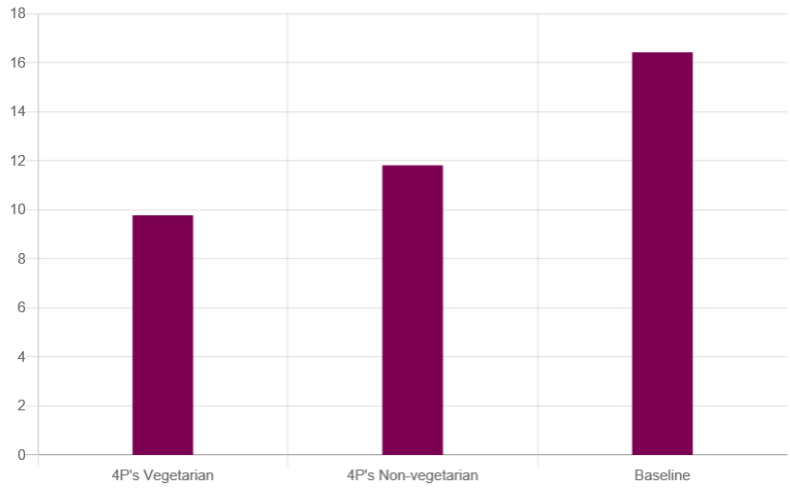

Figure 4. The direct carbon footprint of 4P's vegetarian and non-vegetarian pizza versus the baseline

Another intriguing finding is that 4P's vegetarian pizza has a slightly smaller carbon footprint compared to their non-vegetarian pizza – 9.78 kg of CO_2 eq comparing to 11.8 kg of CO_2 eq. This is quite surprising because normally non-vegetarian ingredients like beef, shrimps emitt significantly more GHG during the production than vegetables (González-García et al.,

2018). Using LCA to track down the entire value chain of 4P's pizzas, we find that the GHG emission of vegetarian ingredients is, in fact, significantly lower than that of non-vegetarian ingredients. However, due to losses incurred through peeling and root removal (roughly 15 percent of weight), the carbon footprint associated with vegetable transportation often surpasses that of meat.

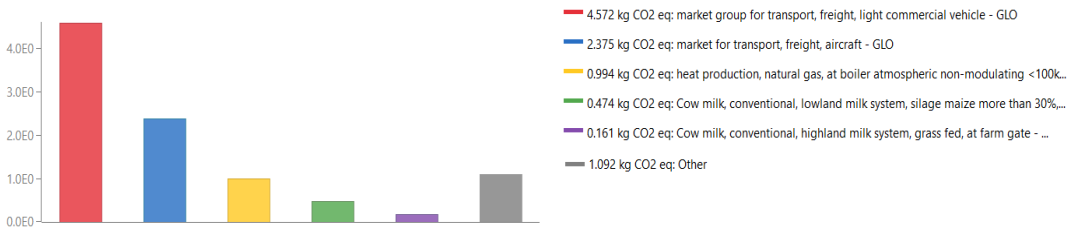

Figure 5. The detailed carbon footprint of 4P's non-vegetarian pizza

This reason is reinforced when we examine the direct carbon footprint of a typical 4P's pizza. In fact, **Figure 5** shows that transport is the biggest direct GHG emitter among all.

Apart from GHG emission, our LCA analysis also provide assessment on the other environmental footprints, such as water use, ozone depletion, land use. The following **Figure 6** shows the relative indicator results of the assessment. For each indicator, the maximum result is set to 100% and the results of the other variants are displayed in relation to this result.

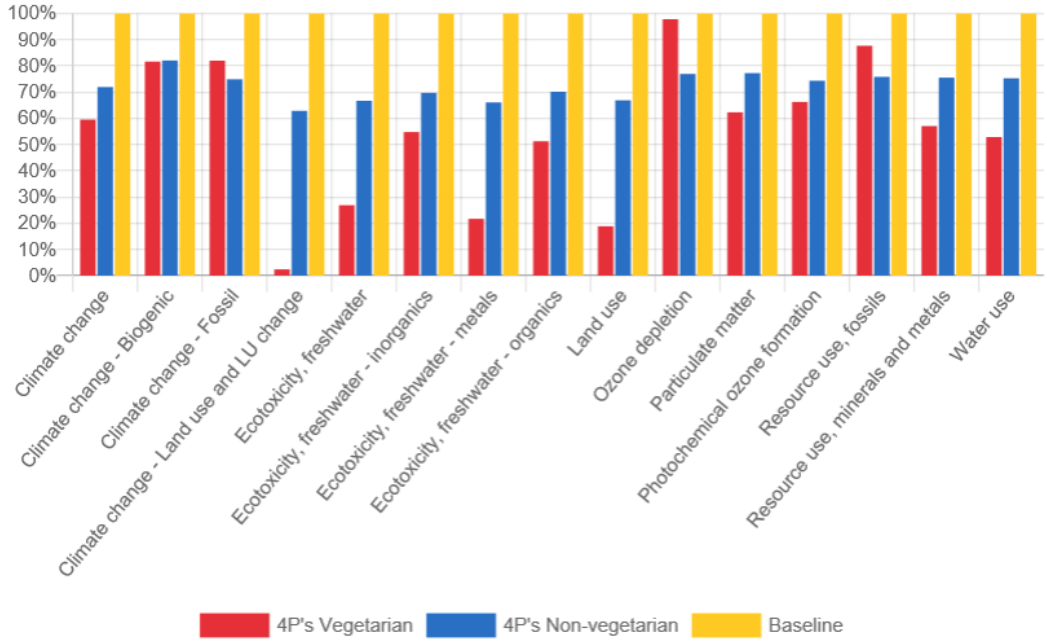

Figure 6. Pizza 4Ps' environmental footprints vs the baseline

As can be seen, 4P's vegetarian pizzas has over all lower environmental footprint than their non-vegetarian pizzas, apart from water use. Two implications can be withdrawn from this finding as follows.

- It is sensible to encourage customers to choose vegetarian pizzas over non-vegetarian pizza. It will help reduce not only 4P's carbon footprints but also their environmental footprints of the entire value chain.
- 4P's should further strengthen their cooperation with vegetable producers who employ innovative water-saving technologies like drip irrigation, vertical farming, and piping systems to conserve water resources (e.g., Orlar Vietnam Joint Stock Company and Hasfarm Green+, see Annex for more details).
- Suppliers should also measure and publish the carbon intensity of their products. Suppliers with large energy consumption and imported inputs (seeds, fertilizers, etc.) (resulting in large carbon emissions from transportation) should have a plan to reduce the carbon intensity of their products.
- Food processing losses and food waste should be utilized based on the circular economy approach for organic wastes.

4. Conclusion

This study aims to assess the value chain and measure the carbon footprint of 4P's, a renowned restaurant chain known for its commitment to sustainability. Through the application of life-cycle assessment (LCA) methodology and the utilization of Open LCA software, the study provides insights into the environmental impacts associated with 4P's value chain and identified areas for improvement. The findings shed light on the sustainability efforts of 4P's, their partnerships with sustainable suppliers, and the carbon footprint of their pizzas.

The study reveals several intriguing findings regarding 4P's value chain. One notable observation is the presence of sustainable partners who share the same long-term vision as 4P's, focusing on customer satisfaction, happiness, and environmentally friendly solutions. This unity of vision not only ensures the sustainability of their partnerships but also showcases the positive impact of 4P's on their partners.

The analysis of 4P's value chain highlights both strengths and areas for improvement. While 4P's has a wide range of sustainable suppliers for vegetables, meat, and imported products, there is room for improvement as these partners can only meet a fraction of the ingredient demands. Furthermore, the majority of sustainable partners primarily provide local ingredients sourced from Vietnam, with a few imported ingredients necessary due to the unavailability of high-quality alternatives within the country.

Within the realm of carbon footprint analysis, the study focuses on pizzas as they are the flagship dishes of 4P's. The LCA assessment using Open LCA software reveals the

environmental footprints of different types of pizzas, including vegetarian and non-vegetarian options, as well as a baseline pizza for comparison. The results showcase that 4P's pizzas has significantly lower carbon footprints compared to the normal pizza available in the market. Additionally, it is surprising to find that the vegetarian pizza had a slightly lower carbon footprint than the non-vegetarian pizza, challenging the common perception that non-vegetarian ingredients have higher GHG emissions. The study attributes this finding to the higher carbon footprint associated with vegetable transportation due to losses incurred through peeling and root removal. Overall, Pizza 4P's vegetarian pizzas has lower environmental footprints compared to their non-vegetarian counterparts, except for water use. Accordingly, this study provides some recommendation for 4P's as follows.

Firstly, the long-term vision of "Make the World Smile for Peace" should remain at the forefront of 4P's sustainability efforts. This vision not only benefits the business and customers but also contributes to environmental sustainability, including addressing Scope 3 GHG emissions. It is crucial to continue measuring and reducing emissions throughout the value chain, including the production and transportation of raw materials.

Secondly, 4P's has achieved commendable success in crafting and disseminating their sustainability reports, thereby offering comprehensive and transparent insights regarding their environmental performance, sustainability endeavors, and advancements towards their objectives. This information stands readily available to patrons, stakeholders, and the general populace, thereby underscoring 4P's unwavering dedication to sustainability and cultivating confidence in their brand. Nonetheless, it is imperative for partnering suppliers to similarly divulge their sustainable methodologies and pertinent details, encompassing aspects like water consumption and the carbon intensity of their merchandise. This approach would enable other F&B enterprises to glean insights, potentially emulating these sustainable initiatives.

Thirdly, recognize the large room for improvement and take proactive steps to address it. While 4P's has made significant progress in partnering with sustainable suppliers, it is essential to acknowledge that sustainable partners still represent a minority. To further reduce environmental impacts, 4P's should actively expand their network of sustainable suppliers. However, it is crucial to navigate some technical constraints, such as the availability and effectiveness of local seeds compared to imported ones. Additionally, careful consideration should be given to the cultivation of high-quality vegetables in northern Vietnam, where certain challenges may arise.

Forthly, it is recommended that food processing losses and food waste should be utilized based on the circular economy approach for organic wastes. Hence, finding relevant partners in treating the organic wastes and reporting these treatment activities would enhance both the environmental and reporting activities of 4P's.

Fifthly, Strengthen cooperation with vegetable producers employing innovative water-saving technologies. 4P's should actively seek partnerships with vegetable producers who utilize advanced water-saving techniques such as drip irrigation, vertical farming, and piping systems. These innovative approaches can significantly reduce water consumption in agriculture, contributing to water resource conservation. By collaborating with such producers, 4P's can not only enhance the sustainability of their supply chain but also showcase their commitment to environmental stewardship. This recommendation aligns with the objective of reducing the environmental footprint and demonstrates 4P's dedication to sustainability.

Furthermore, encouraging customers to choose vegetarian pizzas can help promote a shift towards more sustainable and environmentally friendly options, further reducing both the carbon footprint and environmental footprints associated with 4P's operations.

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