International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Life Cycle Assessment of Barbecue Food Stall in Barangay San Vicente, Liloan, Cebu

Delfa G. Castilla[1], Mary Lu P. Aratia[2], Clyde Nozreme A. Baritua[3], Troy Joshua A. Basaca[4], Harly Gel S. Dorog[5], Jess Bae Riblora[6], Alfred Lhesley Tortor[7]

[1]Professor, College of Engineering, Cebu Technological University - Danao Campus
[2,3,4,5,6]Student, College of Engineering, Cebu Technological University - Danao Campus

Abstract
This study evaluated the environmental impacts of barbecue food stalls in Barangay San Vicente, Liloan, Cebu, through a Life Cycle Assessment (LCA). The analysis encompassed key operational stages, including raw material sourcing, food preparation, cooking, energy and water use, and waste management. The results revealed significant environmental concerns, such as high carbon emissions from daily charcoal usage, substantial water consumption, and challenges in waste disposal. Each stall emitted approximately 144–180 kg of CO2 equivalent daily and consumed 18 gallons of water. Improper waste management practices further exacerbated the ecological footprint. To address these issues, the study recommended transitioning to energy-efficient cooking methods, implementing sustainable waste management systems, and promoting responsible sourcing practices. These measures aimed to reduce the stalls' environmental impacts while preserving their cultural and economic contributions to the local community.

Keywords: environmental impact, carbon emissions, waste management, sustainability, resource consumption

1. Introduction

Barbecue food stalls are a popular and integral part of the local food scene in Barangay San Vicente, Liloan, Cebu, providing affordable and delicious meals to residents and visitors. These small-scale businesses contribute significantly to the local economy and culture. However, like many informal food enterprises, the environmental impact of these stalls has largely been overlooked. As consumer awareness of sustainability grows, understanding the ecological consequences of everyday practices becomes essential, particularly in industries with high resource consumption and waste production.

This study aims to evaluate the environmental impact of barbecue food stalls in Barangay San Vicente through a Life Cycle Assessment (LCA) approach. LCA is a systematic method that evaluates the entire lifecycle of a product or service, from raw material extraction through to production, use, and disposal. The focus of this research is on the stages involved in barbecue food stalls' operations, including raw material sourcing, food preparation and cooking processes, energy use, water consumption, and waste management practices. By assessing the environmental effects at each stage, the study seeks to identify areas for improvement and provide actionable recommendations to reduce the ecological footprint of these

food stalls.

Through this research, we hope to raise awareness among stall owners, local authorities, and the community about the environmental challenges associated with food vending operations. The findings will also serve as a starting point for sustainable practices that can help minimize waste, reduce carbon emissions, and promote responsible resource usage, ensuring that the economic and cultural contributions of the barbecue food stalls align with environmental sustainability goals.

2. Related Research Work

The growing challenges of environmental degradation and resource scarcity have placed a spotlight on the need for sustainability across the food production and waste management sectors. In recent years, research has delved into various facets of food systems, offering valuable insights into the development of sustainable practices that mitigate environmental impacts while promoting efficiency and innovation. From production technologies to waste reduction strategies, these studies underscore the necessity of adopting integrated approaches to ensure the long-term viability of food systems.

A significant area of focus in this regard has been the application of Life Cycle Assessment (LCA)**,** a tool that enables the comprehensive evaluation of environmental impacts associated with different stages of a product's lifecycle. According to V. Silva et al. (2019)**,** LCA can serve as a critical framework for improving the assessment of alternative food processing technologies. By emphasizing cleaner production techniques, decision scaling, and the inclusion of nutritional, sensorial, and socio-economic dimensions, this research highlights the need for a multidisciplinary approach to decision-making in food production. Such an approach not only enhances the sustainability of food systems but also ensures that diverse stakeholder priorities are considered in the process. Expanding on the role of LCA in food-related innovations, Eleonora Foschi et al. (2020) demonstrated the potential of integrating LCA with eco-design principles in packaging design. Their findings revealed that thoughtful packaging strategies can significantly reduce plastic consumption and marine pollution, contributing to a circular economy that prioritizes resource efficiency. Similarly, C. Thomas et al. (2020) proposed a three-step modular LCA method that offers a structured and adaptable framework for assessing the environmental impacts of imprecise food pre-concepts. This method provides companies with the tools they need to embed eco-design principles into their processes, thereby improving sustainability outcomes from the initial stages of product development.

Beyond production and packaging, street food vending—a sector that plays a significant role in providing accessible and affordable food in urban and semi-urban areas—has also come under scrutiny for its sustainability and food safety practices. Belay Desye et al. (2023) explored the knowledge, attitudes, and practices of street food vendors in low- and middle-income countries, revealing substantial gaps in food safety compliance. These findings underscore the urgent need for targeted training and health education programs to empower street food vendors with the skills and knowledge required to uphold food safety standards. Addressing these gaps is not only critical for protecting public health but also for supporting the livelihoods of vendors who rely on this sector for their income. Also, improving food safety practices can enhance the overall reputation and trustworthiness of street food markets, fostering a more sustainable and resilient informal food economy.

Another critical aspect of sustainability in food systems pertains to waste management practices in small-scale and commercial food establishments. Food waste represents a significant environmental and economic challenge, with far-reaching implications for resource efficiency and climate change mitigation.

According to R. Nair (2024), adopting sustainable waste management practices in small-scale food processing units can significantly reduce the accumulation of food waste, ultimately improving the operational efficiency of these units. This aligns with the findings of M. Tomaszewska et al. (2020), who emphasized the importance of staff and customer education in reducing food waste in food service establishments. Their study also highlighted the need for operational adjustments, such as aligning business hours with customer demand and refining management practices, to minimize waste. Building on these perspectives, Carlos Martín-Ríos et al. (2022) proposed a comprehensive framework for sustainable waste management in the foodservice industry, introducing 41 indicators that establish waste management standards for restaurants, hospitality services, and non-commercial catering. Their approach combines process, service, and organizational innovations to create a holistic model for waste reduction. Meanwhile, V. Filimonau et al. (2020) provided actionable insights into preventing food waste in restaurants through systematic management practices. Their research identified key areas such as menu planning, responsible sourcing, preparation techniques, and customer engagement as critical levers for waste prevention. These studies collectively emphasize the importance of both systemic and behavioral changes in addressing food waste challenges.

Taken together, these bodies of work illustrate the interconnected nature of sustainability challenges and the need for a multi-pronged approach to address them effectively. By leveraging advanced tools like LCA, fostering innovation in eco-design, and addressing gaps in education and management practices, stakeholders in the food industry can create systems that are not only environmentally sustainable but also socially equitable and economically viable. Whether it is enhancing the safety practices of street food vendors, reducing the environmental footprint of packaging, or implementing systematic waste management strategies in restaurants, these research contributions provide actionable pathways for transforming food systems. As the global community continues to grapple with the dual challenges of feeding a growing population and mitigating climate change, these insights serve as a valuable resource for policymakers, industry leaders, and researchers seeking to drive meaningful and lasting change in the food sector.

3. Research Methods

Goal and Scope Definition

For the Life Cycle Assessment (LCA) of the barbecue food stalls in Barangay San Vicente, Liloan, Cebu, which consists of 5 barbecue food stalls, the goal is to assess the environmental impacts throughout the entire life cycle of the barbecue products sold at these stalls. This assessment will cover the sourcing of ingredients to their end-of-life disposal. The system being measured includes the production, use, and disposal phases, with a focus on key environmental factors such as carbon emissions (CO2) and water consumption. The production phase includes the sourcing of raw materials like meat, skewers, and charcoal, as well as the preparation processes involved in creating the barbecue. The use phase examines the energy consumed during the cooking process, while the end-of-life phase focuses on the disposal or potential recycling of the product. Exclusions may include packaging, transportation, or recycling processes if they are considered negligible or difficult to assess. This approach will provide a comprehensive understanding of the environmental impacts of the barbecue food stalls and guide decisions for improving their sustainability.

Inventory Analysis (Life Cycle Inventory or LCI)

In the Life Cycle Inventory (LCI) for the barbecue food stalls in Barangay San Vicente, Liloan, Cebu, the

raw materials and resources involved in the operation of the stalls are as follows: each stall utilizes one sack of charcoal per day, which is essential for cooking the barbecue. Water consumption is 18 gallons per day per stall, primarily for food preparation, cleaning, and other operational activities. In terms of meat sales, the daily consumption includes 15 kg of pork, 10 kg of blood, 15 kg of intestines, 5 kg of head, and 5 kg of feet. For the BBQ stick usage, each stall requires 25 bundles of large sticks and 25 bundles of small sticks per day, amounting to a total of 500 sticks daily. These materials contribute significantly to the environmental footprint of the barbecue food stalls. Also, emissions from charcoal combustion, water usage, and waste disposal (such as leftover meat and charcoal ashes) are key factors to consider in the assessment of environmental impacts. According to the GIZ HERA Cooking Energy Compendium, one kilogram of charcoal can produce between 7.2 and 9 kilograms of carbon dioxide equivalent (CO_2e) in emissions, primarily due to the greenhouse gases released during the carbonization process as well as from deforestation and forest degradation. Given that each stall uses 20 kg of charcoal per day, this results in substantial CO_2 emissions, further contributing to the environmental footprint of the food stalls.

Water consumption might also lead to wastewater generation, especially from food preparation and cleaning processes, which may contain residues from the meat and cleaning agents. According to C. Rusănescu et al. (2022), untreated wastewater may contain toxic compounds, bacteria, viruses, and helminths, which, if used for long periods of time in irrigation, can negatively impact health and the environment. Also, the disposal of waste materials, such as leftover meat and charcoal ashes, will contribute to land use impacts. As noted by A. S. Ouedraogo et al. (2021), landfilling is a higher contributor to global warming, acidification, smog formation, eutrophication, ecotoxicity, and human health categories compared to gasification for municipal solid waste disposal. Improper disposal of waste could lead to land degradation and pollution, posing significant environmental and health risks.

Impact Assessment (Life Cycle Impact Assessment or LCIA)

The Life Cycle Impact Assessment (LCIA) conducted for the barbecue food stalls in Barangay San Vicente, Liloan, Cebu, highlights the significant environmental challenges associated with their operations. Among the most pressing concerns are carbon emissions, with each stall consuming approximately 20 kg of charcoal daily, resulting in an estimated 144 to 180 kg of CO_2e emissions per stall per day. This contributes to a substantial carbon footprint across all five stalls. Also, the stalls' high water consumption of around 18 gallons per day for food preparation and cleaning generates wastewater that, if untreated, poses serious risks. The wastewater may contain harmful pathogens such as Norovirus and Hepatitis A, which can cause gastrointestinal diseases, along with parasites like Giardia and Cryptosporidium, leading to waterborne infections. The wastewater may also include chemical residues from cleaning agents, disinfectants, and antibiotics used in animal care, further threatening human health and the environment if not properly managed. Waste management is another critical issue, with leftover meat, charcoal ashes, and other waste materials contributing to land pollution and potential health hazards. The unsustainable procurement of raw materials like meat and barbecue sticks adds to the environmental burden of the stalls' operations. As D. S. Kharat (2019) emphasizes, effective treatment and disposal of meat industry wastes can minimize pollution and facilitate the recovery of valuable by-products, which are essential for reducing environmental impacts.

Also, abattoir activities have been shown to degrade the physical, chemical, and microbiological quality of water bodies, as highlighted by N. Mujere (2020), underscoring the need for improved wastewater treatment and sustainable practices to protect local water resources. Recent studies also shed light on the health implications of untreated wastewater. According to Maria Hellmér et al. (2019), the detection of

pathogenic viruses in untreated sewage can provide early warnings of outbreaks, such as Norovirus and Hepatitis A virus, thus helping mitigate potential public health risks. What's more, C. McCall et al. (2020) suggest that wastewater-based epidemiology can be a valuable tool in identifying and monitoring various viruses in large urban areas, potentially improving public health responses to large-scale outbreaks and viral pandemics.

The findings from the LCIA highlight the urgent need for action to mitigate these environmental impacts. Recommendations include improving energy efficiency to reduce carbon emissions, adopting superior waste management practices, and promoting sustainable sourcing of ingredients. These strategies are essential to reducing the ecological footprint of the barbecue stalls while ensuring their long-term environmental sustainability and safeguarding public health.

Interpretation

The Life Cycle Inventory (LCI) and Life Cycle Impact Assessment (LCIA) for the barbecue food stalls in Barangay San Vicente, Liloan, Cebu, highlight key environmental and health concerns. The stalls consume significant resources, including 20 kg of charcoal and 18 gallons of water daily, contributing to carbon emissions and wastewater generation. The emissions from charcoal combustion contribute to climate change, while wastewater, if untreated, poses serious health risks due to pathogens like Norovirus and Hepatitis A. Waste management issues, including leftover meat and charcoal ashes, also contribute to pollution. To mitigate these impacts, recommendations include improving energy efficiency, adopting better waste management practices, and sourcing ingredients sustainably. These measures are crucial for reducing the stalls' environmental footprint and protecting public health.

4. Conclusion

The Life Cycle Assessment of barbecue food stalls in Barangay San Vicente, Liloan, Cebu, underscores the environmental challenges associated with their operations. The study reveals that high carbon emissions from charcoal use, substantial water consumption, and inefficient waste disposal significantly impact the environment. Without intervention, these factors could contribute to long-term ecological degradation.To mitigate these effects, the adoption of sustainable practices is imperative. Recommendations include transitioning to more energy-efficient cooking methods, improving waste management systems, and sourcing raw materials responsibly. Educating stall owners and the community about environmental impacts and sustainable alternatives will also play a crucial role in reducing the ecological footprint of these food stalls.

By implementing these strategies, barbecue food stalls can continue to provide economic and cultural value to the local community while aligning their operations with sustainability goals. This study serves as a call to action for stakeholders to work collectively in promoting environmentally responsible practices within the food vending sector.

5. References

1. V. Silva, N. Sanjuán "Opening up the black box: A systematic literature review of life cycle assessment in alternative food processing technologies", https://www.sciencedirect.com/science/article/abs/pii/S026087741930024X?via%3Dihub, June 2019
2. Eleonora Foschi, S. Zanni, A. Bonoli "Combining Eco-Design and LCA as Decision-Making Process to Prevent Plastics in Packaging Application", https://www.semanticscholar.org/paper/Combining-

Eco-Design-and-LCA-as-Decision-Making-to-Foschi-Zanni/d6a5b655d8bc4af0c55fc98a10dfa739a23bcf68?utm_source=consensus, November 2020

3. C. Thomas, C. Grémy-Gros, A. Perrin, R. Symoneaux, I. Maître "Implementing LCA early in food innovation processes: Study on spirulina-based food products", https://www.sciencedirect.com/science/article/abs/pii/S0959652620318400?via%3Dihub, September 2020
4. Belay Desye, Amensisa Hailu Tesfaye, Chala Daba, Gete Berihun "Food safety knowledge, attitude, and practice of street food vendors and associated factors in low-and middle-income countries: A Systematic review and Meta-analysis", https://www.semanticscholar.org/paper/Food-safety-knowledge%2C-attitude%2C-and-practice-of-in-Desye-Tesfaye/a754e7806dea7f36c587ea8977c966285f5c9c62?utm_source=consensus, July 2023
5. M. Tomaszewska "Estimation of the Scale of Food Waste in Hotel Food Services—A Case Study" https://www.mdpi.com/2071-1050/13/1/421, January 2021
6. Carlos Martín-Ríos "Sustainable waste management solutions for the foodservice industry: A Delphi study", https://journals.sagepub.com/doi/10.1177/0734242X221079306, February 2022
7. C. Rusănescu "Wastewater Management in Agriculture" https://www.mdpi.com/2073-4441/14/21/3351, October 2022
8. A. S. Ouedraogo "Comparative Life Cycle Assessment of Gasification and Landfilling for Disposal of Municipal Solid Wastes" https://www.mdpi.com/1996-1073/14/21/7032, October 2021
9. D. S. Kharat "Pollution Control in Meat Industry", https://www.eurekaselect.com/article/96323, July 2019
10. N. Mujere "Water Quality Impacts of Abattoir Activities in Southern Africa", https://www.igi-global.com/gateway/chapter/139619, June 2020
11. Maria Hellmér, N. Paxéus, L. Magnius, Lucica Enache, B. Arnholm, Annette Johansson, T. Bergström, H. Norder, "Detection of Pathogenic Viruses in Sewage Provided Early Warnings of Hepatitis A Virus and Norovirus Outbreaks", https://journals.asm.org/doi/10.1128/aem.01981-14, August 2019
12. C. McCall, Huiyun Wu, Brijen Miyani, I. Xagoraraki "Identification of multiple potential viral diseases in a large urban center using wastewater surveillance", https://www.sciencedirect.com/science/article/pii/S0043135420306977?via%3Dihub, July 2020