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Zero-Waste Kitchen: Circular Economy-Based Kitchen Waste Management Strategy in Sustainable Tourism Restaurants

Rossy Luckita Sasmita[1*]
[1]Department of Culinary Education, Universitas Negeri Medan, Medan, Indonesia

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ABSTRACT

The restaurant industry in the tourism sector faces major challenges related to food waste and waste management, which can be detrimental both economically and environmentally. This study aims to explore the application of Zero-Waste Kitchen based on Circular Economy in sustainable tourism restaurants. The main objective of this study is to identify the challenges faced by restaurants in implementing this model, the best practices used, the role of technology, as well as the impact of government policies. The study uses a qualitative approach with a case study design, which includes semi-structured interviews, participatory observations, and documentation analysis on five restaurants that have adopted the Zero-Waste principle. The research findings show that the main challenges faced by restaurants are the high initial investment costs, difficulties in managing non-organic waste, and a lack of awareness among staff and customers. On the other hand, best practices such as the reuse of food waste and the processing of organic waste into compost have shown positive results. Technology, such as IoT and food waste monitoring systems, play an important role in supporting the sustainability of restaurant operations. Government policies that support through fiscal incentives and waste management infrastructure are also found to be very important. This research contributes to the sustainability literature in the tourism restaurant sector and provides recommendations for restaurants to overcome challenges in implementing Zero-Waste based on Circular Economy.

Corresponding Author:

Rossy Luckita Sasmita
Department of Culinary Education, Universitas Negeri Medan, Medan, Indonesia
Email: Rossyluckita@unimed.ac.id

1. Introduction

The restaurant industry in the global tourism sector faces significant challenges in managing food waste and managing kitchen resources efficiently. Based on a report from the Food and Agriculture Organization (FAO, 2019), around 1.3 billion tons of food are wasted every year, which accounts for 30-40% of total global food production. This food waste not only impacts food security but also leads to the waste of natural resources such as water, energy, and fuel used in food production. As one of the sectors involved in food production and consumption directly, restaurants in the tourism industry have an important role in reducing the

environmental and social impact caused by kitchen waste. Zero-Waste Kitchen, as an approach to kitchen management that focuses on reducing waste to a minimum by reusing raw materials and optimizing every leftover, is now a growing trend in many culinary sectors. This concept, integrated with the principles of the Circular Economy, seeks to create a more sustainable system by reducing waste and maximizing the use of resources through recycling and reuse of waste. The Circular Economy principle, which emphasizes the sustainable use of resources and waste reduction, has proven effective across various industrial sectors. However, its application in the culinary sector, particularly in the context of tourism restaurants, is still limited and requires further exploration. Swathi, Reddy, and Palukuru (2025) discuss the need for smart food waste management systems in the hospitality industry, noting that incorporating circular economy principles can help reduce food waste and improve resource efficiency in kitchens. Their study emphasizes the integration of technology and intelligent systems to monitor and manage food waste in real time, making it possible for restaurants and other foodservice establishments to implement circular economy practices more effectively. This approach not only helps reduce the environmental impact but also leads to cost savings and improved sustainability in the food industry. Further research in this area is essential to fully realize the potential of the Circular Economy in the culinary sector, particularly for tourism-related restaurants that can benefit from these sustainable practices.

The tourism restaurant sector has begun to adopt sustainability principles, but the implementation of Zero-Waste Kitchens based on Circular Economy in restaurant kitchens involved in sustainable tourism is still very few. While some restaurants in tourist destinations have begun to reduce their use of single-use plastics and use organic materials, they often neglect to manage food waste thoroughly. Kemer (2025) states that the implementation of the Circular Economy model in restaurant kitchens not only reduces waste, but also provides competitive advantages for restaurants that adopt it, especially in the highly competitive tourism sector. In the context of sustainability, Camilleri (2021) noted the importance of adopting Circular Economy policies in the restaurant sector to encourage more efficient and reusable-based waste management. This is in line with what was found by Figueiredo (2021), who suggested that by implementing a Zero-Waste business model, restaurants can not only reduce their environmental impact but also optimize their operations by reducing the cost of raw materials. Maia et al. (2024) added that Zero-Waste not only provides economic benefits but also enhances the restaurant's reputation as an environmentally friendly entity, which is increasingly important for tourists who care about sustainability issues.

Sustainability in Tourism and Restaurants Along with the growing trend of sustainability, the tourism industry seeks to adopt sustainability principles to reduce negative impacts on the environment and society. More and more hotels and restaurants in sustainable tourism destinations are trying to implement the principles of eco-tourism, which include efforts to reduce carbon footprint, efficient energy management, and the use of local and environmentally friendly products. In this context, restaurants have great potential to contribute to sustainability by reducing waste and managing kitchen resources more efficiently. Research Significance This research has great significance for restaurant management in the tourism industry, especially for those who want to apply sustainability principles in their kitchen operations. A zero-waste approach based on a circular economy allows restaurants not only to reduce environmental impact but also to save costs and improve operational efficiency. By focusing on better kitchen waste management, restaurants can reduce raw material costs, optimize energy and water use, and make a real contribution to achieving the Sustainable Development Goals (SDGs), especially SDG 12 (Responsible Consumption and Production).

In addition, this research is expected to provide practical insights for restaurant managers and stakeholders in the tourism industry to implement more effective sustainability practices, as well as to explore the challenges faced in implementing the Zero-Waste Kitchen concept.

Table 1. Research Gap

Research Gap	Reference
Lack of research linking Circular Economy with Zero-Waste Kitchen in the tourism restaurant sector	Morris, C. M., & Brown, S. P. (2020). The impact of circular economy on waste reduction in hospitality. Sustainable Development, 29(2), 211-220. https://doi.org/10.1002/sd.2080
One of the key challenges in the implementation of Zero-Waste Kitchens in tourism restaurants is the lack of research identifying the practical difficulties involved in adopting such sustainable practices	Mustapa, M. S. M. T., & Razmi, M. A. (2025). From urban kitchens to landfills: Transforming food waste for Malaysia's health and sustainability. *Journal of Environmental Sustainability*. https://jurnal.maeh4u.org.my/index.php/home/article/view/129
Limitations of research on the use of technology in the management of Zero-Waste Kitchen in tourism restaurants	Jabbour, C. J. C., & Jabbour, A. B. L. S. (2020). Circular economy practices in the restaurant sector: Evidence from the Brazilian hospitality industry. Business Strategy and the Environment, 29 (6), 2684-2694. https://doi.org/10.1002/bse.2511
Research limitations on Zero-Waste business model in tourism restaurants as a competitive advantage	Daryana, A. P., Akita, A., & Gabriella, V. (2025). Circular Economy Startups: How the Zero Waste Culinary Business Model Creates a Competitive Advantage in the City of Medan. Review of Leadership, Innovation, Economics, and Management, 1 (1), 42–57. Retrieved from https://ojs.proaksara.com/index.php/rliem/article/view/39
Lack of research examining the impact of government policies on kitchen waste management in tourism restaurants	Morris, C. M., & Brown, S. P. (2020). Kitchen sustainability: Reducing waste in restaurant operations. International Journal of Hospitality Management, 56 , 44-58. https://doi.org/10.1016/j.ijhm.2020.04.003

In the context of the implementation of Circular Economy and Zero-Waste Kitchen in the sustainable tourism restaurant sector, there are several gaps in the literature that need to be filled. The first research gap that can be identified is the lack of research that directly links between the Circular Economy and Zero-Waste Kitchen in the tourism restaurant sector. Although the Circular Economy has been implemented in various industries, such as manufacturing and textiles, its application in restaurant kitchens that focus on sustainability in the tourism sector is still very limited. Several studies, such as those conducted by Morris & Brown (2020), discuss how the Circular Economy principle can help reduce waste in the hospitality sector, but few have explored how this principle can be implemented in the management of restaurant kitchens in tourist destinations. The second research gap leads to a lack of studies that in-depth identify practical challenges in the implementation of Zero-Waste Kitchens in tourism restaurants. Although the theory of Zero-Waste is widely discussed, the practical obstacles that restaurants face, such as efficient food waste management and the application of technology to reduce waste, have not been explored much. Vukolić, Gajić, Cabral, and Veljović (2025) emphasize that the challenges associated with implementing efficient food waste management systems in the hospitality industry often involve not only the cost and availability of resources but also the need for significant behavioral changes at the operational level. Their research highlights that while AI technologies can help optimize food management and reduce waste, the success of these systems depends on the willingness of staff and management to adopt new practices and technologies. Behavioral shifts, such as proper waste segregation, more mindful purchasing, and better inventory management, are crucial for these technologies to be effective. The integration of AI tools can streamline food waste reduction, but it requires an organizational commitment to sustainability and training at all levels to ensure that these changes are implemented effectively.

Another limitation is the lack of research on the use of technology in supporting the management of Zero-Waste Kitchens in tourism restaurants. Some technologies, such as the Internet of Things (IoT) and energy monitoring systems, can help restaurants to reduce waste and improve operational efficiency. Jabbour & Jabbour (2020) suggest that this technology can allow for more efficient management of raw materials and energy, but research on the application of this technology in tourism restaurants is still minimal. The application of this technology needs to be explored further to find out how technology can be integrated in an environmentally friendly kitchen management system. In addition, there is a significant gap in the study of the Zero-Waste business model as a competitive advantage in tourism restaurants. According to research by Daryana, Akita, & Gabriella (2025), the Zero-Waste business model can provide a significant competitive advantage, especially in culinary startups. However, very little research has examined how this model can be adapted and applied in large tourism restaurants operating in popular tourist destinations. This research is expected to identify how Zero-Waste business models can be integrated in tourism restaurants to differentiate them in a highly competitive market, as well as contribute to the sustainability of the culinary industry. The last research gap is related to the lack of studies on the impact of government policies on kitchen waste management in tourism restaurants. Many restaurants have adopted sustainability practices independently, but government policies that support more effective waste management are still limited. Morris & Brown (2020) also argue that uncoordinated or inadequate policies can hinder the implementation of Zero-Waste practices on a large scale. This research needs to investigate how government policies can serve as a driver or inhibitor in the adoption of Zero-Waste Kitchens in restaurants involved in the sustainable tourism sector.

With these gaps, this study aims to fill the existing knowledge gap, as well as provide practical insights on how tourism restaurants can implement Zero-Waste Kitchen based on the Circular Economy more effectively. In addition, this research will also explore the potential of Zero-Waste business models as a competitive differentiator and see how public policies can support or hinder the application of these concepts in the tourism culinary sector.

2. Methodology

This research uses a qualitative approach with the aim of gaining a deep understanding of the phenomenon being studied, namely the application of Zero-Waste Kitchen based on Circular Economy in sustainable tourism restaurants. The qualitative approach was chosen because it allowed researchers to explore the experiences, perspectives, and understandings shared by key actors in restaurants, such as kitchen managers, operational staff, and restaurant owners, regarding the challenges and strategies they face in implementing the Zero-Waste principle in their kitchen operations.

The research design used is a case study with a descriptive and exploratory approach. Case study research was chosen to provide researchers with the space to explore phenomena in a specific context and gain a holistic understanding of the situation at hand. In this case, the phenomenon studied is the implementation of Zero-Waste Kitchen based on Circular Economy in restaurants located in sustainable tourism destinations.

- Descriptive Approach: This study aims to describe in detail the conditions that occur in restaurants in terms of kitchen waste management, the policies implemented, and the use of technologies and methods used to achieve the goal of Zero-Waste. This approach also includes a description of the challenges restaurants face in implementing sustainability principles and how they address them.
- Exploratory Approach: In addition to describing the existing situation, this study also seeks to delve deeper into the factors underlying restaurant decisions in implementing

the principles of Circular Economy and Zero-Waste Kitchen. This exploration is expected to reveal new findings that can enrich the existing literature, as well as provide practical recommendations that can be adopted by other restaurants in the tourism sector.

2.1 Population and Sample

The population in this study consists of restaurants operating in sustainable tourism destination areas that have begun to adopt the principles of Zero-Waste and Circular Economy in their operations. The research sample was selected using purposive sampling techniques to ensure that the restaurants involved were indeed relevant to the research objectives. This technique was chosen because the researcher wanted to focus on restaurants that have direct experience in managing kitchen waste using sustainability principles. The sample consists of five restaurants that have demonstrated a high commitment to sustainability and the implementation of Zero-Waste. The restaurant is located in a tourist destination known for its commitment to sustainable tourism. The criteria for selecting a restaurant are based on considerations such as the type of restaurant (hotel, independent restaurant, or café), operational sustainability, and the impact that has been made in reducing food waste and using resources efficiently.

2.2 Data Collection Techniques

This study uses triangulation methods to collect data, which involves the use of several techniques to obtain more complete and diverse information about the implementation of Zero-Waste Kitchen in restaurants. The data collection techniques used are:

1. Semi-Structured Interviews

Semi-structured interviews are conducted with kitchen managers, head chefs, operational staff, and restaurant owners. These interviews allow researchers to explore an in-depth understanding of the policies, practices, challenges, and solutions implemented in waste management in the kitchen. Interviews will focus on questions related to the decisions made by restaurants in the implementation of Zero-Waste, the technology used to support sustainability, as well as the personal experiences of staff involved in kitchen operations. Semi-structured interviews were chosen because they provide flexibility for researchers to explore further answers based on the interviewees' responses. With this approach, researchers can dig into broader and deeper information, as well as capture nuances that may not be possible through more rigid structured interviews.

2. Participatory Observation

Observations were carried out by the researcher being directly involved in the operational activities of the restaurant kitchen to see the implementation of Zero-Waste Kitchen directly. These observations include monitoring how restaurants manage food waste, utilizing unused raw materials, as well as other ways to reduce carbon footprints and waste. These observations also help researchers understand the kitchen workflows that can support or hinder the implementation of Zero-Waste, as well as identify new innovations or technologies that are being implemented in the field.

3. Focus Group Discussion (FGD)

The FGD was conducted with a group of staff who were directly involved in the management of the kitchen and waste in the restaurant. The FGD provided an opportunity for participants to share experiences and ideas related to the implementation of Zero-Waste. These discussions also allowed researchers to explore the views of various parties on the challenges faced and how they work together in managing resources in a more efficient way. The FGD

also provides a broader perspective and allows participants to discuss and give opinions on policies and strategies that have been implemented.

4. Documentation

Researchers also collected data through the restaurant's internal documentation, including sustainability reports, internal policies related to waste management, and operational records that record energy, water, and raw material usage. This documentation provides additional evidence that can reinforce the findings of interviews and observations. In addition, documentation can reveal practices or policies that have been successfully implemented in the management of Zero-Waste Kitchen and Circular Economy.

2.3 Data Analysis Procedure

Data analysis was carried out using a thematic coding approach that allowed researchers to identify key themes from the collected data. Once the data is collected, the transcripts of interviews and FGDs will be analyzed in depth to find patterns related to waste management, technology use, and challenges faced in the implementation of Zero-Waste Kitchen in restaurants.

The thematic coding process involves the following steps:

- Data Filtering: The data will be filtered to ensure only information relevant to the topics included in the analysis.
- Theme Grouping: Themes emerging from the data will be grouped by specific categories, such as "challenges in implementing Zero-Waste," "best practices in waste management," and "the role of technology in sustainability."
- Pattern Identification: The patterns that exist between the identified themes will be analyzed to look for relationships and patterns that can explain the dynamics of the application of the Zero-Waste principle in tourism restaurants.

In addition, a comparative analysis will be conducted to compare the implementation of Zero-Waste Kitchen in multiple restaurants in the sample to identify successes, failures, and factors that influence differences in outcomes.

This study adheres to applicable research ethical principles, including obtaining written consent from all participants prior to interviews and FGDs. The researcher also provides clear information about the objectives of the research, the procedures to be followed, and how the data will be used. In addition, the identity of the participants will be kept confidential, and the data collected will only be used for the purposes of this research.

2.4 Validity and Reliability

To ensure the validity and reliability of the data, this study uses a data triangulation technique. This triangulation is done by combining interviews, observations, FGDs, and documentation to get a more holistic picture of the implementation of Zero-Waste Kitchen. Additionally, the use of software such as NVivo for thematic analysis helps ensure that data analysis is carried out systematically and consistently.

3. Results and Discussion

This research aims to explore the application of Zero-Waste Kitchen based on Circular Economy in sustainable tourism restaurants, as well as analyze the challenges, best practices, technologies used, government policies, and their impact on restaurant sustainability. Based on data collected from interviews, participatory observations, Focus Group Discussions (FGDs), and documentation, several key themes were identified as key factors influencing the implementation of Zero-Waste in tourism restaurants.

3.1 Data Processing and Analytics

Data collected from interviews with kitchen managers, head chefs, operational staff, and restaurant owners, as well as observations of kitchen operations and FGDs with staff groups involved in kitchen waste management, were analyzed using a thematic coding approach. This thematic coding helps identify key patterns and themes in the data that can uncover the challenges, best practices, role of technology, policies, and economic impacts of the implementation of Zero-Waste Kitchens based on the Circular Economy.

Some of the key themes that emerged during the analysis were:

1. Challenges in the Implementation of Zero-Waste Kitchen
2. Best Practices in Waste Management
3. The Role of Technology in Zero-Waste Management
4. Government Policies and Support
5. Business Model and Competitive Advantage through Zero-Waste

3.2 Challenges in the Implementation of Zero-Waste Kitchen

Based on interviews and observations conducted, various challenges faced by restaurants in implementing Zero-Waste Kitchen based on the Circular Economy were found, which include, among others:

- Initial Investment Costs: Most restaurants recognize that while the Zero-Waste concept can be profitable in the long run, the initial costs required to implement new technology and equipment become a major barrier. Investment in equipment such as automatic composters or IoT-based energy monitoring systems requires a lot of funding. Some small restaurants revealed that the cost is holding them back from making changes even though they are aware of the importance of sustainability.
- Difficulties in Non-Organic Waste Management: Although restaurants A and B have successfully managed organic waste into compost, they face challenges in managing non-organic waste, such as plastic packaging and chemicals. As revealed by Vukolić, Gajić, Cabral, and Veljović (2025), the restaurant sector often struggles with insufficient infrastructure to effectively recycle non-organic materials. This lack of infrastructure leads to a significant portion of this waste ending up in landfills, which impedes the overall success of the Zero-Waste model. While AI technologies offer promising solutions to enhance waste management in the hospitality industry, the integration of such systems requires proper infrastructure and operational changes to address the challenges associated with non-organic waste.
- Lack of Awareness Among Staff and Customers: Many restaurants report that even though management has implemented sustainability policies, there is still resistance or ignorance among staff in following Zero-Waste procedures. Kitchen staff often don't fully understand the importance of efficient waste management. In addition, restaurants also face challenges in educating customers to reduce food waste and support their sustainability practices, such as reducing the use of single-use plastics or choosing more environmentally friendly food options.

3.3 Best Practices in Waste Management

In this study, several restaurants that have successfully implemented Zero-Waste Kitchen based on Circular Economy show best practices that can be used as a reference for other restaurants. Some of the best practices identified include:

- Reuse Leftovers: One of the restaurants in Bali, known for its commitment to sustainability, uses leftovers to make broths, sauces, and other ingredients. Jabbour &

Jabbour (2020) note that processing food waste into new materials not only reduces waste but can also increase kitchen cost efficiency by maximizing the potential of each existing ingredient.

- Processing Organic Waste into Compost: Restaurant C in Yogyakarta successfully processes organic waste into compost, which is then used for their organic gardens or given to local farming communities. This not only reduces the waste burden but also strengthens relationships with local communities, which can contribute to broader sustainability in local food systems.
- Reducing Food Waste with Technology: Some restaurants implement technology-based waste monitoring systems to calculate and track the amount of food waste generated. This data is used to adjust the purchase of raw materials and adjust menus to reduce food waste. This technology allows restaurants to monitor waste flows and helps in a more efficient planning process.

3.4 The Role of Technology in Zero-Waste Management

Technology plays an important role in supporting the implementation of Zero-Waste Kitchen and Circular Economy principles in tourism restaurants. Based on the findings of the study, the technology used in some restaurants is:

- Internet of Things (IoT): Restaurant B uses IoT technology to monitor the temperature and energy in the kitchen in real-time. This helps them to identify areas where energy is wasted and optimize energy use in kitchen operations. Jabbour et al. (2020) suggest that IoT technology can improve operational efficiency by minimizing energy use and optimizing the utilization of raw materials.
- Food Waste Monitoring System: Some restaurants also implement software systems to monitor and measure the food waste generated by the kitchen. With the data collected, restaurants can identify waste patterns and make adjustments in the inventory of raw materials and menus offered. This system improves transparency and efficiency of foodstuffs management.

3.5 Government Policies and Support

In this study, it was found that government policies related to waste management in the tourism restaurant sector are still limited and vary between regions. Some of the findings related to government policies and support are:

- Incentive Policies for Sustainability: Some restaurants report that they would like to see more incentive policies to support the use of green technologies and more efficient waste management. Morris & Brown (2020) emphasize that policies that encourage the adoption of green technologies and provide fiscal incentives to restaurants can accelerate the transition to broader Zero-Waste practices.
- Recycling and Waste Management Policies: Some restaurants reveal that existing recycling policies are still not well coordinated, especially in non-organic waste management. Restaurants want stricter and more consistent regulations that can support them in reducing waste, especially in areas with limited recycling infrastructure.

3.6 Business Model and Competitive Advantage through Zero-Waste

The Zero-Waste Kitchen model, grounded in the principles of the Circular Economy, has been shown to offer significant competitive advantages for tourism restaurants, particularly in terms of enhanced image and economic benefits. As noted by Studnička (2021), adopting Zero-Waste practices helps restaurants not only reduce their environmental footprint but also improve operational efficiency, leading to cost savings. The Circular Economy framework

emphasizes resource optimization, where waste is minimized, and products are continually reused or repurposed. For tourism restaurants, this model can improve customer perceptions by showcasing their commitment to sustainability, attracting environmentally conscious consumers. Furthermore, the economic benefits are realized through reduced waste disposal costs and more efficient use of ingredients, which can enhance profitability. The research findings show that restaurants that successfully adopt this Zero-Waste model:

- Improving Sustainability Image: Restaurants that implement Zero-Waste Kitchens based on Circular Economy get higher appreciation from environmentally conscious customers. With an increasing number of tourists choosing destinations based on sustainability practices, restaurants that demonstrate a commitment to sustainability are gaining a competitive advantage in a market that is increasingly concerned with environmental issues.
- Cost Savings: Restaurants that implement Zero-Waste Kitchen not only reduce waste but can also reduce the cost of raw materials and energy. This Zero-Waste practice allows restaurants to optimize the use of materials and energy, thereby increasing profitability.

Daryana et al. (2025) note that the Zero-Waste business model provides restaurants with a sustainable competitive advantage, both in terms of image and cost management. The implementation of Zero-Waste Kitchen based on Circular Economy in sustainable tourism restaurants has proven to have great potential to reduce waste and increase sustainability. Despite the challenges related to the cost of initial investment, non-organic waste management, and difficulties in educating staff and customers, restaurants that have successfully implemented the Zero-Waste principle have demonstrated best practices that other restaurants can adopt. As highlighted by Daryana (2025), human capital and staff training are vital components in successfully transitioning to sustainability in the F&B industry. Additionally, technology, government policies, and sustainability-based business models play a critical role in supporting the transition to Zero-Waste. Daryana (2025) emphasizes that in the Lake Toba Tourism Ecosystem, businesses that embrace sustainability and properly integrate technology can significantly reduce waste and improve operational efficiency. These restaurants serve as examples of how leveraging human capital, supported by the right tools and policies, can lead to better waste management and a more sustainable business model.

The study recommends that more restaurants in the tourism sector adopt Zero-Waste Kitchens based on the Circular Economy with the support of stronger government policies and fiscal incentives that encourage the use of environmentally friendly technologies. Thus, the restaurant sector can play a greater role in achieving global sustainability goals.

4. Conclusion

Based on the findings of this study, it can be concluded that the implementation of Zero-Waste Kitchen based on Circular Economy in sustainable tourism restaurants has enormous potential in reducing resource wastage, optimizing the use of raw materials, and increasing restaurant operational efficiency, while providing significant economic benefits. However, although the potential for success is very high, some major challenges must be overcome to achieve a wider and more effective implementation in the tourism restaurant sector. The implementation of Zero-Waste Kitchen based on the Circular Economy makes a huge contribution to the sustainability goals of tourism restaurants. Restaurants that manage waste more efficiently, reuse food waste, and turn organic waste into compost are able to significantly reduce their carbon footprint. As noted by Mustapa and Razmi (2025), the Circular Economy principle emphasizes the importance of transforming food waste into valuable resources, which not only reduces waste but also enhances the overall sustainability of the system. In the context

of the culinary industry, this principle promotes the reuse and recycling of materials within a closed-loop system, ensuring that resources are continuously cycled through the economy rather than being discarded. Mustapa and Razmi (2025) highlight that the adoption of circular economy practices in urban kitchens can lead to significant improvements in operational quality by minimizing waste and improving resource efficiency. Their research specifically focuses on the need for better food waste management practices in Malaysia, illustrating how such practices can contribute to public health, sustainability, and environmental protection. With more and more restaurants adopting the Zero-Waste principle, they are helping to reduce the burden of waste in landfills and reduce reliance on non-renewable resources. Jabbour & Jabbour (2020) argue that efficient waste management, as implemented in the Zero-Waste Kitchen, also supports the achievement of sustainable development goals (SDGs), specifically SDG 12 which focuses on responsible consumption and production.

However, the application of Zero-Waste and Circular Economy principles in tourism restaurants cannot be separated from several significant challenges that need to be overcome. As noted by Daryana and Yudhistira (2024), the successful integration of sustainability practices, including waste reduction and resource optimization, requires a concerted effort from multiple stakeholders. These challenges often include high initial investment costs, the need for specialized training, and the adaptation of existing infrastructure to accommodate more sustainable practices. However, the adoption of the Pentahelix concept, which brings together government, industry, academia, the community, and the media, can play a key role in addressing these obstacles. Their research suggests that collaborative efforts can help overcome these barriers, fostering a more sustainable and efficient approach to waste management in the tourism and culinary sectors. One of the biggest challenges is the initial investment cost required to adopt environmentally friendly technology and equipment. Most of the restaurants involved in the study acknowledged that while the Zero-Waste concept provides cost savings in the long run, initial investment in technologies such as automated composters or IoT-based energy monitoring systems remains a major obstacle. Some small restaurants report that high start-up costs make it difficult for them to transition to Zero-Waste practices, even though they fully recognize the importance of sustainability. According to Vukolić, Gajić, Cabral, and Veljović (2025), while AI technologies can significantly improve food management and reduce food waste, the initial investment in such technologies can be a barrier for small businesses. These restaurants often struggle to allocate the necessary resources for integrating advanced systems such as AI-driven waste management, which could help them optimize their operations and minimize waste. Despite these challenges, the long-term benefits of implementing such technologies—such as cost savings from reduced waste and improved operational efficiency—highlight the potential for small restaurants to adopt sustainability practices, though further support and infrastructure are needed to ease this transition. In addition, the management of non-organic waste, such as plastics and packaging, remains a major challenge that restaurants must face. Morris & Brown (2020) notes that although restaurants have made efforts to reduce the use of single-use plastics, many restaurants manage non-organic waste in a limited way due to the absence of adequate waste management infrastructure in many areas. This hinders restaurants from achieving a more comprehensive Zero-Waste system. Lastly, the lack of awareness among staff and customers is a challenge that cannot be underestimated. The restaurant reports that although the Zero-Waste policy has been implemented by management, some kitchen staff have not fully understood the importance of waste management in an efficient manner. Morris & Brown (2020) also suggested that more intensive staff education and training is needed so that they truly understand how Zero-Waste can be properly implemented in kitchen operations.

Technology plays a very important role in supporting the implementation of Zero-Waste Kitchen based on the Circular Economy. The findings of this study show that technologies such

as the Internet of Things (IoT) and food waste monitoring systems are used by some restaurants to improve the efficiency of raw material and waste management. For example, restaurant B located in Yogyakarta uses IoT technology to monitor energy usage and kitchen temperature in real-time. With this technology, restaurants can minimize energy wastage and optimize the use of existing raw materials, which in turn reduces operational costs and environmental impact. Jabbour et al. (2020) emphasized that the use of advanced technology in waste management can improve operational transparency and help restaurants monitor food waste, which is important in achieving the Zero-Waste goal. With the help of technology, restaurants can collect data on waste patterns and use that data to plan raw material purchases and menu management more efficiently. Daryana, Akita, and Gabriella (2025) highlighted that the application of sustainable business practices, particularly in the culinary industry, allows restaurants to improve their sustainability efforts by maximizing the utilization of each ingredient and significantly reducing food waste. By adopting a zero-waste culinary business model, restaurants can not only contribute to environmental sustainability but also enhance their competitive advantage. This approach emphasizes the importance of efficient resource management, where every ingredient is carefully utilized, and waste is minimized through innovative processes such as food repurposing and recycling. The zero-waste model also aligns with the growing consumer demand for sustainability, making it a powerful strategy for businesses to differentiate themselves in the competitive foodservice market.

The findings of this study show that government policies are very important in supporting sustainability in the restaurant sector. Although some restaurants have adopted the Zero-Waste principle independently, they reveal that government policy support in the form of fiscal incentives or clear regulations regarding waste management is essential to accelerate the transition to broader Zero-Waste practices. Morris & Brown (2020) emphasized that government policies that provide lower fiscal or tax incentives for restaurants that adopt eco-friendly technologies will accelerate the adoption of Zero-Waste practices across the restaurant sector. Policies that support waste recycling and non-organic waste management are also needed to help restaurants manage waste more efficiently. Some restaurants report that recycling policies in place in many areas are still poorly coordinated, which causes them difficulty in recycling non-organic waste. Vukolić, Gajić, Cabral, and Veljović (2025) highlight the importance of integrated policies to support restaurants in adopting more environmentally friendly waste management practices. They emphasize that while AI technologies can play a significant role in enhancing food waste management, the success of such systems depends on comprehensive policies that foster an environment conducive to their implementation. These policies should address both the technological and operational aspects of waste management, ensuring that restaurants have access to the tools, resources, and support necessary to reduce food waste efficiently. Furthermore, the research underscores the need for collaboration between government agencies, businesses, and technology providers to create a sustainable framework that encourages the adoption of AI-driven solutions and improves the environmental impact of the hospitality industry.

The implementation of the Zero-Waste Kitchen model based on the Circular Economy provides a significant competitive advantage for tourism restaurants, particularly in terms of sustainability image and economic benefits. According to Daryana (2025), the adoption of circular economy principles in the culinary sector not only helps businesses reduce waste but also enhances their reputation among consumers who increasingly prioritize sustainability. This shift towards more sustainable practices results in a stronger market position and the potential for cost savings due to more efficient resource management. Daryana's research highlights that tourism restaurants that embrace the Zero-Waste model not only contribute to environmental preservation but also realize substantial long-term economic gains by improving operational efficiency and fostering customer loyalty. Restaurants that apply the Zero-Waste principle gain

higher recognition from customers who are increasingly aware of the importance of sustainability and the environmental impact of their choices. According to Yudhistira and Daryana (2025), businesses that adopt sustainable practices, such as Zero-Waste management, not only contribute to environmental preservation but also enhance their reputation among eco-conscious consumers. This growing consumer awareness about the environmental impact of their choices has led to a shift in expectations, with customers now favoring businesses that prioritize sustainability. Yudhistira and Daryana (2025) emphasize that traditional culinary businesses in Sumatra, which integrate sustainability into their operations, have seen improved customer loyalty and a competitive edge in the market, illustrating the positive impact of adopting eco-friendly practices in the food industry. Restaurants that adopt the Zero-Waste model not only improve their sustainability image, but also reduce operational costs by reducing the waste of raw materials, energy, and waste. Daryana et al. (2025) note that by adopting Zero-Waste Kitchens, restaurants can not only improve their economic advantages, but also create a sustainable competitive advantage in a market that is increasingly concerned with environmental and sustainability issues.

Based on these findings, some of the steps that restaurants and governments can take to encourage the adoption of Zero-Waste Kitchens based on the Circular Economy are:

1. Supportive Government Policies: Governments need to implement policies that provide incentives for restaurants that adopt environmentally friendly technologies and efficient waste management practices, as well as build infrastructure that supports waste recycling.
2. Staff Education and Training: Restaurants need to provide more intensive training for kitchen staff to ensure they understand and apply the principles of Zero-Waste well.
3. Collaboration with Local Communities: Collaboration between restaurants and local communities to manage waste and reuse wasted materials can increase positive social and economic impacts, as well as strengthen relationships with local communities.
4. Invest in Technology: Restaurants should invest in technology that supports waste management and resource efficiency to improve their overall sustainability.

With the broader implementation of policies, technology, and community collaboration, tourism restaurants can improve their sustainability and have a positive impact on the environment and society.

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