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SUSTAINABLE HOSPITALITY THROUGH CIRCULAR ECONOMY: FOOD WASTE MANAGEMENT IN THE RESTAURANT SECTOR IN MANILA, PHILIPPINES

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Abstract

This study examines how circular economy practices – reduce, reuse, recycle, and recover – predict environmental sustainability in Manila's restaurant sector using a foundational, sector-wide exploratory survey approach. While the hospitality industry is a significant contributor to global food waste, there remains conceptual ambiguity between specific "environmental benefits" and long-term "environmental sustainability." A total of 150 establishments reported consistent adoption of the 4Rs. Confirmatory Factor Analysis (CFA) validated the measurement model, with all standardized factor loadings exceeding the 0.60 threshold (ranging from 0.684 to 0.946), indicating strong construct validity. Multiple Linear Regression analysis confirmed positive and statistically significant predictive relationships between the 4Rs framework and environmental sustainability, explaining 81.2% of the variance ($R^2 = 0.812$), with the recover principle ($\beta = 0.865$) and the recycle principle ($\beta = 0.832$) emerging as the strongest individual predictors. The composite 4Rs score demonstrated the highest predictive strength ($\beta = 0.901$, $p < 0.001$). The findings confirm that while individual circular practices provide immediate environmental benefits, sustainable outcomes are achieved through the holistic integration of the 4Rs into long-term operational frameworks. Given the exploratory nature of the study and existing sample imbalances across restaurant types, these results serve as an empirical baseline for the urban hospitality landscape in the Manila restaurant sector, providing novel evidence in the Philippine context. The study recommends that policy interventions and corporate initiatives prioritize structured recovery and recycling mechanisms to bridge the gap between theoretical circularity and environmental sustainability outcomes. Future research should expand across regions and employ mixed methods designs to enhance generalizability and contextual depth.

Keywords: circular economy, 4Rs framework, environmental sustainability, Manila, Philippines

JEL Classification: L83, Q53, M14

1. Introduction

The year 2030 marks the final assessment of progress toward the United Nations Sustainable Development Goals (SDGs), established in 2015. Many principles outlined in SDG 12.3, which calls for a 50% reduction in retail and consumer food waste, remain significant challenges for the hospitality sector (de Visser-Amundson, 2022). Effective sustainable resource management, waste reduction, and environmental sustainability highlight the importance of these principles in contemporary tourism and hospitality practices. This approach is explicitly referred to as the Circular Economy (CE) within the tourism and hospitality sectors. CE has become a vital framework for decoupling economic growth from resource consumption by shifting from a linear "take-make-dispose" model to a restorative system (Geissdoerfer et al., 2017; UNWTO, 2023). The food industry significantly contributes to waste generation and the depletion of natural resources. To address these challenges, the circular economy offers a viable framework for sustainable waste management (Tamasiga, 2022). Various strategies, including waste reduction, reuse, recycling, and

resource recovery, have been explored for their potential to reduce environmental impact while enhancing economic benefits within the sector (Alonso-Muñoz et al., 2022).

According to the Food and Agriculture Organization of the United Nations (FAO, 2013), about one-third of food produced globally for human consumption, or roughly 1.3 billion tons, is lost or wasted. Meanwhile, 795 million people out of a global population of 7.5 billion suffer from chronic malnutrition, meaning one in nine people worldwide experiences hunger (World Hunger Education Service, n.d.). Although circular economy practices in the restaurant sector have been documented since the 1990s, recent global initiatives and evolving understanding have renewed attention on their crucial role in sustainable hospitality. In emerging economies such as the Philippines, this issue is intensified by rapid urban expansion, which strains waste management infrastructure and limits its ability to keep up with growth (Adeborode & Owoigbe, 2025). Manila, as a major metropolitan center, offers a unique case for study. While localized measures such as banning single-use plastics and repurposing waste for animal feed have been reported in Entrepreneurship.org.ph (2025), sectoral engagement remains fragmented and lacks a structured theoretical foundation (Philhost, 2025).

Corporate firms and policymakers increasingly recognize the circular economy as they shift from linear production models to circular methodologies. However, its implementation in service-oriented industries, particularly the hospitality sector, remains underexplored compared to its well-documented applications in manufacturing (Ellen MacArthur Foundation, 2012). While circular economy applications are well-documented in manufacturing, their integration into service-oriented industries, especially the restaurant sector, is still nascent and underexplored (Ghisellini et al., 2016).

Several scholars, including Allwood et al. (2011), and Kirchherr et al. (2017), have discussed the food waste hierarchy within the broader context of the circular economy. However, the existing literature lacks a comprehensive review that consolidates methodologies, practices, and solutions to reduce food waste and loss. To address this gap, the present study aims to compile and present practical strategies for prevention and reduction, offering valuable insights for decision-makers and stakeholders throughout the food supply chain. Despite the growing global focus on food waste management, a significant research gap remains in analyzing waste patterns and developing tailored solutions in developing nations, where infrastructure development often lags behind urban expansion (Adeborode and Owoigbe, 2025).

A significant development in circular economy (CE) theory is the shift from the traditional 3R framework (Recycle, Recover, Reuse) to more comprehensive models promoted by the Ellen MacArthur Foundation (EMF). The 3R concept offers practical solutions for restaurant sustainability, particularly in reducing food waste and food loss, ensuring resources are used efficiently rather than discarded (Papargyropoulou et al., 2014). However, recent scholars argue that it does not adequately prioritize waste prevention and they therefore adopt the 4Rs framework, incorporating "Reduce" as the primary foundation of environmental sustainability (Närvänen et al., 2021). By emphasizing source reduction along with reuse, recycling, and recovery, hospitality businesses can better align with the Food Waste Hierarchy (Allwood et al., 2011). This study adopts the 4Rs in the circular economy, as outlined in the existing literature. This approach aligns with the research agenda of Strippoli, Gallucci, and Ingrao (2024), which examines the role of the circular economy in food waste management literature, and seeks to bridge the gap by exploring the practical applications of the CE framework in Manila's restaurant sector, focusing on how the 4Rs predict environmental sustainability.

Recent literature, both globally and locally, highlights the ongoing circularity gaps in empirically measuring how these principles predict environmental sustainability in urban hospitality settings in Philippine restaurants, despite promising isolated initiatives and consumer-driven changes (Barrion et al., 2023; Philhost, 2025). Most existing studies focus on specific, short-term "environmental benefits" such as cost savings, rather than on "environmental sustainability," which refers to the long-term operational resilience of an establishment. Additionally, there is a lack of baseline data on the perceptions of industry practitioners who manage these systems daily.

To address these gaps, this research is designed as a foundational, sector-wide exploratory survey to examine the predictive relationship between the 4Rs framework and environmental sustainability outcomes in Manila's restaurant sector. By drawing on the insights of knowledgeable stakeholders, primarily industry practitioners with significant institutional experience, this study aims to bridge the gap between theoretical circularity and practical application. The findings provide an empirical baseline for urban hospitality in the Philippines, offering actionable strategies to enhance both environmental resilience and economic stability in a rapidly evolving service landscape.

2. Literature review

2.1 Circular economy in the hospitality industry

Food waste has become a critical environmental and economic challenge, requiring innovative strategies for sustainable management. Defined as "any food suitable and intended for human consumption that is discarded, regardless of whether it has surpassed its expiration date or has been allowed to spoil" (Chauhan et al., 2021), food waste significantly affects global food security, depletes natural resources, and contributes to ecological degradation. According to the Food and Agriculture Organization (FAO, 2013), nearly one-third of food produced globally – equivalent to 1.3 billion tons annually – is wasted, increasing environmental stress while millions experience food insecurity.

In response to the growing issue of food waste management, the Circular Economy (CE) model has gained prominence as a transformative approach, shifting from the traditional linear "take-make-dispose" economy to a closed-loop system that emphasizes resource efficiency, waste minimization, and sustainability (Jurgilevich et al., 2016). CE principles promote reducing waste generation, encouraging recycling, and extending resource lifecycles through systematic waste repurposing (Gonçalves & Maximo, 2022). Although CE initially became popular in industrial manufacturing, focusing on technical materials and durable products, its implementation in the hospitality sector presents distinct challenges due to the high perishability of food inventory and the fluctuating nature of daily consumer demand (Renfors, & Wendt, 2024). The author noted that while studies on the circular economy in the food sector are growing, there is a gap regarding research related to food establishments and to manager and consumer perceptions, particularly in the context of restaurants in Brazil.

Food waste management, a fundamental component of the circular economy (CE), requires robust frameworks to ensure environmental sustainability. As Renfors and Wendt (2024) note, circularity in hospitality involves shifting from maximizing service output to optimizing resource loops, maintaining food's value at its highest utility for as long as possible. The ReFED (2024) report emphasizes the need to move from linear disposal methods, such as landfilling and incineration, to circular models that recover and reuse discarded food products.

Despite growing recognition of CE strategies, research has primarily focused on industrial applications, leaving the hospitality industry underexplored (Borrello et al., 2017; Ellen MacArthur Foundation, 2012). Sustainable waste practices in restaurants remain inconsistent, unlike in industrial sectors where waste streams are often uniform, as restaurant waste is dispersed across pre-consumer (kitchen) stages. Additionally, post-consumer (plate) stages make systemic intervention difficult, with most establishments relying on short-term measures rather than comprehensive waste management strategies (Banaite, 2016). To address this gap, this study examines the integration of CE-based food waste management in the restaurant sector, focusing on the 4Rs framework to enhance perceptions of sustainability outcomes.

2.2 Philippine-specific circular economy (CE) practices: challenges in Manila's restaurant sector

A working paper on the Circular Economy for MSMEs (Entrepreneurship.org.ph, 2025) discusses practical CE applications in the Philippine food sector, including restaurants, and highlights efforts such as reducing disposable plastic, using biodegradable packaging, and repurposing food waste as animal feed. It emphasizes that while these grassroots practices are promising, they remain

insufficient for achieving full circularity. The WWF-Philippines (2022) Sustainable Diner project exemplifies local programs that engage food service businesses, government, and consumers in sustainable dining and waste-reduction strategies tailored to the Philippine context. This initiative demonstrates concrete efforts to formalize CE principles in local food systems. (World Wide Fund for Nature Philippines, 2021).

Mendoza and Felicen (2024) examined food waste strategies in casual dining restaurants in the CALABARZON region, assessed employee behaviors and practices, and developed a framework for food waste management relevant to Philippine restaurants, finding inconsistent implementation across establishments (Mendoza & Felicen, 2024). Studies such as Barrion et al. (2023) provide empirical data on food waste generation and management challenges in Philippine food establishments. They note distinctions between fast-food and fine-dining waste patterns, supporting the development of a nuanced circular economy strategy. Corporate partnerships, such as the Jollibee Group's collaboration to convert food waste into sustainable fertilizer (Jollibee Group, 2025), exemplify institutional involvement in advancing circular economy practices. Nevertheless, the objective of collecting specific food waste metrics remains difficult in the Philippines, with no available data on the exact amount of food waste to be accounted for. Studying management perceptions is the necessary first step.

2.3 Conceptualizing environmental sustainability and benefits in food waste management

Environmental sustainability has become a global priority, especially in food waste management, as excessive food loss contributes to climate change, resource depletion, and threats to biodiversity (UNEP, 2024). The hospitality industry, despite advancements in eco-friendly technologies, remains one of the largest contributors to food waste, accounting for approximately 12% of total waste generation (Lee & Huang, 2023). In the restaurant sector, environmental sustainability is conceptually defined as the organizational capacity to operate in ways that maintain ecological balance without depleting natural resources or compromising future environmental health (Morelli, 2011). It represents a systemic state of resilience in which a restaurant's ecological footprint remains within the carrying capacity of its local environment.

The broad concept of environmental sustainability is distinct from environmental benefits, which refer to specific, measurable improvements or positive externalities resulting from individual interventions, such as reductions in carbon emissions or increases in waste management efficiency. While environmental benefits are the positive outcomes of circular practices, environmental sustainability is the overarching objective achieved when these benefits are integrated into a long-term operational framework. For example, a restaurant may realize the benefit of reduced procurement costs through reuse practices; however, these practices contribute to sustainability only if they reduce overall resource consumption without causing secondary ecological harms, such as increased chemical use for cleaning reused items.

The restaurant sector plays a dual role in sustainability, serving as both a major contributor to food waste and a potential leader in structured waste reduction (Maynard et al., 2020). By integrating circular economy (CE) principles, restaurants can reduce operational waste, improve resource efficiency, and attract environmentally conscious consumers, aligning with global sustainability goals (Chou, 2012). Research indicates that sustainable practices enhance customer loyalty, suggesting that restaurants prioritizing CE principles experience long-term business advantages (Gazal et al., 2025). Accordingly, the researchers adopt a nuanced approach by explicitly operationalizing sustainability outcomes through key performance indicators such as energy efficiency, water conservation, and pollution prevention (Sakaguchi et al., 2022). In addition, the authors emphasize that by identifying 4R practices that may have ambiguous or limited environmental benefits, this research aligns with the green restaurant ecosystem framework, which emphasizes comprehensive impact assessment to refine sustainable hospitality practices.

Within the 4Rs framework – Reduce, Reuse, Recycle, and Recover – each principle generally aims to enhance environmental sustainability by minimizing resource consumption and waste production or by repurposing waste streams for further use (Närvänen et al., 2021). However, not

every practice labeled under the 4Rs is inherently or exclusively focused on environmental sustainability. For example, some "Reuse" practices may prioritize cost savings or operational convenience without optimizing environmental benefits (e.g., reusing single-use plastics). Similarly, recovery methods focused solely on energy extraction may involve trade-offs in emissions, depending on the technology used.

Despite its benefits, many restaurants encounter barriers to implementing circular economy-driven sustainability programs, including low awareness, concerns about high operational costs, and infrastructure limitations (Schubert et al., 2010). Studies highlight the need for policy interventions, corporate sustainability initiatives, and industry-wide collaboration to effectively integrate food waste management strategies within hospitality businesses (Adeborode & Owoigbe, 2025; Närvänen et al., 2021).

While the circular economy is well-theorized in global manufacturing, its application in the high-density urban restaurant sectors of emerging markets such as Manila remains under-documented. Current literature identifies the 4R principles as essential, yet empirical evidence linking these practices to long-term environmental sustainability, rather than immediate operational benefits, is limited. This study addresses this gap by using a validated 4Rs framework to predict sustainability outcomes from the perspectives of industry practitioners.

2.4 Theoretical framework

The United Nations Sustainable Development Goal (SDG) 12.3 mandates a 50% reduction in retail and consumer food waste by 2030, reinforcing the need for structured sustainability strategies (de Visser-Amundson, 2022). This supports the transition from a linear "take-make-dispose" model to a Circular Economy (CE).

Circular Economy Theory, based on the traditional 3R framework (Reuse, Recycle, and Recover), has provided the foundation for Circular Economy applications (Ellen MacArthur Foundation, 2012). However, applying these principles to the hospitality sector requires a structured prioritization of actions, traditionally guided by the Food Waste Hierarchy (Allwood et al., 2011) This hierarchy establishes that waste prevention at the source is the most effective strategy for environmental resilience, followed by resource recovery and recycling.

In view of this, the 3R framework has recently highlighted its limitations in addressing the hospitality sector's high volume of avoidable waste (Papargyropoulou et al., 2014). Consequently, the 4Rs framework builds on the 3R principles by incorporating "Reduce," a critical prevention strategy that minimizes waste before it is generated (Martin-Rios et al., 2018). The 4Rs model expands by integrating "Reduce" with Reuse, Recycle, and Recover, forming a widely adopted framework for mitigating waste and enhancing environmental resilience (Martin-Rios et al., 2020). The expanded 4Rs framework strengthens restaurant sustainability initiatives by offering a more comprehensive approach to waste reduction than traditional models (Närvänen et al., 2021). By transitioning from a 3R to a 4R framework, hospitality businesses can reduce environmental impact while reinforcing long-term sustainability efforts. Notably, the Urban Sustainability and Food Systems (Adeborode & Owoigbe, 2025; Ellen MacArthur Foundation, 2022) addresses localized waste patterns and regulatory influences in urban areas such as Manila. As restaurant waste management practices vary by location and restaurant type, this framework ensures that circular economy initiatives are tailored to specific metropolitan sustainability challenges.

These theoretical foundations established the predictive relationships between respondents' perceptions of the four circular economy principles – Reduce, Recover, Reuse, and Recycle – as independent variables and environmental sustainability outcomes in restaurant food waste management. The study provides a basis for assessing the impact of circular economy principles on sustainability efforts in Manila's restaurant sector, bridging the gap between theoretical insights and practical applications in urban hospitality contexts.

2.5 Hypothesis development and conceptual framework

The following hypotheses examine the predictive relationships between the four CE principles and environmental sustainability outcomes as shown in Figure 1.

The Reduce principle aims to prevent food waste at its source through inventory management, portion control, and eco-design strategies. By minimizing waste before it occurs, restaurants can significantly decrease their environmental impact and improve efficiency (Geissdoerfer et al., 2017).

H1: The Reduce principle has a positive and significant relationship with environmental sustainability.

The Reuse principle ensures that materials stay in circulation through repurposing or redistribution, preventing waste accumulation (Närvänen et al., 2021). Studies suggest that food redistribution or repurposing effectively enhances environmental sustainability, such as donating surplus food to charities or turning "ugly" produce into new dishes, like making croutons from day-old bread.

H2: The Reuse principle has a positive and significant relationship with environmental sustainability.

The Recycle principle advocates transforming food waste into secondary resources to minimize the impacts of disposal (EPA, 2024). Urban sustainability initiatives prioritize recycling food products to support biodiversity conservation and reduce ecological harm (Ghisellini et al., 2016).

H3: The Recycle principle has a positive and significant relationship with environmental sustainability.

The Recover principle focuses on extracting value from food waste through industrial applications, composting, and biogas production (Alonso-Muñoz et al., 2022). Advanced recovery mechanisms ensure that food waste is repurposed into renewable resources, promoting long-term environmental resilience.

H4: The Recover principle has a positive and significant relationship with environmental sustainability.

The study by Siakas et al. (2023) examines how emerging technologies facilitate the transition to a sustainable, circular economy using the 4Rs Framework. It emphasizes that the circular economy model, by design, minimizes waste and maximizes resource efficiency, thereby improving environmental outcomes. This is supported by another comprehensive source, the systematic literature review by Nazir and Capocchi (2024), which analyzes 145 academic articles and 20 organizational reports. It concludes that circular economy practices, especially those aligned with the 4Rs, enhance sustainable development by optimizing resource use, reducing environmental impact, and promoting long-term ecological balance.

H5: Adoption of the Circular Economy Framework (4Rs) as a composite practice positively and significantly influences environmental sustainability outcomes.

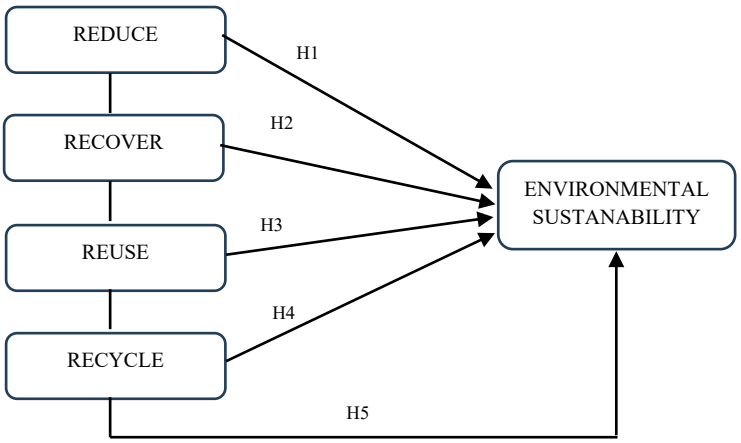

Figure 1. Hypothesized model
Source: Authors' own research

3. Methodology

The study uses a sector-wide exploratory survey research design to examine the directional relationships between Circular Economy (CE) principles and food waste management practices in selected restaurants in Manila. This approach was chosen to establish a baseline understanding of management perceptions across the food sector before conducting more detailed comparative or causal analyses. The design emphasizes a comprehensive assessment of the 4Rs framework's applicability in a dense metropolitan context such as Manila. A structured survey questionnaire collected quantitative data, ensuring an empirical approach to assessing causality. The study focuses on restaurants operating within Manila, selected based on four main factors. First, compared to manufacturing, retail, and service industries, the hospitality sector is underexplored in circular economy research. Second, participating restaurants were classified as stand-alone restaurants, restaurant chains, canteens, and buffets to ensure comprehensive industry representation. Third, these restaurants are located in Manila, a rapidly growing urban center where food waste management is particularly relevant. Finally, the sector benefits from a broad base of eco-conscious consumers who engage directly with restaurants' sustainability practices.

The respondents in this study were restaurant owners, managers, and sustainability officers who were knowledgeable about the circular economy within their establishments, including the application of the 4Rs framework and its implications for waste volume and reduction outcomes. They were considered knowledgeable stakeholders for this exploratory survey based on their professional and academic backgrounds. Specifically, over half of the participants (55.33%) are college graduates, and a significant portion (18.67%) have more than a decade of industry experience. This is consistent with previous hospitality research indicating that long-term tenure in restaurant operations correlates with a deeper understanding of institutional sustainability planning and waste management protocols. This dual focus enables a comprehensive understanding of sustainable practices and their measurable impacts, aligning managerial knowledge with operational waste outcomes. The sample size was estimated using G*Power 3.1.9.7 (Faul et al., 2007), resulting in a minimum sample size of 129 with a 15% effect size and 95% power, given four predictors. However, to ensure robust responses, the researcher increased the sample to 150 respondents, reinforcing statistical rigor. Lakens (2022) supports this approach, stating that larger sample sizes improve the inferential strength of research findings. The selected restaurants were chosen based on years in operation, geographic location, and business classification, ensuring adequate representation of food service establishments in Manila. Table 1 presents the demographic profile of the respondents.

Table 1. Demographic profile of the respondents

Profile	Classification	Frequency N-150	Percentage 100%
Age	18-20 years old	16	10.67
	21-30 years old	68	45.33
	31-40 years old	41	27.33
	41-50 years old	13	8.67
	51-60 years old	6	4
	61 years old and above	6	4
Sex	Male	64	42.67
	Female	86	57.33
Civil Status	Single	107	71.33
	Married	36	24
	Widowed	2	3.33
	Separated	5	1.33
Educational Attainment	High School Graduate	32	21.33
	Vocational Course Graduate	11	7.33
	College Graduate	83	55.33
	Post-graduate	24	16
Years of experience in the restaurant business	1-3 years	75	50
	4-6 years	27	18
	7-9 years	20	13.33
	10 years or more	28	18.67
	Total	150	100

Source: Authors' elaboration

In terms of age, 45.33% of respondents are aged 21–30 and 27.33% are aged 31-40, representing the majority of younger working-age brackets. This distribution reflects the labor composition of the Philippine hospitality workforce, which is characterized by a high concentration of early - to mid-career professionals (Philippine Statistics Authority, 2023). Operationally, this demographic profile suggests that a large segment of the workforce was trained during the period when Sustainable Development Goals (SDGs) were integrated into hospitality curricula and corporate social responsibility (CSR) mandates (Legrand et al., 2022). As a result, this group may be more technically prepared to adopt digital and circular frameworks for waste management than previous generations of practitioners. In contrast, only 8% are aged 51 or older, indicating a limited presence of older individuals in managerial or supervisory roles, which may affect the institutional memory of long-term waste practices (Kirchherr et al., 2017).

The respondent pool is slightly skewed toward females (57%), which aligns with the gender composition of foodservice staff in many hospitality settings. Studies have shown that women, especially in frontline service roles, often actively participate in sustainability behaviors when provided with training and recognition opportunities (Alonso-Muñoz et al., 2022). This may increase receptiveness to reuse, recycling, and source-reduction protocols, especially in kitchen and dining operations. It also highlights the importance of gender-sensitive training programs that leverage this engagement potential.

Regarding civil status, 71.33% of respondents identified as single, indicating that the workforce consists mainly of early-career individuals. This group may demonstrate greater flexibility and openness to innovation, which can facilitate the adoption of new sustainability practices. However, the lack of long-term institutional attachment among single, early-career staff may present challenges in maintaining consistency in sustainability efforts. This highlights the importance of a strong organizational culture, effective onboarding programs, and ongoing training to embed circular economic behaviors.

A high proportion of college graduates (55.33%) and postgraduates (16%) suggest a workforce capable of understanding environmental issues, following technical protocols, and adapting to systemic innovations such as circular economy frameworks. However, the presence of 21.33% high school graduates and 11.00% vocational graduates highlight the need for practical, inclusive

sustainability training that does not assume advanced academic backgrounds. Practical, hands-on sustainability modules should be developed to ensure that all staff, regardless of educational attainment, can contribute meaningfully to environmental goals.

Table 2. Business Profile of the Restaurant Sector in Manila

Profile	Classification	Frequency N-150	Percentage 100%
Type of Restaurant	Full Service	64	42.67
	Fast food /Quick Service restaurant	50	33.33
	Fine Dining	18	12
	Buffet	8	5.33
	Carinderia or Eatery	10	6.67
Years of Operation	1-3 years	78	52
	4-6 years	15	10
	7-9 years	17	11.33
	10 years or more	40	26.67
Form of Ownership	Sole proprietorship	45	30
	Partnership	51	34
	Corporation	43	28.67
	Cooperative	11	7.33
Total		150	100

Source: Authors' elaboration

According to table 2, full-service restaurants (42.67%) and fast-food/quick service establishments (33.33%) make up most of the sample. These types typically have structured operations and standardized procedures, which can support the implementation of sustainability protocols such as food waste tracking and recycling. Carinderias (6.67%) and buffets (5.33%), though less common, play important roles in food waste discussions – buffets due to overproduction and carinderias due to informal practices. Tailored interventions are necessary for these segments. The study includes a range of restaurant types, including quick service, full service, and fine dining, to provide a comprehensive view of the restaurant sector. However, a noted limitation of the study is the lack of data comparison. For example, quick-service restaurants (QSRs) primarily generate packaging waste because of their focus on takeout and fast dining, which relies on disposable containers, bags, and utensils, posing significant challenges for plastic waste management (Gallego-Schmid et al., 2019). In contrast, fine-dining establishments produce more food waste, often due to strict dish presentation standards, elaborate preparation processes, and higher volumes of kitchen trimmings and "dead plates" rejected before serving (McAdams et al., 2019). This differentiation is essential for tailoring circular economy solutions to each segment's operational realities.

Over half (52%) of the businesses are relatively new (1–3 years old), while 26.67% have been operating for a decade or more. Newer businesses may be more open to integrating sustainability from the outset, especially if founded by younger entrepreneurs or staffed by early-career workers. Older establishments may have more ingrained practices but also possess institutional knowledge that can be leveraged for long-term sustainability planning. The high concentration of newer establishments supports the assertion that modern restaurant startups in Manila are increasingly designed around contemporary sustainability mandates, such as SDG-aligned mandates (e.g., SDG 12.3), and are more likely to integrate Circular Economy principles into their initial business models. In terms of ownership, sole proprietorships are the most common at 34%, followed by corporations at 28.67%. Smaller ownership structures may enable quicker decision-making and grassroots sustainability efforts but may lack the resources for large-scale implementation. Corporations, although fewer in number, may have more formal sustainability policies and access to funding for infrastructure upgrades.

The study used cross-sectional data to measure food waste management practices and environmental sustainability metrics with a researcher-designed questionnaire. This instrument was adapted from existing circular economy research (Ellen MacArthur Foundation, 2012; Närvänen et al., 2021) and modified for the restaurant industry in Manila. To ensure validity, expert consultation and factor loading analysis were conducted, followed by pilot testing. The study

measured the 4Rs using survey items detailing specific food waste management practices in Manila's restaurant sector, each rated on a 4-point Likert scale reflecting frequency of use (1 = Never, 4 = Always), with the following ranges: 1.00–1.75 Never (N), 1.76–2.50 Sometimes (S), 2.51–3.25 Often (O), 3.26–4.00 Always (A). The instrument did not explicitly differentiate waste volume or type by item; instead, the composite scores broadly capture the implementation intensity of circular behaviors. This approach aligns with validated circular economy measurement scales in service sectors and supports hypothesis testing through predictive modeling. To minimize bias and error, validation measures were implemented to ensure data integrity and reliability. The study used both procedural and statistical safeguards to address Common Method Bias (CMB). Procedurally, respondents were assured of complete anonymity and encouraged to provide honest responses to minimize social desirability bias (Kock, 2015; Podsakoff et al., 2003). A Full Collinearity Assessment using Variance Inflation Factors (VIFs) for the predictors was conducted. Validity and reliability were assessed through Confirmatory Factor Analysis.

For data collection, questionnaires were distributed using a hybrid approach that included both face-to-face and online surveys among 150 respondents at selected restaurants in Manila. Purposive sampling was used to select restaurants actively engaged in food waste management practices (Etikan et al., 2016). This technique was chosen over random sampling to ensure the inclusion of restaurants with established sustainability initiatives, aligning with the study's objectives. To achieve proportional representation, the sample included various restaurant types – stand-alone restaurants, chains, canteens, and buffets – reflecting the broader industry landscape in Manila (Cohen, Manion, & Morrison, 2018; Patton, 2015). Collected responses were processed in SPSS, providing valuable insights into food waste management and sustainability efforts in the restaurant industry.

Ethical considerations were strictly observed throughout the research process. Respondents provided informed consent to ensure research transparency and ethical integrity. The study complied with Republic Act No. 10173 (Data Privacy Act of 2012) to protect participants' confidentiality and data. Participation was voluntary, with no coercion, deception, or undue influence during data collection. Transparency, impartiality, and research integrity were maintained at all stages to uphold ethical standards in the study.

Descriptive statistics outlined respondent profiles, followed by weighted mean scores to assess adoption levels of circular economy (CE) practices. Regression analysis then tested the predictive relationships of the four CE principles – Reduce, Reuse, Recycle, and Recover – on environmental sustainability outcomes. Each CE principle was operationalized through survey items detailing specific food waste management practices, which were aggregated into composite scores serving as independent variables. Environmental sustainability was measured as a composite dependent variable using validated indicators reflecting respondents' perceptions of sustainability outcomes in waste management. Regression analysis was chosen as an appropriate tool for predictive and causal testing, as it assesses the directional influence of multiple independent variables on a single dependent variable. In the context of food waste management research, this statistical approach identifies which CE principles contribute most to sustainability outcomes. To minimize confounding effects, control variables such as restaurant classification, years in operation, and sustainability initiatives were included in the regression model, thereby reinforcing the robustness of the findings (Närvänen et al., 2021). Furthermore, Confirmatory Factor Analysis (CFA) was conducted prior to regression to validate construct reliability and convergent validity of the 4Rs framework and environmental sustainability indicators. This ensured that the predictive relationships tested were grounded in a reliable measurement model.

4. Results and Discussions

4.1 Assessment of the circular economy (4R's)

Table 3 shows the descriptive results among the 4R principles of Reduce, Recover, Reuse and Recycle. Respondents reported the highest perceived frequency of adopting the "Reduce" principle (M = 3.46), interpreted as "always," indicating a priority on minimizing waste and resource

consumption, which is often the most impactful of the 4Rs. This aligns with the Food Waste Hierarchy, considered the frontline strategy for food waste mitigation within the circular economy framework (Bigdeloo et al., 2021; Tamasiga et al., 2022). The high score may reflect conscious efforts to avoid excess, such as reducing energy consumption or limiting single-use plastics, indicating a shift toward preventive sustainability and consumption restraint (Ghisellini et al., 2016).

Table 3. Descriptive Statistics

4R's		M	SD	VI	Rank
1.	Reduce	3.46	0.80	A	1
2.	Recover	3.38	0.75	A	3
3.	Reuse	3.22	0.78	O	4
4.	Recycle	3.40	0.71	A	2
Total		3.36	0.76	A	

Legend: 1.00-1.75 Never (N), 1.76-2.50-Sometimes (S), 2.51-3.25-Often (O), 3.26-4.00- Always (A)
Source: Authors' elaboration

Following this, Recycle (M = 3.40) and Recover (M = 3.38) were closely matched, suggesting that recycling may be more habitual or policy-driven. In contrast, recovery focuses on extracting usable resources from waste, often linked to restaurant processes or incentive structures. These practices contribute to material loop closure and resource valorization, which are central to circular economy strategies in the food sector (Tamasiga et al., 2022). However, some scholars argue that recycling, although necessary, is energy-intensive and less preferable than upstream interventions such as reduction and reuse (Bigdeloo et al., 2021).

Interpreted as "Often," Reuse (M = 3.22) received the lowest score among the 4Rs. This indicates a critical gap in the circularity loop within the Manila restaurant sector. The lower rating suggests that practical constraints, such as limited availability of reusable materials or a lack of enabling systems (e.g., refill stations, reusable packaging initiatives), remain evident in restaurant food-waste practices. Reuse represents a key circular strategy for product life extension, often underutilized due to infrastructural and behavioral barriers (Alonso-Muñoz et al., 2022; Katigbak & Villaruel, 2023). Contrasting literature highlights that while reuse has high potential for waste reduction, its adoption is hindered by consumer habits and logistical challenges (Ouro-Salim & Guarnieri, 2021).

The overall mean of 3.365 indicates that self-reported perceptions align with frequent engagement in sustainable practices among respondents. However, the variation between these practices shows that, while food waste management is generally well integrated, opportunities for reuse are often overlooked, which may result in higher waste generation. This gap could undermine broader sustainability efforts by missing the potential to reduce waste through more efficient resource use and increased product longevity (Teigiserova et al., 2019). The consistently high ratings for 4Rs practices may reflect aspirational reporting or social desirability bias, especially in a context where sustainability is increasingly valued in public discourse (Fisher, 1993).

This behavioral pattern aligns with circular economy principles, where waste is minimized and resources are kept in use for as long as possible (Ellen MacArthur Foundation, 2012; Figueroa et al., 2021). The prominence of "Reduce" highlights a shift toward upstream interventions, while the relatively lower score for "Reuse" reveals systemic gaps. To address this, reuse practices should be encouraged through infrastructure such as refill and repair stations, mobile platforms that promote item exchange, and partnerships with social enterprises focused on repurposing goods. Community-led swap drives, donation programs, and circular retail models can further help normalize reuse behavior and close the loop in food service operations (Alonso-Muñoz et al., 2022).

4.2 Assessment of environmental sustainability

Environmental sustainability refers to parameters such as energy efficiency, water conservation, waste reduction, greenhouse gas emissions mitigation, sustainable sourcing, and pollution prevention (Sakaguchi et al., 2022) and is aligned with UNEP (2024).

Table 4. Descriptive Statistics

Variable	WM	SD	VI
Environmental Sustainability	3.47	0.70	A

Legend: 1.00-1.75 Never (N), 1.76-2.50-Sometimes (S), 2.51-3.25-Often (O), 3.26-4.00- Always (A)
Source: Authors' elaboration

As denoted by Table 4, the environmental sustainability indicator, interpreted as "always" practiced (M = 3.47), suggests that respondents engage not only in individual sustainability actions but also view a broader ecological ethic as normative within Manila's restaurant sector. This supports the conceptual framework's premise that habitual circular behaviors – Reduce, Reuse, Recycle, and Recover – have a cumulative and positive impact on sustainability outcomes. The perception of effectiveness may be influenced by visible efforts in waste reduction, urban greening, and climate resilience initiatives, especially those related to food waste management practices in commercial establishments (Rebullida & Taguibao, 2023).

In this study, environmental sustainability was defined as a multidimensional construct comprising eight items adapted, with modification, from validated environmental research by Närvänen et al., (2021) and Maynard et al. (2020). These eight items assessed restaurants' operational commitment to ecosystem protection, resource efficiency, climate change mitigation, carbon footprint reduction, responsible disposal, capacity building, consumer insights, and stakeholder collaboration. These indicators were measured using a 4-point Likert scale (1 = Never to 4 = Always) to capture the frequency of these sustainable practices. This approach ensures that the variable reflects both internal operational changes (such as training and resource use) and external environmental impacts (such as carbon footprint reduction and waste management) relevant to the hospitality industry. These indicators serve as critical benchmarks for evaluating how effectively a restaurant conserves natural resources, reduces its ecological footprint, and contributes to broader environmental objectives. Mean scores reflect aggregated perceptions of these parameters.

The integration of Republic Act 9003 and municipal ordinances has established waste segregation and recovery as behavioral norms, with institutional mechanisms increasingly embedded in restaurant operations (Buenaflor, 2024). These policy frameworks, along with public advocacy, appear to have fostered a culture of sustainability awareness that normalizes environmental responsibility.

However, contrasting literature presents a more complex reality. Manila remains a major waste generator, facing persistent challenges such as landfill saturation, informal recycling labor, and increasing plastic and organic waste streams, including food waste from the hospitality sector (Sapuay, 2018; UNDP, 2022). Despite strong behavioral intent and visible engagement, structural limitations in circular infrastructure, enforcement mechanisms, and market incentives hinder the full achievement of sustainability goals (Kohli et al., 2024).

The data also indicate that food waste remains a critical blind spot in the city's waste portfolio, often overlooked in circular program design. While restaurants show a commitment to source reduction and post-consumer segregation, limited reuse systems, a lack of redistribution channels, and gaps in organic recovery dilute their impact. Addressing these constraints requires enhanced employee engagement initiatives, such as incentive-based green behavior programs, sustainability-oriented training, and participatory waste audits that embed circularity not only in policy but also in daily food service operations (Katigbak & Villaruel, 2023; Kohli et al., 2024).

4.3 Confirmatory Factor Analysis (CFA) in evaluating the measurement model

The measurement model was evaluated using Confirmatory Factor Analysis (CFA) to ensure the construct validity and reliability of the 4Rs and Environmental Sustainability constructs before hypothesis testing, as presented in Table 5.

Table 5. CFA Results

Factor	Indicator	Estimate	SE	Z	p	Std.Estimate
Reduce	Reduce 1	0.646	0.0712	9.07	<.001	0.789
	Reduce 2	0.664	0.0686	9.68	<.001	0.823
	Reduce 3	0.717	0.0655	10.94	<.001	0.888
	Reduce 4	0.697	0.0633	11.00	<.001	0.891
	Reduce 5	0.740	0.0606	12.21	<.001	0.946
Recover	Recover 1	0.740	0.0799	9.26	<.001	0.802
	Recover 2	0.729	0.0705	10.35	<.001	0.861
	Recover 3	0.727	0.0652	11.16	<.001	0.899
	Recover 4	0.703	0.0713	9.86	<.001	0.833
	Recover 5	0.685	0.0686	9.99	<.001	0.840
Reuse	Reuse 1	0.739	0.0942	7.84	<.001	0.730
	Reuse 2	0.725	0.0704	10.30	<.001	0.866
	Reuse 3	0.765	0.1079	7.08	<.001	0.684
	Reuse 4	0.660	0.0855	7.71	<.001	0.712
	Reuse 5	0.669	0.0724	9.24	<.001	0.818
Recycle	Recycle 1	0.652	0.0750	8.69	<.001	0.773
	Recycle 2	0.666	0.0583	11.41	<.001	0.917
	Recycle 3	0.669	0.0762	8.77	<.001	0.780
	Recycle 4	0.654	0.0741	8.83	<.001	0.784
	Recycle 5	0.683	0.0612	11.16	<.001	0.905
Environmental Sustainability	Environmental Sustainability 1	0.668	0.0587	11.38	<.001	0.906
	Environmental Sustainability 2	0.681	0.0634	10.74	<.001	0.875
	Environmental Sustainability 3	0.675	0.0700	9.65	<.001	0.818
	Environmental Sustainability 4	0.693	0.0628	11.03	<.001	0.889
	Environmental Sustainability 5	0.697	0.0591	11.78	<.001	0.924
	Environmental Sustainability 6	0.696	0.0573	12.15	<.001	0.940

Factor	Indicator	Estimate	SE	Z	p	Std.Estimate
	Environmental Sustainability 7	0.690	0.0596	11.59	<.001	0.915
	Environmental Sustainability 8	0.694	0.0573	12.11	<.001	0.938

Source: Authors' elaboration

All factor loadings exceeded 0.65 and were statistically significant ($p < .001$), with standardized estimates ranging from 0.68 to 0.95, confirming convergent validity. Moreover, Table 6 presents the results for factor covariances ($r = 0.691–0.913$) and fit indices ($\chi^2 = 1019$, $df = 340$, $p < .001$; CFI = 0.802; TLI = 0.780; RMSEA = 0.146), indicating inadequate fit. Although these values are below conventional thresholds (Hu & Bentler, 1999; Kline, 2015; Hair et al., 2017), they are acceptable for the exploratory nature of the study, given the heterogeneous contexts of restaurants, and serve as preliminary evidence. The study acknowledges that the diversity of operational models may result in weaker global fit indices despite strong factor loadings.

Table 6. Model Fit Indices

Test / Fit Measure	Index / Statistic	Value / Estimate
Test for Exact Fit	χ^2	1019
	df	340
	p	< .001
Fit Measures	CFI	0.802
	TLI	0.780
	RMSEA	0.146
	90% CI Lower	0.135
	90% CI Upper	0.156

Note: CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation; CI = Confidence Interval.
Source: Authors' elaboration

According to table 6, the CFA shows that the measurement model for the 4Rs and Environmental Sustainability is robust. All standardized factor loadings exceed the recommended academic threshold of 0.50, ranging from 0.684 to 0.946, indicating strong convergent validity for each construct. Although the RMSEA and CFI suggest that model fit could be improved, the high significance ($p < .001$) and strong individual factor estimate provide a sufficient empirical basis for the subsequent regression analysis.

4.4 Result of the hypothesis and the regression model

Table 7 presents the regression analysis examining the predictive relationship between the 4Rs–Reduce, Recover, Reuse, and Recycle – and Environmental Sustainability (ES). Multiple linear regression analysis confirmed statistically significant positive predictive relationships between the 4Rs framework and environmental sustainability, explaining 81.2% of the variance ($R^2 = 0.812$). This relatively high R^2 value (0.812) indicates a strong interrelationship among the 4R constructs, as confirmed in the CFA. The value is high for perceptual survey data and may be attributed to the strong conceptual overlap among the 4Rs, with transparent acknowledgment that refinement is needed in future research. Nevertheless, caution is warranted in interpreting this strength, as perceptual measures may inflate explained variance. Among the 4Rs, the Recover principle ($\beta = 0.865$) and the Recycle principle ($\beta = 0.832$) emerged as the strongest individual predictors. The finding implies that the 4Rs are not merely "related" to sustainability but are the primary drivers of it in the Manila restaurant context. The composite 4Rs score demonstrated the highest predictive strength ($\beta = 0.901$, $p < 0.001$), confirming that holistic adoption of the entire framework is more effective than any single practice alone. Accordingly, all hypotheses (H1–H5) were accepted.

Table 7. Regression Results Predicting Environmental Sustainability

Predictor (4Rs)	β (Standardized Coefficient)	*t*-value	*p*-value	VIF
Reduce	0.745	13.7	.001*	2.67
Recover	0.865	20.4	.001*	4.12
Reuse	0.746	13.8	.001*	3.85
Recycle	0.832	18.0	.001*	4.08
Composite 4Rs	0.901	24.9	.001*	1.000

*Notes: Dependent variable = Environmental Sustainability. α = 0.05. *All predictors were significant at p < .001.*
Source: Authors' elaboration

The model summary is as follows: R^2 is 0.812 and Adjusted R^2 is 0.809 (estimated with N = 150). The F-statistic is 156.42 ($p < .001$). Full collinearity VIFs range from 2.67 to 4.12, indicating no significant threat from multicollinearity or common method bias. The computed t-values from the regression analysis confirm that all predictors are highly significant. A low VIF value of 2.67 typically reflects the reduce-and-reuse principles, while the higher value of 4.12 is characteristic of recovery and recycling principles, which often show high synergy among circular principles. This value remains below the conservative threshold of 5.0 (Hair et al., 2017). Additionally, no inter-construct correlations exceeded the 0.90 threshold, indicating that the data are sufficiently free from common method variance to proceed with the analysis.

Reduce (β = 0.745): Source reduction emerged as a strong predictor of sustainability, consistent with literature that identifies prevention as the most effective stage in circular food systems (FAO, 2012). Practices such as portion control, menu planning, and just-in-time purchasing directly minimize waste generation. This finding aligns with Carvalho et al. (2025), who emphasize that upstream interventions are critical for reducing greenhouse gas emissions and conserving water resources. The significant relationship supports H1 and reflects Manila's growing policy commitment, as exemplified by the Food Waste Reduction Act (Barrion et al., 2023).

Reuse (β = 0.746): Reuse strategies demonstrated positive but comparatively weaker predictive strength. While initiatives such as food rescue programs and ingredient upcycling reduce landfill pressure and promote ethical consumption, their effectiveness often depends on infrastructure and regulatory support (Better Waste Solutions, 2023). This is consistent with Tennakoon et al. (2024), who caution that food safety concerns and logistical barriers can limit the scalability of reuse. The result supports H2 but highlights the need for stronger institutional frameworks to maximize the potential of reuse.

Recycle (β = 0.832): Recycling practices, including composting and anaerobic digestion, demonstrated strong predictive power. Studies by Bigdeloo et al. (2021) and Keng et al. (2020) confirm that composting provides measurable environmental benefits and is more sustainable than landfilling in dense urban areas. The significant relationship supports H3, affirming recycling as a visible and accessible practice with proven ecological benefits.

Recover (β = 0.865): Recover emerged as the strongest individual predictor, underscoring its strategic importance in circular energy and resource reclamation. Practices such as biogas production and the valorization of food waste into animal feed or industrial inputs demonstrate advanced recovery mechanisms. Tamasiga et al. (2022) highlight the environmental benefits of recover despite infrastructural challenges. The empirical strength of recover supports H4 and reflects Metro Manila's growing maturity in organic waste recovery initiatives.

Composite 4Rs (β = 0.901): The integrated adoption of the 4Rs framework demonstrated the strongest influence on sustainability outcomes, supporting H5. This finding confirms that circular practices are most effective when implemented together, resulting in systemic sustainability gains. It aligns with Kohli et al. (2024) and UNDP (2022), who emphasize that integrated circular behaviors drive ecological resilience at both organizational and sectoral levels.

Despite these promising results, the literature cautions against overgeneralization. Siakas et al. (2023) note that industrial adoption of circular strategies remains inconsistent, while Kirchherr et al. (2017) highlight definitional ambiguities that complicate implementation. These insights underscore the importance of inclusive infrastructure, participatory governance, and ongoing monitoring to ensure equitable and long-term progress.

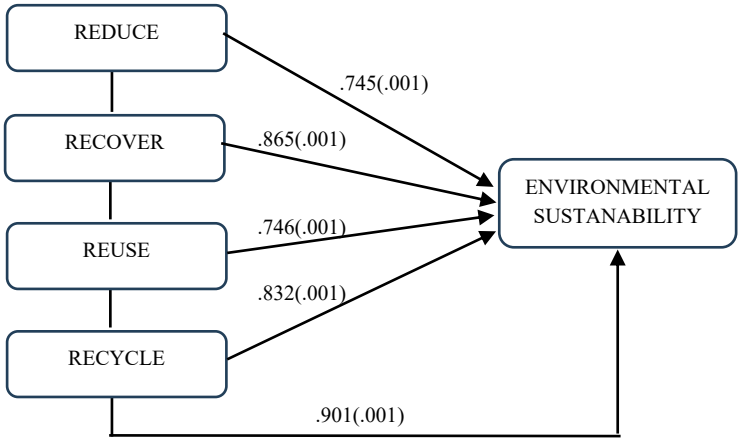

Figure 2. The resulted regression model
Source: Authors' elaboration

To complement the statistical findings in Table 7, Figure 2 illustrates the regression model linking the four dimensions of the circular economy framework– Reduce, Reuse, Recycle, and Recover– to environmental sustainability outcomes. The diagram visually represents the predictive pathways, highlighting the relative strength of each principle in shaping perceptions of sustainability within Manila's restaurant sector. This model reinforces the study's conceptual framework by demonstrating how integrated circular practices collectively contribute to ecological resilience.

Conclusions

The study provides an empirical baseline for the adoption of circular economy practices in the restaurant sector in Manila, resulting in technical readiness and a commitment to "reduce" as an operational priority. This indicates that restaurants are successfully prioritizing waste prevention, which is the most impactful level of the food waste hierarchy. However, the "reuse" principle received the lowest rating, highlighting a stark contrast. While reduction and recycling are well integrated, the industry lacks the systemic infrastructure necessary to "close the loop" through material reuse, which remains the most significant bottleneck to achieving full sectoral circularity. Regression analysis confirms that the 4Rs framework is a highly robust predictor of environmental sustainability, explaining 81.2% of the variance. Among the predictors, Recover and Recycle emerged as the strongest individual drivers, suggesting that in Manila's current urban context, structured waste diversion and resource valorization are perceived as the most effective routes to achieving sustainability goals. While this study identifies strong predictive relationships (R^2 = 0.812), this finding is interpreted within the context of a perception-based exploratory survey, serving as a behavioral baseline rather than a direct measurement of physical waste reduction. Moreover, each component showed statistically significant positive correlations with environmental sustainability, and the combined 4Rs variable ($\beta = .901$, $p < .001$) demonstrated the strongest predictive power. These findings support the study's conceptual framework and emphasize the importance of habitual engagement in circular behaviors, especially in food waste management, as a key driver of sustainable urban development. From a food systems perspective, the results are relevant by sector. Reducing food waste at its source, redistributing edible surplus, composting organic waste, and recovering energy from food byproducts collectively enhance

environmental resilience. These practices align with global and local sustainability goals, offering both ecological and social benefits in densely populated urban areas.

Practical, managerial and policy implications

Restaurants and food service providers are encouraged to move beyond single-use practices by investing in decentralized reuse systems, such as industrial-grade washing facilities and partnerships with refill-and-return suppliers. Infrastructure for reuse and redistribution, including surplus donation systems and refill packaging, should be expanded to address behavioral and logistical gaps in food circularity. Management should implement Green Behavior incentive programs to encourage frontline staff to participate in waste audits and actively pursue resource recovery. Given the high impact of recovery on sustainability, managers should focus on waste-to-energy or composting partnerships as their quickest win for sustainability. The local government of Manila should prioritize developing centralized composting and organic waste recovery facilities to support the strong recovery intent reported by businesses. Local government units should invest in food recovery centers, composting facilities, and public education campaigns to raise awareness of food waste. Legislative measures that support donation incentives and organic waste management can strengthen community-based efforts in the circular economy.

Limitations and directions for future research

Several limitations define the scope of this study and suggest directions for future research. First, while the findings provide valuable insights into Manila's restaurant sector, the study is based on a sector-wide survey designed to capture a broad overview of the industry. As a result, the sample was not stratified to ensure equal representation across all restaurant types and serves as an aggregate exploratory baseline. This led to an imbalance in sample sizes across categories, preventing robust comparative analysis. These findings, therefore, offer essential empirical groundwork for future studies that address the uneven distribution of restaurant categories by employing stratified sampling, which will yield a more balanced representation and enable comparative insights into how different operational models influence the adoption of 4R practices. Future research should also use larger, more stratified samples to improve model fit and reduce potential bias in perceptual measures. Advanced modeling approaches, such as multi-group CFA or SEM with bootstrapping, may further clarify the robustness of the 4R framework across restaurant categories.

Future studies should investigate food-waste-specific reuse systems to address the "Reuse Gap" identified in this research. Using mixed-methods approaches that combine surveys and interviews would provide a more comprehensive evaluation of food waste management outcomes. Replicating the study in other Philippine regions and neighboring Southeast Asian countries, and incorporating mediating factors such as cultural norms or regulatory enforcement, will enhance the generalizability of the findings. Establishing food-waste metric standards that align with circular economy goals will be essential for positioning Manila as a regional leader in sustainable urban food governance.

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Data Availability Statement: The data supporting the findings of this study are available upon reasonable request from the corresponding author. Due to confidentiality safeguards under Republic Act No. 10173 (Data Privacy Act of 2012), individual-level data cannot be publicly shared. Aggregated or anonymized datasets may be provided to qualified researchers to ensure transparency while protecting participants' privacy.

Compliance with ethical standards: The authors declare that all ethical considerations were strictly observed in the conduct of this study. Informed consent was obtained from all participants, and

confidentiality was safeguarded in accordance with Republic Act No. 10173 (Data Privacy Act of 2012). Participation was voluntary, with no coercion or undue influence, and the study adhered to principles of transparency, impartiality, and integrity throughout.

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References

Adeborode, O., & Owoigbe, K. V. (2025). Food waste management in urban areas: Challenges and sustainable solutions. *IRE Journals, 8*(11), 460-470. Retrieved May 15, 2026, from https://www.irejournals.com/formatedpaper/1708371.pdf

Allwood, J. M., Ashby, M. F., Gutowski, T. G., & Worrell, E. (2011). Material efficiency: A white paper. *Resources, Conservation and Recycling, 55*(3), 362-381. https://doi.org/10.1016/j.resconrec.2010.11.002

Alonso-Muñoz, S., García-Muiña, F. E., Medina-Salgado, M.-S., & González-Sánchez, R. (2022). Towards circular economy practices in food waste management: A retrospective overview and a research agenda. *British Food Journal, 124*(13), 478-500. https://doi.org/10.1108/BFJ-01-2022-0072

Banaite, D. (2016). Towards circular economy: Analysis of indicators in the context of sustainable development. *Social Transformations in Contemporary Society, 4*, 142-150. Retrieved May 21, 2026, from http://stics.mruni.eu/wp-content/uploads/2016/07/STICS_2016_4_142-150.pdf

Barrion, A. S. A., Calayag, J. A. S., Nguyen-Orca, M. F. R., & Melo-Rijik, M. N. (2023). Food loss and waste in the Philippines: A literature review. *Food Research, 7*(6), 278-289. https://doi.org/10.26656/fr.2017.7(6).127

Better Waste Solutions. (2023, August 24). *The 4Rs and sustainability: A guide from a waste management company*. Retrieved May 21, 2026, from https://betterwaste.co.uk/the-4rs-and-sustainability-a-guide-from-a-waste-management-company/

Bigdeloo, M., Teymourian, T., Kowsari, E., Ramakrishna, S., & Ehsani, A. (2021). Sustainability and circular economy of food wastes: Waste reduction strategies, higher recycling methods, and improved valorization. *Materials Circular Economy, 3*(3). https://doi.org/10.1007/s42824-021-00017-3

Borrello, M., Caracciolo, F., Lombardi, A., Pascucci, S., & Cembalo, L. (2017). Consumers' perspective on circular economy strategies for reducing food waste. *Sustainability, 9*(1), 141. https://doi.org/10.3390/su9010141

Buenaflor, K. B. (2024). Local governance of solid waste management in selected highly urbanized cities in Metro Manila, Philippines, for sustainable development. *World Journal of Advanced Research and Reviews, 22*(3), 1296-1301. https://doi.org/10.30574/wjarr.2024.22.3.1878

Carvalho, R., Lucas, M. R., & Marta-Costa, A. (2025). Food waste reduction: A systematic literature review on integrating policies, consumer behavior, and innovation. *Sustainability, 17*(7), 3236. https://doi.org/10.3390/su17073236

Chauhan, C., Dhir, A., Shahadan, M. U., & Salo, J. (2021). Food loss and waste in food supply chains: A systematic literature review and framework development approach. *Journal of Cleaner Production, 295*, Article 126438. https://doi.org/10.1016/j.jclepro.2021.126438

Chou, C. J., Chen, K. S., & Wang, Y. Y. (2012). Green practices in the restaurant industry from an innovation adoption perspective: Evidence from Taiwan. *International Journal of Hospitality Management, 31*(3), 703-711. https://doi.org/10.1016/j.ijhm.2011.09.006

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge. https://doi.org/10.4324/9781315456539

de Visser-Amundson, A. (2022). A multi-stakeholder partnership to fight food waste in the hospitality industry: A contribution to the United Nations Sustainable Development Goals 12 and 17. *Journal of Sustainable Tourism, 30*(10), 2448-2475. https://doi.org/10.1080/09669582.2020.1849232

Ellen MacArthur Foundation. (2012). *Towards the circular economy: Economic and business rationale for an accelerated transition*. Ellen MacArthur Foundation. Retrieved May 21, 2026, from https://content.ellenmacarthurfoundation.org/m/27265af68f11ef30/original/Towards-the-circular-economy-Vol-1.pdf

Entrepreneurship.org.ph. (2025). *The road to circularity: An introduction to circular economy for MSMEs*. Retrieved May 15, 2026, from https://beta.entrepreneurship.org.ph/2025/03/24/the-road-to-circularity-an-introduction-to-circular-economy-for-msmes/

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics, 5*(1), 1-4. https://doi.org/10.11648/j.ajtas.20160501.11

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191. https://doi.org/10.3758/BF03193146

Figueroa, A. M. I., Pintor, L. L., Sapuay, G. P., Ancheta, A. A., Atienza, V. A., Hintural, W. P., Abris, M. I. V., & Ghosh, S. K. (2021). Circular economy strategies and implementation in the Philippines. In S. K. Ghosh (Ed.), *Circular economy: Recent trends in global perspective* (pp. 219-257). Springer. https://doi.org/10.1007/978-981-16-0913-8_7

Fisher, R. J. (1993). Social desirability bias and the validity of indirect questioning. *Journal of Consumer Research, 20*(2), 303-315. https://doi.org/10.1086/209351

Food and Agriculture Organization of the United Nations. (2012). *Global initiative on food loss and waste reduction*. https://openknowledge.fao.org/handle/20.500.14283/i2776e

Food and Agriculture Organization of the United Nations. (2013). *The state of food insecurity in the world: Strengthening the enabling environment for food security and nutrition*. FAO. http://www.fao.org/3/a-i4030e.pdf

Gallego-Schmid, A., Mendoza, J. M. F., & Azapagic, A. (2019). Environmental impacts of takeaway food containers and alternatives. *Science of the Total Environment, 649*, 1316-1328. https://doi.org/10.1016/j.scitotenv.2018.08.408

Gazal, A. A., Bonnet, S., Silalertruksa, T., & Gheewala, S. H. (2025). Circular economy strategies for agri-food production: A review. *Circular Economy and Sustainability, 5*(3), 2467-2493. https://doi.org/10.1007/s43615-025-00528-0

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The circular economy: A new sustainability paradigm? *Journal of Cleaner Production, 143*, 757-768. https://doi.org/10.1016/j.jclepro.2016.12.048

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interrelationship between environmental and economic systems. *Journal of Cleaner Production, 114*, 11-32. https://doi.org/10.1016/j.jclepro.2015.09.005

Gonçalves, M. L. M. B. B., & Maximo, G. J. (2022). Circular economy in the food chain: Production, processing and waste management. *Circular Economy and Sustainability, 3*(3), 1405-1423. https://doi.org/10.1007/s43615-022-00243-0

Hair, J. F., Jr., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). SAGE Publications.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1-55. https://doi.org/10.1080/10705519909540118

Jollibee Group. (2025). *Jollibee Group enters a partnership to convert food waste into sustainable fertilizer to help Filipino farmers*. Retrieved May 15, 2026, from https://www.jollibeegroup.com/stories/jollibee-group-enters-partnership-to-convert-food-waste-into-sustainable-fertilizer-to-help-filipino-farmers/

Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Lapinjoki, J., Saikku, L., Tynkkynen, S., & Schösler, H. (2016). Transition towards circular economy in the food system. *Sustainability, 8*(1), Article 69. https://doi.org/10.3390/su8010069

Katigbak, J. J. P., & Villaruel, J. J. C. (2023). *Assessing the adoption of circular economy among women-led MSMEs in Metro Manila: A pilot study* (Discussion Paper Series No. 2023-30). Philippine Institute for Development Studies. https://doi.org/10.62986/dp2023.30

Keng, Z. X., Chong, S., Ng, C. G., Ridzuan, N. I., Hanson, S., Pan, G. T., Lau, P. L., Supramaniam, C. V., Singh, A., & Chin, C. F. (2020). Community-scale composting for food waste: A life-cycle assessment-supported case study. *Journal of Cleaner Production, 261*, Article 121220. https://doi.org/10.1016/j.jclepro.2020.121220

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling, 127*, 221-232. https://doi.org/10.1016/j.resconrec.2017.09.005

Kline, R. B. (2015). *Principles and practice of structural equation modeling* (4th ed.). Guilford Press.

Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *International Journal of e-Collaboration, 11*(4), 1–10. https://doi.org/10.4018/IJEC.2015100101

Kohli, K., Prajapati, R., Shah, R., Das, M., & Sharma, B. K. (2024). Food waste: Environmental impact and possible solutions. *Sustainable Food Technology, 2*, 70–80. https://doi.org/10.1039/D3FB00141E

Lakens, D. (2022). Sample size justification. *Collabra: Psychology, 8*(1), Article 33267. https://doi.org/10.1525/collabra.33267

Lee, H.-H., & Huang, P.-Y. (2023). Food waste and environmental sustainability of the hotel industry in Taiwan. *Sustainability, 15*(21), Article 15459. https://doi.org/10.3390/su152115459

Legrand, W., Chen, J. S., & Sloan, P. (2022). *Sustainability in the hospitality industry: Principles of sustainable operations* (4th ed.). Routledge. https://doi.org/10.4324/9781003081122

Martin-Rios, C., Demen-Meier, C., Gössling, S., & Cornuz, C. (2018). Food waste management innovations in the foodservice industry. *Waste Management, 79*, 196-206. https://doi.org/10.1016/j.wasman.2018.07.033

Martin-Rios, C., Hofmann, A., & Mackenzie, N. (2020). Sustainability-oriented innovations in food waste management technology. *Sustainability, 13*(1), 210. https://doi.org/10.3390/su13010210

Maynard, D. D. C., Zandonadi, R. P., Nakano, E. Y., & Botelho, R. B. A. (2020). Sustainability indicators in restaurants: The development of a checklist. *Sustainability, 12*(10), 4076. https://doi.org/10.3390/su12104076

McAdams, B., von Massow, M., Gallant, M., & Hayhoe, M. A. (2019). A cross industry evaluation of food waste in restaurants. *Journal of Foodservice Business Research, 22*(5), 449-466. https://doi.org/10.1080/15378020.2019.1637220

Mendoza, A. S. E., & Felicen, S. S. (2024). Proposed framework for food waste strategies of city restaurants in CALABARZON, Philippines. *International Journal of Research Studies in Management, 12*(7), 27-35. https://doi.org/10.5861/ijrsm.2024.2003

Morelli, J. (2011). Environmental sustainability: A definition for environmental professionals. *Journal of Environmental Sustainability, 1*(1), Article 2. https://doi.org/10.14448/jes.01.0002

Närvänen, E., Mattila, M., & Mesiranta, N. (2021). Institutional work in food waste reduction: Start-ups' role in moving towards a circular economy. *Industrial Marketing Management, 93*, 605-616. https://doi.org/10.1016/j.indmarman.2020.08.009

Nazir, S., & Capocchi, A. (2024). Systematic literature review of circular economy and sustainable development. In *Sustainability reporting practices and the circular economy* (pp. 15-81). Springer. https://doi.org/10.1007/978-3-031-51845-4_2

Ouro-Salim, O., & Guarnieri, P. (2025). Sustainable food waste management: Comparative study of NGO and restaurant practices in Brazil and Togo. *Review of Agricultural, Food and Environmental Studies, 106*(1), 99-136. https://doi.org/10.1007/s41130-025-00226-3

Papargyropoulou, E., Lozano, R., Steinberger, J. K., Wright, N., & Ujang, Z. bin. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *Journal of Cleaner Production, 76*, 106-115. https://doi.org/10.1016/j.jclepro.2014.04.020

Patton, M. Q. (2015). *Qualitative research and evaluation methods* (4th ed.). Sage Publications.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879-903. https://doi.org/10.1037/0021-9010.88.5.879

Philippine Hospitality on Sustainable Tourism – Philhost. (2025). *Philhost 2025 sustainability forum: Circular economy principles in hospitality*. Tajara Hospitality. Retrieved May 15, 2026, from https://philhost.tajarahospitality.com

Philippine Statistics Authority. (2023). *Labor force survey 2023*. PSA. https://psa.gov.ph/statistics/labor-force-survey

Renfors, S. M., & Wendt, T. (2024). Restaurants without bins: How does a circular restaurant operate? *Sustainability, 16*(6), Article 2312. https://doi.org/10.3390/su16062312

Rebullida, M. L. G., & Taguibao, J. G. (2023). Urban environmental governance and sustainable development: Empowering national and local governments for solid waste management in the Philippines. In *A better Metro Manila?* (pp. 371-406). Springer. https://doi.org/10.1007/978-981-19-7804-3_12

ReFED. (2024). *The circular economy and food waste*. https://refed.org/food-waste/circular-economy/

Sakaguchi, L., et al. (2022). Environmental sustainability in restaurants: A systematic review. *Journal of Sustainable Tourism, 30*(12), 2858–2876. https://doi.org/10.1080/15022250.2022.2134203

Sapuay, G. P. (2018). Solid waste management and sustainable development: The case of Philippine cities. In H. S. Shin (Ed.), *Sustainable solid waste management in Asia* (pp. 35-58). Springer. https://doi.org/10.1007/978-4-431-54385-5_2

Schubert, F., Kandampully, J., Solnet, D., & Kralj, A. (2010). Exploring consumer perceptions of green restaurants in the US. *Tourism and Hospitality Research, 10*(4), 286-300. https://doi.org/10.1057/thr.2010.17

Siakas, D., Lampropoulos, G., Rahanu, H., Georgiadou, E., & Siakas, K. (2023). Emerging technologies enabling the transition to a sustainable, circular economy: The 4R sustainability framework. In *Systems, software and services process improvement* (pp. 166-181). Springer. https://doi.org/10.1007/978-3-031-42310-9_12

Strippoli, R., Gallucci, T., & Ingrao, C. (2024). Circular economy and sustainable development in the tourism sector: An overview of the truly effective strategies and related benefits. *Heliyon, 10*, e36801. https://doi.org/10.1016/j.heliyon.2024.e36801

Tamasiga, P., Miri, T., Onyeaka, H., & Hart, A. (2022). Food waste and circular economy: Challenges and opportunities. *Sustainability, 14*(16), 9896. https://doi.org/10.3390/su14169896

Teigiserova, D. A., Hamelin, L., & Thomsen, M. (2019). Review of high-value food waste and food residues biorefineries with focus on unavoidable wastes from processing. *Resources, Conservation and Recycling, 149*, 413-426. https://doi.org/10.1016/j.resconrec.2019.05.003

Tennakoon, W. D. N. M. S., Janadari, M. P. N., & Wattuhewa, I. D. (2024). Environmental sustainability practices: A systematic literature review. *European Journal of Sustainable Development Research, 8*(3), em0259. https://doi.org/10.29333/ejosdr/14604

United Nations Development Programme. (2022). *Circular economy in the city: A rapid ethnographic research on circular economy in a Philippine urban setting*. Retrieved from https://www.undp.org/philippines/publications/circular-economy-city-rapid-ethnographic-research-circular-economy-philippine-urban-setting

United Nations Environment Programme. (2024). *Food waste index report 2024: Think.Eat.Save. Tracking progress to halve global food waste*. https://wedocs.unep.org/20.500.11822/45230

United Nations World Tourism Organization. (2023). *Circular economy in travel and tourism: A conceptual framework for a sustainable, resilient, and future-proof industry transition*. Retrieved from https://www.unwto.org/sustainable-development/circular-economy

United States Environmental Protection Agency (EPA). (2024). Food waste and environmental sustainability: Best practices for the hospitality industry. Retrieved from https://www.epa.gov/sustainable-management-food.

World Hunger Education Service. (n.d.). *World hunger facts and statistics*. *World Hunger News*. Retrieved May 21, 2026, from https://www.worldhunger.org

WWF-Philippines. (2022). *Sustainable diner project overview*. Retrieved from https://archive.wwf.org.ph/what-we-do/food/thesustainablediner/

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