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# EXPLORING INSTITUTIONAL READINESS FOR SUSTAINABLE FOOD WASTE MANAGEMENT: INSIGHTS FROM A FOOD WASTE AUDIT USING THE FIVE-PILLAR FRAMEWORK

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**Abstract:**

Food waste poses a significant challenge to sustainable resource management, particularly within institutional environments. This study quantifies campus food waste generation at Universiti Kuala Lumpur Malaysian Institute of Chemical & Bioengineering Technology (UniKL MICET) and evaluates institutional readiness based on five key pillars: policy, infrastructure, financial support, program implementation, and awareness and training. A campus-based audit was conducted over three sampling cycles, measuring pre-consumer waste from three cafés and post-consumer plate waste from a centralized collection point, complemented by survey responses to assess operational practices and stakeholder engagement. Results show that UniKL MICET generates over 60 kg of food waste per cycle (0.079–0.093 kg/capita), with 96% originating from kitchen operations and only 4% from plate waste, identifying food preparation as the primary intervention area. Despite strong awareness among staff and students, the absence of a formal policy, adequate infrastructure, financial allocation, and structured training programs contributes to fragmented management efforts. The findings conclude that UniKL MICET faces significant institutional barriers across all five pillars, limiting its capacity to achieve effective food waste reduction and align with

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Malaysia's circular economy goals. Implications: Strengthening institutional readiness across five pillars, in terms of policy, infrastructure, finance, programs, and training that enable universities to institutionalize food waste management and actively support circular economy and national sustainability goals.

**Keywords:**

Food Audit, Food Waste Management, Sustainable Practice, Institutional Capacity, Five-Pillar Framework

## Introduction

Food waste has emerged as a pressing environmental and socio-economic challenge, with far-reaching implications for sustainability. It is a key focus of the United Nations Sustainable Development Goal (SDG) 12 on responsible consumption and production. Globally, nearly one-third of all food produced is lost or wasted, contributing substantially to greenhouse gas emissions, inefficient use of land and water resources, and significant economic losses (Al-Rumaihi et al., 2020). Recognizing the urgency of the issue, SDG 12.3 sets a target to halve global food waste by 2030 (Gonçalves et al., 2023). Inadequate food waste management is also linked to SDG 11 on sustainable cities and communities, as poor practices can exacerbate public health concerns. For instance, landfill leachate contaminating groundwater and posing risks to human health (Ghazali et al., 2025a). Addressing these challenges requires not only fostering a 'green' mindset and institutional commitment (Syazwan & Syed-Hassan, 2024). Then, these need to align with national strategies, policies, and practical on-the-ground actions to ensure meaningful change.

## Literature Review

In Malaysia, food waste accounts for up to 44.5% of total municipal solid waste, with the majority ending up in landfills (International Trade Administration, 2024). Over the past decade, the Malaysian government, together with various NGOs, has worked continuously to foster environmental literacy through multiple strategies, frameworks, and plans. Notable initiatives include the Blueprint for a Clean and Beautiful Malaysia (ABC), the Solid Waste Management Policy, and the 3R (Reduce, Reuse, Recycle) Programme (Bashir et al., 2018). The Food Waste Management Development Plan for Industrial, Commercial, and Institutional Sectors (2016–2026) set a target to reduce food waste to below 25% for key food-generating sectors such as hotels, markets, and restaurants (JPSPN-KPKT., n.d.). Recently, the Madani Government launched the National Circular Economy Council (NCEC) under the Ministry of Local Government Development (KPKT) to accelerate Malaysia's transition from a linear to a circular economy. This effort is aligned with the Circular Economy of Solid Waste in Malaysia (2025–2035), which provides a roadmap for achieving a 40% national recycling rate by 2025 while addressing climate change, environmental degradation, and biodiversity loss (Malaysian Investment Development Authority., 2023: Ministry of Natural Resources and Environmental Sustainability n.d.).

The prior researches highlight the need for multi-level interventions to reduce food waste through targeted campaigns, institutional programs, and regulatory measures such as laws, policies, and standards that incentivize preventive behaviors (Mganga et al., 2021). Stronger institutional support is essential, including accessible waste management infrastructure, frequent awareness campaigns, and experiential learning opportunities to bridge the knowledge-practice gap. Beyond legislation, enforcement mechanisms must be strengthened,

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as Malaysia currently lacks a unified digital system to monitor industrial waste flows (Idris et al., 2025). To guide action, researchers recommend adopting seven Environmental Management Tools (EMT): Environmental Policy, Environmental Budget, Environmental Monitoring Committee, Environmental Facility, Environmental Efficiency, Environmental Reporting and Communication, and Environmental Transparency (Nee et al.,2024.).

The New Industrial Master Plan 2030 (NIMP 2030) is Malaysia's strategic framework aimed at driving industrial transformation and strengthening the nation's economic competitiveness, including through the creation of high-value job opportunities (Malaysian Investment Development Authority, 2023). Where the institution is also a pillar in the leadership of the new industrial master plan. Institutions of higher education, as a microcosm of society, play an important role in shaping sustainable behavior among the younger generation.

In 2022, approximately 282,000 male students and over 405,000 female students were enrolled in public higher education institutions in Malaysia (Malaysia: Number of University Students by Gender, 2024). Alattar et al. (2020) noted that universities offer unique opportunities for change, but programs must address context-specific behavioral factors to achieve lasting waste reduction (Alattar et al., 2020). Despite universities' role in promoting sustainability, food waste remains a persistent challenge (Ghazali et al., 2025b). This reflects the large student and staff population that contributes significantly to food waste generation. Prior research has emphasized the need to better understand food waste generation patterns and identify feasible treatment options for effective campus waste management. Kamaruddin et al. (2020) reported food waste generation rates of 0.01–0.119 kg/cap/day, with 25.31% ash content and a higher calorific value in dry samples (4539.9 kcal/kg). Composting was recommended as the most suitable treatment option, though implementation challenges persist (Kamaruddin et al., 2020). Research on food waste in higher education is limited compared to school lunch programs, focusing on drivers, behaviors, operational strategies, diversion processes, and barriers (Kaur et al., 2020). Awareness campaigns and simple "how-to" strategies can reduce plate waste when supported by trained staff and institutional commitment (Pinto et al., 2018). However, universities continue to face persistent challenges such as relying on conventional methods, lack of incentives, inadequate infrastructure, and weak policy enforcement (Ghazali et al., 2025b).

While several studies have examined food waste generation in Malaysian campus cafeterias, few have linked audit findings to institutional capacity for action. The study seeks to bridge that gap by conducting a systematic food waste audit at UniKL MICET and evaluating campus readiness across five key pillars: institutional policy, financial capacity, awareness, programs, and infrastructure. The combined insights aim to guide institutional policy development and foster community engagement for sustainable food waste management).

## Methodology

A campus-based food waste audit was conducted at Universiti Kuala Lumpur Malaysian Institute of Chemical & Bioengineering Technology (UniKL MICET) to quantify and characterize food waste generation in university food service facilities. Currently, the campus operates under a conventional waste management approach. The selection of this site also considered its moderate size and centralized dining system, which allow for controlled observation of food waste generation and management practices.

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The target population of approximately 800 individuals comprised students, staff, and food operators who regularly utilized the campus cafeterias. Samples of food waste were obtained from three cafés and a centralized collection point (CCP). The study was conducted over three sampling cycles within a defined period, covering Café A, Café B, Café C, and the CCP for plate waste. Sampling activities were carried out during operational hours between 8:00 a.m. and 5:00 p.m. to capture breakfast, brunch, and lunch waste streams, while dinner service was excluded.

***Sampling Cycles and Data Collection***

A total sampling approach was employed, in which all food waste generated from the cafes and CCP was collected, segregated, and weighed across three consecutive sampling cycles. Each cycle consisted of a full working day's waste from all targeted sources. Waste from the cafés represented pre-consumer waste, including food scraps from preparation, spoiled items, and expired food. Waste from the CCP represented post-consumer waste, or plate waste, discarded by patrons after meals. The location of each bin as in figure 1, type 1 represent type bin in cafes and type 2 refer to bins in CCP.

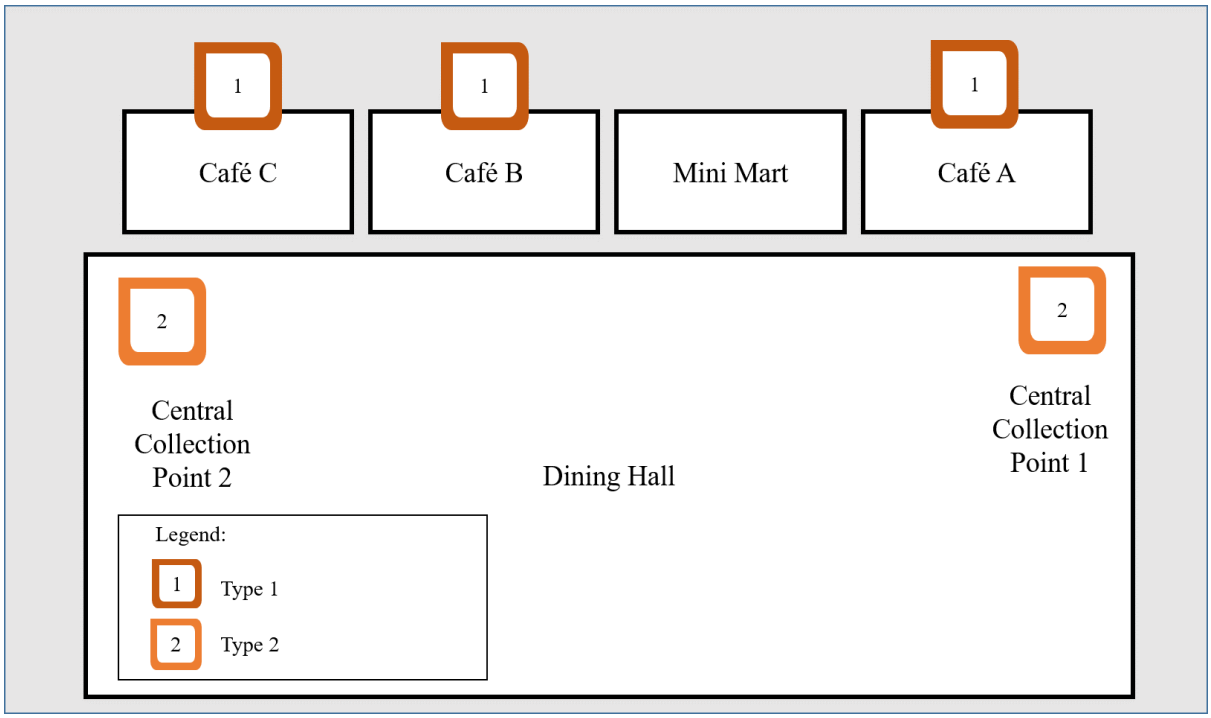


**Figure 1: Illustration of Collection Location at Each of the Cafeterias and Central Collection Points**

At the end of each cycle, food waste from each source was weighed using a calibrated digital weighing scale. Data was recorded in kilograms for each café and the CCP. Per capita food waste was calculated based on an estimated student population of approximately 800 individuals utilising the cafés.

***Café Waste Classification***

Waste collected from cafés (Type 1) was sorted into three main categories:

1. Meat and bones – animal-based food scraps from preparation or trimming.

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2. Fruits and vegetables – plant-based scraps from peeling, trimming, or discarding unused produce.
3. Spoiled and expired food – unused items past their shelf life or deemed unfit for consumption due to improper storage.

***Plate Waste Classification***

Plate waste collected at the CCP (Type 2) was categorised into:

1. Carbohydrate and vegetable-based waste – rice, noodles, and vegetables.
2. Protein and bone-based waste – uneaten meat, fish, and bones.

Sorting and classification were performed manually following hygiene protocols, including gloves and protective aprons, to minimise contamination and ensure safety.

***Operational Practices and Institutional Readiness Assessment***

A questionnaire survey was conducted among café operators, staff, and students to assess:

- Awareness of food waste management importance.
- Current disposal methods used (municipal bins, animal feeding, composting).
- Perceived barriers to sustainable waste management.

In addition, institutional readiness was evaluated using a gap analysis framework, comparing current campus practices to recognised best practices across five pillars: policy, infrastructure, awareness/training, financial support, and program implementation.

***Data Analysis***

Quantitative data (waste weights, percentages) were analysed using descriptive statistics (mean, percentage, range) to determine total waste generation, per capita waste, and category proportions. Waste generation patterns were compared across cafés and sampling cycles to identify high-contribution sources. Survey data were analysed to identify operational trends and barriers to implementation of sustainable practices.

**Result and Discussion**

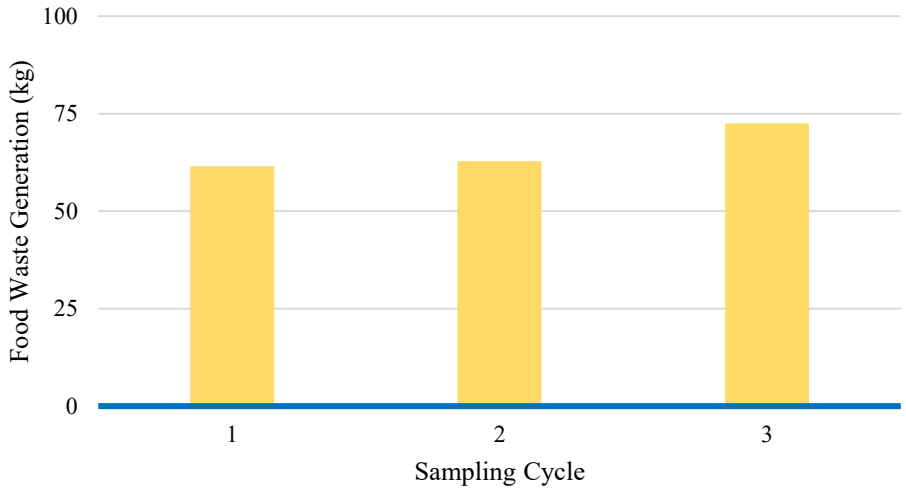


**Figure 2 Total Food Waste Generation in Three Consecutive Sampling Cycle.**

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Figure 2 illustrates the total food waste generated (in kilogram) over three consecutive sampling cycles, involving four main sources**:** cafe A, cafe B, cafe C**,** and a centralised collection point (CCP)**.** The results show that the generation of food waste in each period exceeds 60 kilograms. With an estimated student population of 800 individuals using the cafés, the average food waste per capita per cycle is calculated to be approximately 0.079 kg to 0.093 kg per person. This amount is significantly lower than the average Malaysian household, which discards about 0.5 to 0.8 kg of food waste per day (Ghafar, 2017). The lower figure in this study can be attributed to the limited sampling period, which only covers 8.00 a.m. to 5.00 p.m., due the study excluding dinner from the data collection.

**Table 1: Breakdown of Food Waste Based On the Cafes and Collection Points**

| Sampling Cycle | 1 | 2 | 3 | Average |
|---|---|---|---|---|
| | | (kg) | | |
| Café A | 4.4 | 9.9 | 7.5 | 7.3 |
| Café B | 18.7 | 15.9 | 23 | 19.3 |
| Café C | 36.5 | 35.8 | 40.5 | 37.6 |
| CCP * | 1.9 | 1.2 | 1.5 | 1.5 |

* Centralise Collect Point

Table 1 show the breakdown of food waste based on the cafes and collection points. The waste data is categorised into two distinct components; first, generated by café: originating from food preparation activities and spoiled foods, including expired food. Secondly, plate waste: collected at the CCP, reflecting uneaten food discarded by patrons after meals. The findings indicated Café C consistently generated the highest amount of food waste, reaching a peak of 40.5 kg in sampling cycle 3. This was followed by Café B, which recorded an average of 19.2 kg of waste per cycle. Meanwhile, Café A recorded the lowest level of food waste (average of 7.3 kg) across all three sampling cycles.

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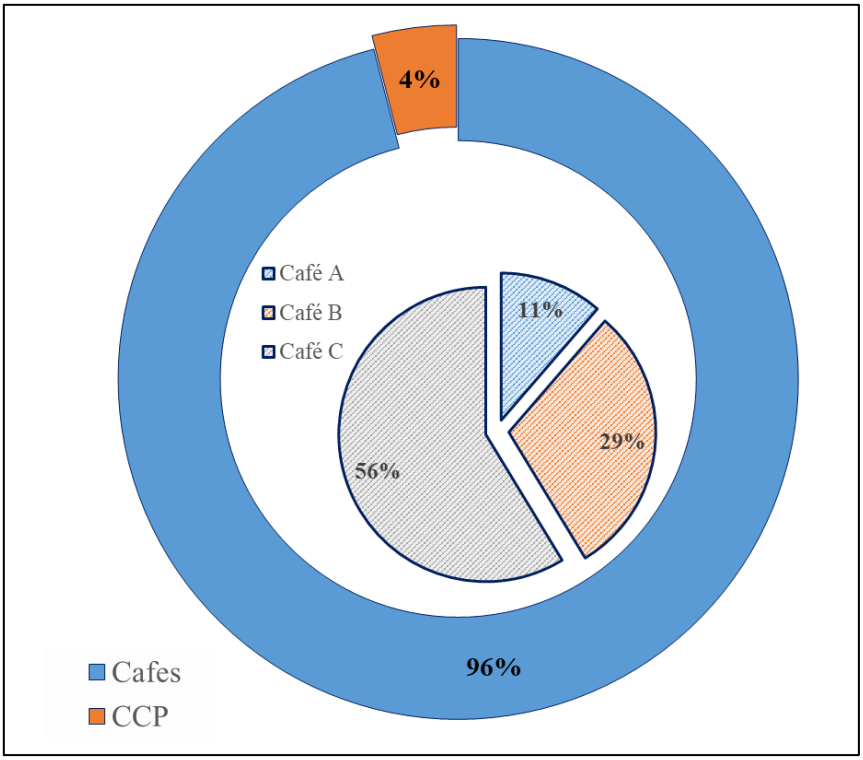


**Figure 3: Percentage of Total Food Waste Collected**

The data in Figure 3 shows that the majority of the food waste (96%) originates from the cafes. In contrast, the CCP collects plate waste from patrons, which accounts for only 4% of the total waste. This clearly indicates that the majority of food waste originates from food preparation and on-premises activities, rather than from consumer leftovers. This finding aligns with a prior study that reported that in Southeast Asia, a significant portion of food waste occurs at the production and also preparation stage due to limited access to advanced technology, inadequate transportation infrastructure, and a lack of expertise in food preservation (Kasavan et al., 2019). In addition, the findings also reveal significant variation in waste generation among cafeterias, highlights differences in management practices and control measures among cafeteria operators.

***Food Waste Distribution by Cafes***

**Table 2: Breakdown Percentage of Food Waste Generated by The Cafés**

| Café | Food Scraps | | Spoiled & Expired |
|---|---|---|---|
| | Meat and bones | Fruits and vegetable | |
| | (%) | | |
| Café A | 24.6% | 42.0% | 33.4% |
| Café B | 25.7% | 42.6% | 31.7% |
| Café C | 26.6% | 40.1% | 33.3% |
| Average | 25.6% | 41.5% | 32.8% |

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Table 2 presents the percentage breakdown of food waste generated by Café A, B, and C, categorized into food scraps (comprising meat and bones, and fruits and vegetables) and spoiled or expired food. The data reveals that the majority of food waste comes from preparation-related activities, with an average of 67.2% consisting of food scraps. These include animal-based trimmings (25.6%) and plant-based waste such as fruits and vegetables (41.5%). The remaining 32.8% is attributed to spoiled and expired food, which reflects food that was not used in time or was improperly stored.

According to Keegan & Breadsell, (2021), food scraps constitutes the largest portion of overall food waste, aligning with the findings above. It also represents one of the greatest challenges in reducing and diverting food waste effectively. The findings show a similar trend, where fruits and vegetable waste (41.5%) is consistently higher than meat and bones (25.6%). This is likely because fruit and vegetable wastes are used in larger quantities, the resulting from peeling, trimming, or discarding parts that are not typically consumed.

Food scraps is inevitable from the cooking process and inedible, however could be reduced through better kitchen training and scrap reuse, such as for broth or composting (Lin et al., 2013). The percentage of spoiled food indicates a need for improved procurement and storage practices. This type of waste can be minimized through strategies such as proper stock rotation, more accurate demand forecasting to prevent overproduction or over-purchasing, and enhancing storage conditions to preserve food quality (Woolley et al., 2023).

***Food Waste Distribution by Central Collection Point***

**Table 3: Categories of Plate Waste at Centralise Collection Point (CCP)**

| Sampling Cycle | Carbohydrate and vegetable | Protein and Bones |
|---|---|---|
| 1 | 41% | 59% |
| 2 | 54% | 46% |
| 3 | 46% | 54% |
| Average | 47% | 53% |

Table 3 shows the percentage breakdown of food waste in CCP. Two main categories are classified, namely Carbohydrate and Vegetable-based waste (e.g., rice, noodles, vegetables) and Protein and Bone-based waste (e.g., uneaten meat, bones).

The data do not show a clear or consistent trend in the proportion of carbohydrate and vegetable waste versus protein and bone waste across the three sampling cycles. Instead, the percentages fluctuate modestly, suggesting that students tend to discard both types of food in relatively similar proportions over time. In Sampling Cycle 1, protein and bone waste slightly exceeded carbohydrates, whereas in Cycle 2, the reverse occurred. By Cycle 3, the proportions were nearly even again. This inconsistency likely reflects shifting student preferences and varying menu offerings, influenced by multiple factors, including individual factors like time and convenience, social influences such as peer choices, physical aspects like food placement, and broader environmental factors such as overall food provision (Devine et al., 2023).

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***Operational Practices and Their Impact on Waste***

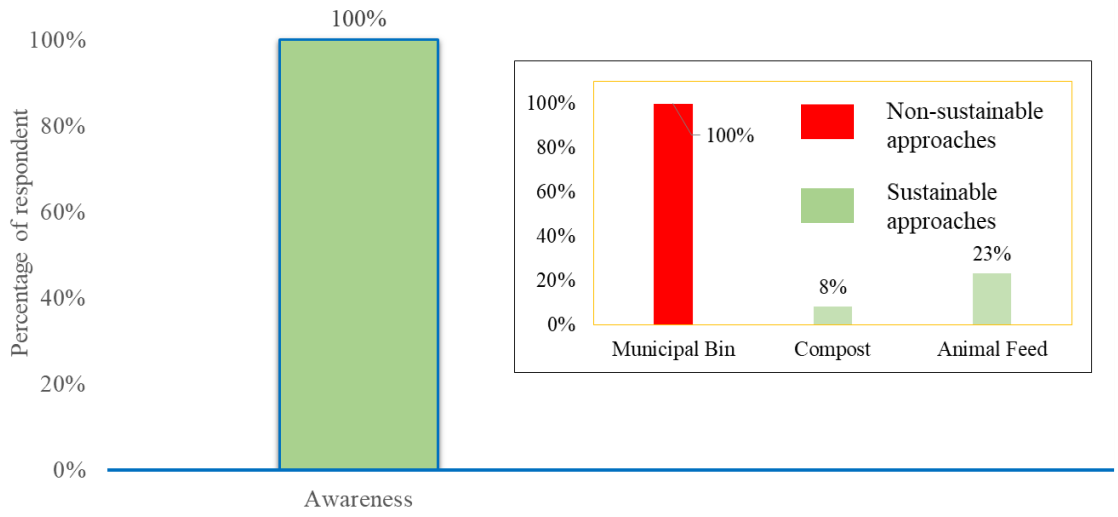


**Figure 4: Waste Management Awareness And Disposal Practices in UniKL MICET Cafeterias.**

Figure 4 presents the recognition of food waste management importance and the approaches adopted by the respondents. The findings indicate that all of respondents dispose of food waste, while unanimously recognizing the importance of proper food waste management. This unanimous agreement highlights a strong awareness of the issue among respondent (university staff and students).

The awareness is a primary step toward sustainable food waste management. According to (Hennchen, 2019), many waste-related challenges stem from a general lack of awareness. Increasing human awareness of this issue can lead to stronger intentions to reduce food waste, ultimately shaping attitudes and behaviors (Aydin & Yildirim, 2021). Both awareness and attitudes significantly influence intentions and actions, aligning with the *theory of planned behavior* (Tunner et al., 1989).

However, the findings indicate that 100% of respondents, with most relying on municipal waste bins. Alternative disposal methods, such as feeding animals or composting, were practiced by only a minority. This suggests that food waste management at UniKL MICET is largely dependent on conventional municipal waste collection systems, ended in the landfill. The findings support the statement by (Lim et al., 2016), which indicates that landfilling is the most common disposal method in Malaysia. This presents a concerning trend, as it ultimately contributes to landfill accumulation. Furthermore, this situation may stem from the lack of legal enforcement or regulatory measures designed to minimize food waste, as highlighted by Zakarya et al., (2021).

Feeding animals serves as an alternative for staff and students (23%) who own livestock, while some choose to feed stray cats. However, in hostel environments, feeding animals is discouraged as it attracts more stray cats, leading to hygiene concerns. Although small in number (2% of respondent), composting, on the other hand, is practiced on an individual and small scale, mainly for personal planting purposes. Due to the absence of large-scale composting facilities, this method remains limited in impact. These findings show that reaching

International Journal of Politics, Public Policy and Social Work
IJPPSW
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Volume 7 Issue 18 (September 2025) PP. 01-15
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the 40% recycling target in the Circular Economy of Solid Waste (2025–2035) will be challenging.

***Readiness of the Institutional Toward Sustainable Program and Community Engagement***

**Table 4: Gap Analysis of Current Campus Food Waste Management Practices Compared to Best Practices**

| Component | Current Campus Condition | Gap/Barrier Identified | Status |
|---|---|---|---|
| Institutional Policy | No formal food waste policy | Lack of formal structure | Critical |
| Infrastructure | Reliance on municipal waste collection | No on-site processing | Vulnerable |
| Awareness & Training | Limited to academic courses or select initiatives | Low engagement, unclear guidance | Need some improvement |
| Financial Support | No visible investment or funding stream | Financial barrier to implementation | Vulnerable |
| Program Implementation | Exists only in welfare or course-based initiatives | Not scaled or institutionalized | Critical |

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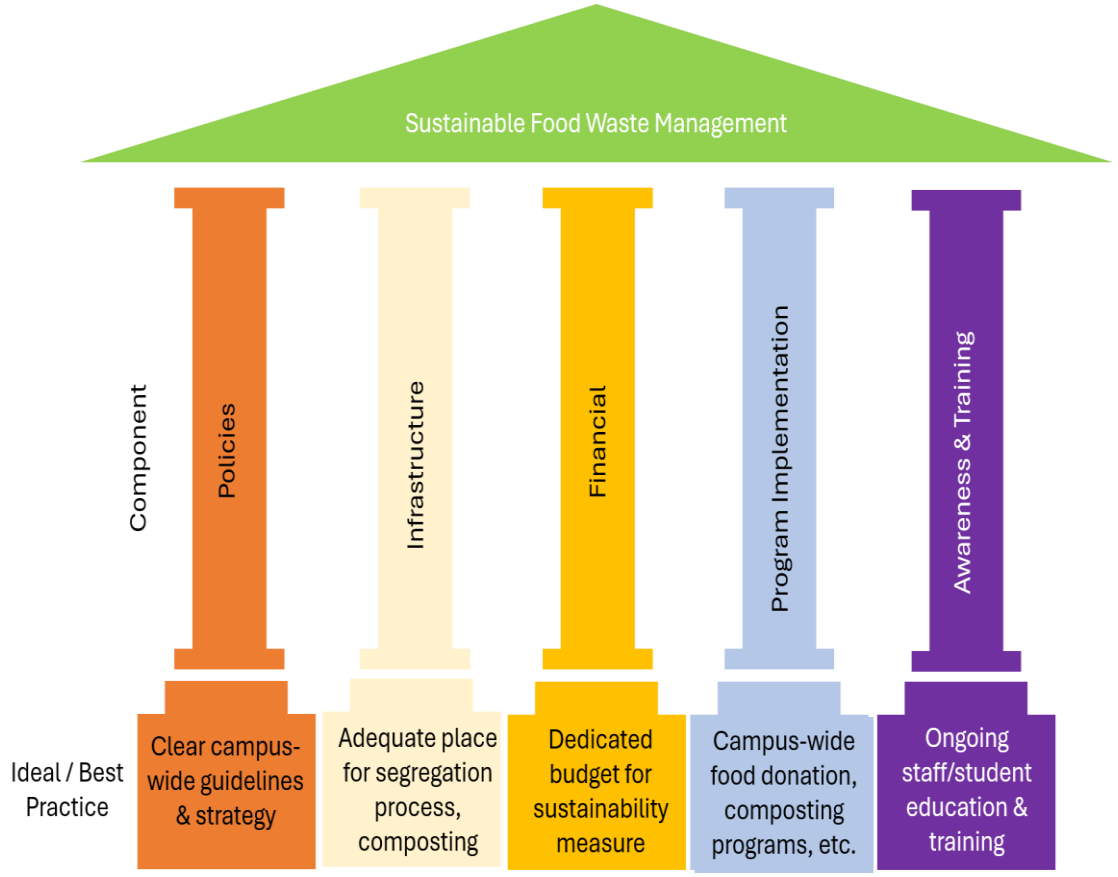


**Figure 5: Five-Pillar Framework for Sustainable Food Waste Management,**

Figure 5 illustrates the five-pillar framework for sustainable food waste management within the institution, reflecting the campus's readiness to achieve sustainable practices and align with national aspirations. The pillars represent the roles of policies, infrastructure, financial support, program implementation, and awareness & training. Building on this framework, Table 4 compares current campus food waste management practices with best practices, highlighting the key gaps and barriers that must be addressed.

From a policy perspective, this represents a critical gap. As Mahayuddin, (2024) observes, unclear or inadequate guidelines often hinder the adoption of sustainable practices. The absence of a formal food waste policy means there is no strategic framework to guide reduction, segregation, or reuse efforts. Consequently, initiatives tend to be fragmented and driven by individual efforts rather than supported by institutional commitment.

In terms of infrastructure readiness**,** the university currently relies solely on municipal waste collection services, without dedicated on-campus systems for segregation, composting, or recycling. This vulnerability significantly restricts the adoption of sustainable practices, primarily due to inadequate facilities, as highlighted by Hashim et al., (2021) and N. Kasmuri et al., (2023). This continues to pose a significant challenge for effective food waste management.

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IJPPSW
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Although awareness levels are high, as shown in Figure 4, proper training and handling practices are still not well-implemented. While education is essential to encourage participation and behavioral change, current efforts are mostly limited to academic courses or small-scale initiatives, leading to low engagement and unclear responsibilities among staff and students. Financial readiness also remains a major challenge, as there is no dedicated sustainability budget to support equipment procurement, training, or monitoring systems. This financial gap disrupts program development and limits scalability. As suggested by Nee (2024), management should allocate an annual budget for environmental activities as part of the Environmental Management Tools (EMT) framework (Nee et al.,2024).

Finally, program implementation readiness remains critically low, as food donation and composting initiatives are mostly limited to welfare activities or coursework-based projects, restricting their impact at the campus level. Without clear policies, adequate infrastructure, sustained funding, and comprehensive training, UniKL MICET is not yet fully equipped to integrate sustainable food waste management into its institutional framework.

**Conclusion**

The findings from this pilot study reveal that UniKL MICET faces significant challenges in achieving sustainable food waste management and aligning with national circular economy aspirations. Although 100% of respondents acknowledged the importance of proper food waste management, the absence of a formal food waste policy, dedicated infrastructure, financial allocation, and comprehensive training continues to limit the campus's ability to take meaningful action.

Across three consecutive sampling cycles, total food waste generation consistently exceeded 60 kg per cycle, with an estimated per capita generation of 0.079–0.093 kg per person, significantly lower than the national household average (0.5–0.8 kg/day). Most of the waste originated from food preparation activities, with Café C alone contributing over 56% of the total waste, highlighting major operational hotspots. Only 4% of waste came from plate waste, indicating that intervention efforts should focus on kitchen operations, procurement, and storage practices.

The five-pillar readiness assessment highlights critical gaps:

- Policy: No formal food waste policy to guide reduction or segregation.
- Infrastructure: Full reliance on municipal waste collection, with no on-site composting or segregation facilities.
- Financial Support: No dedicated sustainability budget to fund equipment, training, or monitoring systems.
- Program Implementation: Limited to welfare or coursework-based projects, lacking scalability.
- Awareness & Training: High awareness but weak training and unclear responsibilities, resulting in low engagement.

Without addressing these barriers, achieving the 40% recycling target under the Circular Economy of Solid Waste in Malaysia (2025–2035) will remain difficult.

This research highlights critical areas for action and policy reform in food waste management within higher education. These findings emphasize how important it is for universities to institutionalize food waste management through clear policies, dedicated budgets, and adequate infrastructure. The study also advances theoretical understanding by linking

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institutional readiness. The significant five pillars cross policy, infrastructure, financial, and behavioral dimensions significant in reducing food waste in higher education. From a policy standpoint, UniKL MICET can serve as a model for aligning campus operations with Malaysia's circular economy goals through education-driven behavioral change and operational improvements. Overall, a comprehensive, campus-wide framework integrating policy, infrastructure, funding, awareness, and scalable programs is essential to reduce waste at the source and support the national circular economy transition.

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