



From Urban Kitchens to Landfills: Transforming Food Waste for Malaysia's Health and Sustainability

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Abstract

Food waste is a pressing global issue that poses significant challenges to the environment, economy, and society, particularly regarding food security and resource sustainability. In Malaysia, food waste constitutes the largest segment of municipal solid waste, exacerbating landfill burdens and contributing to severe pollution, including greenhouse gas emissions such as methane and leachate. This manuscript presents a comprehensive study that qualitatively analyzes interviews conducted with Malaysian industry experts from the hospitality and food manufacturing sectors, as well as academics and government representatives, alongside a review of existing literature. This study aims to map the prevalence of food wastage, identify its causes, and examine the implications of food waste in Malaysian urban households and the hospitality and food service (HaFS) sectors. The findings indicate that while larger companies often implement commendable internal waste management practices driven by Environment, Social, and Governance (ESG) criteria, substantial food waste persists in the HaFS sector. This waste primarily arises from operational inefficiencies, overproduction, and consumer behaviour. Crucially, the study highlights systemic shortcomings in Malaysia's governance of food waste, including the absence of mandatory reporting, ineffective incentives or penalties, poor data management and enforcement coordination, and a general lack of public awareness. To address these issues, this paper proposes transformative mechanisms to help achieve Malaysia's sustainable development goals. These include enforcing stronger policies, mandating data tracking, and establishing robust regulatory frameworks. Enhanced public-private collaboration among government, industry, and academia is recommended to develop integrated waste-to-resource solutions. Moreover, innovative technologies, such as advanced composting and Black Soldier Fly (BSF) bioconversion, play a vital role in effectively diverting organic waste. Finally, ongoing public awareness and educational initiatives are essential to foster responsible consumer behaviours and proper waste segregation practices. This interdisciplinary approach aims to propel Malaysia toward a circular economy, yielding benefits for environmental sustainability and overall well-being.

Keywords: sustainability, food service, Black Soldier Fly, composting, circular economy

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INTRODUCTION

Food is a fundamental necessity for human life; however, a significant portion of it is lost or wasted worldwide. According to the United Nations Environment Programme (UNEP) Food Waste Index Report 2021, 17% of all food available to consumers across stores, households, and restaurants is wasted. This breakdown includes 11% from households, 5% from food service, and 2% from retail. Such global waste

imposes substantial environmental and socio-economic burdens.

In Malaysia, food waste has emerged as a critical issue. Recent data from the Solid Waste Management and Public Cleansing Corporation (SWCorp) indicates that Malaysians discard up to 17,000 tonnes of food daily, with 24% still fit for consumption. This alarming statistic positions food waste as the predominant component of municipal solid waste (MSW), often

exceeding 40% and in some reports, as high as 45% of the total daily waste sent to landfills. This increasing trend is driven by rising affluence, changing dietary habits, inefficient food supply chains, and a widespread lack of awareness regarding food waste prevention at both consumer and business levels.

The repercussions of this escalating problem are profound. Environmentally, food waste that ends up in landfills decomposes and emits harmful gases like methane, a significant contributor to global warming. Methane is approximately 25 times more potent than carbon dioxide over a 100-year period, making food waste a critical factor in Malaysia's carbon footprint. Additionally, it produces toxic leachate that contaminates soil and water, posing serious risks to ecosystems and water supplies. Public health concerns include deteriorating food waste that attracts pests such as rodents and insects, leading to unsanitary conditions that can foster diseases, including respiratory infections.

Economically, discarding edible food represents a reprehensible waste of valuable resources, including the vast amounts of water, energy, and labour invested in food production, processing, and transportation. This waste translates into significant financial losses for families, businesses, and the nation as a whole. As illustrated in Figure 1, food constitutes the largest fraction of waste in Malaysia, accounting for 44.5%. Other major categories include plastics (13.2%), diapers/sanitary napkins (12.1%), and paper (8.5%). This data underscores that food waste is the most pressing challenge in waste management in Malaysia.

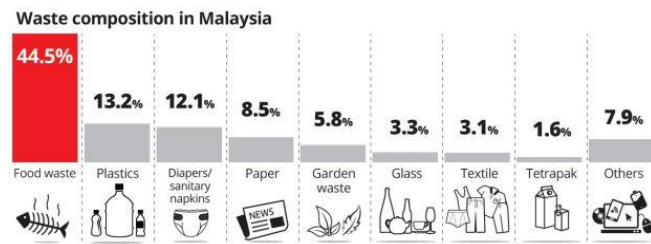


Figure 1. Waste composition in Malaysia (Huilie, 2020)

Recognizing the urgency of the situation, this manuscript aims to provide a comprehensive analysis of food waste in Malaysia. It seeks to illuminate the scale of the problem and its detrimental impacts, critically evaluate current management approaches and propose actionable strategies for transforming food waste from a burden into a valuable resource. By fostering a circular economy approach, Malaysia can move towards a more resilient, healthy and sustainable future.

CURRENT STATE AND IMPACTS OF FOOD WASTE IN MALAYSIA

Scale and Composition of Food Waste

Annual composition studies conducted by SW Corp across seven states in Malaysia consistently identify food waste as the largest contributor to landfills by weight. Malaysia experienced a daily burden of food waste which each day over 17,000 tonnes of food waste are generated, creating significant challenges for both society and the environment (Yoong, et al., 2022). This is largely attributed to the high-water content in food waste. While there has been a slight downward trend in the overall volume of food waste reaching landfills, the problem remains significant especially given the rapid rate of landfill saturation.

Sources of Food Waste

Food waste comes from many different stages in the food journey including when it's first produced, processed, distributed

and finally eaten (Porpino et al., 2015). In Malaysia, a lot of this waste comes from a few main places. Based on available statistics for 2022 and other recent years, Malaysia consistently shows a high and in some reports, the highest percentage of food waste generated per capita when compared to other nations, particularly within Southeast Asia. Figure 2 provides a succinct and insightful comparison of food waste generation across several Southeast Asian nations. The data, measured in kilograms per person, disaggregates waste into retail, out-of-home consumption and household sources.

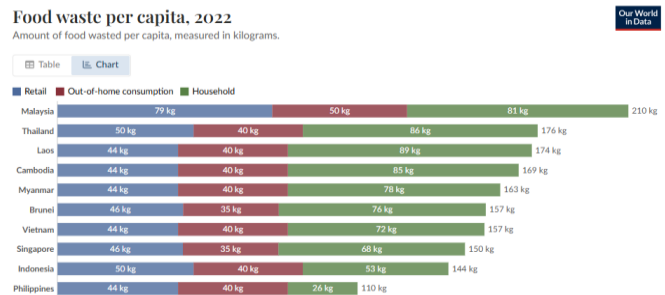


Figure 2. Food Waste per Capita (United Nations Environment Programme – processed by Our World in Data, 2022)

Evidently, Malaysia records the highest per capita food waste among the featured countries which total up to 230 kg. This figure is substantially driven by household waste (81 kg) and retail waste (79 kg) with out-of-home consumption contributing 70 kg. In contrast, countries like the Philippines (110 kg) and Indonesia (104 kg) exhibit significantly lower overall per capita waste. This visualization underscores Malaysia's prominent position in per capita food waste within the region, indicating a pressing national challenge requiring targeted interventions across its supply chain and consumption behaviours.

Firstly, households are a significant contributor to food waste with the management of this waste often proving less regulated than industrial waste. The amount of food discarded from homes is heavily influenced by consumer behaviours, including purchasing habits, cooking practices and food storage methods. Although awareness programmes are in place, studies show that behaviour change alone is not always sustained without long-term structural or institutional support (Teo et al., 2021).

Secondly, there are commercial, retail and institutional sectors, which include restaurants, hotels, markets and cafeterias. These places produce a lot of waste, often from overproduction, large portion sizes and the unpredictability of customer demand. In these sectors, avoidable waste can result from lack of real-time inventory tracking and limited use of freshness-monitoring tools (technologies or methods used to accurately track and predict the remaining shelf life or quality of food products.) (Zhang et al., 2023; Poyatos-Racionero et al., 2024). The hospitality and food service (HaFS) sector has been identified as having a great chance to prevent a lot of waste (Papargyropoulou et al., 2016).

Third, the industrial sector also contributes to food waste. Although companies like Mamee and Secret Recipe implement stringent protocols for waste sorting and management, issues such as quality control rejections and expired products inevitably add to the overall food waste challenge. According to Arshad et al. (2025), manufacturers often discard products due to strict shape, texture or packaging standards even when the food remains edible. Small and medium enterprises (SMEs), particularly face constraints in adopting digital solutions to optimise production and reduce waste generation at source.

Environmental and Economic Impacts

The environmental problems caused by food waste are significant. First, there is a heavy landfill burden. Food waste takes up a lot of space in our garbage dumps which means we constantly need to build new and expensive landfills. Second, greenhouse gas emissions. When organic food waste breaks down without air in landfills, it produces methane which is a very powerful greenhouse gas that is 25 times more effective at trapping heat than carbon dioxide (Ghani et al., 2013). This makes global warming worse. Third, leachate production. The high amount of water in food waste leads to a contaminated liquid or leachate which can pollute our soil and water if not managed properly as shown in Figure 3.

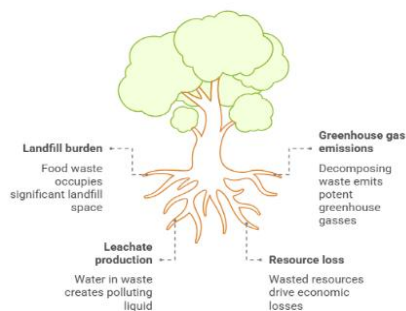


Figure 3. Significant environmental and economic burden from food waste.

Economically, food waste means a great loss of resources including water, energy and the labour used to produce the food (Quested et al., 2013). For businesses, this turns into direct financial losses from food that is thrown away and the costs of managing that waste (Papargyropoulou et al., 2016). For example, according to W. Mohd Khair W.M.H. (personal communication, June 19, 2025) a hotel in Putrajaya reported spending RM 7,000 each month hiring contractors to manage their waste.

FOOD WASTE MANAGEMENT IN THE HOSPITALITY AND FOOD SERVICE (HAFS) SECTOR

The Hospitality and Food Service (HaFS) sector which comprising hotels, restaurants and large-scale food operators, is a key contributor to food waste but also holds great potential for innovation in waste reduction and valorisation. Insights from the Focus Group Discussion (FGD) held on June 19, 2024, revealed diverse approaches adopted by industry players, reflecting varying levels of awareness, resources and operational constraints.

Hotel Operations

Hotels, especially those aiming for 5-star ratings are pushed by environmental, social and governance (ESG) factors and requirements from the Ministry of Tourism, Arts and Culture (MOTAC) to manage waste effectively. According to the W. Mohd Khair W.M.H. (personal communication, June 19, 2025), the source of food waste comes from their hotel's restaurant which served in a buffet style. He also highlighted that menu preparation is guided by historical consumption data to reduce overproduction, especially during peak events like Ramadan buffet promotions. As known, buffet style is well known with a system which led the restaurants to have a lot of food waste as well as food security issues. To manage the waste wisely, the hotel kitchen staff will prepare the food according to the number of hotel guests or an event guest. These to ensure the number of foods prepared are balanced with the number of guests. Leftover foods, according to the manager, will then be distributed

to the staff cafeteria also the welfare houses nearby or collaborated with. He emphasized that all donated food must comply with safety SOPs such as having been kept in an industrial warmer for less than four hours, to ensure hygiene and avoid liability issues.

Other than that, sometimes the hotel makes a promotion on certain events such as Ramadhan Buffet which the number of crowds might be slightly higher than other normal days. To optimize resource utilization and mitigate excessive food waste, preparation volumes were precisely calibrated against past consumption patterns, with a slight, deliberate reduction from projected quantities. Such a meticulously managed approach exemplifies a best practice with high transferability to other industrial operations and restaurants. The method of cooking the broth and the fish or chicken were done separately to maintain the freshness of the foods. Additionally, the separate cooking of broth and proteins will enhancing freshness and enabling superior portion control to indirectly reduce spoilage and kitchen waste. This may concurrently increase preparation time, demand more distinct storage space and potentially elevate energy consumption due to multiple cooking processes.

Table 1 shows a broad spectrum of HaFS models. For instance, HaFS Operation 1, a banquet facility, distinguishes itself by serving a substantial 500 meals daily at a premium price point (RM180-250/USD40-60), primarily catering to formal events for local families, wedding parties and professionals. In stark contrast, HaFS Operation 5, a university food court, demonstrates a high-volume, low-cost model, providing 6,440 meals daily at a significantly lower average price (RM5-20/USD1-4) to students and university staff. Intermediate models include HaFS Operations 2 and 3, which are Chinese and Malay cuisine restaurants, respectively, characterized by moderate daily meal counts (250-360) and mid-range pricing (RM30-100/USD8-28), serving a mix of local families and professionals. HaFS Operation 4, a five-star hotel restaurant, serves 370 meals daily at a higher price bracket (RM80-150/USD18-35), targeting both tourists and local clientele across various mealtimes. This comprehensive overview underscores the varied operational scales, economic models, service delivery mechanisms and consumer bases that define the HaFS sector, highlighting the heterogeneity relevant for targeted analyses such as waste management studies.

Table 1. Case studies summary table for Hotel Operation

	Description	Size (Av. No. of Meals served Per Day)	Average Meal Price (RM/USD ²)	Type of Service	Type of Customer & Function
HaFS Operation 1	Banquet facility	560	RM60-150 (USD22-68)	Buffet (all you can eat) Full table service Lunch, dinner, mid-morning and mid-afternoon coffee breaks	Local families/weddings, professionals on conferences, workshops, annual dinners, promotional events
HaFS Operation 2	Chinese cuisine restaurant	210	RM60-150 (USD16-41)	A la carte Lunch, dinner	Local families, professionals in meetings, work colleagues
HaFS Operation 3	Malay cuisine restaurant	160	RM40-100 (USD11-28)	Buffet (all you can eat) A la carte Lunch, dinner	Local families, work colleagues, professionals in meetings
HaFS Operation 4	Five-star hotel restaurant	170	RM80-150 (USD22-35)	Buffet (all you can eat) A la carte Breakfast, lunch, dinner	Tourists, professionals in meetings, local families
HaFS Operation 5	University food court	6,440	RM5-20 (USD1-4)	Canteen buffet (pay what you eat) Breakfast, lunch, dinner	Students and university staff

¹ RM: Ringgit Malaysia; ² USD: United States Dollar.

Restaurant Operations

Secret Recipe's operational model, characterized by the centralization of most food preparation in factories, substantially mitigates food waste generation at the individual restaurant level, primarily confining it to post-consumer remnants. According to Ibrahim I.I.I (personal communication, June 19, 2025), waste management at these outlets is overseen by external contractors, who provide comprehensive documentation on all waste categories, particularly highlighting plastic and tin. This specific emphasis on non-organic components underscores a strategic shift in waste management priorities from organic kitchen by-products to packaging materials. Consequently, it highlights the imperative of meticulous tracking and the potential

for valorising recyclable streams within broader waste sustainability initiatives.

Ibrahim I.I.I (personal communication, June 19, 2025), shared that their waste contractor also prepares reports regularly for ESG tracking, which supports collaborations with other corporate partners like IKEA. Secret Recipe has invested a significant amount of money, RM 88,000, in composting machines, utilizing the resulting compost for its Corporate Social Responsibility (CSR) programs such as distribution at carnivals, which are public events or festivals offering various forms of entertainment, food and activities to a large gathering. While this reflects a strong CSR commitment, Ibrahim I.I.I (personal communication, June 19, 2025) noted that the compost produced is not commercially viable due to limited demand, hence is mostly given away for free. This shows their commitment goes beyond just following rules, even though selling compost is not their main business. They also collect used cooking oil, though the amount from individual restaurants might be too small for contractors to profitably turn into biodiesel. The company's effort in collecting used cooking oil shows a willingness to participate in broader circular initiatives, although small outlet volumes limit biodiesel recovery potential.

Manufacturing Operations

Food manufacturers like Mamee face unique challenges. According to Majudin A.B (personal communication, June 19, 2025), a lot of their food waste comes from products that are rejected during quality control. For example, if a can is dented or a snack doesn't meet specific standards, it must be thrown away due to food safety concerns, even if it might seem edible. Stringent food safety regulations restrict the repurposing or donation of rejected products even when they remain physically intact and visually acceptable. While waste from raw materials is minimal, Majudin A.B (personal communication, June 19, 2025) said Mamee makes sure to strictly sort its waste, sending recyclable materials to recycling centres and disposing of non-recyclable waste as general waste. The absence of established downstream buyers for waste-derived by-products poses an additional challenge for manufacturing sectors aiming to enhance waste valorisation.

CHALLENGES AND LOOPHOLES IN CURRENT FOOD WASTE MANAGEMENT

Despite the efforts being made, several challenges and weaknesses prevent effective food waste management in Malaysia. There is a lack of specific rules for the industrial sector to track how much raw material they use or how much food waste they produce. This means that collecting data is mostly voluntary and scattered among different agencies. It was also observed that food waste reporting is often treated as a voluntary initiative rather than an operational requirement. While certain companies produce internal waste reports to meet ESG commitments, there is currently no centralized or standardised national platform that mandates submission of food waste data across sectors said Ishak A.R. (personal communication, June 19, 2025). Zhang et al. (2023) emphasised that fragmented data systems and the lack of real-time integration across stakeholders significantly hamper coordinated waste reduction efforts. There are also not enough incentives or penalties. According to Md. Arifin N.A. (personal communication, June 19, 2025) although certain financial concessions exist for households purchasing compost, comprehensive financial concessions for industries and robust penalties for food waste creation are notably missing. This reduces the motivation for businesses to invest in reducing waste beyond just their social responsibility efforts.

Other than that, W. Mohd Khair W.M.H. (personal communication, June 19, 2025) mention the company should

use their own money to provide a better infrastructure or machines to manage their food waste which some companies feel unmotivated in the efforts of reducing the food waste manageably. Furthermore, the absence of tangible financial incentives such as government grants, equipment subsidies or utility discounts discourages some businesses from investing in in-house composting systems or advanced waste processing infrastructure. For smaller-scale operators, capital constraints further limit their willingness to adopt sustainable waste practices without clear short-term benefits. This is consistent with findings by Arshad et al. (2025), who noted that high costs and low digital readiness among SMEs are major barriers to adopting Industry Revolution 4.0 solutions for food waste reduction.

Fragmented data management constitutes a significant impediment. Information pertaining to food waste, while often gathered by licensed waste collectors, lacks consistent reporting and standardization across the diverse array of businesses generating such waste said Ishak A.R. (personal communication, June 19, 2025). This inconsistency culminates in a nebulous and incomplete understanding of the overall food waste landscape. Furthermore, this challenge is exacerbated by discernible gaps in enforcement. Despite the existence of pertinent laws and regulations, their implementation and oversight, particularly concerning commercial and institutional entities outside the large-scale industrial sector, remain demonstrably weak.

Penalisation for not sorting food waste, a method of stringent requirement on other types of scheduled waste, such as rigid plastic waste, indicates where there is room for improvement to rectify the deficiency. Furthermore, (Mohd Hashim N., personal communication, 19 June 2025), the reliance on private waste contractors for food waste disposal, commonly seen in Nepal, results in the fact that important data is either owned by the waste contractor, hidden from the starting organization, or reported back to the starting organization inconsistently. This lack of connection with the data makes it really difficult to have any national view on the consolidation of food waste trends in different sectors. As noted by Zhang et al. (2023), data flows are also crucial, however, a requirement for accurate and reliable waste tracking, again something poorly implemented in practice to date.

Additionally, as stated by Md. Arifin N.A. (personal communication, June 19, 2025), 'there is also the issue that individual states in the country have different legislative frameworks for waste management.' Such diversity in legal adoption and enforcement between the states poses considerable obstacles to effective monitoring and compliance. For example, the state in Penang is managing waste under a local government act, as it also fought Johor or Melaka that regulating the waste in a centralized way (Md. Arifin N.A., personal communication, June 19, 2025). This difference in legal requirements also means that in some parts of the country, businesses won't be legally required to separately collect food waste at all, while others will be without even the most fundamental infrastructure in place, such as sets of appropriate separate bins or any information explaining what to do. This fragmentation of regulation diminishes the overall effectiveness of more general national environmental policies directed at waste control and waste management.

A critical need is for "hero" organizations. We need organizations or companies that are willing to take charge of the entire food waste cycle from collecting it and processing it to selling the final products like compost. Without such champions, compost often goes unsold or is given away for free, despite its value. Despite ongoing public education campaigns like those spearheaded by the Solid Waste Corporation (SWCorp) in schools, there remains a significant gap in public awareness regarding waste sorting practices state by Md. Arifin N.A. (personal communication, June 19, 2025). The inconsistency in

adherence to these practices can be traced back to ingrained behaviours and limited understanding of the importance of proper waste sorting. As found by Teo et al. (2021), school-based interventions may temporarily influence attitudes but lack long-term reinforcement unless integrated with broader community and policy support. There is also a recognised gap in industry-wide leadership. Without designated stakeholders or organisations to drive comprehensive food waste solutions from collection to valorisation many initiatives remain isolated or unsustainable. Bathmanathan et al. (2023) similarly highlighted that school pilot projects in Malaysia require infrastructure, consistent monitoring and stakeholder commitment to scale and sustain impact. The need for a “champion” entity to integrate stakeholders, mobilise funding and scale successful models was identified as critical during the FGD.

STRATEGIES FOR TRANSFORMATION: MOVING TOWARDS A CIRCULAR ECONOMY

Sustainable management of food waste in Malaysia requires a holistic approach, based on strong partnerships among the government agencies, industries, academia, and communities. It sets out telephone pole broad strokes on what can be changed under five key strategic areas to tackle food waste, namely improving policy and enforcement, encouraging multi-stakeholder action, increasing technological innovation and accessibility, and raising awareness and understanding. If done in command, this plan should allow for the circular economy of food and agricultural businesses.

Strengthening Policy and Enforcement

One of the key strategies for mitigating food wastage is by strengthening current policies and enforcing existing legislation (Hashim et al., 2021). This means implementing mandatory regulations for key food industry players, including hotels, manufacturers and supermarkets, to systematically track their food waste generation. Such data would be crucial for developing tailored waste management plans. Simultaneously, governmental policies and their enforcement must become more stringent, mirroring the regulatory framework for scheduled waste to ensure proper segregation and management of all waste streams in industrial contexts. To further incentivize compliance, discernible incentives like tax exemptions or recognition awards should be introduced for businesses that demonstrate significant progress in reducing and properly managing food waste. Conversely, imposing penalties for non-compliance would reinforce accountability. Establishing a standardized national system for reporting food waste data, potentially facilitated through licensed contractors is also essential for enhanced tracking and analytical capabilities.

Fostering Multi-Stakeholder Collaboration

Collaboration among multiple stakeholders is paramount. Governmental entities should provide essential funding and policy support while industries contribute their specialized knowledge and operational expertise to implement effective waste reduction measures. Academic institutions are well-positioned to play a vital role in conducting research and pilot projects, including exploring the efficacy of Black Soldier Fly (BSF) technology stated by Ishak A.R. (personal communication, June 19, 2025). Industries can supply necessary samples for such research and communities can actively participate in waste segregation and composting initiatives.

Furthermore, establishing centralized waste management centers is recommended. According to Ishak A.R. (personal communication, June 19, 2025), these facilities, ideally managed by a dedicated organization, would streamline food waste collection, processing (e.g., composting or BSF farming), and the distribution of derived products. This integrated approach would

foster sustainability and potentially transform food waste management into a viable economic model.

Amplifying Technological Innovation and Adoption

The impetus for technological innovation and adoption must be amplified. This includes promoting the widespread deployment of composting machines, particularly in public markets and food courts, to enable on-site food waste management. Furthermore, substantial investment in and expansion of Black Soldier Fly (BSF) technology are critical said Ishak A.R. (personal communication, June 19, 2025). BSF larvae possess the capacity to efficiently consume food waste and be converted into animal feed, offering a sustainable alternative to landfill disposal. The establishment of centralized BSF facilities in each state, underpinned by governmental funding and academic research is essential for achieving scale and success.

Further research and extension of the use of other advanced technologies such as vermicomposting, which employs worms for degradation of wastes, and biogas generation through anaerobic digestion should also be considered (Sharvini & Stringer, 2025). Advances in food technology suggest that smart packaging, as well as monitoring based on IoT protocols, could also play a significant role in reducing spoilage and waste from the field until the ultimate point of consumer consumption. For example, intelligent packaging which incorporates sensors to monitor freshness (for example, time-temperature indicators, gas sensors, etc.) can aid in real-time evaluation of product quality cited in W.M.H.W.M., Khair, (personal communication, June 19, 2025). Such systems facilitate traceability and good control of shelf-life management, particularly for perishable products (Poyatos-Racionero et al., 2024).

At the same time, big data and predictive analytics can help with inventory management and waste reduction, especially serving the large-scale food retail and service sector (Zhang et al., 2023). In addition, industry 4.0 tools, including automation, robotics and AI, are being increasingly examined as potential economical solutions for minimizing food losses on industrial processing lines. Such systems increase the accuracy of sorting and grading, maximize logistics operations, and minimize human error, thus enhancing efficiency in the food supply chain (Arshad et al., 2025).

Advantages and Disadvantages of Black Soldier Fly (BSF) Technology

Black Soldier Fly (BSF) larvae (BSFL) are gaining recognition as an innovative and eco-friendly tool for managing organic waste due to their bioconversion capabilities, offering a sustainable and cost-effective solution (Gunggot & Lardizabal, 2024; Fairuz et al. 2023). The benefits of BSF technology are associated with effective bioconversion of organic matter, as BSF can successfully convert a wide range of organic wastes (e.g., livestock manure, food waste, fruit wastes) into valuable materials, minimizing solid waste at landfills (Gunggot & Lardizabal, 2024; Fairuz et al., 2023). This approach also results in the generation of valuable byproducts via bioremediation. BSFL efficiently convert biosolids into value-added biomass containing high levels of proteins, oils, lipids, chitin, and biofertilizer, which can serve as alternative protein/fat sources for aquaculture and lower-quality animal feed (Gunggot & Lardizabal, 2024; Fairuz et al., 2023). BSF technology is eco-friendly and sustainable as the process does not require or produce toxic chemicals and contributes to a sustainable circular economy (Gunggot & Lardizabal, 2024; Fairuz et al. 2023). It also leads to reduced environmental impact by lowering bacterial growth and odour and helping to reduce greenhouse gas emissions from decomposing waste (Gunggot & Lardizabal, 2024). Furthermore, adult BSF are not considered pests and do

not spread diseases (Gunggot & Lardizabal, 2024), and BSFL can treat organic waste rapidly (Gunggot & Lardizabal, 2024). Their adaptability to various substrates is another advantage, as BSFL effectively decompose a wide range of organic materials, provided sufficient protein and carbohydrates (Mohd Rasdi et al., 2022).

However, there are also disadvantages and challenges. A primary concern is substrate-dependent performance, where BSFL growth and development are significantly influenced by the quality and type of food they consume. Nutrient-deficient wastes may require supplementation to optimize BSFL growth (Gunggot & Lardizabal, 2024; Mohd Rasdi et al., 2022).

5.5 Enhancing Awareness and Education

Awareness and education are pivotal components of this transformative strategy. According to Md. Arifin N.A. (personal communication, June 19, 2025), it's essential to continue and expand school programs, collaborating with the Ministry of Education to instill responsible waste management habits in younger generations. Empirical studies have consistently highlighted the significant role of education interventions in reducing food waste. For instance, a school-based program in Malaysia demonstrated that integrating nutrition education with supportive canteen environments increased student awareness and shifted attitudes toward waste even though controlling plate waste remained challenging (Teo et al., 2021). Another Malaysian case study at a secondary school showcased a successful pilot food waste management system through awareness activities, the installation of a food-waste composting machine and participatory data collection which recovered 339.5 kg of food waste over 38 days, converting it into bio-fertilizer for resale (Bathmanathan et al., 2023). These findings reinforce the efficacy of combining awareness, participatory learning and behavioral mechanisms in transforming sustainability practices.

Additionally, Mohd Hashim N. (personal communication, June 19, 2025) mentioned that there is the need for the implementation of a targeted public awareness programme, which not only reminds people that it is possible to avoid the environmental and economic cost of food waste but also emphasizes the significance of the correct recovery of waste (Papargyropoulou et al., 2016). Moreover, such steps need to be targeted at consumer "value for money" perceptions, particularly in buffet-type services, to better internalize consumption attitudes (Papargyropoulou et al., 2016). Companies should also be incentivized to share the innovations that have worked for them in reducing waste data across the entire value chain, promoting a shared sustainability mindset.

CONCLUSION

Food wastage in Malaysia is a complicated issue and needs prompt, concerted efforts to combat it. Although some sectors have shown considerable success in waste management, systemic issues persist, notably in adherence to policies, data, and public participation. Through better-regulated, environment-friendly options and empowering government, industry, and academia partnerships, embracing advanced technologies such as BSF and composting, and propagating public knowledge, Malaysia could make an about-face on organic residual waste disposal. The aim is to divert precious resources from landfill, diminish environmental costs, and make a substantial contribution to the health and well-being of the nation, as well as contribute to the nation's sustainability goals, with the goal of creating a more circular economy. This journey requires a shared commitment to change, recognizing that our future depends on how effectively we manage our waste today.

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