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Food waste management strategies: A comparative study of Singapore and Indonesia

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ABSTRACT
Background: Food waste is one of the global issues that continues to face many challenges in its resolution. Food waste causes losses in various aspects. The environmental and economic losses caused by food waste are related to the loss of water and energy, while the social losses are associated with food security. Based on available data, Southeast Asia is among the five largest contributors of food waste in the world; therefore, this article aims to compare food waste management strategies in Singapore as a developed country and Indonesia as a developing country based on regulatory approaches and implementation strategies. **Methods**: The method used in this study is a comparative descriptive study using secondary data derived from journal articles, reports, and country guidelines on food waste. **Findings:** The comparison results show that Singapore and Indonesia have similar strategies in certain aspects, despite differences in the implementation and approaches to addressing food waste. Singapore has a more established food waste management system because they have effective synergy between policies, infrastructure, and cross-sector collaboration. In contrast, Indonesia still requires significant improvements, as it continues to grapple with issues regarding priorities, regulations, infrastructure, and sectoral silos. **Conclusion**: Indonesia can learn from Singapore's approach to establishing guidelines as an educational effort and optimizing the use of technology for food waste recycling. In the longer term, Indonesia could consider adopting a collaborative governance approach incorporating the Water-Energy-Food nexus, alongside food waste valorization strategies, drawing on relevant practices implemented in Singapore. **Novelty/Originality of this article:** This study highlights the comparative differences in food waste management strategies between Singapore and Indonesia and emphasizes the potential role of guidelines and technology-based approaches for future food waste prevention in Indonesia.

KEYWORDS: circular economy; food waste management; regulatory approaches; sustainable development; waste management strategies.

1. Introduction

Food encompasses any substance, whether processed or raw, intended for human consumption, including beverages. It also includes items that have spoiled and are thus unfit for human consumption. Unconsumed food becomes waste, categorized into two types: food loss and food waste. Specifically, food loss refers to edible plant and livestock commodities that exit the supply chain, either directly or indirectly, without being utilized for other purposes, resulting in a loss of value. In contrast, food waste comprises discarded material that includes both parts intended for human consumption and parts that are inedible, such as bones, skins, and seeds (Olabode et al., 2025; United Nations Environment Programme (UNEP), 2024).

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In developing countries, food waste typically originates at the beginning of the supply chain due to financial or technical constraints, commonly termed as food loss. Conversely, in developed countries, the majority of food waste arises at the end of the supply chain, which happens during distribution and consumption (Eitiveni et al., 2025). The journey of food from harvest to the consumer is long and complex, creating a high risk of both food loss and food waste (FLW). These issues generally stem from supply chain inefficiencies, such as overstocking, spoilage, and suboptimal storage temperatures. The volume and type of food waste vary by country, influenced by factors such as economics, culture, climate, location, and consumption patterns (Batool et al., 2024).

The global human population is projected to exceed 9 billion by 2050, a trend that will drive up the global demand for food. This increase is fueled by rising per capita demand linked to higher individual incomes; although the proportion of income spent on food decreases as earnings rise, the overall global demand for food continues to grow (Fukase & Martin, 2017). As global demand for food continues to increase, the potential for food waste generation is likewise expected to grow, resulting in substantial economic losses estimated at approximately USD 940 billion annually worldwide (Tutar et al., 2025).

Sustainable Development Goals (SDGs) Goal 12 Target 3 commits to halving global per capita food waste at the retail and consumer levels and reducing food losses along production and supply chains, including post-harvest losses. These efforts focus on food and its inedible parts that exit the supply chain and are therefore lost or wasted (UNEP, 2024). Socially, the issue of food waste represents a paradox related to SDGs, particularly Targets 2.1 and 2.2, which aim to end hunger, food insecurity, and malnutrition by 2030 (Food and Agriculture Organization (FAO) et al., 2024). Approximately 1.3 billion tons of food are wasted annually (Tutar et al., 2025), with households representing one of the largest sources of food waste. Discarded food is estimated to be sufficient to provide approximately one billion meals each day. This situation is particularly concerning given that one in eleven people worldwide experiences hunger, while one in three lacks access to an affordable and nutritionally adequate diet (United Nations, 2025).

From an environmental perspective, food waste contributes 24% to waste accumulation in landfills and 22% to the incineration of solid waste, producing 4.4 gigatons of CO_2 per year, equivalent to 8% of anthropogenic greenhouse gas emissions (Kohli et al., 2024). In addition, food waste is not only about wasted food but also involves the loss of energy, water, and land resources (Batool et al., 2024). Producing food requires significant energy and water resources. Energy is required from production to consumption. The production process accounts for approximately 15 to 20% of the global food energy footprint, while food processing accounts for up to 25% of the total energy footprint. Household cooking contributes 15 to 55% of the total food energy footprint in high-income countries compared to developing countries (Coudard et al., 2021). Food production, particularly in the agricultural sector, uses more than 90% of global freshwater consumption (Marston et al., 2021). High water use poses a challenge to food production because freshwater availability is increasingly limited due to exploitation (Hoehn et al., 2021).

The Environmental Protection Agency (EPA) offers a food recovery strategy (Figure 1) by ranking potential approaches from the most to the least preferred options. Source prevention is identified as the most preferred strategy, while disposal in landfills represents the least preferred option (EPA, 2025). At the household level, food waste prevention is closely associated with food-related activities, including meal planning, purchasing, storage, and preparation. However, effective food waste prevention cannot rely solely on individual motivation and behavioral changes, but also requires support from the broader system. Such support includes adequate tools and accessible information that enable households to manage food more effectively. Moreover, individual food management practices are shaped by market conditions, including marketing strategies, packaging design, portion sizes, and expiration date labeling, all of which can influence household habits and decision-making (Soloha et al., 2026).

Unlike food waste, surplus food refers to food that remains safe and suitable for human consumption but is not sold or utilized. Effective management of surplus food is essential to prevent economic losses and the depletion of resources invested throughout the food production and distribution processes. It also has important implications for food security, particularly by improving access to food. In 2025, approximately 778.6 million people experienced severe food insecurity worldwide. Although this figure represents a decline from previous years, continued efforts are needed to further improve food access and strengthen food security (FAO et al., 2026; Nasso et al., 2026). In this regard, food donations can serve as a solution for the food insecurity problem. Within the same hierarchy, food upcycling also plays a role in waste reduction by utilizing food materials that would otherwise go to waste to create value-added products. However, this approach requires specific strategies to gain public acceptance, as upcycled foods represent a new category that prompts consumers to consider aspects such as safety, quality, taste, and nutritional value (Hwang et al., 2026).

In addition to being utilized for human consumption, food waste can also serve as animal feed. The nutrients within food waste can be converted into nutritious food sources, such as meat, milk, and eggs, that later can be consumed by humans. However, since not all food waste is suitable for animal feed, composting offers an alternative approach for recovering organic resources that can be returned to agricultural production. Finally, landfill disposal represents the least preferred option for managing food waste because piles of food waste in anaerobic conditions can generate methane gas, which contributes to global warming (Dou et al., 2024). However, at this stage, food waste can be utilized for energy recovery, such as through anaerobic digestion and incineration. Nevertheless, numerous challenges arise for the implementation, generally relating to technical, economic, and social aspects (Shukla et al., 2024).

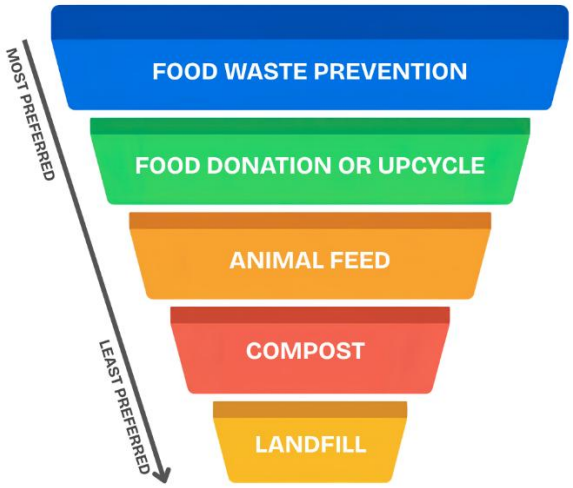

Fig. 1. Food recovery strategy
(Author's elaboration based on (EPA, 2025))

Food waste is a global challenge that affects countries across different income levels, including high, upper-middle, and lower-middle-income nations (United Nations, 2025). East Asia and Southeast Asia ranked fourth in total per capita food waste in 2019, reaching 123.3 kg (Eitiveni et al., 2025). Currently, consumption patterns in Asia are shifting due to demographic factors, population growth, urbanization, and increasing income. These factors support improvements in food security and nutritional fulfillment; however, Southeast Asia also faces climate change risks such as shifts in rainfall patterns and droughts that may affect the production of food loss and waste (FLW). For example, high temperatures in tropical regions can cause vegetables and fruits to spoil due to the lack of cooling systems, while flooding can hinder food logistics distribution. In addition, limited data also poses a challenge in addressing food waste (Pottinger-Glass et al., 2025).

This article conducts a comparative study between Singapore and Indonesia regarding food waste management. Singapore is a city-state located at the southern tip of the Malay Peninsula in Southeast Asia, covering approximately 710 km^2 and has a population of 6,036,860 (Ministry of Foreign Affairs Singapore, 2025; World Bank, 2024). Statistically, in 2025, food waste in Singapore accounts for approximately 11% of the total waste generated. In the same year, approximately 649 thousand tons of food waste were produced; however, only 140,000 tons were recycled (National Environment Agency, 2026b). To address the problem, Singapore implements a comprehensive food waste management strategy that prioritizes source reduction, followed by the redistribution of surplus food, food waste recycling, and energy recovery (National Environment Agency, 2020a). Regarding food waste recycling, Singapore has demonstrated its commitment by promoting waste valorization and investing in integrated waste management infrastructure, exemplified by the development of Tuas Nexus (Heng et al., 2024).

Meanwhile, Indonesia is an archipelagic nation located in Southeast Asia, covering an area of 1,904,569 km^2 and comprising 38 provinces. It is the most populous country in Southeast Asia, with a population reaching 279.2 million in 2024 (Bappenas, 2025). In Indonesia, food waste generation in 2025 is projected to be the largest among all waste categories, accounting for 40.25%, while waste sources are generally dominated by household waste, which constitutes 51.41% *(*Ministry of Environment, 2025). The Government of Indonesia has developed strategies to reduce food waste, namely through behavioral change, improvement of food system support, strengthening regulations, optimizing funding, utilization of FLW, as well as the development of studies and data collection on FLW (*Badan Perencanaan Pembangunan Nasional* (Bappenas), 2021).

Addressing food waste issue therefore requires collaborative efforts, with public–private partnerships playing an important role in developing and implementing effective food waste reduction strategies (United Nations, 2025). The distinct approaches adopted by the two countries to address food waste provide an important basis for examining similarities and differences in their respective management strategies. In this case, the existing literature on food waste management and comparative studies between Southeast Asia countries remains limited. Addressing this gap, the present study aims to identify similarities and differences in food waste management strategies, especially from a regulatory approach, and examine the key factors influencing their development and implementation. Based on the findings, key lessons for Indonesia's food waste management can be derived by examining the experiences of a developed country, while considering Indonesia's context as a developing nation.

2. Methods

The method used in writing this article is a comparative study utilizing secondary data such as journal articles, reports, and country guidelines related to food waste management. The secondary data analyzed in this study were selected based on their relevance to the research topic and were limited to publications issued between 2020 and 2025. Furthermore, the analysis was conducted from regulatory and implementation strategy perspectives to provide a comprehensive understanding of current approaches to food waste management.

3. Results and Discussion

The comparative study reveals similarities and differences between the two countries regarding food waste management. The results of the comparative study are presented in Table 1.

Table 1. Comparative results between Singapore and Indonesia

Aspect	Singapore	Indonesia
Management strategy	Zero Waste Masterplan	Roadmap for Food Loss and Food Waste Management to Support Food Security towards Golden Indonesia 2045; National Roadmap & Action Plan Circular Economy Indonesia 2025-2045.
Policy	Resource Sustainability Act 2019 Part 5 on Food Waste	Law Number 18 of 2008 on Waste Management; Government Regulation of the Republic of Indonesia Number 81 of 2012 concerning the Management of Household Waste and Household Waste-like Waste.
Prevention	Love Your Food; Say Yes to Waste Less.	*Gerakan selamatkan pangan* (food rescue movement); *Gerakan stop boros pangan* (stop food waste movement).
Excess food distribution	The Food Bank Singapore; Metta Welfare Asssociation; Willing Hearts; Fei Yue Community Services; Food from the Heart; Singapore Red Cross Society; South Central Community.	Food Bank of Indonesia; Foodcycle; Surplus apps; Food distribution from stop food/*stop boros pangan*
Guidelines	Waste Less Food Handbook; Food Waste Minimisation Guidebook for Industry (Supermarket, Manufacture, and Food Retail); Food Waste Segregation and Treatment Guidebook.	-
Food waste recycle	Valorization; Energy Recovery through Tuas Nexus.	-

Badan Pangan Nasional, 2025; Bappenas, 2024a, 2024b; Eitiveni et al., 2025; Gerakan Stop Boros Pangan, 2025; Heng et al., 2024; Ministry of the Environment and Water Resources, 2019; National Environment Agency, 2020b, 2020a, 2026a

3.1 Singapore's strategy in managing food waste

Singapore has a forward-looking vision in efforts to reduce food waste through diverse implementations, making the approach comprehensive. Drawing upon the environmental protection agency (EPA's) food waste management hierarchy, Singapore has adopted a similar framework that prioritizes the prevention and reduction of food waste at the source, followed by the distribution of surplus food, food waste recycling, and energy recovery as a final option (Figure 2). Singapore's efforts to reduce food waste are outlined in the *Zero Waste Masterplan*, which also supports the realization of a circular economy. Through the masterplan, Singapore aims to reduce the per capita amount of waste sent to Semakau Landfill by 30% by 2030. This effort is further motivated by concerns regarding the declining capacity of Semakau Landfill, Singapore's only landfill, which is projected to reach its full capacity by 2035. Within this framework, food waste is designated as one of three priority waste streams, alongside e-waste and packaging (Ministry of the Environment and Water Resources, 2019).

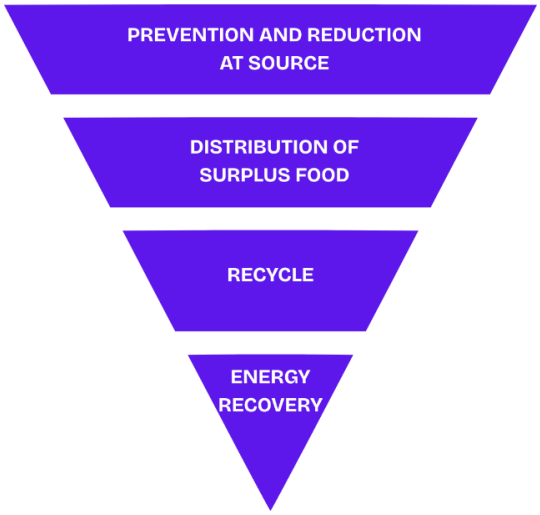

Fig. 2. Singapore's food waste management system
(National Environment Agency, 2026b)

Based on the hierarchy shown in Figure 2, prevention is the primary strategy for addressing food waste. This approach is implemented through public education via campaigns and guidelines accessible online. Education serves as a crucial foundation for raising public awareness, and access to information further supports these efforts. One program launched by the National Environment Agency (NEA) is "Love Your Food." This campaign actively engages the public, notably through Food Waste Reduction Ambassadors, who are trained to amplify the call to reduce food waste within the wider community. Beyond this, efforts to promote food waste reduction also involve collaborations with organizations, schools, and supermarkets, thereby reaching an even broader range of communities. (Ministry of the Environment and Water Resources, 2019).

Regarding guidelines, there are several guidelines on managing food waste tailored to specific audiences, ranging from household to commercial and industrial sectors. Waste Less Food Handbook provides recommendations on household food management practices, encompassing meal preparation, grocery shopping, and food storage, along with strategies to prevent food waste during hosting events (National Environment Agency, 2026b). The Food Waste Minimisation Guidebook, developed for supermarkets, manufacturers, and food retailers, provides a comprehensive framework for food waste prevention. The guidebook addresses key aspects of food-related operations, including planning, purchasing, storage, sales, and staff training, while considering the practical realities faced by the industry (Ministry of the Environment and Water Resources, 2019). Such guidance is particularly important because food waste generation results from a complex range of decisions and is influenced by multiple interconnected factors. Context-specific guidelines are essential for ensuring that stakeholders can effectively understand and implement food waste management practices, given that such approaches cannot be universally applied across different settings.

Singapore's food waste management efforts are also reflected in its regulations, specifically Part 5 of the Resource Sustainability Act 2019. These regulations mandate the segregation and treatment of food waste at the source and establish reporting systems, particularly targeting commercial and industrial buildings. Furthermore, clear provisions govern food waste disposal facilities, requiring licenses issued under Section 23(2) of the Environmental Public Health Act 1987, and licensing requirements also apply to waste collectors involved in food waste segregation. When food waste generation cannot be avoided, segregation at source constitutes a fundamental measure for facilitating appropriate food waste management. This step is crucial not only for managing food waste itself but also for ensuring the proper management of other waste streams. Furthermore,

for surplus food that remains suitable for human consumption, Singapore already has various organizations that facilitate its redistribution to different communities. These organizations operate according to specific guidelines, including criteria for food eligibility and the target beneficiaries of the redistribution (National Environment Agency, 2026a).

The next approach in Singapore's food waste management strategy is recycling. The recycling rate of food waste in Singapore from 2018 to 2023 tended to remain stable, increasing from 126,000 tons in 2018 to 132,000 tons in 2023. Nevertheless, efforts to increase food recycling have not produced sufficiently significant results because the amount remains relatively low compared to the total food waste generated, which reached 755,000 tons in 2023. The difference in the amount of food waste that is not recycled is likely to end up at the Semakau Landfill, which has very limited capacity. One form of food waste recycling strategy employed in Singapore is through valorization, although still implemented on a small scale. Several examples of food waste valorization conducted in Singapore between 2018 and 2024 include the utilization of soybean pulp as probiotic beverages, biscuits, cheese, and biostimulants for plants. Furthermore, spent barley grains have been utilized to produce protein powder and formulated noodles. Another innovation that has been implemented is the utilization of vegetable and fruit waste as raw materials for 3D food printing (Heng et al., 2024). Although food waste valorization offers a promising approach to waste management, careful selection of the processing pathway is necessary to minimize potential environmental impacts. This is because food waste varies in composition, which can influence feasibility, the efficiency of the techniques employed, and the characteristics of the resulting products (Lee et al., 2024).

The final option in the hierarchy is energy recovery. Singapore has developed an integrated waste management facility, namely Tuas Nexus, which includes a food waste treatment facility capable of processing 400 tons of food waste per day (Heng et al., 2024). Tuas Nexus consists of the Integrated Waste Management Facility (IWMF) and the Tuas Water Reclamation Plant (WRP), as shown in Fig. 3. The waste treatment technology is integrated across food, water, and energy sectors. Specifically, food waste originating from the IWMF is converted into slurry and subsequently processed together with the WRP. The results of this treatment can be utilized for biogas production and further processed into electricity generation, which can be reused for the Tuas Nexus waste treatment facilities or for residential households (National Environment Agency, 2020b).



Fig. 3. Schematic of the Tuas Nexus, Singapore
(National Environment Agency, 2020b)

3.2.1 Management strategy

Law Number 18 of 2012 concerning Food states that food is a fundamental human need and constitutes part of human rights as regulated in the 1945 Constitution. However, the issue of FLW in Indonesia still requires special attention. Specifically, the amount of food loss and waste (FLW) generated in Indonesia during 2000–2019 reached 23 to 48 million tons per year. In addition to causing environmental, social, and economic impacts, FLW also results in the loss of nutritional content. The energy content lost from FLW in Indonesia is equivalent to the energy needs of 29–47% of the Indonesian population, while the lost protein content is equivalent to 30–50% of the population, vitamin A is equivalent to 63–166% of the population, and the lost iron content is equivalent to 46–72% of the population in Indonesia (*Badan Perencanaan Pembangunan Nasional* (Bappenas), 2021). This condition is in stark contrast to Indonesia's position, which ranked 77th out of 121 countries worldwide with a moderate level of hunger according to the Global Hunger Index in 2022. The loss of nutritional content due to FLW indicates the government's failure to realize Law 18/2012, which emphasizes that the state has the obligation to ensure the availability, accessibility, and fulfillment of food for the community in a safe, adequate manner and with good quality and nutritional value (Satyawati et al., 2024).

There are both direct and indirect drivers of FLW generation in Indonesia. Direct drivers are caused by actors who directly manage the supply chain, including the lack of implementation of Good Handling Practice (GHP), inadequate storage facilities, limited technology, excessive portion sizes and consumer behavior, as well as poor harvesting and packaging processes. Meanwhile, indirect drivers are influenced by economic, political, and cultural factors within the food system that affect food supply, including market quality standards and consumer preferences, limited education for food handlers and consumers, low purchasing power and market competition, and infrastructure limitations (Bappenas, 2021).

To address the issues, Indonesia has adopted an FLW management strategy that is more technically oriented and context-specific than the approaches reflected in the EPA and Singapore's model. In 2021, National Development Planning Agency (hereafter reffered to as Bappenas) conducted a study on FLW that resulted in an FLW management strategy divided into five policy directions based on issues regarding FLW generation, its causes and drivers, and the associated greenhouse gas (GHG) emissions. These five policy directions encompass behavioral change, improvements to food system support mechanisms, the strengthening of regulations and optimization of funding, FLW utilization, and the development of FLW research and data collection. These outputs subsequently served as the basis for strategic and policy recommendations for FLW management for the 2020–2045 period (Bappenas, 2021).

Indonesia's commitment to reducing FLW was further articulated in The Roadmap for Food Loss and Food Waste Management to Support Food Security towards Golden Indonesia 2045 (hereafter referred to as FLW roadmap), which established a target of reducing FLW by 75% by 2045. The roadmap has five broader strategic pillars: policy and regulatory development, capacity building and education, strengthened coordination and collaboration, technology and infrastructure development, and the implementation of incentive and disincentive mechanisms. The evolution of the strategy reflects the development of a more comprehensive and integrated set of targets and actions for reducing FLW in Indonesia. The roadmap was also developed in alignment with SDG Target 12.3, which aims to reduce food loss by 50% by 2030 (Bappenas, 2024b).

In terms of strategic management, Indonesia can learn from Singapore regarding the Water-Energy-Food (WEF) nexus approach. Singapore indirectly incorporates the WEF nexus approach, which emphasizes the interdependencies among water, energy, and food within the food waste management system. The WEF nexus approach supports more integrated and sustainable management while enhancing the capacity to respond to future

challenges (Jones-Crank, 2024). The WEF nexus approach is crucial in the context of food waste management, given the close interlinkages between food production, energy, and water. However, implementing the WEF nexus is far from easy and faces significant challenges during execution. While the WEF nexus framework can reveal cross-sectoral synergies and trade-offs, systematically integrating these findings into existing governance structures remains difficult. The implementation is often hindered by sectoral silos and obstacles to data sharing, making a transformation toward collaborative governance (Kurniawan & Pramono, 2026; Tatry et al., 2026). To this end, Indonesia could strengthen its efforts to address food waste through a collaborative governance approach, as outlined in the third strategy of the FLW roadmap. Effective implementation of this strategy is essential to enhance coordination and foster collaboration among relevant stakeholders in addressing food waste.

Regarding management strategies, those outlined in Indonesia's FLW roadmap primarily emphasize upstream interventions, particularly the prevention and reduction of FLW generation. In contrast, Singapore's food waste management strategy has also been shaped by the declining capacity of Semakau Landfill, creating a strong urge to reduce the amount of waste requiring final disposal. Although preventing FLW generation remains essential, food waste in Indonesia is projected to account for 40.25% of total waste generation by 2025 (Ministry of Environment, 2025). Furthermore, a substantial proportion of food waste in Indonesia continues to be disposed of in Final Processing Site or landfills/*Tempat Pemrosesan Akhir* (TPA), while declining landfill capacity is becoming an increasingly pressing concern (Budhijanto et al., 2024; Farahdiba et al., 2023).

Although the FLW roadmap models a potential 75% reduction in food waste sent to TPA through its proposed strategies, it provides limited detail on specific interventions to treat or recover food waste. However, downstream disposal challenges are instead listed in a separate document, which is the National Roadmap & Action Plan for Circular Economy Indonesia 2025-2045 (hereafter referred to as Circular Economy Roadmap). In this document, the food sector is identified as one of five priority areas for Indonesia's transition from a linear to a circular economy, alongside plastic packaging, electronics, construction, and textiles. Within the food sector, the strategy emphasizes improving the quality of raw and processed food production while promoting the prevention and utilization of FLW. The strategy incorporates 9R principles across the entire food supply chain, encompassing production, distribution, consumption, and end-of-life stages (Bappenas, 2024a, 2024b).

3.2.2 Policy

Both Indonesia and Singapore already have regulatory instruments that address food waste management. However, a key difference is that Singapore has specific legislation dedicated to food waste, whereas Indonesia does not explicitly mention "food waste", instead, it categorizes it under household waste. Another distinction is that Singapore's legislation targets the industrial and commercial building sectors, while Indonesia's regulations apply to both the household and industrial-commercial sectors. In Indonesia, the issue of food waste is addressed within Government Regulation No. 81 of 2012, which serves as a follow-up to Law No. 18 of 2008 on Waste Management. The regulation covers measures to limit waste generation and outlines waste management processes such as sorting, treatment, final disposal, recycling, and reuse. It also details waste management facilities, including TPS3R (Reduce-Reuse-Recycle Waste Processing Sites), Integrated Waste Processing Sites/*Tempat Pengolahan Sampah Terpadu* (TPST), and Final Processing Site or landfills/*Tempat Pemrosesan Akhir* (TPA). Furthermore, just like Singapore's regulations, this regulation includes requirements for waste reporting and data collection. In the Indonesian context, this encompasses waste sources, generation rates, composition, and characteristics.

3.2.3 Prevention movement and excess food distribution

The governments of Singapore and Indonesia have both demonstrated commitments to addressing the issue of food waste through movement. The Indonesian government, particularly through the National Food Agency (hereafter referred to as *Badan Pangan Nasional* (Bapanas)), has sought to reduce FLW generation through the save food movement/*Gerakan Selamatkan Pangan* (GSP), which was initiated in 2022. The strategy employed in this movement is to prevent food waste through policies and public outreach, as well as to facilitate food rescue actions. This movement is carried out through collaboration involving five stakeholders: government, academia, business, community, and media. This movement also involves food donors from hotels, restaurants, retailers, and the food industry, whose contributions are subsequently distributed by food rescue organizations to people in need (*Badan Pangan Nasional*, 2025).

Furthermore, as a follow-up to the GSP program, Bapanas launched the Stop Food Waste Movement/*Gerakan Stop Boros Pangan* (SBP) platform through a digital application to facilitate multi-stakeholder collaboration in managing surplus food so that these activities can be conducted safely, transparently, and in a well-coordinated manner. The scheme involves collecting food donations, sorting them based on quality control criteria, and subsequently distributing the food to those in need. Based on data as of 23 November 2025, 275,634 kg of food was successfully rescued, and 263,476 kg was distributed, benefiting 632,659 recipients (stop food waste movement/*Gerakan Stop Boros Pangan*, 2025).

A similar application to SBP had previously been launched by the private sector, namely Surplus Indonesia, with the same mission of rescuing surplus food originating from hotels, cafés, and restaurants. However, in the Surplus application, excess food is resold through the platform with discounts ranging from 20% to 50%. Nevertheless, public awareness in Indonesia of contributing to this movement remains low. In 2023, the number of smartphone users in Indonesia reached 70 million people, yet users of the Surplus application were only around 100,000 (Eitiveni et al., 2025). This emphasizes that initiatives to facilitate surplus food management alone are insufficient, but must also be accompanied by behavioral changes within society to promote efforts to reduce food waste. This is in line with the first strategy of Bappenas to address FLW, namely behavioral change, which can be achieved through capacity building for food workers and consumer education to raise awareness of the FLW issue (*Badan Perencanaan Pembangunan Nasional* (Bappenas), 2021).

3.2.4 Guidelines

No specific government-initiated guidelines on food waste education in Indonesia were identified in this study. This stands in contrast to Singapore, which already possesses several context-specific guidelines that are easily accessible to the public. Indonesia could learn from Singapore's approach to facilitate public access to information on food waste, particularly through visual media. In this regard, Indonesia has demonstrated a commitment to enhancing educational capacity through the second strategy of the FLW roadmap. One planned initiative is a public awareness campaign on food loss and waste (FLW) reduction utilizing media such as television, radio, and social media. Additionally, a noteworthy aspect of the second strategy is the effort to integrate the issue of FLW into the curriculum for primary and secondary education, as well as into teacher training programs.

However, the most important aspect of educating people about food waste is considering the local context. In Indonesia, food waste generation in 2025 is projected to be the largest among all waste categories, and in terms of sources, household waste predominates among all types of waste (Ministry of Environment, 2025). Educational efforts, whether through guidelines or campaigns, should place greater emphasis on the household level because the issue of household food waste is highly complex, as it is closely

linked to socioeconomic status, attitudes and awareness, barriers, and other driving factors. Therefore, educational strategies that are culturally relevant to households are required (Meng et al., 2026). One of Singapore's guidelines that can serve as a reference for Indonesia is the Waste Less Food Handbook because it provides recommendations on household food management practices.

Regarding the issue of food waste, developed nations possess an advantage in terms of comprehensive regulations, ranging from established guidelines to clear targets for waste reduction, complemented by educational efforts to raise public awareness (Rahman et al., 2024). Singapore's Food Waste Minimisation Guidebook targets the industrial and commercial sectors, aligning with the resource sustainability act (RSA) 2019. This demonstrates a synergy between regulation and educational efforts that strengthens implementation, and it shows the existence of established food waste management systems underpinned by regulatory support. In this regard, a significant gap is evident in Indonesia compared to Singapore. Therefore, efforts to educate the public about food waste in Indonesia should be underpinned by enabling policy and regulatory frameworks, adequate investment, and strengthened collaboration between government institutions and international organizations (Rahman et al., 2024).

3.2.5 Food waste recycling

The projection of FLW in Indonesia under a Business as Usual (BAU) scenario, without involving macroeconomic scenarios (including GDP, population, GDP per capita, and food demand per capita), indicates that within the period from 2020 to 2045 there will be an increase in FLW generation. At the production stage, the potential FLW generation is estimated at 11.2 to 22.2 million tons; at the post-harvest and storage stage 7.9 to 16 million tons; at the processing and packaging stage 1.3 to 3.1 million tons; at the distribution and marketing stage 5.8 to 13.4 million tons; and at the consumption stage 18.1 to 57.1 million tons (Bappenas, 2021).

Outside the macroeconomic scenario, Indonesia still requires more comprehensive interventions to address the potential generation of FLW. In this regard, Indonesia can learn from Singapore's strategy in developing technologies, considering the substantial potential of food waste in Indonesia. Indeed, addressing food waste in developing countries faces several challenges, such as limited infrastructure, funding constraints, and competing priorities (Rahman et al., 2024). Consequently, directly replicating nexus-based technological approaches like Singapore's may not be feasible without accounting for differences in Indonesia's context. Therefore, regarding technology, Indonesia can focus on previously initiated efforts, specifically, improving the *Tempat Pengolahan Sampah Reduce, Reuse, Recycle* (TPS3R), *Tempat Pengolahan Sampah Terpadu* (TPST), and *Tempat Pemrosesan Akhir* (TPA) system, to ensure that the food waste recycling process can also be carried out efficiently.

Indonesia already possesses waste management schemes ranging from small to large scales. Initially, waste collected at the source enters a TPS3R, where the primary activity is sorting to reduce waste volume for subsequent stages. Specifically, organic waste undergoes processing such as composting, anaerobic digestion, and Black Soldier Fly (BSF) cultivation. Subsequently, both organic and inorganic waste are processed on a larger scale at a TPST, ensuring that only residual waste ultimately reaches the TPA. However, the implementation of these stages remains suboptimal in practice. According to the Ministry of Public Works and Housing, only 538 of 922 TPS3R facilities nationwide were functioning during 2015–2022, while 384 were non-functional. This indicates the need for continued evaluation and improvement of waste management infrastructure in Indonesia, as inadequate facility performance may result in both economic losses and environmental impacts. Moreover, economic viability significantly influences operations at TPS3R and TPST facilities, as it hinges on processing capacity, the ability to sell processed waste products to off-takers, and

waste management fees paid by the community. Other factors such as public awareness regarding waste sorting from the source and collaboration with the private sector also play a crucial role in the success of this waste management system (Rahman et al., 2024).

Another lesson that Indonesia can take from Singapore is the valorization of food waste. Indonesia has the opportunity to implement valorization processes by leveraging the early stages of the food supply chain, specifically for fruits and vegetables, which are big commodities in several regions across the country. For example, in 2024, Indonesia produced 1,823,869.64 quintals of cauliflower and 14,559,335.48 quintals of cabbage (*Badan Pusat Statistik* (BPS), 2025). Waste and by-products from the harvesting of cauliflower and cabbage, such as leaves, stems, and stalks, largely contain biomolecules with high value, including bioactive proteins and phytochemicals, glucosinolates, flavonoids, anthocyanins, carotenoids, and tocopherols. The utilization of post-harvest waste can be maximized through several techniques so that it not only minimizes environmental impacts but also contributes to the development of high value-added products that can be used in the food, pharmaceutical, and other related industries (Shinali et al., 2024). In this regard, Indonesia actually possesses materials with potential for valorization, however, the action plan within the Circular Economy roadmap does not yet include specific plans or priorities in this direction. Food waste valorization could therefore be considered as a potential future strategy. Nevertheless, despite the advantages that can be obtained, the valorization of food waste requires the involvement of researchers because it requires research and development processes with a scientific approach. In addition, collaboration with industry is also highly necessary so that the benefits can be scaled effectively (Heng et al., 2024).

4. Conclusions

Both Singapore and Indonesia face challenges in reducing and managing food waste; however, each country employs similar strategies in certain aspects, despite differences in their implementation and approaches. These shared aspects include management strategies, policies, prevention measures, and the distribution of excess food. Conversely, differences are found in the guidelines and food waste recycling practices. Singapore possesses a robust foundation for handling food waste, characterized by synergy across policies, infrastructure, and cross-sector collaboration. In contrast, Indonesia still faces limitations regarding priorities, public awareness, regulations, sectoral silos, and infrastructure. Although various food waste management initiatives have been proposed in Indonesia, their implementation remains limited, with some initiatives still at the conceptual stages, thus, the implementation requires significant improvement. Regarding lessons to be learned, there are two specific takeaways Indonesia could adopt. The first involves developing guidelines as educational tools for the public, particularly for managing food waste at the household level. The second concerns adopting technological approaches, similar to Singapore's, for recycling food waste, specifically by optimizing operations at TPS3R and TPST. Over the longer term, Indonesia has the potential to adopt a collaborative governance approach incorporating the WEF nexus and also food waste valorization strategies, building on lessons from Singapore.

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Author Contribution

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