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Green Innovation and Waste Management Challenges: Advancing Sustainable Urban Development in Malaysia through New Solutions

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Abstract

Malaysia faces mounting waste management issues due to rapid urbanisation and population growth, which call for more effective and sustainable solutions. The amount of waste generated daily has increased from an estimated 19,000 tonnes in 2005 to over 39,000 tonnes by 2024, exceeding the 30,000 tonnes threshold that the Japan International Cooperation Agency (JICA) had projected for 2020. Despite an increase in the national recycling rate to 17.5%, it is estimated that 82.5% of waste continues to end up in landfills, many of which have already exceeded their capacity. Food waste accounts for more than 30% of the total municipal solid waste (MSW), with an estimated 8.3 million metric tonnes of food waste being disposed of each year by Malaysians, translating to an average of 260 kilograms per person. The continued growth in waste generation is putting a strain on existing landfill infrastructure, increasing the cost of waste disposal, and contributing to environmental degradation. Therefore, it is becoming increasingly important to explore green innovation in waste management practices. This paper explores the structural limitations of current waste management practices, the socio-economic factors contributing to the increase in waste generation, and the role of green innovation in shaping the future of waste management in Malaysia. The paper highlights the need for more integrated, technology-driven solutions and policy reforms that prioritise reducing environmental impact, improving recycling efficiency, and achieving long-term sustainable urban development.

Keywords: Green Innovation, Municipal Solid Waste, Sustainable Waste Management, Food Waste, Recycling, Landfill Capacity, Environmental Sustainability, Malaysia, Urban Development, Waste Policy Reform

Introduction

In today's fast-paced cities and industries, the need for long-term progress has increased significantly, especially in how we handle waste. It is very important for countries like

Malaysia that are still developing to come up with new ideas, make changes, and develop good environmental plans to address the growing problems of municipal solid waste (MSW). As cities expand faster, populations grow, and habits change, more trash is produced, which presents a major challenge to what we have and what we extract from nature (Malaysian Investment Development Authority [MIDA], 2023). To protect the environment and public health, adopting new and sustainable waste management practices—particularly those based on green principles—is now crucial. Malaysia's waste management system faces significant issues. The amount of waste generated each day has more than doubled over the past 20 years, from 19,000 tons in 2005 to over 39,000 tons in 2024. This far exceeds the 30,000 tons per day that JICA predicted would be maximum by 2020 (MIDA, 2023). Although recycling has slightly improved, increasing from 5% to 17.5%, the country still primarily relies on landfills, with 82.5% of all MSW disposed of there (Jau & Ali, 2024). Many of these landfills are now overflowing. A major concern is the large amount of food waste, which accounts for over 30% of MSW. It is estimated that Malaysians throw away 8.3 million metric tons of food annually, about 260 kilograms per person (Pung, 2024). These figures highlight the urgent need to move away from traditional waste disposal methods and adopt better, sustainable solutions.

Green ideas, such as environmentally friendly technologies, resource reuse, and efficient resource utilization, are becoming increasingly important for enhancing the sustainability of trash management systems (Zhang et al., 2023). Malaysia needs to add more green ideas to its plans so that it doesn't have to rely as much on landfills, hurts the environment less, and grows in a more sustainable way. Other countries have shown that using green technologies can help recycle more, deal with trash better, and make rules stronger (Rahman et al., 2022). Malaysia needs to make full trash management plans a top priority if it wants to reach its goals for progress and environmental sustainability. These plans should include technology, changes to the rules, and getting the community involved. Knowing what's going on currently weak spots and what makes people produce trash is key to making good plans that work locally. This writing wants to rate the main problems that Malaysia's MSW system has, check out how green ideas can change things, and suggest plans based on facts to help waste management in the country be strong and sustainable in the future.

Literature Review

Over the past 20 years, Malaysia's management of municipal solid waste (MSW) has evolved significantly, but it remains largely ineffective due to persistent issues with infrastructure, policy, and operations. The rapid growth of cities, industries, and populations has led to a substantial increase in waste generation. As of 2024, the country produces more than 39,000 tonnes of MSW daily. This is a sharp rise from 19,000 tonnes in 2005 and greatly exceeds the earlier estimate by the Japan International Cooperation Agency (JICA) of a 30,000-tonne threshold by 2020 (Malaysian Investment Development Authority [MIDA], 2023).

Multiple government organisations oversee the management of MSW in Malaysia, with the Solid Waste and Public Cleansing Management Corporation (SWCorp) serving as a key coordinator for waste collection, treatment, and disposal operations throughout Peninsular Malaysia. A waste hierarchy model that prioritises final disposal, energy recovery, recycling, reuse, and minimisation was introduced by the National Strategic Plan for Solid Waste Management. Due to disparities in enforcement between states and municipalities,

fragmented governance structures, and inadequate funding, this strategy has been implemented inconsistently, as reported by many (Samsudin, Hamzah & Roslan, 2022).

Issues with Waste Management

Malaysia is largely dependent on landfills, even though it has waste management regulations. Approximately 82.5% of municipal solid waste ends up in landfills, according to statistics. Numerous of these locations are full (Jau & Ali, 2024). This dependence on landfills creates a number of issues. These issues include the potential for water sources to become contaminated, the release of gases like methane, and a decline in the amount of land available near urban areas (Ismail & Manaf, 2019). Inadequate waste sorting increases waste treatment costs and complicates recycling efforts. Since food waste accounts for over 30% of all waste, it is a serious problem.

Every year, more than 8.3 million tonnes of food are thrown away in Malaysia. That's about 260 kilograms per person (Pung, 2024). This high amount of food waste causes landfills to fill up quicker. It reveals issues with public knowledge, problems with food distribution, and inconsistencies in how policies are applied (Yusof, Rahman & Aziz, 2023). To give a bit more background, methane gas, created by waste in landfills, is a strong greenhouse gas and major contributor to climate change. When rainwater filters through landfills, it picks up pollutants and contaminates ground water that can negatively affect the environment and human health. The shortage of land is a major problem. As cities grow, there is more competition for land. Locating new landfill sites becomes a struggle, more so near urban centres.

The impact of improper waste sorting has far reached effects. When recyclables aren't separated, they can't be reused, which wastes resources and increases the need for raw materials. Food waste produces leachate and increases methane emissions when mixed with other waste in landfills. The large amount of food waste shows a need for community education. Educating people about reducing waste, better planning of meals, and appropriate storage of food may lessen the quantity of food that gets thrown away. Improving food distribution networks could make sure that surplus food gets to those who need it, instead of being wasted. More work is required to apply waste management policies consistently across the country. This will create a more practical and all-inclusive strategy for handling waste.

Green Innovation in the Management of Waste

Developing and implementing environmentally friendly technology and systems is known as "green tech" in waste management. The goal is to reduce environmental harm and make prudent use of resources. This includes waste-to-energy technology, composting, smart bins, and methods for reducing waste and reusing items in Malaysia (Zhang, Lee & Hassan, 2023). According to research, using green practices can significantly reduce the amount of waste that ends up in landfills and increase the number of green jobs in the area (Rahman, Ismail & Lee, 2022). This has already been demonstrated to work in countries like South Korea, Germany, and Japan with WTE plants, recycling, and gaining support. Although Malaysia is just getting started, it can learn from these concepts and modify them to suit its own population, financial circumstances, and organizations to handle waste better.

Conceptual Perspectives on Green Innovation

Understanding the application of green innovation in municipal solid waste (MSW) management can be aided by a number of related theoretical concepts. Rogers (2003) developed the Innovation Diffusion Theory (IDT), which allows us to examine how new practices and technologies proliferate across communities and geographical areas. According to this theory, factors like how good something appears, how well it fits with existing things, how difficult it is to understand, how simple it is to test, and how simple it is to see all effect how quickly something is accepted. Green technologies like composting, waste-to-energy (WTE) systems, and smart bin networks haven't taken off in Malaysia. This is frequently attributed to factors like fragmented governance, slow regulatory changes, not enough teamwork, and not enough financial reasons for people to start using them early (Ahmad, Ismail & Rahman, 2021; Samsudin et al., 2022).

Another important idea is Circular Economy (CE) Theory. It questions the usual way of doing things, which is take-make-dispose. It pushes for systems that reuse resources, use them again, and recycle them. Geissdoerfer et al. (2020) pointed out that the CE model wants to save the environment and make the economy strong by making products last longer and creating less waste. If Malaysia used the CE approach, it would have to rethink how it makes and uses things, change its waste rules, and make new business plans that focus on eco-innovation. But moving to this kind of model in growing economies can be hard. Things like not enough public knowledge, not good enough recycling setups, and not having ways for the market to help secondary raw materials can cause problems (Zhang et al., 2023). So, theoretical agreement needs to be backed by real changes in rules, the economy, and education to make the CE model work in Malaysia.

Empirical Data from Malaysia and other Countries

Malaysian research indicates that the application of eco-friendly concepts in waste management is a complex but improving situation. In cities like Selangor, Johor, and Penang, a number of test programs have been launched, including recycling facilities, waste-to-energy plants, oxygen-free waste-breaking systems, and intelligent garbage collection (Cheng, Mohd Yusoff & Hamid, 2022). These initiatives demonstrate that implementing innovative waste management techniques is feasible and environmentally beneficial. Some positive developments include improved trash sorting in some locations and a decrease in the amount of garbage disposed of in landfills. Expanding these initiatives to the entire nation is still challenging. Among the major issues are the high price of constructing eco-friendly facilities, a shortage of skilled workers to run advanced systems, and not enough involvement from the public in sustainability efforts. Also, inconsistent enforcement and a lack of clear cooperation between the national and local governments slow down wider use (Samsudin, Hamzah & Roslan, 2022).

Malaysian research reveals a complex but improving situation with regard to the application of eco-friendly concepts in waste management. Cities such as Selangor, Johor, and Penang have initiated a number of test programs, including recycling facilities, waste-to-energy plants, oxygen-free waste-breaking systems, and intelligent garbage collection (Cheng, Mohd Yusoff and Hamid, 2022). These projects demonstrate that it is feasible and environmentally beneficial to use new waste solutions. Better trash sorting in some locations and a decrease in the amount of garbage disposed of in landfills are some positive developments. Extending

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There are important lessons to be learnt from the waste management practices of nations like South Korea, Taiwan, and Singapore. Singapore has one of the highest rates of resource recovery in Asia thanks to its robust laws, first-rate recycling facilities, and collaborations between the public and private sectors (Lim, Tan and Othman, 2021). People have been encouraged to abide by the nation's mandatory trash sorting laws, as well as educational initiatives and transparent data reporting. Taiwan has also demonstrated that household recycling and composting can be significantly increased by involving people, using digital monitoring, and offering incentives like charging for the quantity of trash disposed of (Rahman, Ismail and Lee, 2022). These international examples demonstrate how crucial it is to align regulations with institutional support and public education to make lasting change.

Local initiatives and community trash programs in Malaysia have shown some promising results, but only in specific regions. In certain towns, initiatives like school recycling, neighbourhood composting, and zero-waste campaigns have raised awareness and influenced behaviour (Yusof, Rahman and Aziz, 2023). Government-private partnerships have also been beneficial, as evidenced by the establishment of neighbourhood recycling facilities and trash collection applications. The lack of a comprehensive national plan to direct all parties, monitor progress, and enforce regulations is a major problem. A multifaceted strategy is required to implement significant and long-lasting changes to Malaysia's waste management system. This entails unambiguous policies, more robust institutions, empowered citizens, and sustained investment in emerging technologies. The table that follows contrasts important parts of trash management and the use of environmentally friendly ideas in Malaysia, Singapore, Taiwan, and South Korea. It focuses on things like government systems, the use of new ideas, and community involvement.

Table 2.1
A Comparative Study of Green Innovation in MSW Management in Malaysia and a Few Other Asian Nations

Country	Institutional Framework	Green Innovation Adoption	Community Engagement	Key Challenges
Malaysia	Fragmented governance across federal, state, and local levels. Weak coordination and inconsistent enforcement (Samsudin et al., 2022).	Pilot projects in WTE, MRFs, and smart waste bins in selected cities (Cheng et al., 2022).	Localised initiatives such as composting and school programmes (Yusof et al., 2023).	High initial costs, limited public participation, and poor data integration.
Singapore	Strong centralised governance under NEA with clear regulations.	Advanced WTE plants, recycling infrastructure, and integrated smart waste systems.	Mandatory waste segregation and extensive awareness campaigns (Lim et al., 2021).	Land scarcity and high dependence on incineration.
Taiwan	Coordinated national waste policy with transparent monitoring systems.	High-tech recycling facilities and PAYT systems; strong emphasis on food waste reduction.	Citizens must use official bags; real-time collection data enhances compliance.	Maintaining participation in rural areas and managing food waste logistics.
South Korea	Centralised waste strategy with municipal autonomy for implementation.	Use of RFID bins, food waste collection systems, and green business incentives.	Education-driven policies with high citizen involvement.	High cost of smart waste tech and enforcement challenges in urban slums.

Research Gaps and Justification for the Study

Even though there is a growing amount of academic research on waste management in Malaysia, a thorough examination of how to integrate green innovation into current waste management frameworks is still critically lacking. Much of the literature that is currently available has focused on particular technological developments or isolated pilot projects, like recycling programs, composting technologies, and waste-to-energy systems (Chong, Teh and Ho, 2020; Lim, Tan and Othman, 2021). These initiatives are in line with national sustainability goals, but they frequently lack a long-term, comprehensive viewpoint that links technological interventions to the development of policies, the capacity of institutions, and the viability of socioeconomic initiatives. Specifically, the innovations' scalability and reproducibility in Malaysia's varied urban and rural contexts have been mainly disregarded, even though they are essential for attaining significant, nationwide transformation (Zhang, Lee, and Hassan, 2023). Moreover, evaluations frequently rely on short-term performance indicators, with limited attention given to the broader environmental, economic, and social implications over time. This fragmented approach constrains the development of evidence-based policies and undermines the formulation of cohesive, long-term waste management strategies. Compounding this issue is a significant research gap regarding the socio-economic, cultural, and behavioural factors that influence the public adoption and sustained success of green innovation strategies. Understanding variables such as environmental awareness, attitudes

towards recycling, and community engagement is crucial, particularly in a Malaysian context where demographic and regional differences play a major role in shaping sustainability outcomes (Yusof, Rahman, and Aziz, 2023; Pung, 2024).

Table 2.2
Strategic Recommendation for Promoting Sustainable Municipal Waste Management and Green Innovation in Malaysia

No.	Recommendation	Description	Supporting References
1	Boost Regulatory and Policy Frameworks	Update and implement waste management regulations to encourage the use of green technologies, require recycling, and lessen reliance on landfills. Innovation and accountability can both be promoted by a clear regulatory framework.	Ahmad et al. (2021); Cheng et al. (2022)
2	Invest in environmentally friendly infrastructure and technologies	Encourage public-private partnerships to finance scalable technologies like automated sorting systems, anaerobic digestion, and waste-to-energy (WTE). These technologies can promote energy recovery and drastically lessen reliance on landfills.	Zhang et al. (2023); Lim et al. (2021)
3	Encourage the Circular Economy and Extended Producer Responsibility (EPR)	By prolonging product lifecycles and reducing waste production, we can move towards a circular economy. Use EPR to make sure manufacturers handle post-consumer waste, especially in the electronics and packaging industries.	Geissdoerfer et al. (2020)
4	Boost Community Involvement and Public Awareness	To promote sustainable waste practices and environmental stewardship, start nationwide campaigns, incorporate environmental education into the curriculum, and work with non-governmental organisations.	Yusof et al. (2023); Pung (2024)
5	Encourage innovation and research Ecosystems	Extend research and development projects that concentrate on affordable, regional green solutions. Encourage cooperation between academic institutions, entrepreneurs, and governmental organisations in order to create and expand sustainable technologies.	Rahman et al. (2022); Ahmad et al. (2021)
6	Increase Local Authorities' Capacity	Give local governments funding, technical assistance, and training to improve the successful application of creative waste management techniques.	Samsudin et al. (2022)

Implementing these strategic recommendations will play a vital role in advancing a more sustainable waste management framework in Malaysia, one that simultaneously addresses environmental degradation, promotes economic efficiency, and safeguards public health. Strengthening regulatory frameworks and investing in green technologies such as waste-to-energy systems and advanced recycling facilities can significantly reduce landfill dependency and greenhouse gas emissions, aligning with global sustainability targets. These measures also

support economic resilience by fostering green industries, generating employment, and reducing long-term operational costs. Furthermore, enhancing public awareness and community participation is essential for cultivating responsible waste behaviours, which contribute to cleaner environments and reduced health risks associated with pollution and improper waste disposal. Capacity building among local authorities ensures effective governance, monitoring, and tailored implementation of waste strategies across urban and rural areas. Collectively, these actions support a circular economy model and reinforce Malaysia's commitment to sustainable development as outlined in the Twelfth Malaysia Plan and the United Nations Sustainable Development Goals.

Conclusion

The nation's continued over-reliance on landfilling, the rapid increase in waste generation, and the negative environmental effects of insufficient recycling and food waste mitigation have all been highlighted in this study's critical analysis of Malaysia's ongoing municipal solid waste (MSW) management issues. From 19,000 tonnes per day in 2005 to over 39,000 tonnes per day by 2024 (MIDA, 2023), waste generation has more than doubled. Of this, 82.5% is still disposed of in landfills, which is an environmentally unsustainable and health-harming practice (Jau & Ali, 2024). More than 30% of all MSW, or about 8.3 million metric tonnes annually, is made up of food waste alone (Pung, 2024). In reaction, green innovation has become a key tool for advancing sustainability by implementing eco-friendly technologies and a circular economy.

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