

Malaysia Waste Management Practices

Subjects: **Green & Sustainable Science & Technology**

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The three main municipalities of Malaysia, Kuala Lumpur, Penang, and Melaka, were discussed in their actions in household waste management practices and strategies in social, economy, information technology, and governance to achieve success for a better sustainability of the environment.

household waste

household waste management

sustainable city

integrated waste management model

Malaysia cities

1. Kuala Lumpur

Kuala Lumpur is Malaysia's main economy-driven area, adjoining the Selangor state area with the highest population density of 6.56 million compared to Penang and Melaka States in 2021 ^[1]. The higher density of population potentially leads to higher municipal waste, which is important, especially for the citizen, who needs to be disciplined and understand that the consequences of the waste may affect the environment. The government should promote activities that can create awareness among households, i.e., reuse and recycling activities ^[2]. One of the ways to reduce plastic packaging is the use of green packaging, which is closely related to Sustainable Development Goal 12—Responsible consumption and production, where the responsibility of managing the waste sustainably falls on the consumer and producer. Findings from Kuala Lumpur's consumers have shown that environmental awareness, inconvenience of support, cost, and lack of government enforcement are most discouraging for green packaging. In Klang, there is The Ecogen Recycle Bank App which is a pilot effort by the council to engage the people of Bandar Bukit Rajah in a recycling cause. The software will assist in tracking the weight of recyclable goods disposed of by individual houses in accordance with the various categories. In addition to the social and governance aspects, the technology aspects such as the waste-to-energy (WTE) incinerator and material recovery facility are considered circular economy projects that will regenerate income from waste ^[3].

2. Penang

Penang is located in north-western Peninsular Malaysia with a total estimated population of 1.77 million (island and mainland) and total area of 1049 km² ^{[1][4]}. Penang is one of the States that does not adopt the Solid Waste Management and Public Cleansing Act 2007 (Act 672), instead follows the Local Government Act 1976, which allows the local authority to have the power to manage waste and carry out sanitary services differs from the Federal level by working together with the local councils ^[5]. The approach in managing solid waste from both island and mainland is still in landfill. Waste is sent to Pulau Burung Sanitary Landfill located at Nibong Tebal, Pulau

Pinang [5]. Penang State had already enforced the Waste Segregation at Source (WSAS) Policy (separation of solid waste into recyclable waste and general waste) since June 2017 in order to increase the recycling rate and prolong the lifespan of the landfill [5]. Since then, Penang has achieved the highest recycling rate of 44.04% among all States in Malaysia, and the government is continuing to pursue more sustainable solutions in the future, for instance, the improvement of segregation and management of rubbish, including plastics [6].

3. Melaka

Melaka is located in the west of Peninsular Malaysia, with a total estimated population of 0.93 million and a total area of 1712 km² [1]. Melaka was declared a Develop State in 2010 by the OECD [7]. Since then, the state has implemented a Green City Action Plan (GCAP) to establish numerous green programs and initiatives, especially related to green technologies. One of Melaka’s primary goals is to become a “Zero Waste” State, particularly to mitigate the emission of waste-related greenhouse gases (GHGs) [7]. Melaka has adopted the practice of “‘2 + 1’ Municipal Waste Collection System” introduced by Solid Waste and Public Cleansing Management Corporation (SWCorp) and SWM Environment since 2013—a solid waste management enforcement agency that is responsible for ensuring that the municipal waste is properly segregated, collected, and transported to the landfill [7]. Based on the ‘2 + 1’ waste collection schedule, organic and non-recyclable wastes will be collected twice a week while recyclable waste (paper, plastic, etc.) are collected once a week [7]. Starting from 1st September 2015, the SAS campaign was implemented whereby all households in Melaka are required to practice waste segregation at source [7]. The Melaka government also initiated three days of ‘No Plastic Bag Day’ (for every Friday, Saturday and Sunday) in 2014 where consumers were encouraged to bring their own bags and it was extended to every day from January 2016 [8].

4. Four Key Aspects and Other Factors of Future Waste Management in Malaysia

The 13 articles reviewed, labeled from A1 to A13, showed the future suggestions and success factors as the solutions towards Malaysia’s sustainable cities based on different areas that have been identified. **Table 1** shows the authors, title of the article, objectives, future suggestions, success factors, and key findings.

Table 1. Summary of selected articles on Malaysia’s household waste management.

No	Authors	Title	Objective	Future Suggestions	Success Factors and Practices	Key Findings
A1	[9]	“Impact of perceived food accessibility on household food waste	“Perceived food accessibility, measured in terms of perceived	- “Over purchase are to prevent wastage and waste creation	- “Changing leftover routines, reducing	- “Three significant paths are found in the model

	behaviors: A case of the Klang Valley, Malaysia”	time and perceived effort, and its impact on household food waste”	<ul style="list-style-type: none"> - Recycling behavior and preventive behavior are needed” 	shopping trips per week.”	<ul style="list-style-type: none"> connecting food waste with effort levels, environmental concern, and price importance.” - “Policymakers may consider improving access to food sources to reduce household food purchase efforts.”
A2	[10] “Resilient Melaka—Creating a striving, livable and smart Melaka”	“Resilient Melaka sets a vision for “a vibrant city, where smart governance, collective leadership, sustainable mobility and protective infrastructure supports a thriving, healthy community that is proud of Melaka’s outstanding universal values as a world heritage city.””	<ul style="list-style-type: none"> - “Green City Action Plan (2017–2030)” - “Promote sustainable ways awareness campaign” - “Creating a Circular Economy for solid waste action” - Improving Solid Waste Collection Systems Action 	<ul style="list-style-type: none"> - “This strategy was developed in collaboration with over 320 city stakeholders from the government, private sector, academia and the general public (i.e., Online engagement surveys and social media, Workshops, Discussions 	<ul style="list-style-type: none"> - “This report builds upon existing strategies by highlighting expanding initiatives to include a resilience approach and identifying new opportunities to incorporate disaster risk management and climate change adaptation in the city’s development.”

				and Interviews)”	
A3	[7]	“Community Participation and Performance of Waste Segregation Program in Malacca: Towards Sustainable Waste Management”	<p>“This paper reviews the current practice and challenges of community’s participation on waste segregation program in Jasin Malacca since 2015–2017 towards achieving the Sustainable city in year 2022.”</p> <ul style="list-style-type: none"> - “At the authority level, provision of integrated structure and stakeholders should be formulated by providing the necessary facilities, including funding equipment, incentives and waste disposal area.” - “The local authority should play their role in working closely with the community committees to address feedback and problems encountered during the period execution.” 	<ul style="list-style-type: none"> - “Various Waste Separation at Source awareness programs were initiated by the local authority agencies such as SWCorp and Malacca Green Technology Corporation (PTHM).” - “Many workshops and programs in educating the kids in school have been implemented and to nurture the “Recycling Culture” into the heart of younger generations.” 	<ul style="list-style-type: none"> - “Through various efforts and campaigns on waste separation at source, the performance has steadily increased from 2015 to 2017. It is expected that the initiative shall be rigorously promoted as to achieve the 30% recycling rate in 2020.”
A4	[11]	“Making a Case for Zero Waste: Laying	“To discuss Penang state’s waste	<ul style="list-style-type: none"> - “Penang will continue to strive for a low- 	<ul style="list-style-type: none"> - “Awareness is important - “A public consultation on

	the Groundwork for Zero Waste"	segregation challenges and future expectations of Penang's zero waste program."	carbon city by 2022 by increasing the recycling rate from 42% to 70% and reducing their landfill-bound waste by 50%."	among all the communities to be responsible for their disposal of waste."	Budget Dialogue in 2012 with the stakeholders cleared one thing: all of them prioritized cleanliness. Cleanliness includes a vast array of things; and recycling, composting, and upcycling are inseparable aspects of it."
A5	^[5] "Stakeholder Consultation on Penang's Green initiatives: Solving Plastic Pollution at Source"	"To discuss and deliberate on the various green initiatives that have taken place thus far in relation to tackling plastic pollution at source in Penang, as well as planning the way forward for 2020 including the know-how in embedding Circular Economy solutions within the Island and mainland's ecosystem."	<ul style="list-style-type: none"> - "Hoping to enforce 'Single-use plastics ban' by 2023." - "Continue education, monitoring & enforcement of WSAS" - "Introduce incentives/recognition for WSAS for plastic and other materials for recycling." - "Polluter Pays Principle and Waste Directory should be adopted in the WSAS Policy." - "A case study for long-term community 	<ul style="list-style-type: none"> - "Applying WSAS policy" - "Total ban on polystyrene packaging, No Plastic Day Campaign, and No Single-use Plastic Campaign were implemented in order to divert and reduce the number of waste." - "Many green initiatives 	<ul style="list-style-type: none"> - "The discussions and key takeaways during the stakeholder consultation provided valuable inputs to the project team to further develop the case study according to the Terms of Reference and how to get multi-stakeholders on board."

				behavioral change requires the involvement of various stakeholders.”	were done by local authorities to reduce the usage of single-use plastics included educational talks, distribution of recycled bags at Bazar Ramadan during the fasting month, and distribution of “Say No to Single-Use Plastics” posters to food and beverage outlets on the island.”	- “Initiatives by organizations in supporting Penang’s state vision and protecting the environment.”
A6	[12]	“Public Survey: The Impacts of Movement	“To investigate the impacts of MCO	- “Suggestions from respondents to increase the number	- “It is essential to heed public opinions as	- “52% of respondents noticed waste

	Control Order (MCO) Towards Waste Generation in Penang Island"	(Malaysia's lockdown) influence on household waste generation and consumer purchasing behavior. To provide data and insights in order to assist policymakers and other related agencies to better deal with similar crises in the future."	<ul style="list-style-type: none"> - of recycling bins at public areas." - "Medical waste or hazardous waste bins should be set up in public areas." - "Incentives from government and businesses could help motivate the public to practise 3R." 	they allow the identification of critical elements that form the foundation in developing effective strategies to tackle this problem."	<ul style="list-style-type: none"> - generated in home has increased" - "MCO had no influence on Waste segregation practice" - "There is general agreement (51%) about MCO causing the increase of single-use plastics" - "The use of face masks has become a norm." - "COVID-19 pandemic has remarkably changed consumer behavior."
A7	[13] "Microplastic Pollution and Health and Relevance to the Malaysia's Roadmap to Zero Single-Use Plastics 2018–2030"	"To discuss the rising threat from microplastics and potential impact to human health."	<ul style="list-style-type: none"> - "It is vital that each relevant stakeholder, including the federal government, state government, non-government agencies, manufacturers and the general public 	<ul style="list-style-type: none"> - "Plastic straws, wrappers and cutlery should be banned and replaced with more eco-friendly materials." 	<ul style="list-style-type: none"> - "Low rate of recycling plastic waste, lack of awareness on sustainable behaviors and habits, lack of integrated

				work together in order to achieve the goal in 2030.”		waste management, inadequate biodegradability products and high cost of plastic alternatives, and lack of cooperation and enforcement from relevant governmental stakeholders.”
A8	[14]	“Extended Producer Responsibility (EPR) in Malaysia—Towards a Sustainable Waste Management System”	“To discuss the opportunities of EPR legal system in Malaysia, especially in supporting management of plastic solid waste”	<ul style="list-style-type: none">- “Governance must be strengthened to form a strong foundation.- Communications & awareness are vital to create a paradigm shift in mindset.”- “Polluter-pay-principle instruments need to be further explored.”- “Government must set a good example by implementing GGP.”- “3R initiatives require strong inter-Agency coordination and collaboration.”	<ul style="list-style-type: none">- “The 11th Malaysia Plan (2016–2020) establishes guiding principles for effective and sustainable waste management for 2016–2020, focusing on green growth for sustainability and resilience. A clear path forward for improving Malaysia's solid waste	<ul style="list-style-type: none">- “Formation of a Producer Responsibility Organization (PRO) responsible for the organization of all tasks associated to the proposed EPR system.”- “A sustainable regulatory framework on EPR covering for example specific types of goods including packaging products, on

- “Clear and definitive roles of stakeholders ranging from manufacturers of packaging”
 - “Enhancement of recycling programs through sustainable extensive public education and publicity campaigns.”
- management system, from changing societal mindsets to enhancing waste database collection systems and mandating or strengthening a single governing body to implement and enforce relevant legislation to ensure waste optimization and minimization in Malaysia.”
- deposit system, waste disposal tax and amount of waste to be utilized in production and collection, sorting and recycling targets.”
- “Material or of packaging, consumer goods companies, distributors, retailers, consumers, waste management operators, government and other public authorities including local municipalities.”
 - “Strengthening of institutional capacities, technical and skilled staff and sufficient financial resources to monitor and control implementation

						of EPR system.”
						- “Charging of fees based on the packaging's degree of recyclability.”
A9	[15]	“Plastic Waste: Environmental Legal Issues and Policy Law Enforcement for Environmental Sustainability”	“To discuss the environmental issues that are related to plastic waste. Especially due to people's habit, changing entrenched habits and law enforcement at the empirical level.”	- “Participation of stakeholders is essential in establishing policies on the provision of the protection of environmental sustainability to ensure the fulfill of the rights of citizens.”	- “Restricting the use of single-use plastic packaging (food and beverages) for the coastal community and visitors.” - “Practicing the habit of proper garbage disposal, i.e., providing trash bins, sorting types of waste (plastic waste and other waste).” - “Banning all people from dumping litter at the beach.” -	- “Preventive approach is important to keep out from the undesirable results caused by the waste” - “The absence of imposing sanctions turns out to be a problem in plastic waste reduction and management.”

		“Imposing sanctions for those who violate the rules.”			
A10	[16]	“Malaysia Moving Towards a Sustainability Municipal Waste Management”	“This paper aims to discuss the application of energy recovery from municipal solid waste in Malaysia.”	<ul style="list-style-type: none">“The government should put effort into solving the current issue by promoting recycling in public, enforcing the legislation, and approaching new technologies for better solid waste management practice in the future.”	<ul style="list-style-type: none">“The solid waste management practices lacking separation and recycling sources become an obstacle for development.”
					<ul style="list-style-type: none">“The recovery system and refuse-derived fuel plant achieved expectations.”“The application of (waste to energy) WtE technologies, especially incineration, is unavoidable in the future in order to reduce the volume of waste being disposed in the landfill.”
A11	[17]	“Forecasting Solid Waste Generation in Negeri Sembilan and Melaka”	“The solid waste produced in Negeri Sembilan and Melaka is forecasted to one year	<ul style="list-style-type: none">“Restrictions on the use of plastic bags and food containers need to be tightened.”	<ul style="list-style-type: none">“ARIMA model in forecasting the solid waste generation is“The estimated solid waste generation for both states also is approaching the maximum
Four Factors		Elements			
Data and Technology		“Automatic product lifecycle data collection”			
		“Real-time data analysis”			
		“Data-driven decision making”			

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Four Factors	Elements
Economy	"Data sharing, open data"
	"Data security and citizen privacy"
	"Intelligent and connected devices, new data acquisition, and communication technologies"
	"Resilient infrastructure"
	"Standardization of technology"
	Articles:
	A10, A12, A13
	"Novel business models"
	"Sharing economy, circular economy models"
	Articles:
	A1, A2, A8, A11, A13
	"Citizens' participation, green behavior"
	"Smart collaboration among stakeholders"
	"Technologies compatible with local culture"
	"Reward-based systems"
Social factor	Articles:
	A2, A3, A4, A6
	"Strategic planning"
	"Non-governmental parties' involvement"
	"Laws and regulations compatible with circular economy concept"
	Articles:
	A5, A7, A9, A13
Governance	

nd utilize machine learning to manage waste. They are using a data-centric system to track users' recycling based on their bin location and create a recycling report for the users. For example, there are applications from AI to detect fraud waste management activity [18].

impediments to these initiatives' success." reason for optimism." management hierarchy." development stages into green energy [19]. Ref. [22] also mentioned the proposed plan, which suggested Penang, and [7] or the Melaka State government should explore incineration technologies as a sustainable waste disposal option impacting the environment has to be considered. In addition, the Penang state government had developed a Trash2Treasure (T2T) smartphone app to encourage the local citizens to turn "trash into cold hard cash or trade them in for valuable items." Moreover, practical waste-to-energy technology can also reproduce energy from anaerobic digestion to treat organic waste without combustion, is a good option and is 30% more efficient than incineration [16].

4.2. Circular Economy

Circular Economy is a systematic approach to green economic development which is transformative and characterized by new business models, innovative approaches to product design, distribution, and refurbishment/remanufacturing products [23]. The main concept (with an example of plastic waste) is visualized in Figure 1. Ref. [24] emphasizes three principles in a sustainable resource, resource conservation, cost efficiency, and human-centered design adaptation. Ref. [19] proposed that Malaysia should take a step forward by implementing a circular economy model with integrated solid waste management as a sustainable solution for complying with the 'New Plastics Economy.'

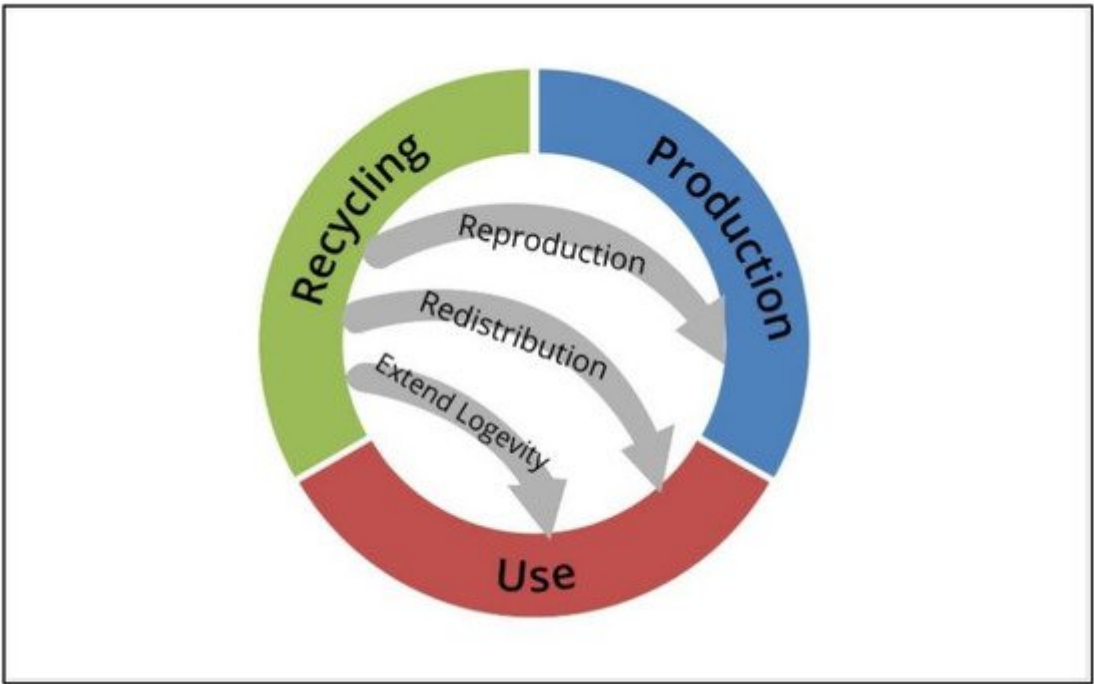


Figure 1. Circular Economy concept for recycling plastic as reusable resources [19].

According to [25], Penang was proposed to establish an innovative Waste Industry Plan to encourage better waste management and a circular economy in the State. Similarly, Ref. [10] mentioned that the State government plans to investigate embedding the circular economy principles into their city's waste management system. The proposed

idea was to focus on mitigating the amount of waste generated to the city environment, making wastes as resources to generate economic value through continuous reuse and recycling, promoting a sustainable solution to the local waste management system, and creating new employment and investment opportunities. However, this initiative will require the participation and engagement of local entrepreneurs as well as citizens to achieve a successful circular economy in waste management.

4.3. Social Factor and Education at All Levels/Roles of Media and Public Service

Education and awareness are the key to reducing waste ^[26]. The amount of waste generated will continue to increase without a consciousness of environmental sustainability ^[26]. Education at a young age is the long-term solution in addressing the waste management issue in the long term and at grassroots level.

4.3.1. Social Service on Penang

In Penang, Penang City Council has made a lot of green efforts in educating the local community and students on reducing single-use plastics, such as: educational talks, campaign, distribution of recycled bags at Bazar Ramadan during the fasting month, and distribution of “Say No to Single-Use Plastics” posters to food and beverage outlets on the island. They are likely to continue their effort in educating the public, especially on Waste Segregation at Source Policy as well as introducing recycling banks in schools ^[5]. Due to the disruption of the COVID-19 pandemic, all environmental campaigns and workshops organized in Penang were transferred to online using a digital platform, for example, conducting a virtual classroom for the program of ‘Virtual Green Adventure Series’ to educate the students and more younger generations about environmental care and green practices. The program is based on the United Nation Sustainable Development Goals (UNSDGs) and is a game-based learning method that provides the students and children with fun and interactive online sessions.

4.3.2. Public Survey on the Impact of MCO on Waste Generation

Conducting a public survey is important to take public opinions into consideration as it allows critical factors to be identified, which serve as a basis for establishing effective strategies to address new emerging issues. According to a recent public survey in Penang Island ^[12], it was revealed that single-use plastics such as: plastic bags, containers, cutleries, and straws were in high demand due to the shift towards online shopping and food delivery services during the pandemic and lockdown. Moreover, the locals in general were aware that the unmanaged PPE waste (i.e., face masks) could cause harm to the environment and hence looking forward for solutions for these issues such as suggesting for more recycling bins including PPE waste bins to be placed in public areas or incentive programs can be initiated by government and businesses to encourage the public to practice 3R or bring their own reusable bags/food containers. The findings and recommendations from the locals provided valuable insights that can assist the policymakers and other related agencies to better cope with future similar crises.

4.3.3. A Goal to “Zero Waste” Model

Usually, zero waste is an ideal concept, a move to zero waste as a goal. It is a social movement from grassroots green initiative. The model of zero waste/or minimization of waste has been recently getting high attention by the youth.

Penang's Zero Waste network focuses on preventing waste by strategically redesigning the life cycles of Earth's precious resources through recycling ^[11]. Among the objectives are: (1) To build a zero-waste economy via carbon footprint reduction, (2) to shorten the travel time of environmentally-conscious individuals, and (3) to increase the time-cost efficiency of recycling.

4.4. Governance: Enforcement Education/Policy Law Enforcement

Among all States in Malaysia, there are only six States (Perlis, Kedah, Pahang, Negeri Sembilan, Melaka, Johor) and two Federal Territories (Kuala Lumpur and Putrajaya) that have accepted and complied with Act 672 (Figure 2). The remaining seven States (Penang, Selangor, Perak, Kelantan, Terengganu, Sabah, and Sarawak) and one Federal Territory (Labuan) are not under the administration and enforcement of Act 672 ^[27].

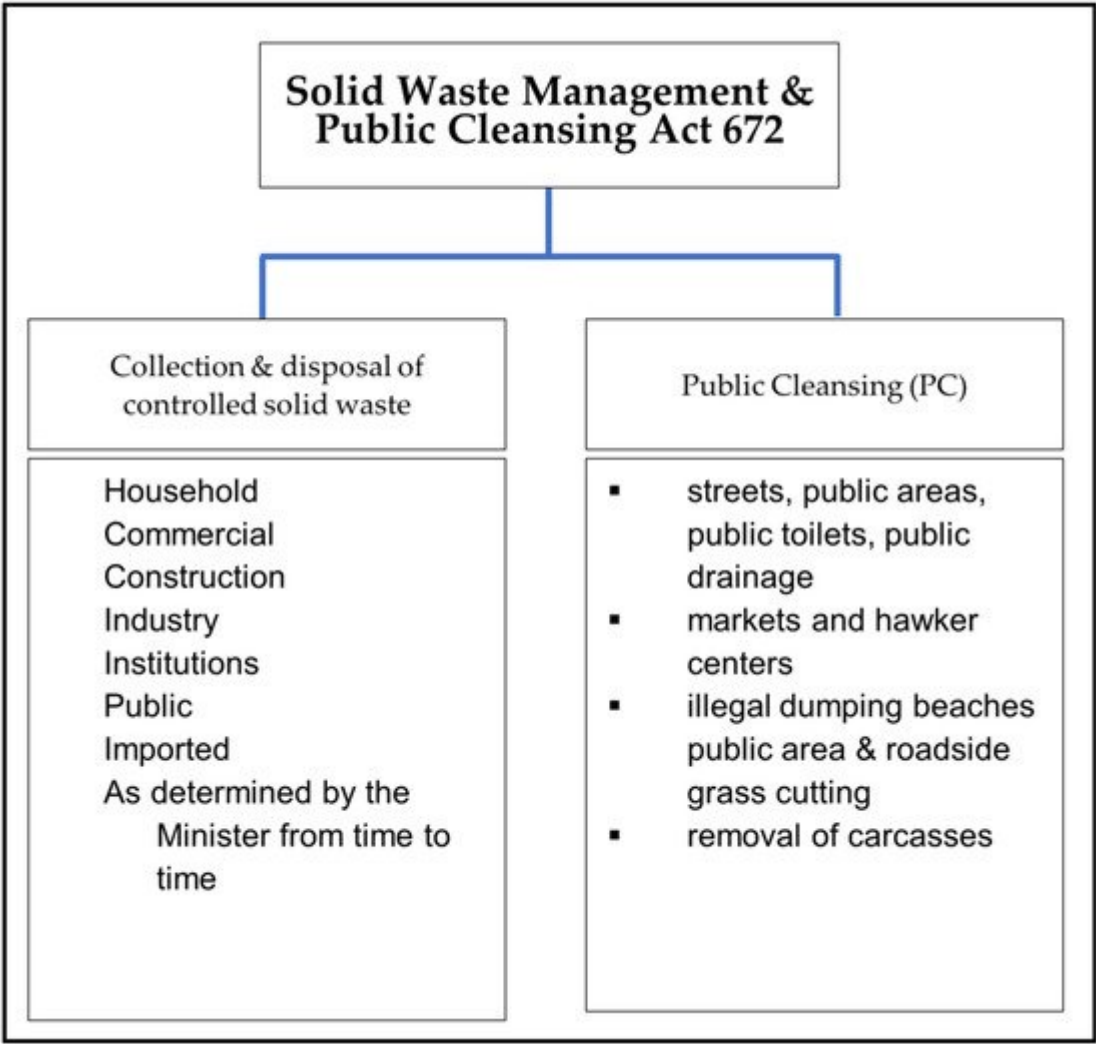


Figure 2. Solid Waste Management and Public Cleansing Act 672 ^[28].

Under the Ministry of Housing and Local Government, the Municipal solid waste has set up the National Solid Waste Management Department as the regulatory body and the Solid Waste and Public Cleansing Management Corporation to conduct the operations. However, local authorities would continue to monitor and enforce in plastic and waste disposal approaches can be made with the enforcement of policy law and sanction imposed to the public [15]. According to [26], enforcement of regulations can control people's behaviors and address current problems in maintaining the environment.

4.4.1. Governance on Kuala Lumpur

Kuala Lumpur is the largest city in Malaysia, and it also has the highest density of population in the country. Smart Selangor, which is the Selangor state government program, has come out with a Smart Selangor Action Plan to 2025 report, with the smart government plan for smarter communities and economy to make use of technology as a catalyst of change. The vision is to make Selangor a livable Smart State in ASEAN by the year 2025. Nature and environment are part of the plan for cleaner and greener public areas in handling domestic waste efficiently and promoting environmentally conscious communities. Smart Selangor has rated reducing domestic waste in 6th place as the citizen prioritization needs and rated clean and green Selangor and reduce domestic waste in Selangor in 9th and 10th place for citizen needs prioritization by the district [29].

4.4.2. Governance on Melaka

According to the [10], one of the major strategies to approach resilience in the city is the extended Green City Action Plan (2017–2030) aimed to improve areas in “solid waste management, energy, local industry development, energy efficiency and transport.” However, Melaka faced the present challenges in SWM that is not sustainable in the long run, insufficient material-sorting facilities and infrastructure, rapid growth of population, lack of public (residents, businesses, and industry) awareness of waste issues in the city as well as lack of maintenance of the existing dump sites [10]. Therefore, the Melaka government (MBMB) will continue to promote a sustainable waste awareness campaign to enhance the awareness of recycling practices and proper waste disposal among the residents, visitors, and businesses to protect the environment and human health.

4.4.3. Governance on Penang City

While looking specifically at how the State government (City Council) green initiatives reduce plastic waste, Penang was the first State that implemented ‘No Free Plastic Bag Policy’ (imposed charges for plastic bags) since 2009 and ‘No Single-use Plastic Policy’ since 2018 (to reduce plastic wastage) “to be in line with ‘Malaysia’s Roadmap towards Zero Single-use Plastics 2018–2030’ under the Federal government’s efforts to encourage eco-friendly products to substitute single-use plastics” [5][30]. Additionally, Penang took a step further in 2019 to totally ban the usage of styrofoam/polystyrene packaging [4][5].

According to the City Council of Penang, they are “aware of the plastic pollution issues” and therefore will look into the matter seriously, especially hoping to enforce a single-use plastics ban by 2023 for the sake of the future generation [4]. On the other hand, the State government are also working towards Penang 2030 vision, which aim

to improve the “livability, economy, civil participation and balanced development to achieve a ‘Family-focused, Green and Smart State’ that inspire the nations” [30].

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